Blue Gem Wind

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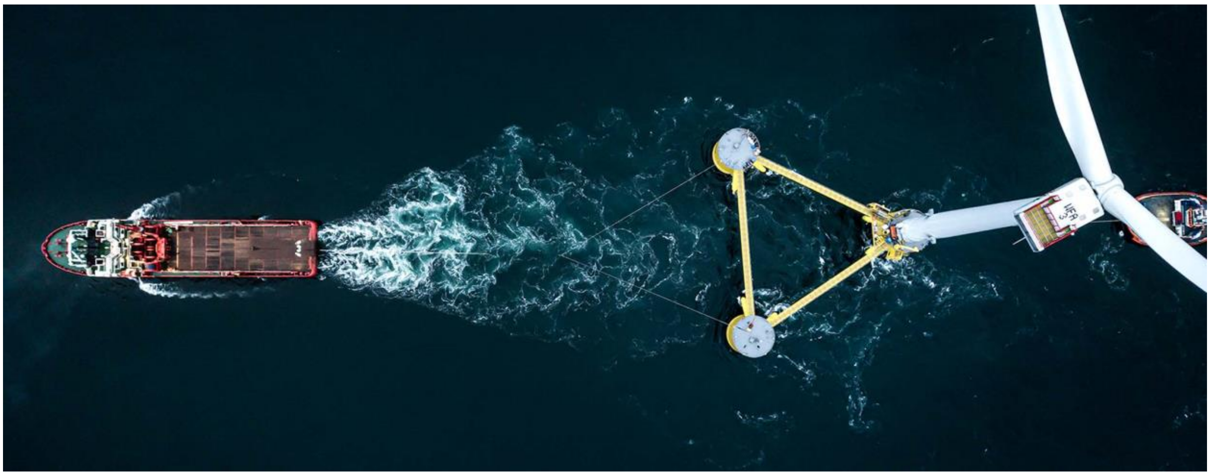

# REPORT

## Blue Gem Wind Project
## Geophysical & Environmental Final Survey Report

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## Confidentiality Notice and Disclaimer



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## Commercial Security

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| Table 1: Table of Abbreviations | |
|---|---|
| A/R | As required |
| AIS | Automatic Identification System |
| BGW | Blue Gem Wind |
| BSH | Broadscale Habitat |
| CoG | Centre of Gravity |
| COSHH | Control of Substances Hazardous to Health |
| CRP | Common Reference Point |
| DDC | Drop Down Camera |
| DDV | Drop Down Video |
| DPR | Daily Progress Report |
| DTM | Digital Terrain Model |
| EBS | Environmental Baseline Survey |
| EPSG | European Petroleum Survey Group |
| EIA | Environmental Impact Assessment |
| EMODnet | European Marine Observation and Data Network |
| EUNIS | European Nature Information System |
| FLOW | Floating Offshore Wind |
| FOCI | Features of Conservation Interest |
| GNSS | Global Navigation Satellite System |
| GPS | Global Positioning System |
| HA | Habitat Assessment |
| HDD | Hard Disk Drive |
| HIRA | Hazard Identification Risk Assessment |
| HSEQS | Health, Safety, Environment, Quality and Security |
| IHO | International Hydrographic Organisation |
| IUCN | International Union for Conservation of Nature |
| JNCC | Joint Nature Conservation Committee |
| LAT | Lowest Astronomical Tide |
| MBES | Multibeam Echosounder |
| MCZ | Marine Conservation Zone |
| MHWS | Mean High Water Springs |
| MLWS | Mean Low Water Springs |
| MNCR | Marine Habitat Classification for Britain and Ireland |
| MOB | Mobilization |
| MoD | Ministry of Defense |
| MRU | Motion Reference Unit |
| MW | Mega Watt |
| MNBAQC | National Marine Biological Quality Control |
| NAS | Network Accessed Storage |
| OEL | Ocean Ecology Limited |
| OEM | Original Equipment Manufacturer |
| PC | Personal Computer |
| PPE | Personal Protective Equipment |
| PSA | Particle Size Analysis |
| PSD | Particle Size Distribution |
| PTW | Permit to Work |
| RAMS | Risk Assessment and Method Statement |

| | |
|---|---|
| SAC | Special Area of Conservation |
| SBP | Sub Bottom Profiler |
| SE | Standard Error |
| SoW | Scope of Work |
| SPA | Special Protection Area |
| SSD | Solid State Drive |
| SSS | Side Scan Sonar |
| SSSI | Site of Special Scientific Interest |
| SVP | Sound Velocity Profile |
| SVS | Sound Velocity Sensor |
| SWL | Safe Working Load |
| TB | Terabyte |
| TBC | To Be Confirmed |
| TBT | Toolbox Talks |
| THU | Total Horizontal Uncertainty |
| TVG | Transverse Gradiometer |
| TVU | Total Vertical Uncertainty |
| UHD | Ultra-High Definition |
| USBL | Ultra-Short Baseline |
| UTC | Coordinated Universal Time |
| UTM | Universal Transverse Mercator |
| UXO | Unexploded Ordnance |
| VORF | Vertical Offshore Reference Frame |
| VRF | Vessel Reference Frame |
| WD | Water Depth |
| WGS84 | World Geodetic System 1984 |
| WTG | Wind Turbine Generator |

# 1. Reference Documents

## 1.1. Blue Gem Wind Documents

| Table 2: Client-Supplied Project Information | | |
|---|---|---|
| Document Name | Document number | Issued By |
| Contract Form | END-OWC-IT-SI-00002_Erebus Geophy Survey ITT – SECTION I II III – CONTRACT FORM.pdf | OWC |
| Scope of Work | ERE-END-OWC-IT-SI-00002_Erebus Geophy Survey ITT – SECTION IV – Part A_Scope of Work.pdf | OWC |
| Technical Specifications | ERE-END-OWC-IT-SI-00002_Erebus Geophy Survey ITT – SECTION IV – Part Technical Specification.pdf | OWC |
| Health and Safety Management Plan | ERE-END-OWC-IT-SI-00002_Erebus Geophy Survey ITT – SECTION V – SBE1 Health Safety Management Plan.pdf | OWC |
| HIRA Process | ERE-END-OWC-IT-SI-00002_Erebus Geophy Survey ITT – SECTION V – SBE1 HIRA Process | OWC |
| HSE Competence Assessment for Suppliers | ERE-END-OWC-IT-SI-00002_Erebus Geophy Survey ITT – SECTION V – SBE1 HSE Competence Assessment for Suppliers.pdf | OWC |
| HSEQ Policy Statement | ERE-END-OWC-IT-SI-00002_Erebus Geophy Survey ITT – SECTION V – SBE1 HSEQ Policy Statement | OWC |
| Minimum HSEQ Requirements for Contractors | ERE-END-OWC-IT-SI-00002_Erebus Geophy Survey ITT – SECTION V – SBE1 Minimum HSEQ Requirements for Contractors | OWC |

## 1.2. Rovco Documents

| Table 3: Rovco documents | |
|---|---|
| ERE-ENG-RVC-MET-GEO-0005 | Geophysical Nearshore Mobilisation Report |
| ERE-ENG-RVC-MET-GEO-0006 | Geophysical Offshore Mobilisation Report |
| ERE-ENG-RVC-REP-ENV-0001 | Environmental Offshore Mobilisation Report |
| ERE-ENG-RVC-REP-GEO-0009 | Fleet demobilisation Report |

## 2. Executive Summary

This report presents the results of the geophysical and habitat assessment analysis with the aim to detail the physical and environmental conditions across the proposed Erebus Floating Offshore Windfarm (FLOW) development. This report aims to inform final cable routing, engineering design and the installation process of the proposed windfarm as well as providing a robust dataset for future comparison if required.

Introduction

Rovco led the delivery of the project with CM Geomatics subcontracted to perform processing, interpretation, and reporting of the geophysical workscopes and Ocean Ecology subcontracted to perform acquisition, processing, interpretation, and reporting of the environmental workscopes.

Project Erebus is a proposed Floating Offshore Wind (FLOW) development in the Celtic Sea. The project is located approximately 44 km southwest of the Pembrokeshire coastline, in an outline area of interest of approximately 43.5 $km^2$.

Operational Strategy

The campaign was delineated into five focus areas: Intertidal landfall surveys, nearshore & offshore geophysical, nearshore & offshore environmental. Each focus was conducted by a different vessel that was suited to the required tasks. Offshore work scopes were conducted on a 24 hour basis with nearshore scopes conducted on 12 hour basis.

To determine a geophysical baseline for the site the following data was acquired:

- Bathymetry and backscatter (MBES)
- Sidescan sonar (SSS)
- Magnetometer/Transverse Gradiometer (TVG)
- Parametric Chirp Sub-bottom Profiler (SBP)
- Sparker SBP

To determine an environmental baseline for the site the following data was acquired:

- Aerial drone imagery of landfall areas
- Walkover surveys of landfall areas
- Water sampling*
- Sediment grab samples*
- Video transects

*Water and sediment chemistry is discussed more thoroughly in ERE-ENG-RVC-REP-ENV-0006 Environmental Baseline Survey (EBS) Report.

Due to protracted offshore geophysical operations acquisition across the array area and associated buffer zone complete survey coverage was not achieved as part of this campaign.

Geophysics

Bathymetry varies from -0.62m LAT at KP0.055 to -70.65m LAT at KP48.6 along the Sawdern Point landfall site and subsequent export cable route. The depth across the array area varies from -86.54m LAT to -65.57m LAT in a sand wave trough and on a sand wave crest, respectively. Bathymetry generally deepens to the north west of the array area.

In total 3,012 targets >0.5m were identified in bathymetry and sidescan datasets. In total 910 magnetic targets were identified, 66 of these were also associated with SSS targets. A suspected buried object has been identified in the SBP dataset near KP2.595 of the export cable route. Targets identified have been interpreted as boulders, debris, fishing equipment, wrecks (2) and a pUXO.

Seven classifications of surface geology were interpreted along the main cable route: ROCK, sandy GRAVEL, muddy sandy GRAVEL, gravelly SAND, SAND, muddy SAND, and sandy MUD. The array area has been generally classified as muddy SAND. Whilst ground truthing shows variance from gravelly SAND to sandy MUD, there is little change in acoustic reflectivity across the area.

Three major subsurface units were identified across the export cable route and array area. Unit A is comprised of recent surficial sediments that form mobile bedforms at the seabed. Unit B includes reworked sediments and fluvial channel fill sediments within channels that have been cut into Unit C, which is interpreted to be the bedrock. The bedrock of unit C is exposed at the seabed at various locations within the cable corridor between approximately KP4.24 and KP8.465. with additional areas of shallow bedrock <5m below seabed present intermittently along the route. The bedrock of unit C is not exposed at the seabed at any point in the array area and the minimum depth below seabed it has been interpreted at is 3.7m. The deepest the bedrock has been observed is 82.4m below seabed. In general, the bedrock deepens to the west, with various channels incised into its surface. The bedrock in the array area is expected to be Cretaceous Chalk.

EUNIS Habitats/Biotopes

The main habitats identified across the survey area at which seabed imagery and grab samples were obtained comprised primarily of the EUNIS biotopes A5.251 '*Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand' and A5.351 '*Amphiura filiformis*, *Mysella bidentata*[1] and *Abra nitida* in circalittoral sandy mud' in the offshore section of the cable route and in the main array (ST033-119).

Stations located along the cable route within the Milford Haven Waterway (ST01-015) were characterised by various EUNIS biotopes including A5.143 '*Protodorvillea kefersteini* and other polychaetes in impoverished circalittoral mixed gravelly sand' and A5.443 '*Mysella bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment'.

Stations located on the outer fringes of the Milford Haven Waterway and the nearshore area of the cable route (ST018-032) were best represented by the EUNIS classifications A5.14 'Circalittoral coarse sediment', A5.25 'Circalittoral fine sand' and A5.44 'Circalittoral mixed sediments'. Low faunal abundances of key species were

[1] To note that the currently accepted name for *Mysella bidentata* is *Kurtiella bidentata*. In this report we maintained the original EUNIS classification and biotope description and used the name *Mysella bidentata*; however, in the main text when assessing community composition, the accepted name of *K. bidentata* was adopted.

present in grab samples collected at these locations. These stations were therefore only assigned level 4 (biotope complex) classifications.

Annex I Habitats

Annex I bedrock and stony reef habitats were identified in areas of the cable route, mostly along the nearshore sections around the entrance to Milford Haven. The stony reef features were assessed to be of both low and medium resemblance. In general, where stony and bedrock reefs were recorded along the same transects, they were deemed to form mosaic habitats meaning it was difficult to differentiate between the two reef types given the lack of clear boundaries in the acoustic data. These features were deemed to form part of the designated Annex I 'reef' feature of the Pembrokeshire Marine /Sir Benfro Forol SAC.

Two areas of sandy habitat were identified as likely Annex I sandbank habitats along the export cable route. The first was assigned a 'High' confidence score given it intersected, and forms part of, the known Turbot Bank Annex I sandbank feature. The second area was found further along the export cable corridor but was assigned a 'Potential' confidence score due to the lack of known adjacent sandbanks.

No Annex I biogenic reef habitat was observed across the survey area.

### Other Features of Interest

Evidence of a potential seagrass bed was observed close to the Sawdern Point landfall due to the presence of low-density eelgrass shoots along a single HA transect. However, due to the time of year, it was deemed unlikely that the full extent of the potential bed was visible both in the seabed imagery and acoustic data.

No beds of maerl (Corallinacea) or native oysters (*Ostrea edulis*) were observed across the survey area although there were observations of discrete patches of live and dead maerl at one location and occasional native oysters at numerous locations along the cable route.

The invasive non-native (INNS) slipper limpet (*Crepidula fornicata*) was recorded forming aggregations along one transect in the nearshore section of the export cable route. No other INNS were observed in the seabed imagery. Based on the analysis of macrobenthic fauna (grab samples), three further non-native species were recorded across the survey area; however only one or two specimens were observed for each species among the 107 analysed stations indicating that these organisms were extremely rare and their distribution across the survey area sporadic.

# 3. Project Background

Project Erebus is a proposed Floating Offshore Wind (FLOW) development in the Celtic Sea. The project is located approximately 44 km southwest of the Pembrokeshire coastline, in an outline area of interest of approximately 43.5 $km^2$. The key Project components are:

- Between 6and 10 floating wind turbine generators (WTGs), of total capacity up to 96MW, as well as the associated semi-submersible platforms and mooring infrastructure.
- Inter-array cables and a single offshore export cable route to landfall.
- Onshore cabling between landfall and the grid connection.
- Onshore substation at the grid connection point.

There are two primary potential landfalls under consideration (Sawdern Point and West Angle Bay) and two further landfall location options (Freshwater West A and B), which branch off the main route. During the operational period the requirement for the two Freshwater West landfall locations were removed, as such Sawdern Point and West Angle Bay became to project's primary focus as displayed in Figure 1.

The route lengths based on the centre line used for acquisition are as follows:

- Sawdern Point – 48.605km.
- West Angle – 44.055km.

The main cable route for both landfall locations converges at approximately 352648.12mE, 5727937.02mN, which is KP6.040 on the Sawdern Point Route and KP1.490 on the West Angle Route.

The primary purpose of this campaign was to characterise the site for the purposes of the EIA process, refine the site boundary, to inform preliminary cable route evaluation and to determine the preferred cable route. Secondary uses of the data may include:

- Informing physical processes.
- Informing water and sediment quality.
- Supporting benthic ecology assessment.
- Supporting marine archaeology.
- Early data to assist UXO studies within the MoD Castlemartin Sea Danger Area.
- Informing preliminary cable engineering studies.
- Informing preliminary mooring design work.

The objective was to perform a geophysical survey of the array area and Sawdern Point and West Angle Bay cable routes.

The geophysical surveys included multibeam bathymetry and backscatter (MBES), sidescan sonar (SSS), shallow sub-bottom profiler (SBP), deep sub-bottom profiler (Sparker, SPK) and magnetic gradiometer data acquisition. Where possible, all sensors were run concurrently to reduce operational durations.

The environmental surveys included drop down camera (DDC) and grab sampling to inform sediment and species location and distribution across the export route and FLOW site.

## 3.1. Site information

Figure 1 below shows the location of the Erebus FLOW site and anticipated cable route off Pembrokeshire, South West Wales. Water depths vary along the route with a maximum measured depth of 70.65m at KP48.6 all the way to MHWS for the scope of this project.

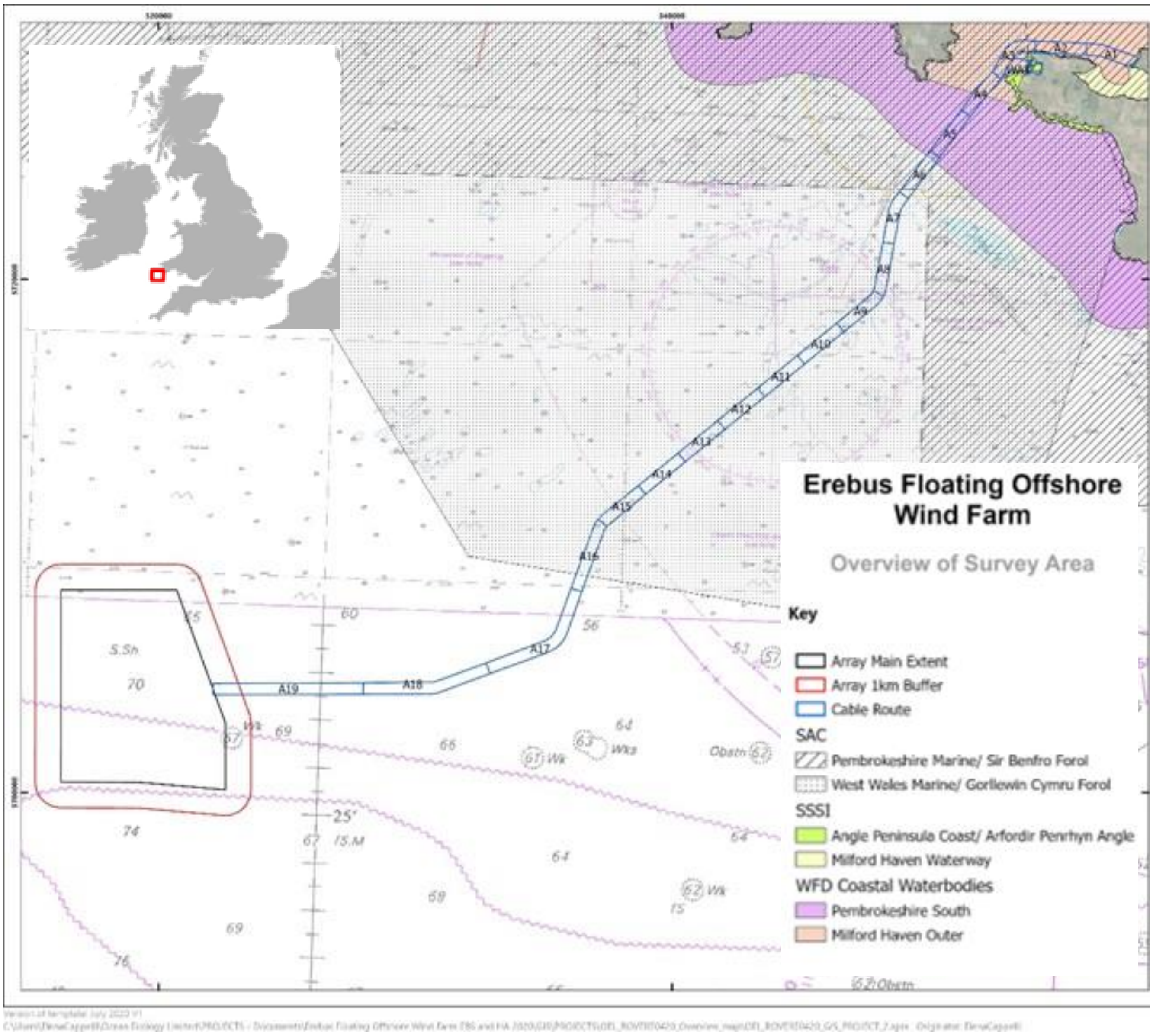


Figure 1: Project Erebus Location Overview

### 3.2. Operational Summary

Operations on the Erebus Geophysical and Environmental Surveys began on the 13th of August with the mobilisation of the Seazip Fix. Data acquisition was completed on the 30th of November when the Glomar Wave completed the offshore environmental work scope.

The project was split in to five focus areas outlined in Table 4 below:

Table 4: Erebus Project Focus Areas

| Focus Area | Vessel | Survey Extent |
|---|---|---|
| Intertidal Landfall Surveys | N/A | Beach Landings |
| Nearshore Geophysical | Iceni Spirit | A1-A5 (WA1) |
| Offshore Geophysical | Seazip Fix | A4-A19 & FLOW Site |
| Nearshore Environmental | Seren Las | A1-A4 (WA1) |
| Offshore Environmental | Glomar Wave | A4-A19 & FLOW Site |

A summary of the key operational dates can be found below, a completed project Gantt chart can be found in Appendix I: Erebus Operational Dates.

Table 5: Key Operational Dates

| Date | Vessel | Activity |
|---|---|---|
| 13/08/2020 | Seazip Fix | Vessel arrives in Milford Haven for mobilisation |
| 14/08/2020 | Iceni Spirit | Vessel arrives in Milford Haven for mobilisation |
| 15/08/2020 | Seren Las | Vessel arrives in Milford Haven for water sampling mobilisation |
| 16/08/2020 | Seren Las | Water sampling complete in blocks A1-A5 and WA1 |
| 17/08/2020 | Iceni Spirit | Sea Trials and Calibrations underway |
| 17/08/2020 | Seazip Fix | Sea Trials and Calibrations underway |
| 01/09/2020 | Iceni Spirit | Sea Trials and Calibrations completed; data collection commences |
| 18/09/2020 | Seazip Fix | Sea Trials and Calibrations completed; data collection commences |
| 16/10/2020 | Intertidal | Intertidal surveys commence – West Angle Bay and Sawdern Point |
| 17/10/2020 | Intertidal | Intertidal surveys complete |
| 22/10/2020 | Seren Las | Nearshore benthic sampling commences |
| 22/10/2020 | Iceni Spirit | Data collection completed |
| 24/10/2020 | Iceni Spirit | Vessel demobilised |
| 07/11/2020 | Glomar Wave | Vessel arrives in Falmouth for mobilisation |
| 10/11/2020 | Glomar Wave | Data collection commences |
| 11/11/2020 | Seren Las | Data collection completed; vessel demobilised |
| 11/11/2020 | Seazip Fix | Data collection completed |
| 14/11/2020 | Seazip Fix | Demobilisation completed |
| 29/11/2020 | Glomar Wave | Data collection completed |
| 30/11/2020 | Glomar Wave | Vessel Demobilised |

### 3.2.1. HSEQ Statistics

Adherence to Project plans or procedures by all employees, contractors and sub-contractors including those on part-time or temporary contracts, consultants, agency, and other personnel working for, or on behalf of Rovco is imperative to ensure a professional and safe working environment.

Table 6 below is a summary of the HSEQ statistics for Project Erebus. The information is split for each vessel involved in the project and includes a total for the sum of all the vessels.

Table 6: Erebus Project HSEQ Statistics

| | Glomar Wave | Iceni | Seazip Fix | Seren Las | | Total |
|---|---|---|---|---|---|---|
| Vessel Hours | 570.5 | 1680 | 2232 | 252 | | 4734.5 |
| Exposure Hours | 15974 | 10080 | 46872 | 756 | | 274601 |
| Leading Indicator Rate ((All leading indicators / person hours) *100 000 | 331.79 | 793.65 | 328.55 | 1058.20 | | 107.43 |
| Accident Incident Rate ((Fatality + Lost time incidents + Medical treatment cases + First aid cases / person hours) * 100 000) | 0.00 | 0.00 | 0.00 | 0.00 | | 0.00 |
| | | | | | | |
| Safety/ Toolbox Meetings | 19 | 48 | 102 | 6 | | 175 |
| Safety Meetings | 0 | 3 | 4 | 1 | | 8 |
| Daily Project Meetings | 22 | 0 | 0 | 0 | | 22 |
| Hazard Observation Cards (HOCs) | 10 | 23 | 44 | 0 | | 77 |
| Drills Performed | 2 | 6 | 4 | 1 | | 13 |
| Total [Contractor] Personnel Onboard | 11 | 3 | 12 | 3 | | 29 |
| Total Marine Crew Personnel Onboard | 16 | 2 | 8 | 0 | | 26 |
| Total Third-Party Personnel Onboard | 0 | 0 | 0 | 0 | | 0 |
| Total Client Personnel Onboard | 1 | 1 | 1 | 0 | | 3 |
| Lost Time Incidents | 0 | 0 | 0 | 0 | | 0 |
| Near Miss incident | 0 | 0 | 0 | 0 | | 0 |
| Non-conformance | 0 | 0 | 0 | 0 | | 0 |
| Lost and Damage | 0 | 0 | 2 | 0 | | 2 |
| Incident Reports | 0 | 1 | 2 | 0 | | 3 |
| Restricted Work Cases | 0 | 0 | 0 | 0 | | 0 |
| Personnel Accidents/Injuries/Fatality | 0 | 0 | 0 | 0 | | 0 |
| Environmental Incidents | 0 | 0 | 0 | 0 | | 0 |
| First Aid / Medical Treatment | 0 | 0 | 0 | 0 | | 0 |

### 3.2.2. Geophysical Acquisition Notes

Due to protracted geophysical acquisition, decreasing frequency and duration of weather windows as the project moved into winter geophysical acquisition at the array area was not completed. The start of the project saw the focus on the array area as the export route could be surveyed during transit to and from the area as needed.

Through October the primary focus was on completing geophysical MBES and SSS acquisition to the 'engineering' specification stated in the Survey Scope[2], outlined below, to inform the export cable route design.

- MBES
  - Gridded accuracy of ±0.25m at 2σ
  - 0.5m DTM with minimum 10 soundings in each cell
  - TVU – 0.25m at 2σ
  - THV – 0.5m at 2σ
- SSS
  - 3 pings per 1m object
  - 200% coverages, 100% overlap (including full covering of the nadir)

As the project continued into November the scope was reduced to a reconnaissance level survey for the array area to try and obtain as much data as possible in a short timeframe. This would be used to inform the location of the environmental sampling locations.

As the focus turned from precision to coverage the following parameters were used once the export route had been completed:

- 195m line spacing (previously 65m)
- 5m DTM – 5 soundings per bin
- SSS set to maximum range

Due to worsening weather conditions during the final phase of the project it was only safe to run the moonpool mounted MBES which resulted in less coverage for the other sensors.

### 3.2.3. Environmental Operations

Ocean Ecology Limited (OEL) was commissioned by Rovco on behalf of Blue Gem Wind to undertake a combined Habitat Assessment (HA) and Environmental Baseline Survey (EBS) of the proposed Project Erebus FLOW development. This was to include the provision of a survey vessel for the nearshore section, and the provision of environmental personnel, sampling equipment and sample analysis for the offshore and nearshore sections. Environmental sampling was undertaken during two survey phases from 21st October to 11th November 2020

[2] The Survey Scope, including technical specifications, was developed alongside discussions with NRW and recommended guidance to ensure that suitable and high quality data were acquired to complete a competent assessment.

(nearshore area) and from 9th November to 29th November 2020 (offshore area) in line with specifications required in the Survey Scope[2].

The data collected during these surveys for the HA was intended to delineate all seabed features identified within high resolution MBES and SSS data collected by Rovco, and from these features, assess for the presence of potentially important and environmentally sensitive features throughout both the nearshore and offshore survey areas including:

- Annex I habitats (EU Habitats Directive 1992);
- Habitats of Principle Importance (Environment Wales Act, 2016); and
- Threatened and/or declining species and habitats (OSPAR, 2008) or species listed on the IUCN Red List (IUCN, 2019).

### 3.2.4. Environmental Findings Summary

#### 3.2.4.1. EUNIS Habitats/Biotopes

The main habitats identified across the survey area at which seabed imagery and grab samples were obtained comprised primarily of the EUNIS biotopes A5.251 '*Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand' and A5.351 '*Amphiura filiformis*, *Mysella bidentata* and *Abra nitida* in circalittoral sandy mud' in the offshore section of the cable route and in the main array (ST033-119).

Stations located along the cable route within the Milford Haven Waterway (ST01-015) were characterised by various EUNIS biotopes including A5.143 '*Protodorvillea kefersteini* and other polychaetes in impoverished circalittoral mixed gravelly sand' and A5.443 '*Mysella bidentata*[3] and *Thyasira* spp. in circalittoral muddy mixed sediment'.

Stations located on the outer fringes of the Milford Haven Waterway and the nearshore area of the cable route (ST018-032) were best represented by the EUNIS classifications A5.14 'Circalittoral coarse sediment', A5.25 'Circalittoral fine sand' and A5.44 'Circalittoral mixed sediments'. Low faunal abundances of key species were present in grab samples collected at these locations. These stations were therefore only assigned level 4 (biotope complex) classifications.

#### 3.2.4.2. Annex I Habitats

Annex I bedrock and stony reef habitats were identified in areas of the cable route, mostly along the nearshore sections around the entrance to Milford Haven. The stony reefs were assessed to be of both low and medium resemblance. In general, where stony and bedrock reefs were recorded along the same transects, they were deemed to form mosaic habitats meaning it was difficult to differentiate between the two reef types given the lack of clear boundaries in the acoustic data. These features were deemed to form part of the designated Annex I 'reef' feature of the Pembrokeshire Marine SAC.

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Two areas of sandy habitat were identified as likely Annex I Sandbank habitats along the export cable route. The first was assigned a 'High' confidence score given it intersected, and forms part of, the known Turbot Bank Annex I sandbank feature. The second area was found further along the export cable corridor but was assigned a 'Potential' confidence score due to the lack of known adjacent sandbanks.

No Annex I biogenic reef habitat was observed across the survey area.

#### 3.2.4.3. Other Features of Interest

Evidence of a potential seagrass bed was observed close to the Sawdern Point landfall due to the presence of low-density eelgrass shoots along a single HA transect although due to the time of year it was deemed unlikely that the full extent of the potential bed was visible both in the seabed imagery and acoustic data.

No beds of maerl or native oysters were observed across the survey area although there were observations of discrete patches of live and dead maerl at one location and occasional native oysters at numerous locations along the cable route.

The invasive non-native (INNS) slipper limpet (*Crepidula fornicata*) was recorded forming aggregations along one transect in the nearshore section of the export cable route. No other INNS were observed in the seabed imagery. Based on the analysis of macrobenthic fauna (grab samples), three further non-native species were recorded across the survey area; however only one or two specimens were observed for each species among the 107 analysed stations indicating that these organisms were extremely rare and their distribution across the survey area sporadic.

### 3.2.5. Geophysical Operations

Geophysical operations were undertaken by Rovco on behalf of Blue Gem Wind to provide supporting geophysical information for preliminary cable engineering studies and mooring design work, inform the Habitat Assessment and Environmental Baseline Surveys and to inform marine archaeology and preliminary UXO studies.

To achieve the above Rovco provisioned two survey vessels, survey equipment and personnel to acquire the geophysical datasets. CMG were commissioned by Rovco to undertake the final processing of deliverables, reporting and charting; pre-processing was undertaken onboard the Seazip Fix to provide QC and coverage mapping of the deeper water surveys to inform operations while offshore.

Offshore operations began on 13$^{th}$ August 2020, concluding on 11$^{th}$ November 2020. Nearshore operations began on the 14$^{th}$ August 2020, concluding on the 24$^{th}$ October 2020.

Refer to Geophysical Acquisition Notes for information in specifications changes during the project.

### 3.2.6. Geophysical Summary

#### 3.2.6.1. WA1 Nearshore

Bathymetry across the WA1 nearshore survey area varies between -1.5m at KP0.082m and -20.8m at KP1.49. at the largest change in gradient along the centreline is found at KP13.43 with a slope angle of -5.27° cause by the edge of an outcropping bedrock. Seabed slopes of less than 4° degrees are present around the centreline if bedrock outcrops are avoided. The data shows bedrock outcrop along most of the nearshore limit of coverage, however a gap in the bedrock outcrop approximately 70m north of a centreline is present that would require investigation to determine its extent inshore as a possible route option.

Three classifications of surface sediment were interpreted: SAND, sandy GRAVEL and ROCK. Areas of mobile bedforms and boulder fields were also interpreted and observed to intersect the centre line.

Two major subsurface geological units, Unit B and Unit C, were interpreted. Unit B is present at the surface and fills channels present in the top surface of (Unit C). Unit C is interpreted as bedrock and is observed to outcrop at the start of the exposed channel feature as the WA1 landfall centre line joins the Sawdern route centre line at KP5.749 and continues to outcrop until KP8.465

#### 3.2.6.2. Sawdern Nearshore and Export Cable Route

Bathymetry along the main cable route centre line varies between landfall at -0.62m LAT (KP0.055) to the array areas at -70.65m LAT (KP48.6). The largest gradient along the centreline, of 11.9°, occurs at KP5.749 where the centreline intersects an outcrop of ROCK. Gradients near the centreline, avoiding bedrock outcrops, are usually less than 3°, except in areas of sandwaves where they can exceed 5°. Seabed slopes around the centre line, avoiding areas of outcropping bedrock, vary between 0.2° and 14.9°, with most of the variation associated with mobile bedforms. The slopes greater than 5° are primarily present between KP10 and KP25, and also briefly between KP33 and KP34, where large sandwaves and megaripples exist. Maximum slopes perpendicular to sandwaves crests within the survey corridor can reach 7° but are usually less than 4°.

In total 1874 targets were identified in including boulders, debris, fishing equipment, a wreck and a suspected UXO object. Of these, 710 magnetic targets have been interpreted, 62 of which have been associated with SSS targets.

Seven classifications for surface sediments have been interpreted along the main cable route: ROCK, sandy GRAVEL, muddy sandy GRAVEL, gravelly SAND, SAND, muddy SAND and sandy MUD. Areas of mobile bedforms and boulder fields have also been interpretated and observed to intersect the centre line. Mobile bedforms range from ripples to sandwaves.

Three major subsurface geological units have been interpreted along the cable route; Units A, B and C. Unit A is comprised of recent surficial sediments that form mobile bedforms at the seabed and overlie the units beneath. Unit B includes reworked outwash sediments and fluvial channel fill that have infilled channels that have been incised into Unit C which is interpreted to be the bedrock. The bedrock of unit C is exposed at the seabed at various locations within the cable corridor between approximately KP4.24 and KP8.465. with additional areas of shallow bedrock <5m below seabed present intermittently along the route.

### 3.2.6.3. FLOW Site

The bathymetry within the array area varies from -86.54m, within a sandwave trough, to -65.57m, on a sandwave crest. Bathymetry generally deepens to the north west along a gentle slope superimposed by mobile bedforms ranging from ripples to sandwaves.

In total 1138 contacts were identified in the SSS/MBES including boulders, debris and a suspected wreck. The suspected wreck is small with a length of 5.5m and may be a particularly large item of debris, however it possesses peculiar shape as observed on SSS data. 200 magnetic targets were identified with four associated with a SSS target. Two long, linear targets have been interpreted as buried cables. The plotted positions of these linear targets do not correlate to any existing infrastructure on the EMODnet database.

The array area has been generally classified as muddy SAND. Whilst ground truthing shows variance from gravelly SAND to sandy MUD, there is little change in acoustic reflectivity across the area. The entire Array area has areas of mobile bedforms. Ripples are present in the south which evolve into megaripples and sandwaves to the north. Boulder fields have been identified in areas where the surficial sediment grows thin, especially to the south of the array area and in sandwave troughs in the north.

Three major subsurface geological units have been interpreted within the array area; Units A, B and C. Unit A is comprised of recent surficial sediments that form mobile bedforms at the seabed. Unit B includes reworked outwash sediments and fluvial channel fill sediments within channels that have been cut into Unit C, which is interpreted to be the bedrock.

# 4. Personnel, Vessels, Equipment and Calibrations

## 4.1. Onshore Personnel

The following section outlines the personnel involved through the various stages of the project.

### 4.1.1. Rovco Onshore Personnel

Table 7: Onshore Rovco Personnel

| Name | Role | Start Date | End Date |
|---|---|---|---|
| Hardy Sidhu | Project Manager | July 2020 | September 2020 |
| Gregor Carfrae | Operations and Project Delivery Manager | August 2020 | February 2021 |
| Megan Wright | HSEQ Manager | July 2020 | March 2021 |
| Meeta Tallow | HSE Officer | July 2020 | March 2021 |
| Gary Nicholl | Mobilisation Manager | July 2020 | August 2020 |
| Douglas Miller | Senior Surveyor | July 2020 | October 2020 |
| Thomas Drummond | Project Co-ordinator | August 2020 | September 2020 |
| Donna McGregor | Project Co-ordinator | September 2020 | September 2020 |
| Neil Biscoe | Project Cost Manager | September 2020 | March 2021 |
| Joe Tidball | Project Manager | September 2020 | March 2021 |
| Joe Wheeler | Project Co-ordinator | October 2020 | October 2020 |
| Alastair Blower | Data Processor – SSS | December 2020 | December 2020 |
| Alejandro Santabárbara | Data Processor – MBES | December 2020 | December 2020 |

### 4.1.2. CMG Onshore Personnel

Table 8: CMG Onshore Personnel

| Name | Role | Start Date | End Date |
|---|---|---|---|
| Dave Cullen | Director / Processing Manager | July 2020 | February 2021 |
| Kayur Patel | Geoscience Manager | July 2020 | February 2021 |
| Mike Caraher | Associate Director / Reports Manager | July 2020 | February 2021 |
| David Walsh | Hydrographic Processor | July 2020 | December 2020 |
| John Bunt | Geophysicist (Mag) | July 2020 | December 2020 |
| Matt Hooke | Geophysicist (SBP / SPK) | July 2020 | February 2021 |
| Max Stacey | Geophysicist (SSS) | July 2020 | February 2021 |
| Jason Quinn | Geologist (SBP / SPK) | July 2020 | December 2020 |
| Ewa Lesner | GIS Specialist | July 2020 | February 2021 |

### 4.1.3. Ocean Ecology Onshore Personnel

Table 9: Ocean Ecology Onshore Personnel

| Name | Role | Start Date | End Date |
|---|---|---|---|
| Ross Griffin | Technical Director | July 2020 | March 2021 |
| Gary Robinson | Operations Director | July 2020 | March 2021 |
| Edward Rickard | Marine Ecologist | July 2020 | March 2021 |
| Elena Cappelli | Senior Marine Ecologist | November 2020 | March 2021 |
| Karen Boswarva | Senior Marine Ecologist | November 2020 | March 2021 |

## 4.2. Offshore Geophysical Survey Vessel– Seazip Fix

### 4.2.1. Offshore Geophysical Survey Vessel

The *Seazip Fix* was contracted by Rovco to undertake the Offshore Geophysical scope. Encompassing geophysical work in Blocks A5 to Block A19 of the export cable route as well as the designated FLOW site. Mobilisation of the *Seazip Fix* began on the 12th of August 2020 with the demobilisation completed on 14th November 2020.

The *Seazip Fix* is a 42.25m DP1 survey vessel with moonpool, A-Frame, over-the-side survey pole and ROV hanger for offshore Survey and ROV operations. A full vessel specification is provided in Appendix II – Vessel Specification Sheets.

Table 10: Seazip Fix Basic Specification

| | |
|---|---|
| **Type of Vessel** | Monohull Survey Vessel |
| **Build Year** | 1981, 2015 Rebuild |
| **Length o.a.** | 42.25m |
| **Beam o.a.** | 10.0m |
| **Draught** | 5.0 |
| **Speed** | 10 knots |
| **Main Engine** | 1 x 969 kW Cat C-32 |


Figure 2: Seazip Fix Offshore Geophysical Survey Vessel

### 4.2.2. Offshore Geophysical Survey Personnel

Table 11: Offshore Geophysical Personnel - Seazip Fix

| Name | Role | Start Date | End Date |
|---|---|---|---|
| Chris Weller | Party Chief | 02/08/2020 | 24/08/2020 |
| Aston Spinks | Online Surveyor | 12/08/2020 | 07/09/2020 |
| Francesco Zoleo | Reports Co-ordinator | 12/08/2020 | 17/09/2020 |
| Stuart Fyfe | Online Surveyor | 09/08/2020 | 06/09/2020 |
| Leslie Weightman | Online Engineer | 08/08/2020 | 05/09/2020 |
| Joe Wheeler | Online Engineer | 09/08/2020 | 07/09/2020 |
| Gregory McLean | Online Engineer | 19/08/2020 | 03/09/2020 |
| Vanessa Oliveria | Hydrographic Processor | 12/08/2020 | 18/09/2020 |
| Michael Mowat | Hydrographic Processor | 09/08/2020 | 20/08/2020 |
| Jason Quinn | Geophysicist | 12/08/2020 | 11/09/2020 |
| Conor Smyth | Geophysicist | 11/08/2020 | 18/09/2020 |
| Georgios Kontogonis | Geophysicist | 09/08/2020 | 18/09/2020 |
| Christos Angelopoulous | Geophysicist | 12/08/2020 | 18/09/2020 |
| Ben Cooley | Party Chief | 22/08/2020 | 05/10/2020 |
| Jamie Turner | Online Surveyor | 05/09/2020 | 05/10/2020 |
| Marco Cesareo | Online Surveyor | 05/09/2020 | 06/10/2020 |
| Andrew Williams | Online Engineer | 05/09/2020 | 05/10/2020 |
| Richard Lindsay | EIC | 05/09/2020 | 06/10/2020 |
| Luca Trapassi | Geophysicist | 15/09/2020 | 21/10/2020 |
| Jonathan Hall | Geophysicist | 15/09/2020 | 17/10/2020 |
| Juri Muzi | Geophysicist | 22/09/2020 | 26/10/2020 |
| Joao Cunha | Geophysicist | 11/09/2020 | 19/09/2020 |
| Marek Wojakowski | Online Engineer | 18/09/2020 | 05/10/2020 |
| Bart Vanacker | Geophysicist | 15/09/2020 | 21/10/2020 |
| James Acton | Online Engineer | 04/10/2020 | 26/10/2020 |
| David Linsley | Online Engineer | 04/10/2020 | 28/10/2020 |
| Nicholas Williams | Party Chief | 04/10/2020 | 14/11/2020 |
| Giuseppe Finocchiaro | Online Surveyor | 04/10/2020 | 04/11/2020 |
| Danielle Waters | Online Surveyor | 04/10/2020 | 27/10/2020 |
| Andrei Lykowski | Online Engineer | 03/09/2020 | 14/11/2020 |
| Gareth Davies | Online Engineer | 04/10/2020 | 14/11/2020 |
| Kirk Gooch | Online Engineer | 26/10/2020 | 12/11/2020 |
| Alex Crook | Online Engineer | 02/11/2020 | 14/11/2020 |
| Ross Cosgrove | Geophysicist | 16/10/2020 | 14/11/2020 |
| Darren Marshall | Geophysicist | 19/10/2020 | 14/11/2020 |
| James Farrington | Geophysicist | 19/10/2020 | 14/11/2020 |
| Samantha Toms | Geophysicist | 16/09/2020 | 03/11/2020 |
| Bror Preen | Geophysicist | 29/10/2020 | 15/11/2020 |
| Michal Zygmunt | Online Surveyor | 01/11/2020 | 16/11/2020 |
| Greg Hudson | Online Surveyor | 02/11/2020 | 14/11/2020 |
| Adriana Comanescu | Geophysicist | 02/11/2020 | 14/11/2020 |

### 4.2.3. Offshore Geophysical Survey Equipment

The following equipment was mobilised to the Seazip Fix to complete the scope of works.

Technical specification sheets can be found in Appendix III – Survey Equipment Specification Sheets.

Table 12: Offshore Geophysical Equipment

| Sensor Type | Sensor Model |
|---|---|
| Primary GNSS | Applanix Wavemaster II |
| Primary GNSS Corrections | Fugro Starfix G2+ |
| Secondary GNSS | Trimble |
| Secondary GNSS Corrections | Fugro Marinestar |
| USBL | Sonardyne Mini Ranger 2 |
| USBL Beacons | Sonardyne WSM 6+ x 4 |
| Primary Heading Sensor | Applanix WaveMaster II |
| Secondary Heading Sensor | Ixsea Octans |
| Primary Motion Compensation | Applanix WaveMaster II |
| Secondary Motion Compensation | Ixsea Octans |
| Navigation Software | QPS QINSy |
| Tidal Data | GNSS Tides & VORF |
| Bathymetry | R2Sonic 2024 MBES |
| Sound velocity sensor | Valeport mini SVS x 2 |
| Sound velocity probe | Valeport Swift + Valeport Midas |
| Timing | QPS Trigger box |
| Bathymetric acquisition s/w | QPS QINSy |
| Sidescan Sonar | Edgetech 4200 300/600 kHz, |
| Sidescan TPU | Edgetech Digital 701 DL Interface and spare Edgetech Starmux surface unit |
| Winch, Control, T-count | AGO CMW2, AGO 50m winch control, T Count 14 wireless and deck cable |
| Sidescan acquisition software | Edgetech Discover with laptop |
| High frequency SBP | Innomar Medium (primary 100kHz – secondary 10kHz) |
| Deployment | Pole and flange |
| HF SBP acquisition software | Innomar SESWin |
| Low frequency SBP | GSO 360 (1.8kHz central frequency) |
| Seismic Energy Source | Applied Acoustics CSP-N |
| Hydrophone | GSO Single Channel 24 Element Hydrophone |
| Trigger box | Internal/Coda |
| LF SBP acquisition software | Coda /DA4G |
| Magnetic gradiometer | STR Transverse Gradiometer Frame with Telemetry Bottle and 2 x Geometrics G-882 Caesium Vapour Magnetometers |
| Spare magnetometer unit | Geometrics G882 |
| Topside | Umbilical and telemetry unit |

| Sensor Type | Sensor Model |
|---|---|
| Winch, Control, T-count | AGO CMW2, AGO 50m winch control, T Count 14 wireless and deck cable |
| Magnetic acquisition software | QPS QINSy 9.2.2 |
| NavPos processing system | QPS QINSy 9.2.2 |
| MBES processing system | QPS Qimera 2.2.5 |
| SSS processing system | SonarWiz Sidescan 7.06.03 |
| HF/LF SBP processing system | Radex Pro 19.2 |
| MAG processing system | Oasis Montaj 9.7 |

#### 4.2.3.1. Offshore Geophysical Survey Equipment Calibrations

A complete summary of the calibrations undertaken for the equipment mobilised to the Seazip Fix can be found in document 'ERE-ENG-RVC-REP-GEO-0006 A04 Geophysical Offshore Mobilisation Report SZ Complete'. A summary of the calibrations undertaken are listed below:

- Vessel dimensional control survey
- Static GNSS Verification
- Draft check
- Heading calibration
- Motion calibration
- Sound Velocity Verification
- Multibeam Echosounder Patch Test
- USBL Cardinal Point Calibration
- Sidescan Sonar Position Verification
- Magnetometer depth and altimeter scale and bias
- Magnetometer noise test
- Magnetometer position verification
- Sub Bottom Profiler position verification
- Sparker receiver tap test
- Sparker pulse test
- Sparker position verification
- Full system wet tests

## 4.3. Nearshore Geophysical Survey Vessel – Iceni Spirit

### 4.3.1. Nearshore Geophysical Survey Vessel

The *Iceni Spirit* was contracted by Rovco to undertake the Nearshore Geophysical scope. Encompassing geophysical work in Blocks A1 to A5 as well as WA1 of the export cable route and Sawdern Point and West Angle bay landfalls. Mobilisation of the *Iceni Spirit* began on the 15th of August 2020 with the demobilisation completed on 25th October 2020.

The *Iceni Spirit* is a 15.43m catamaran style crew transfer vessel fitted with a stern crane and an over-the-side survey pole on each rail for nearshore survey and ROV operations. A full vessel specification is provided in Appendix II – Vessel Specification Sheets.

Table 13: Iceni Spirit Basic Specification

| | |
|---|---|
| Type of Vessel | Twin hull crew transfer & survey vessel |
| Build Year | 2010 |
| Length o.a. | 15.43m |
| Beam o.a. | 6.30m |
| Draught | 0.87m |
| Speed | 22 knots |
| Main Engine | 2 x Scania 625 HP, Ultrajet water jets UJ451 |


Figure 3: Iceni Spirit Nearshore Geophysical Survey Vessel

### 4.3.2. Nearshore Geophysical Survey Personnel

Table 14: Nearshore Geophysical Personnel - Iceni Spirit

| Name | Role | Start Date | End Date |
|---|---|---|---|
| Gary Mathieson | Party Chief | 31/07/2020 | 04/09/2020 |
| Andy Rodgers | Geophysicist | 08/08/2020 | 05/09/2020 |
| Smart Iyamu | Online Surveyor | 08/08/2020 | 25/08/2020 |
| Mimmo Pazzanese | Party Chief | 04/09/2020 | 14/10/2020 |
| Kirk Gooch | Geophysicist | 03/09/2020 | 26/10/2020 |
| Gregory McLean | Online Surveyor | 04/09/2020 | 05/10/2020 |
| Peter Thursfield | Online Surveyor | 04/09/2020 | 19/10/2020 |
| Andy Simpson | Party Chief | 12/10/2020 | 27/10/2020 |
| Joe Wheeler | Project Co-ordinator/Online Surveyor | 19/10/2020 | 26/10/2020 |

### 4.3.3. Nearshore Geophysical Survey Equipment

The following equipment was mobilised to the Iceni Spirit to complete the scope of works.

Technical specification sheets can be found in Appendix III – Survey Equipment Specification Sheets.

Table 15: Nearshore Geophysical Equipment

| Sensor Type | Sensor Model |
|---|---|
| Primary GNSS | Applanix Wavemaster II |
| Primary GNSS Corrections | Starfix G2+ |
| Secondary GNSS | Hemisphere VS330 and Hemisphere H10 corrections |
| Secondary GNSS Corrections | Hemisphere H10 |
| USBL | IXBLUE GAPS G3 |
| USBL Beacons | Ixsea MT9 Beacons |
| Primary Heading Sensor | Applanix WaveMaster II |
| Secondary Heading Sensor | TSS Meridian Surveyor Gyrocompass |
| Primary Motion Compensation | Applanix WaveMaster II |
| Secondary Motion Compensation | Kongsberg Seatex MRU5 |
| Navigation Software | Eiva NaviPac |
| Tidal Data | GNSS Tides & VORF |
| Bathymetry | R2Sonic 2024 MBES and spare head |
| Sound velocity sensor | Valeport mini SVS |
| Sound velocity probe | Valeport Swift |
| Bathymetric acquisition s/w | Eiva NaviPac and NaviScan |
| Sidescan Sonar | Edgetech 4200 300/600 kHz |
| Sidescan TPU | Edgetech Digital 701 DL Interface and spare Edgetech Starmux surface unit |
| Winch, Control, T-count | AGO CSW7, AGO 50m winch control, T Count 14 wireless and deck cable |
| Sidescan acquisition software | Edgetech Discover with laptop |
| High frequency SBP | Innomar SES2000 Medium (primary 100kHz – secondary 8kHz) |
| Deployment | Over-side pole mount |
| HF SBP acquisition software | Innomar |
| Low frequency SBP | GSO 360 (1.8kHz central frequency) |
| Seismic Energy Source | Negatively charged Sparker GSO 360 |
| Hydrophone | GSO Single Channel Hydrophone 24 Element |
| Trigger box | Internal/Coda |
| LF SBP acquisition software | Coda/DA4G |
| Magnetometer | Geometrics G-882 magnetometer |
| Topside | Umbilical and telemetry unit |
| Winch, Control, T-count | N/A - shared with sidescan sonar |
| Magnetic acquisition software | Geometrics MagLog dongle, laptop, s/w |

#### 4.3.3.1. Nearshore Geophysical Survey Equipment Calibrations

A complete summary of the calibrations undertaken for the equipment mobilised to the Iceni Spirit can be found in document 'ERE-ENG-RVC-REP-GEO-0005 A07 Geo Mob Report Iceni Spirit Complete'. A summary of the calibrations undertaken are listed below:

- Vessel dimension control survey
- Time synchronisation
- Static GNSS Verification
- Draft Check
- Heading calibration
- Motion calibration
- Sound velocity verification
- Multibeam Echosounder Patch Test
- USBL Box In
- USBL verification check (GAPS)
- Sidescan Sonar Position Verification
- Magnetometer depth and altimeter scale and bias
- Magnetometer noise test
- Sub Bottom Profiler position verification
- Sparker receiver tap test
- Sparker pulse test
- Sparker position verification
- Full system wet tests

## 4.4. Offshore Environmental Survey Vessel – Glomar Wave

### 4.4.1. Offshore Environmental Survey Vessel

The *Glomar Wave* was contracted by Rovco to undertake the Offshore Environmental scope. Encompassing environmental work in Blocks A5 to A19 of the export route as well as the designated FLOW site. Mobilisation of the *Glomar Wave* began on the 7th of November 2020 with the demobilisation completed on 30th November 2020.

The *Glomar Wave* is a 66.44m DP2 offshore support vessel fitted with multiple cranes and USBL moonpool for offshore survey, ROV and diving support operations. A full vessel specification is provided in Appendix II – Vessel Specification Sheets

Table 16: Glomar Wave Basic Specification

| | |
|---|---|
| Type of Vessel | DP2 Multi Role Vessel |
| Build Year | 2014 |
| Length o.a. | 66.44m |
| Beam o.a. | 13.20m |
| Draught | 4.80 |
| Speed | 12.5 knots |
| Main Engine | 2 x Mitsubishi 1628 KW<br>1 x Mitsubishi 602 KW |


Figure 4: Glomar Wave Offshore Environmental Survey Vessel

### 4.4.2. Offshore Environmental Survey Personnel – Glomar Wave

Table 17: Offshore Environmental Personnel

| Name | Role | Start Date | End Date |
|---|---|---|---|
| Peter Van Poppel | Online Surveyor | 05/11/2020 | 08/11/2020 |
| Andy Simpson | Party Chief | 06/11/2020 | 30/11/2020 |
| Sebastiano Bruno | Online Surveyor | 05/11/2020 | 01/12/2020 |
| Aden Cucinello | Online Surveyor | 12/11/2020 | 30/11/2020 |
| Grant Hay | ROV Pilot / Technician | 12/11/2020 | 19/11/2020 |
| Marcello Aloia | ROV Supervisor | 12/11/2020 | 20/11/2020 |
| Dan Auton | ROV Pilot / Technician | 12/11/2020 | 19/11/2020 |
| Joseph Pickering | Lead Ecologist | 07/11/2020 | 30/11/2020 |
| Robyn Jones | Ecologist | 07/11/2020 | 30/11/2020 |
| Ashley Kirby | Survey Manager | 07/11/2020 | 07/11/2020 |
| Edward Rickard | Lead Ecologist | 07/11/2020 | 30/11/2020 |
| Karen Boswarva | Ecologist | 07/11/2020 | 30/11/2020 |

### 4.4.3. Offshore Environmental Survey Equipment

The following equipment was mobilised to the Glomar Wave to complete the scope of works. Technical specification sheets can be found in Appendix III – Survey Equipment Specification Sheets.

Table 18: Offshore Environmental Equipment

| Sensor Type | Sensor Model |
|---|---|
| Primary GNSS | Fugro Seastar 9205 |
| Primary GNSS Corrections | Fugro 9200-IPDU |
| Secondary GNSS | Hemisphere Vector VS330 |
| Secondary GNSS Corrections | Hemisphere H10 Offshore |
| USBL | Sonardyne Ranger |
| USBL Beacons | Sonardyne WSM 6+ x 4 |
| Primary Heading Sensor | Anschütz DigitalGyro STD 22 |
| Secondary Heading Sensor | Marine Technologies Meridian |
| Primary Motion Compensation | Marine Technologies DMS 535-RP |
| Navigation Software | EIVA |
| Tidal Data | GNSS Tides & VORF |
| | |
| Primary Camera System | STR SeaSpyder |
| Redundancy Camera System | OEL DDC system equipped with fresh water housing |
| Primary Grab Sampler | 0.1m$^2$ Dual Van Veen Grab |
| Redundancy Grab Sampler | 0.1m$^2$ Hamon Grab |

#### 4.4.3.1. Offshore Environmental Survey Equipment Calibrations

A complete summary of the calibrations undertaken for the equipment mobilised to the Glomar Wave can be found in document 'ERE-ENG-RVC-REP-ENV-0001-CRS_Environmental Offshore Mobilisation Report'. A summary of the calibrations undertaken are listed below:

- Vessel dimension control survey
- Static GNSS Verification
- Heading calibration
- Motion calibration
- USBL spin and sail away tests
- Drop down camera system wet tests
- Grab sampler wet tests

## 4.5. Nearshore Environmental Survey Vessel – Seren Las

### 4.5.1. Offshore Environmental Survey Vessel

The *Seren Las* was contracted through Ocean Ecology by Rovco to undertake the Nearshore Environmental scope. Encompassing water sampling in Blocks A1 to A6, as well as drop down camera and grab sampling in Blocks A1-A4 and WA1. Mobilisation of the Iceni Spirit began on the 15th of August 2020 with an interim demobilsation on the 16th of August 2020 after water sampling has been completed. Operations recommenced on 21/10/2020 for DDC and grab sampling with the demobilisation completed on 11th November 2020.

The *Seren Las* is a 10.00m single hull vessel fitted with an a-frame, deck winch and capstan nearshore environmental and survey operations. A full vessel specification is provided in Appendix II – Vessel Specification Sheets.

Table 19: Seren Las Basic Specification

| | |
|---|---|
| Type of Vessel | Single hull survey and dive SV |
| Build Year | 2017 refit |
| Length o.a. | 10.0m |
| Beam o.a. | 3.5m |
| Draught | 1.5m |
| Speed | 12 knots |
| Main Engine | Caterpillar 3126 (350hp) with bow thruster |


Figure 5: Seren Las Nearshore Environmental Survey Vessel

### 4.5.2. Nearshore Environmental Survey Personnel

Table 20: Nearshore Environmental Personnel - Seren Las

| Name | Role | Start Date | End Date |
|---|---|---|---|
| Gary Robinson | Operations Director | 15/08/2020 | 16/08/2020 |
| Ross Griffin | Technical Director | 15/08/2020 | 16/08/2020 |
| Jack Findlater | Crew | 15/08/2020 | 16/08/2020 |
| Edward Rickard | Skipper | 15/08/2020 | 16/08/2020 |
| | | | |
| Gary Robinson | Operations Director | 21/10/2020 | 01/11/2020 |
| Ashley Kirby | Skipper | 21/10/2020 | 11/11/2020 |
| Robyn Jones | Ecologist | 21/10/2020 | 06/11/2020 |
| Joseph Pickering | Ecologist | 02/11/2020 | 06/11/2020 |
| Jason Argent | Ecologist | 07/11/2020 | 11/11/2020 |
| Elena Lo Guidice Cappelli | Ecologist | 07/11/2020 | 11/11/2020 |

### 4.5.3. Nearshore Environmental Survey Equipment

Table 21: Nearshore Environmental Equipment

| Sensor Type | Sensor Model |
|---|---|
| Primary GNSS | Hemisphere V104s |
| Primary Heading Sensor | Hemisphere V104s |
| Navigation Software | EIVA |
| Tidal Data | GNSS Tides |
| Primary Camera System | OEL fresh water housing system |
| Primary Grab Sampler | Day Grab |

#### 4.5.3.1. Nearshore Environmental Survey Equipment Calibrations

A complete summary of the calibrations undertaken for the equipment mobilised to the Glomar Wave can be found in document 'ERE-ENG-RVC-REP-ENV-0002-Environmental Nearshore Mobilisation Report'. A summary of the calibrations undertaken are listed below:

- Navigation system function check
- Drop down camera system wet tests
- Grab sampler wet tests

# 5. Methodology

## 5.1. Project Details

### 5.1.1. Geographic and Vertical Reference

#### 5.1.1.1. Horizontal Reference System

Table 22: Client Provided Geodetic Parameters

| Parameter | Value |
|---|---|
| Datum | World Geodetic System 1984 |
| Ellipsoid | World Geodetic System 1984 |
| Spheroid | World Geodetic System 1984 |
| Semi Major Axis [m] | 6378137.0 |
| Semi Minor Axis [m] | 6356752.314245179 |
| Inverse Flattening (1/f) | 298.257223563 |
| Angular Unit | Degree |

Table 23: Client Provided Projection Parameters

| Parameter | Value |
|---|---|
| Projection | UTM Zone 30N (EPSG 32630) |
| Longitude at Central Meridian | 003°00′00.0″ W |
| Latitude of Origin | 000°00′00.0″ N |
| False Northing [m] | 0 |
| Scale Factor | 0.9996 |
| Linear Unit | Metre |
| Time Datum | UTC |

#### 5.1.1.2. Vertical Reference System

The offshore vertical datum is lowest astronomical tide (LAT).

Table 24: Vertical reference parameter from client supplied survey specification.

| Parameter | Value |
|---|---|
| Vertical reference (offshore) | Lowest astronomical tide (LAT) |
| Height model (offshore) | Vertical offshore reference frame (VORF) |

## 5.2. Geophysical Survey Methods

### 5.2.1. Geophysical Acquisition Methods

#### 5.2.1.1. Nearshore Geophysical Acquisition Methods

The Iceni Spirit was mobilised with all sensors with the intention of running all sensors simultaneously on all lines. However, it was determined that due to a number of factors; shallow water, jet wash, acoustic noise, it was more effective to run the sparker independently of the other sensors.

Line spacing was nominally the centre line with ±25m winglines. From ±25m the winglines were then spaced at ±35m out to ±235m to cover the width of the export cable route and WA1 landfall. Crosslines were run at 500m spacing. Once these mainlines had been completed and the data density and coverage assessed for all sensors infill lines were run on a 'by sensor' basis to close out gaps in the data.

The MBES was run as primary sensor during the operations. Data collected prior to 27/09/20 was at the standard density, data collected after 27/09/20 was done so in UHD mode to maximise data density across the nearshore survey area. Acoustic settings and opening angles were kept as consistent as possible to provide a contiguous backscatter deliverable.

The sidescan sonar was run simultaneously with the MBES, once the main survey line acquisition was complete any gaps were closed by flying the SSS on a dedicated infill line to achieve to required coverage.

Due to the shallow depths and limited deck space a single magnetometer was towed, piggy backed to the sidescan sonar. The nominal line spacing discussed above was followed in blocks A1 to the elbow of A3, in the southerly leading part of A3 out to A5 centre and ±25m winglines were run. The same approach was undertaken in WA1. An additional two lines were run on the outer extent of block A5

Initially the sparker was to be run on all lines as with the other sensors. However, in A1 to A3 the sediment cover was determined to be relatively thick with geology and soils present that were conducive to good penetration and imaging with the parametric SBP. As such the number of lines the sparker was reduced where necessary. Due to the encroaching coastline to the South of blocks A1 to A3, no sparker lines were run to the south of the centreline in Blocks A2 and A3. The majority of the centreline in A2 was completed with a 155m gap between KP2.785 and KP2.940, lines to the North of centre were run from approximately KP3.140 to the western end of the block. No lines were run between KP1.115 and KP2.005. Five lines: centreline, +25, +50, -25 and -50 were run from approximately KP0.100 to KP1.115. As the parametric SBP performed well it was run simultaneously during MBES acquisition and where necessary additional infill lines were rerun to close coverage areas.

#### 5.2.1.2. Offshore Geophysical Acquisition Methods – Export Cable Route

The Seazip Fix was mobilised with all sensors to allow simultaneous acquisition on all lines for both the export cable route and the array area.

The nominal line spacing for the export cable route was the centreline with ±25m winglines. From ±25m the winglines were spaced at 75m out to 175m. Where necessary additional outer lines were added to provide coverage at the outer limits of the corridor. Crosslines were performed at 1000m spacing. Once these mainlines had been completed and the data density and coverage assessed for all sensors infill lines were run on a 'by sensor' basis to close out gaps in the data. Due to the specification required a significant amount of effort was spent infilling MBES and SSS data. During infill efforts the central ±25m corridor was the main focus as it was believed this would represent the most likely cable route. To maximise workability the MBES was often run as the only sensor when the weather and sea state was too poor to tow equipment behind the vessel.

The parametric SBP was run as the main sensor during the first acquisition stages. This ensured even spacing of the grid, removing the potential for overlapping lines and data stacking had another sensor been used.

The sidescan was towed behind the vessel during the mainline acquisition. At times the tow fish would be significantly offline due to the currents experienced onsite. As such additional data were acquired during MBES infill to close out some gaps in the SSS data. Where necessary the tow fish was made the steered node to ensure specific, smaller holes were closed out.

The TVG was towed behind the vessel during the mainline acquisition. At times the array would be significantly offline due to the currents experienced onsite. As such additional data were acquired during MBES infill to close out some gaps in the TVG data. Where necessary the TVG was made the steered node to ensure specific, smaller holes were closed out.

The sparker and hydrophone were towed behind the vessel during the mainline acquisition. Where necessary lines were re-acquired if a reshoot was needed. Typically, this would-be part of additional data acquisition for other sensors.

#### 5.2.1.3. Offshore Geophysical Acquisition Methods – FLOW Site

Operations were started in the east of the array area, however completing the export cable route became priority, with the array area revisited after the export route was complete. Due to delays during the survey, the scope of the survey across the array area was amened to ensure a broad level of detail was captured prior to the vessel standing down.

The nominal line space on the FLOW was 65m with cross lines every 1000m and these lines were run during the first phase of the acquisition. Infill lines were also run during this first phase before attention was turned to the export cable route. During this phase all sensors were run simultaneously where possible.

During the second phase of acquisition on the FLOW site every third line was run, giving an effective line spacing of 195m. This allowed a large area to be covered across the site but did result in data gaps in the MBES and SSS. Where possible all sensors were run simultaneously. At times when the weather increased beyond acceptable limits the MBES was run singularly to maximise data coverage given the conditions.

#### 5.2.1.4. MBES Data Acquisition Methods - Nearshore

Data were acquired in EIVA NaviScan. Processing and QC was completed using EIVA NaviEdit and NaviModel.

The raw data were imported daily, with the vessel offsets configuration and processing parameters checked to confirm no changes were made. The necessary offsets are then applied to the data. Tide data were also imported along with SVP data into the NaviEdit database. The tide data were then QC'd and despiked to produce a final tide file.

The data from NaviEdit were loaded into NaviModel for a QC of the MBES data. Lines are manually cleaned by rejecting spikes and noise, thus reducing the standard deviation of the mean layer. Occasionally, specific beam ranges were rejected to remove soundings and improve overlap between lines. The cleaned edits were written back to the NaviEdit database. A QC of the MBES data with tide applied was carried out to check for tidal discrepancies between survey lines. If tidal differences were apparent, then a z shift is calculated and applied to the data in order to correct the observed discrepancies.

A DTM was generated from the accepted data and Level Out Depth Correction is applied to this DTM to correct for any remaining small discrepancies between STB levels.

A TPU calculation is then run on the final DTM to determine TVU/THU and density of the final DTM.

Backscatter data were acquired in EIVA NaviScan. Processing and QC was completed using EIVA NaviEdit, NaviModel and Geocoder.
Backscatter intensities were imported using corrections used during the bathymetry processing. Data were layered and backscatter intensities were normalised automatically within NaviModel.

#### 5.2.1.5. MBES Data Acquisition Methods – Offshore

Data were acquired in QPS Qinsy, Processing and QC was completed using QPS Qimera.

The raw data were imported daily, with the vessel offsets configuration and processing parameters checked to confirm no changes were made. The necessary offsets are then applied to the data. Tide data were also imported along with SVP data into the Qimera database. The tide data were then QC'd and despiked to produce a final tide file.

Post project a full initial data QC was performed in order to identify which lines / areas had been surveyed with a correct VORF model and which ones did not. Once the lines which were surveyed with the wrong VORF model had been identified, those lines were replayed in Qinsy with the correct VORF model file and GNSS accurate heights mode were used, which outcome was MBES data already reduced to LAT.

Once all data (per block) had been reduced to the correct VORF – LAT plane, the next step was to clean all spurious data. The offshore team had noted that during the offshore data acquisition phase, the data quality was very often affected by dolphins which were following the vessel and quite often right under the MBES transducer. The impact on the MBES data quality had been quite critical at times which forced significant effort to achieve a usable product. The data cleaning steps which were followed are described below:

i. *Automatic Spline Filtering*

At an initial stage, a strong or very strong spline filtering was used depending on the data quality assessment.

However, this filtering was not enough due to the data disruption created often by dolphins. Whenever this had happened, a process of manual cleaning was performed.

ii. *Manual cleaning*

As mentioned before, the MBES data were quite often affected by dolphins and the first filtering approach was not always able to remove all spurious data. Such manual cleaning was performed over a dynamic surface and alternating 2D/3D views, point cloud and swath display cleaning to help to assess on data quality.

After tide and cleaning was completed QC of the MBES data were carried out to check for tidal discrepancies between survey lines. If differences were apparent, then a z shift is calculated and applied to the data in order to correct the observed discrepancies.

A DTM was generated from the accepted data and Level Out Depth Correction is applied to this DTM to correct for any remaining small discrepancies between adjacent swath levels.

A TPU calculation was then run on the final DTM to determine TVU/THU and density of the final DTM.

#### 5.2.1.6. Side Scan Sonar Data Acquisition Methods

The SSS data were recorded in Edgetech Discover software in JSF and XTF format throughout. Both 600kHz and 300kHz frequency data were processed in SonarWiz. Data were imported using the optimal sample per channel dependant on the acquisition sample rate and the first available software defined preset below the raw recording as to prevent upscaling, as recommended by the software. Acquisition sample rate varied by frequency and maximum range, hence import sample rate varied between lines.

The high frequency (600kHz) content of the JSF was used for target picking and seabed features, whilst the low frequency (300kHz) was used to interpret seabed sediments. Navigation was projected from latitude and longitude into WGS UTM30 datum and displayed using sensor heading. A 50-ping smoothing was applied to the navigation on import.

After import into SonarWiz, navigation data within the files were amended to correct for dropouts in the acquired USBL navigation originally recorded into the JSF. Once all navigation had been corrected, a light 'boxcar' moving average filter was applied to the navigation and heading to remove outliers. Bottom tracking was then carried out on each file to ensure the correct slant-range correction is applied to data to allow correct position and measurements of contacts in the interpretation phase. An adjustment to the sensor position was made referencing features observed in MBES data to improve positioning. A quality control of the data was also completed at this stage. Files found unsuitable for final delivery were flagged and removed from the final dataset. Marginal files are adjusted to allow for the use of as much useable data as possible.

Data were then gained using Empirical Gain Normalisation (EGN) and destriping to remove any snatching or weather artefacts. Each mosaic was checked to ensure homogeneous gains between corresponding lines as well as ensuring areas of low and high acoustic reflectivity, linked to seabed sediments and features, were not processed out.

A final mosaic was produced including all suitable survey lines, which were layered to optimise the aesthetics of the mosaic and produce a good representation of seabed conditions. Figure 6 shows a section of the final high frequency mosaic producing from the Iceni Spirit dataset over West Angle Bay.

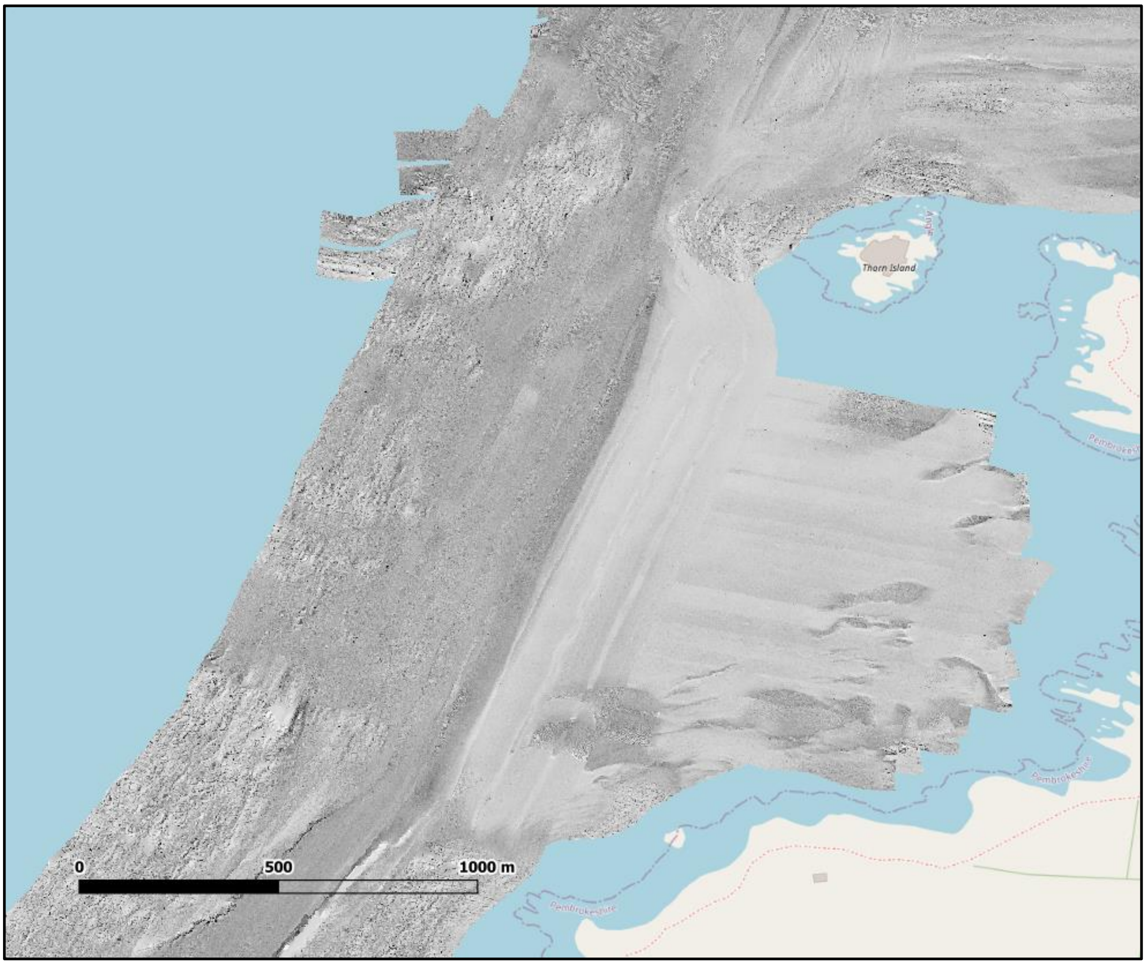



Figure 6: Example of processed high frequency SSS mosaic

The data were then interpreted on a line-by-line basis identifying targets over 0.5m. Targets below 0.5m were not interpreted. Targets were classified as; Boulder, Cable, Debris, Possible UXO, Fishing Equipment or Wreck. A confidence value was given to substantiate the positioning of the target and to indicate the datasets the target has been observed on. An associated feature is drawn to highlight linear targets and the central point used as the target position. Boulder fields, defined by areas containing greater than 10 boulders in area of 100m x 100m, were distinguished and catalogued as such. Boulders withing these boulder fields have not been individually picked or measured.

On client request, an in-depth analysis of boulder density was undertaken on a large boulder field present between KP8 and KP11. For this area, a boulder density heatmap was produced (see Figure 50).This was produced from manual picks on the final SSS mosaic, identifying the location of all clear boulder targets regardless of minimum size. A grid was then produced from the pick locations where 10m bins were populated with the number of targets within a one-hectare circle centred around that bin.

The MBES data and additional available background data were then loaded into QGIS with the SSS data to complete the surficial geology interpretation. Boundaries for bedrock outcrops, sediment classes and potential obstructions or hazards were marked. Seabed features, such as mobile bedforms, were picked to aid the interpretation of the surficial geology and geohazards model.

#### 5.2.1.7. Innomar Sub-bottom Profiler Data Acquisition Methods

SBP data on both Iceni and SeaZip Fix were acquired using pole mounted Innomar parametric echosounders. Data were acquired in Innomar SESWin acquisition software in RAW format which were subsequently converted to SGY using SESConvert. RadExPro was used for the processing of raw sub-bottom profiler data for both Iceni and SeaZip Fix datasets. Data were imported and processed on a day-by-day basis. Continuous quality control was carried out at each phase of processing to ensure no artefacts are created and that the processing flow works to improve the quality of the raw data. Processed data received from site were reprocessed using optimised processing flows and parameters to improve data interpretability,

Once the data were imported, a Butterworth filter was applied to remove excessive high and low-frequency noise from external sources unrelated to the Innomar's central frequency. Burst noise removal was applied to remove any isolated areas of noise. Once the excessive noise was removed amplitude normalisation and time-varied gain were applied to increase the interpretability of the processed data.

A swell filter was applied to remove any motion not already compensated for during acquisition. Although the SBP system was heave compensated in real time, given the Innomar system's high directionality, some residual motion was present which was likely to be the sum effect of roll and pitch with a small component of residual heave. In general, the swell filter applied was correcting small motion changes less than 50cm in amplitude.

Tide data were imported into the data and applied to each trace individually. This adjusted the data to LAT to ensure tidally correct data when interpreting the data. The tidal correction was checked against bathymetry to ensure tide has been correctly applied.

Once the data were tidally corrected, the navigation is filtered to remove any small spikes and smoothed. Processed SEGYs are then exported ready for interpretation in IHS Kingdom.

Interpretation has been undertaken in the time domain and then converted to depth relative to LAT and below seabed. The time-depth conversion has been undertaken using a simple 2-layer model; with an average water velocity of 1500m/s and an average subsurface velocity of 1650m/s. Subsurface velocity has been estimated in lieu of any measured velocities from geotechnical data, based on typical acoustic velocity values expected for shallow unconsolidated material. As no horizons beneath the top of bedrock have been interpreted, the change in velocity that would be associated with the sediment-bedrock interface will not affect any reported depths.

Figure 7 and Figure 8 show examples of the raw and processed Innomar data, respectively, taken from the Iceni dataset between approximately KP2 and KP4. The processing applied has acted to remove swell noise observed as the oscillating seabed in the raw data, producing a flatter seabed which is more representative of seabed conditions. Whilst the system was heave compensated onboard, it appears though the compensation did not fully remove all motion. Given the high directionality of the Innomar system it is likely that rolling and pitching of the transducer further added to the amplitude of motion observed on the data, which was typically less than 50cm. Hence the need for further swell filtering. Checks were made against bathymetry to ensure the seabed was not over flattened by this process. In the swell filtered data deeper reflectors have become more distinguishable and continuous, whilst shallower reflectors have become more enhanced.

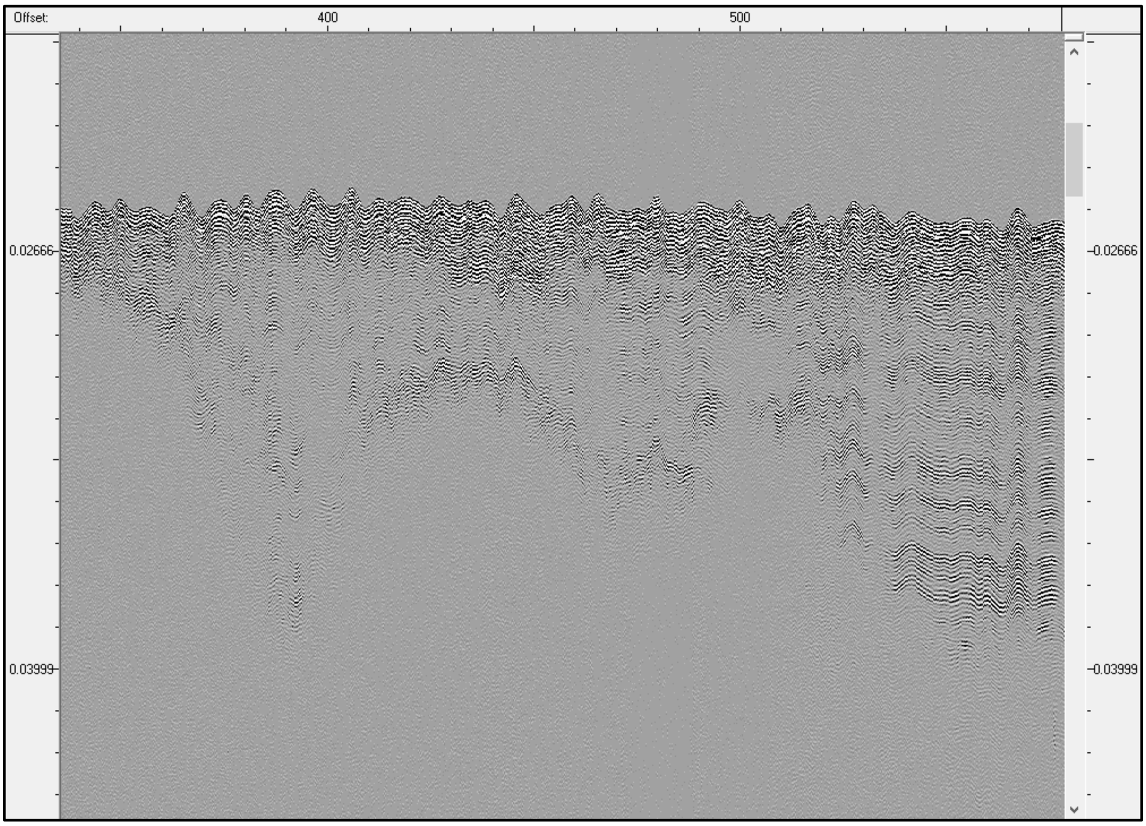



Figure 7: Raw Innomar data example from line B_135_A

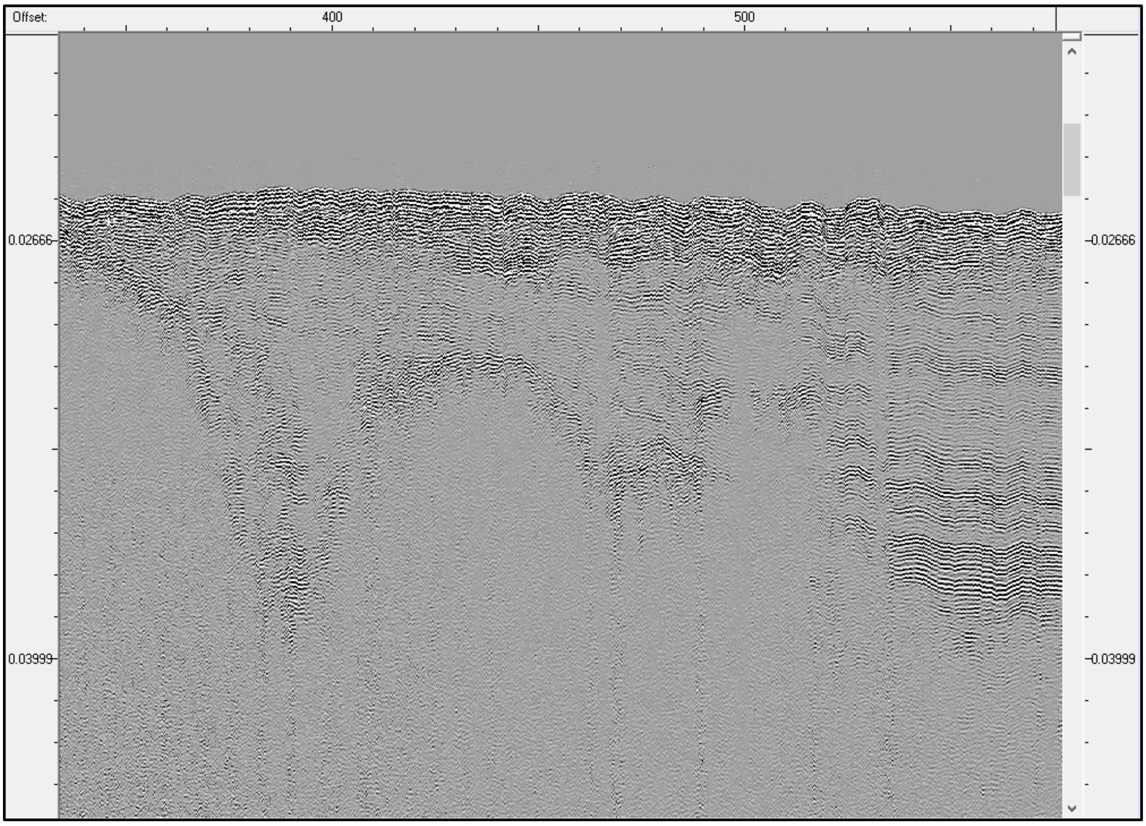



Figure 8: Processed Innomar data example from B_135_A

### 5.2.1.8. Sparker Data Acquisition Methods

Sparker data on both Iceni and SeaZip Fix were acquired using a stern towed sparker catamaran with an independently towed hydrophone. Data were acquired in CODA acquisition software in COD format which were subsequently converted to SGY using SonarWiz. RadExPro was used for the processing of raw sparker data. Data were imported and processed on a day-by-day basis. Continuous quality control was carried out at each phase of processing to ensure no artefacts are created and that the processing flow works to improve the quality of the raw data. Processing flow varied slightly between survey vessels; details of which flows were applied to each dataset are listed in Table 24.

Once the data were imported the seabed was accurately tracked to ensure optimal processing of subsequent processes. Swell statics were calculated and reduced from the dataset, aiming to remove the undulating pattern of all reflectors. A Butterworth filter was applied to remove excessive high and low-frequency noise from external sources unrelated to the sparker system's central frequency.

A 1D Designature filter was applied to remove the source signature. This filter was designed by flattening the water bottom and stacking all traces to simulate a far-field signature, which is characterized by a direct wavelet plus its reflection ghost from the air-water interface and bubble.

The data were then run through a de-ghosting workflow. The deghosting algorithm estimates the necessary parameters adaptively to the data within a sliding window by resolving the nonlinear optimization problem. It allows the removal of the frequency notches present in the raw data and the recovery of low-frequency energy. This increased the signal to noise ratio and improved the vertical resolution and penetration of the data.

In order to supress the seabed multiple, a zero offset de-multiple algorithm was used. The algorithm created a multiple model by a series of auto-convolution, and then it is adaptatively subtracted from the data. This was only applied to the Iceni dataset to reduce the effect on the multiple within the area of interest, in the shallow nearshore environment. In the deeper water where the SeaZip Fix operated, the multiple did not pose an obstruction to interpretation.

A spherical divergence correction was applied to the data along with time-varied gains to increase the interpretability of the processed data.

Tide data were imported into the data and applied to each trace individually. This adjusted the data to LAT to ensure tidally correct data when interpreting the data. The tidal correction was checked against bathymetry to ensure tide has been correctly applied. Once the data were tidally corrected, the navigation was filtered to remove any small spikes and smoothed. Processed SEGYs were then exported ready for interpretation in IHS Kingdom.

Interpretation has been undertaken in the time domain and then converted to depth relative to LAT and below seabed. The time-depth conversion has been undertaken using a simple 2-layer model; with an average water velocity of 1500m/s and an average subsurface velocity of 1650m/s. Subsurface velocity has been estimated in lieu of any measured velocities from geotechnical data, based on typical acoustic velocity values expected for shallow unconsolidated material. As no horizons beneath the top of bedrock have been interpreted, the change in velocity that would be associated with the sediment-bedrock interface will not affect any reported depths.

Table 25: Summary of Sparker Processing

| Process | Iceni Sparker | SeaZip Fix Sparker |
|---|---|---|
| Butterworth Filtering | Yes | Yes |
| 1D Designature Filter | Yes | Yes |
| Deghosting | Yes | Yes |
| Zero Offset Demultiple | Yes | No |
| Gains | Yes | Yes |
| Vertical Correction (tide) | Yes | Yes |

Figure 9 and Figure 10 show the difference between the raw and processed sparker data, respectively, taken from the Iceni dataset between approximately KP4 and KP5. The processing has been able to supress a significant amount of noise present in the data. The noise is primarily vessel and wash related, as the source/receiver passed though the wash trails the data reduced in quality substantially. However, for the most part, the processed data is sufficient to determine depth to rockhead and cross correlate horizons with the SBP dataset. The demultiple process has worked well to allow deeper penetration in the shallow waters to give better context in interpretation.

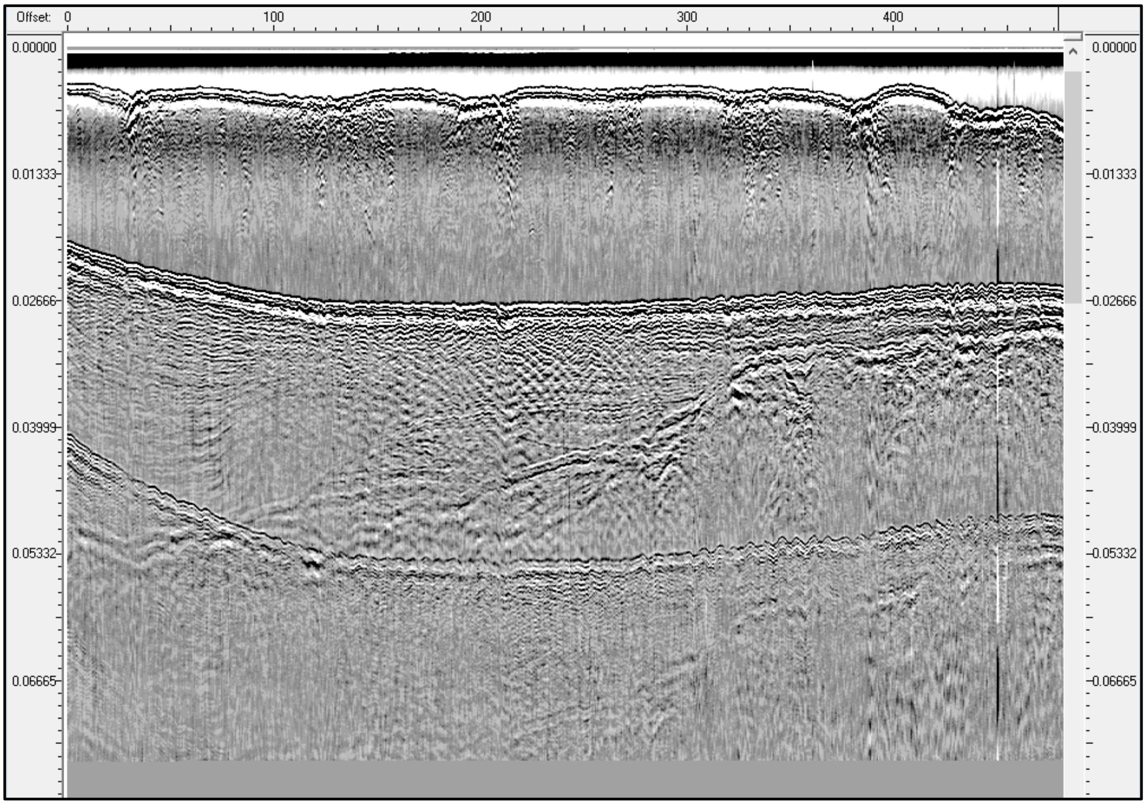



Figure 9: Raw sparker data example from line C_X7

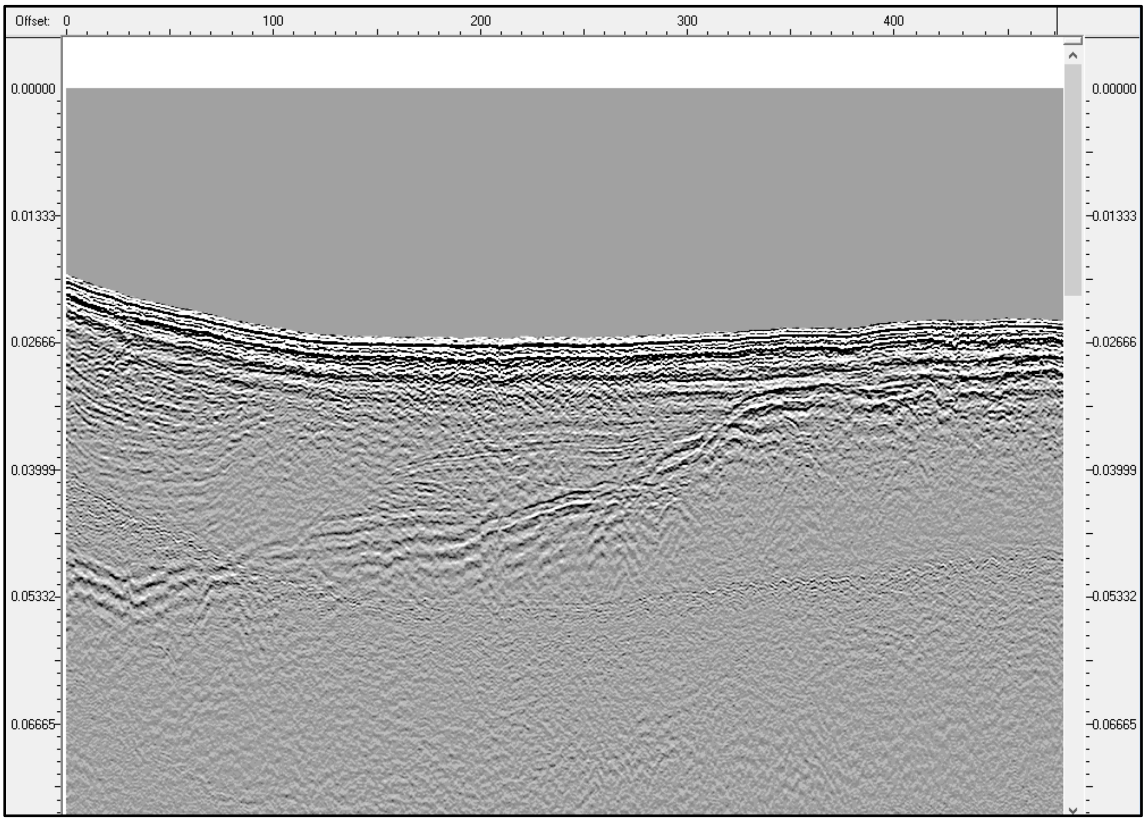



Figure 10: Processed sparker data example from line C_X7

#### 5.2.1.9. Magnetometer Data Acquisition Methods

The magnetometer data were recorded throughout in MagLog Lite along with the navigation data. The data were imported into Oasis Montaj for processing and interpretation.

Raw total field and altitude data were de-spiked, altitude was also smoothed, aiding with the interpretation. Raw USBL navigation was de-spiked and corrected. Once data had been cleaned and corrected, each line was subject to quality control and data points not meeting specification are removed.

A series of non-linear filters were applied to the de-spiked version of the total magnetic field data to estimate the background magnetic field. The calculated background field was then subtracted from the original de-spiked total magnetic field to find the anthropogenic residual field composed of signals unrelated to the bulk earth and diurnal effects. The anthropogenic residual field was then gridded.

Target picking was then undertaken using the total field, residual field, and profile data. Using a picking threshold of 5nT, targets were reconciled between the two MAG sensors on each pass. These targets were then correlated against seafloor contacts identified from MBES/SSS data.

## 5.3. Environmental Acquisition Methodology

### 5.3.1. Survey Strategy and Objectives

A total of 116 Environmental Baseline Survey (EBS) locations were proposed across the export cable corridor and array areas to be targeted with drop-down camera (DDC) and/or grab sampling. A further 82 Habitat Assessment (HA) locations were proposed to be targeted with DDC transects. The survey was undertaken during nearshore and offshore phases conducted aboard the vessels Seren Las (nearshore) and Glomar Wave (offshore) between 21st October to 11th November 2020 and from 9th November to 29th November 2020, respectively.

The overall purpose of the surveys conducted in October and November 2020 was to acquire environmental data throughout the proposed Project Erebus survey area, to inform the EBS and HA survey aspects of the project Environmental Impact Assessment (EIA).

The HA aspect of the survey had the following objectives:

- Collect video/stills footage and grab samples at targeted locations positioned along the proposed nearshore and offshore cable route and throughout the wind farm array area to characterise seabed sediments and associated benthic communities.
- Collect additional video/stills to fully delineate seabed features and allow for high confidence mapping of key features and for a robust assessment of any sensitive habitats identified (e.g., Annex I geogenic and/or biogenic reef habitats).

A total of 201 stations were selected and targeted during the 2020 survey (including 3 additional stations). Further detail is provided in section 5.3.1 and full rationale for the selection of each sampling station is provided as Appendix IV.

These stations consisted of EBS grab and drop-down camera (DDC) sampling, and HA transects (Table 25 and Figure 11, Figure 12, Figure 13, Figure 14 & Figure 21). Of the 201 stations all DDC and HA transects were completed and 9 grab samples were abandoned due to failed attempts on hard substrate. It is noted that some of the offshore DDC stations and transects had to be relocated as detailed in Appendix XI.

Table 26: A summary of the stations targeted for the Project Erebus FLOW survey

| Type | Proposed | Completed | Abandoned | Comments |
|---|---|---|---|---|
| Nearshore | | | | |
| EBS (Grab) | 21 | 16 | 5 | 5 abandoned due to failed attempts on hard substrate. |
| EBS (DDC) | 21 | 21 | 0 | |
| HA (Transects) | 22 | 25 | 0 | 3 additional transects sampled due to potential Annex I reef habitat at T020. |
| Offshore | | | | |
| EBS (DDC) | 35 | 35 | 0 | |
| EBS (Grab) | 35 | 34 | 1 | 1 abandoned due to failed attempts on hard substrate. |
| HA (Transects) | 13 | 13 | 0 | |
| WTG Array Area | | | | |
| EBS (DDC) | 15 | 14 | 0 | |
| EBS (Grab) | 60 | 57 | 3 | 3 abandoned due to failed attempts on hard substrate. |
| EBS/HA (Transects) | 47 | 47 | 0 | |

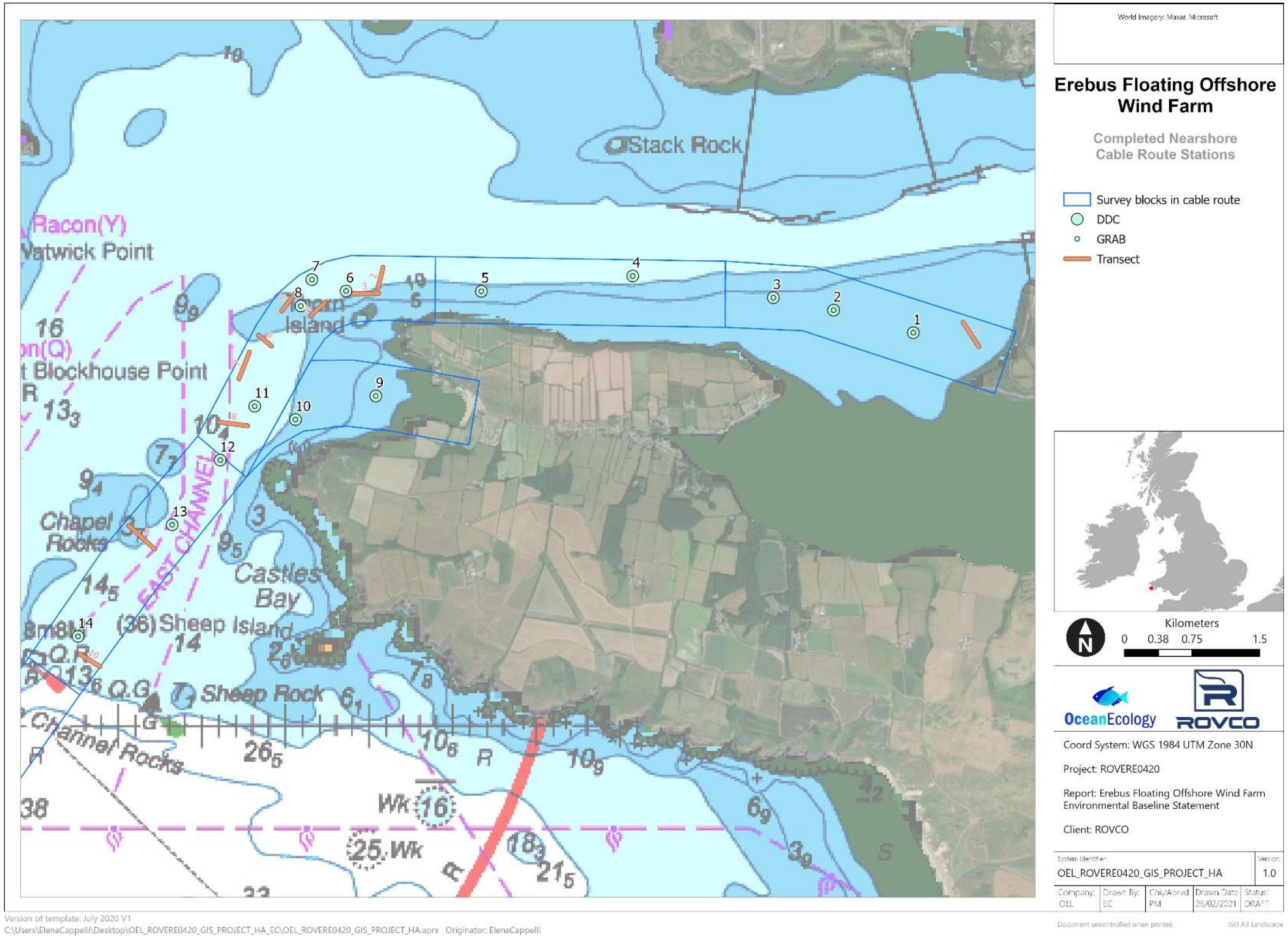



Figure 11: Stations sampled during the nearshore cable route section of the Project Erebus Offshore Floating Wind Farm survey.

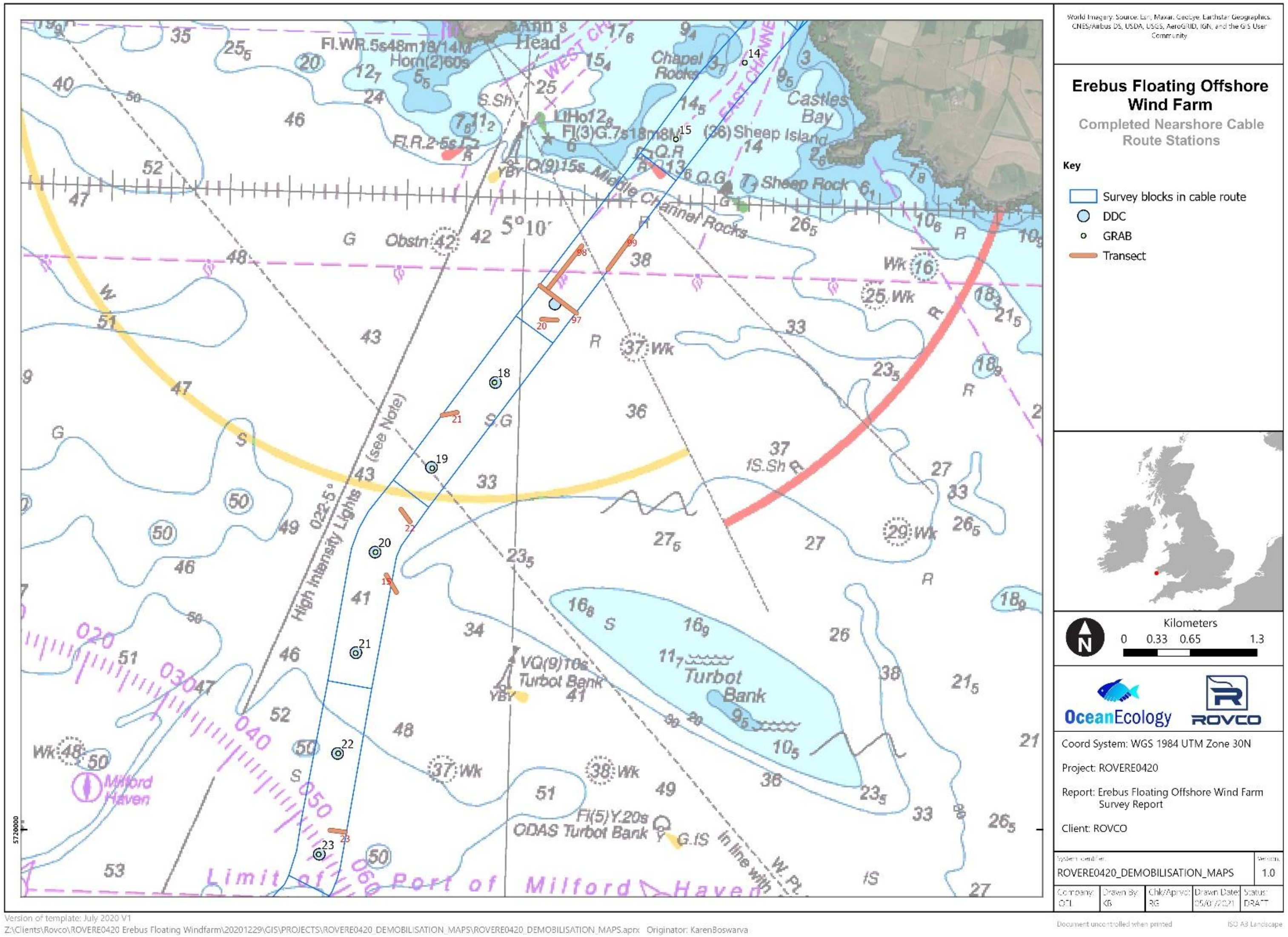



Figure 12: Stations sampled during the nearshore cable route section of the Project Erebus FLOW survey

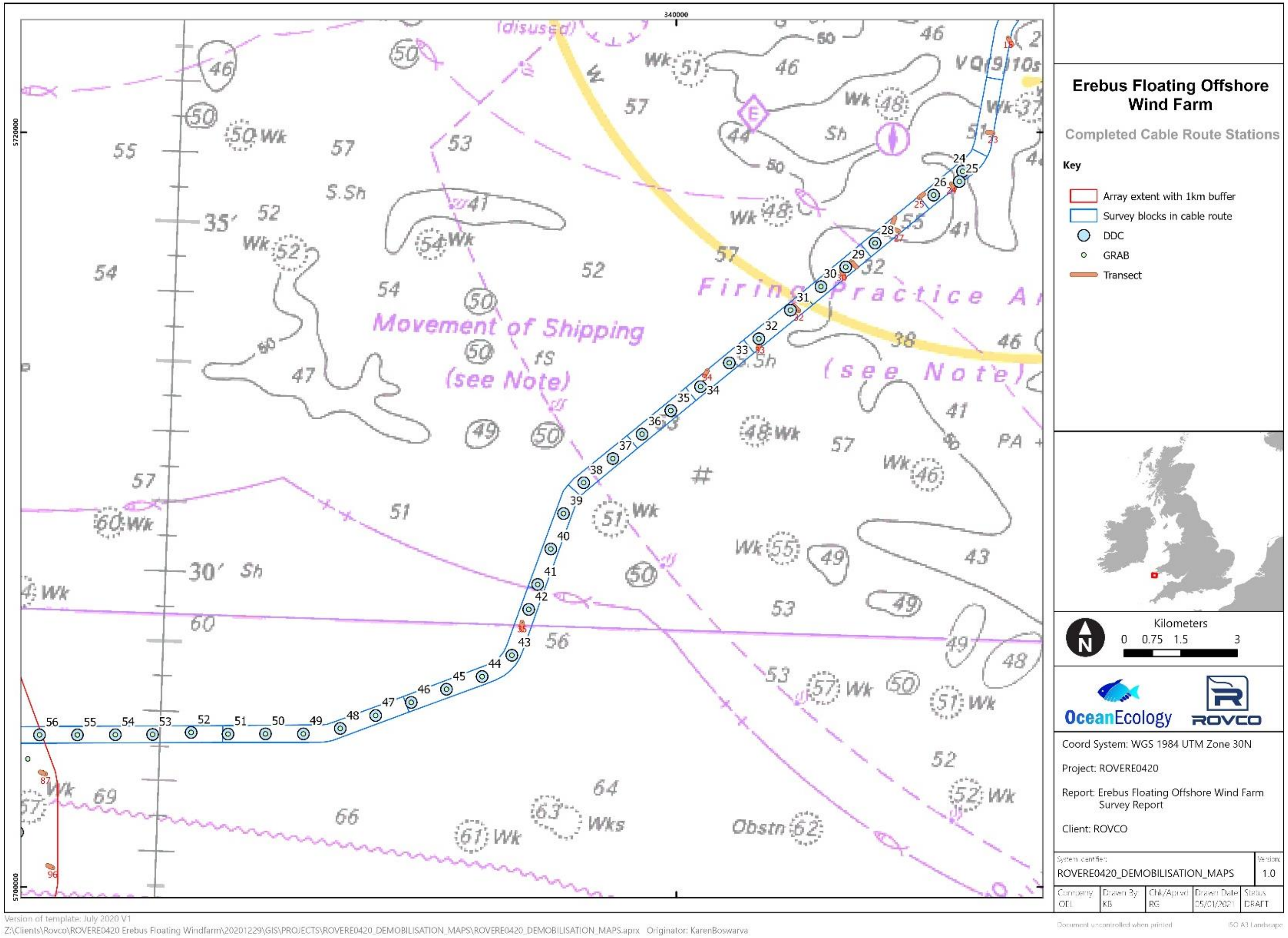



Figure 13: Stations sampled during the offshore cable route section of the Project Erebus Offshore Floating Wind Farm survey.

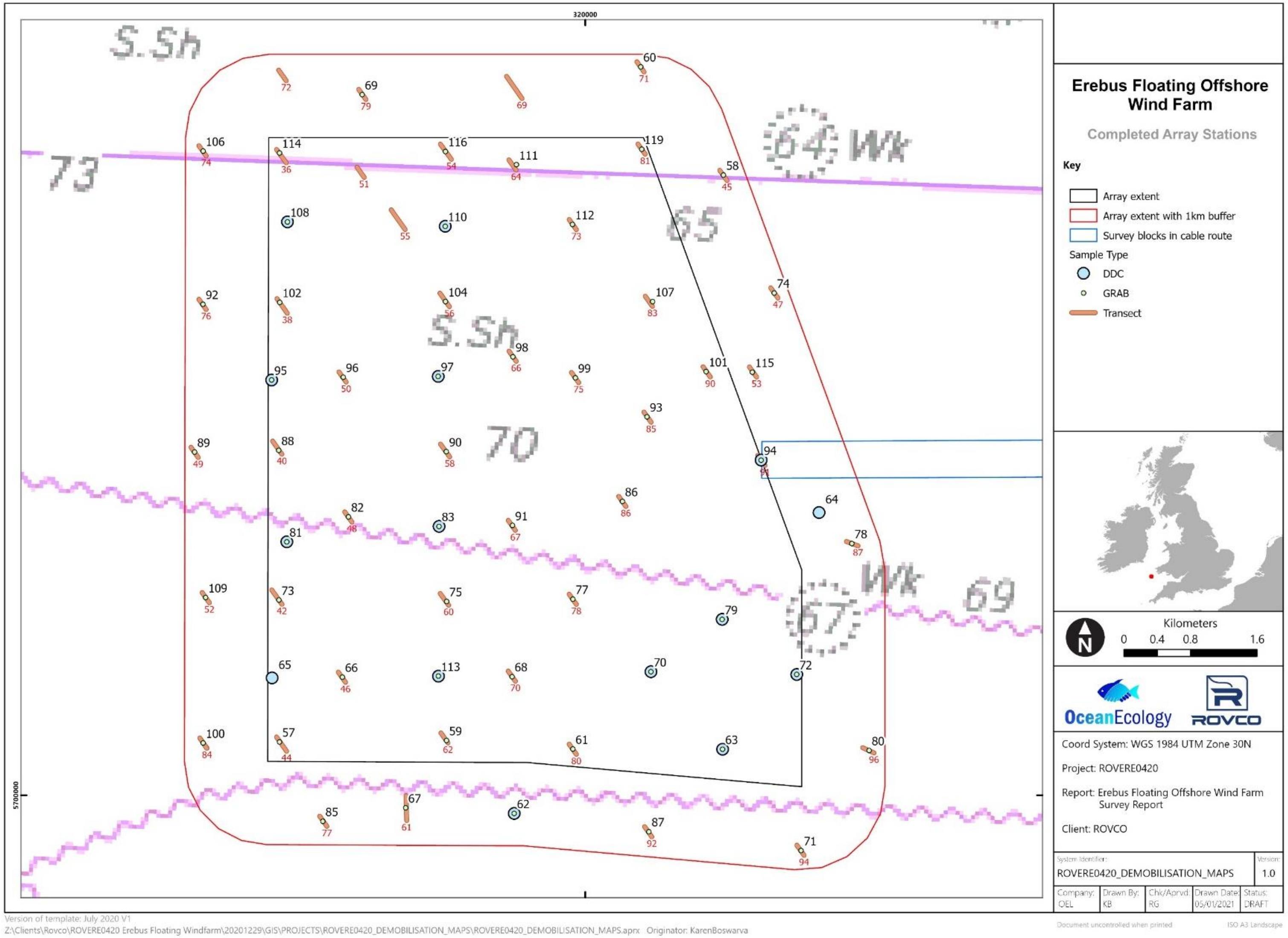



Figure 14: Stations sampled during the wind farm array section of the Project Erebus FLOW survey

### 5.3.2. Benthic Sample Acquisition

The benthic sampling array was designed to provide maximum geographic coverage of the proposed nearshore and offshore cable corridors and the windfarm array (plus 1 km buffer), whilst also ensuring that all key habitats and communities likely to be encountered across the survey area were adequately ground-truthed to allow for the production of an accurate habitat map of the entire survey area. This was achieved through a review of existing habitat mapping (EMODnet) and of the geophysical data collected in summer and autumn 2020. Sample selection followed an iterative process whereby OEL undertook the review of existing information and proposed sampling positions which were then signed-off by Blue Gem Wind's marine EIA consultant MarineSpace. A full audit trail of the sample selection process is provided as Appendix IV. For the purposes of survey planning, the cable route was divided up into 20 separate blocks (A1-A19) extending from the Sawdern Point landfall to the array area with the West Angle landfall encompassed by an additional block, WA1. The nearshore section of the export cable route was defined to include Blocks A1-A7 including WA1 whilst the offshore section was defined to include Blocks A8-A19.

#### 5.3.2.1. Benthic Sampling - Export Cable Corridor

EBS sampling stations were selected in line with Scope of Work (SoW) and as confirmed with regulators at approximately 1 km intervals along the proposed export cable corridor although each was micro sited to ensure sedimentary habitats evident in the geophysical data coverage were targeted and where relevant, bedforms and other features of interest were investigated (e.g., sand wave crests and troughs). Prior to the collection of grab samples at each EBS sampling station, imagery was collected of the seabed using a drop-down optical camera system as a means of screening for important and/or sensitive features (e.g., Annex I reefs). This meant that the EBS stations 'doubled up' as HA stations as the resulting seabed imagery could be used to confirm the presence/absence of habitats of interest.

A series of HA transects were also positioned along the export cable corridor at no set interval but where necessary to identify or assess areas/feature of interest, such as:

- Assess areas of and/or boundaries between high, low and heterogeneous acoustic reflectivity (usually associated with Annex I reef habitats);
- Ground-truth boundaries between predicted habitats/biotopes based on existing habitat mapping;
- Assess slopes, crests and troughs associated with notable topographic features (e.g., sand waves and potential sand banks);
- Confirm the absence of key habitats (e.g., seagrass beds) with the potential to occur in areas lacking geophysical data coverage (e.g., close to the LAT mark at the landfall locations).

#### 5.3.2.2. Benthic Sampling - FLOW Array Area

The approach to sample station selection across the array differed to that used for the export cable corridor due to the geophysical data for much of the area being of lower resolution (5 m) and reduced spatial coverage, with some areas lacking bathymetry, SSS backscatter or both (see sections 5.2.1.4, 5.2.1.5 and 5.2.1.6 for the sampling strategy related to the collection of MBES and SSS data). The sampling plan for the array was therefore based on an 'intelligent grid' approach that initially involved positioning EBS stations at approximately 1 km spacing to provide an even spatial coverage of sampling across the survey area. Where necessary, sample locations were then re-distributed from areas determined to be homogenous sandy sediment (based on interpretation of the geophysical data and/or existing habitat mapping) to areas of low or no geophysical data coverage whilst others were micro-sited to target particular features and/or bedforms (e.g. sand waves). This was in line with SoW and confirmed with the regulators.

Each EBS station was also 'screened' for important and/or sensitive features (e.g., Annex I reefs) via the collection of seabed imagery using a drop-down optical camera system prior to grab sampling. As with the export cable corridor stations, this meant that the array EBS stations 'doubled up' as HA stations as the resulting seabed imagery could be used to confirm the presence/absence of habitats of interest. The spatial coverage of imagery collected at the array EBS stations was however increased compared to the approach taken for the export cable corridor stations in that imagery was collected along transects of 150-300m rather than at single point locations. 'Screening' prior to grab sampling was not deemed necessary at all of the array EBS stations due to the presence of obvious areas of homogenous sandy seabed devoid of acoustic signatures characteristic of potentially important and environmentally sensitive features.

#### 5.3.2.3. Environmental Sampling Equipment

##### 5.3.2.3..1. Seabed Camera Systems

Seabed imagery (simultaneous video and stills) was collected using two high-definition optical camera systems across the cable corridor and array areas. The majority of the nearshore and some of the offshore imagery was collected using OEL's ROVTech subsea camera system providing 1080p High Definition (HD) video and 20 Megapixel (MP) stills imagery. Due to greater turbidity in the shallower nearshore areas, the camera was mounted in a Clear Liquid Optical Chamber (CLOC) filled with fresh water to ensure imagery of suitable quality was obtained (Jones et al. 2020). Lighting from two LED strip lamps and two lasers separated by 10 cm were projected into the field of view for illumination and scaling.

All other seabed imagery was collected using a Subsea Technology and Rentals (STR) Seaspyder-HD Drop Camera System, providing 1080p High Definition (HD) video and 18 Megapixel (MP) stills imagery. The camera was mounted on an aluminium sledge-like frame and illuminated by four high intensity, adjustable LED lamps each emitting max 1200 lumens. Quad scaling lasers, altimeter, depth, and heading sensors were also integrated into the frame.

##### 5.3.2.3..2. Grab Samplers

Sediment samples collected at each EBS station visited by the Seren Las were collected using 0.1m$^2$ Day grab whereas stations visited by the Glomar Wave were collected using a dual (2 x 0.1m$^2$) Van Veen (DVV) grab. The DVV enables two samples of undisturbed surface sediment to be retrieved simultaneously. At stations where the DVV was unsuitable for sampling due to the presence of coarse sediments and/or rocky seabed, a 0.1 m$^2$ mini-Hamon grab was deployed instead. The mini-Hamon grab collects a single sample of sediment per deployment, therefore multiple deployments are required to obtain two replicates. Two sediment samples were required at each sampling station as per SoW and NRW Guidance note GN030h.

#### 5.3.2.4. Sampling Approach

##### 5.3.2.4..1. Drop Down Video Sampling

As per SoW, all seabed imagery was collected in consideration of the Joint Nature Conservation Committee (JNCC) epibiota remote monitoring operational guidelines (Hitchin et al. 2015). A minimum of five images were captured from each EBS station along with a minimum of 2 minutes of video where the seabed was visible. Between images, the camera was moved to ensure a good overview of the station was obtained and any heterogeneity in the substrate was identified. Along the HA transects, images were taken at least every 10m and more often when features of interest were encountered. All video footage was reviewed on board the vessel by OEL's environmental scientists to ensure quality

##### 5.3.2.4..2. Grab Sampling

All grab sample collection and processing was undertaken in consideration of version 8 of the Regional Seabed Monitoring Programme (RSMP) protocol (Cooper & Mason 2019). Grab sampling was only conducted once suitable seabed video and stills of the seabed had been collected from each sampling station and no obstructions to inhibit the collection of grab samples had been identified. Samples with a volume less than 5 L were rejected and sampling at the location reattempted. If continued attempts also failed to collect a valid sample, then the station was either repositioned, abandoned or reattempted using the Hamon grab. Appendix VI provides a detailed account of grab sample survey logs. Two replicates (A and B) for Hydrocarbons (HC) and Organics (TOC and TOM) analysis were collected from one replicate sample from each station using a metal scoop to a nominal depth of 2 cm and placed in a glass sample pot. Two replicates (A and B) for Heavy Metal (HM) analysis were also collected from the same replicate sample using a plastic scoop to a nominal depth of 2 cm and placed in a plastic sample pot followed by two replicates (A and B) for PSA. All chemical and PSA samples were frozen immediately (<-18°C). The remaining sample (either the second DVV sample or second Day or Hamon grab sample) was then released into a container and photographed. It was then emptied onto a 1 mm sieve net laid over 4 mm sieve table and washed through using gentle rinsing with seawater hose. The remaining sample was then photographed and backwashed into a suitably sized sample container using seawater and diluted 10% formalin solution added to fix sample prior to laboratory analysis.

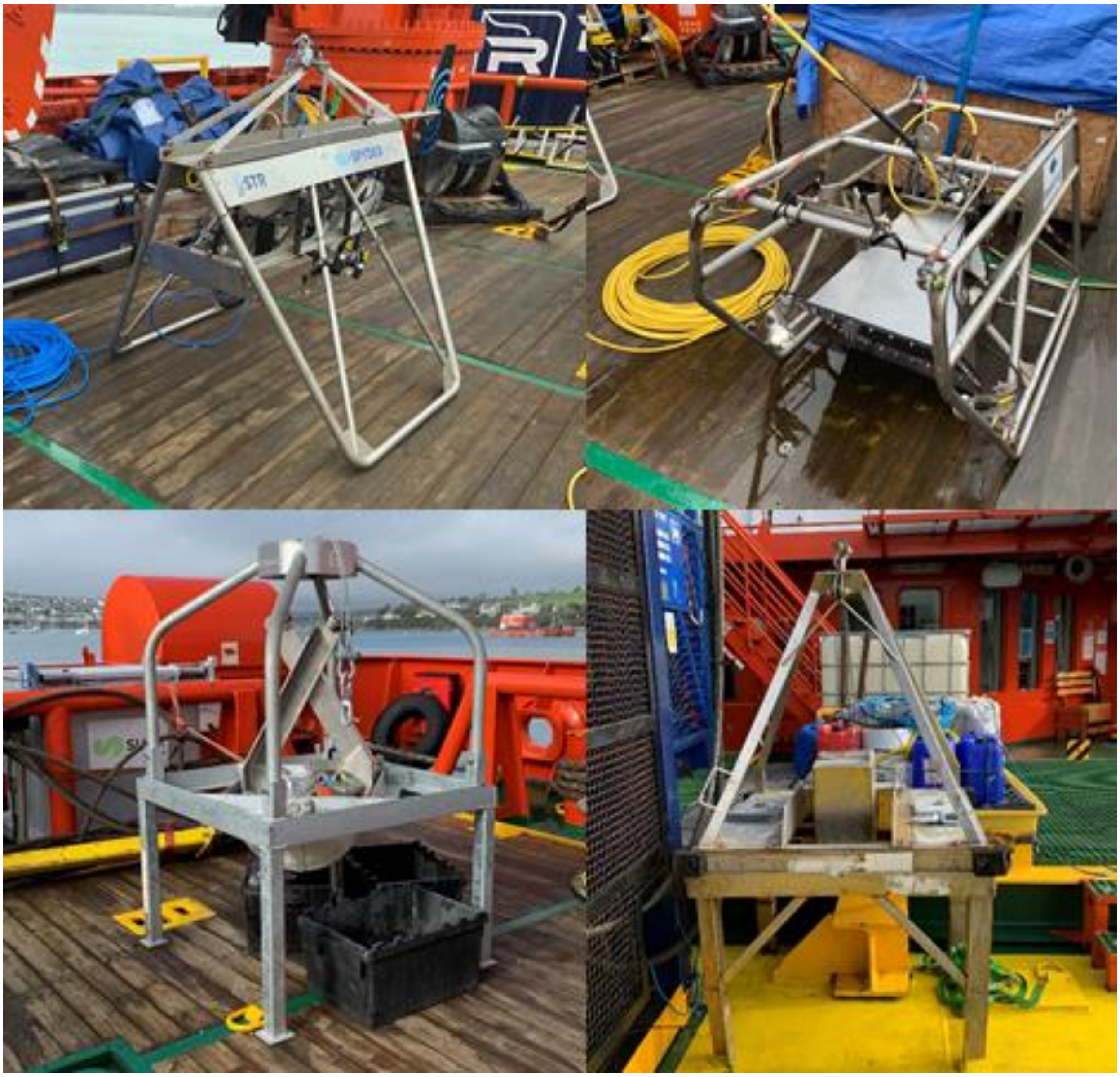


Figure 15: Top left: STR SeaSpyder camera system. Top right: OEL's ROVTech camera system equipped with CLOC. Bottom left: Dual Van Veen grab sampler. Bottom right: Mini-Hamon grab sampler.

### 5.3.3. Laboratory and Analytical Methods

On arrival to the laboratory, all samples were logged in and entered into the project database created in OEL's web-based data management application ABACUS in line with in-house Standard Operating Procedures (SOPs) and OEL's Quality Management System (QMS).

#### 5.3.3.1. Particle Size Distribution Analysis

PSD analysis was undertaken by in-house laboratory technicians at OEL's NE Atlantic Marine Biological Quality Control (NMBAQC) participating laboratory in line with NMBAQC protocols (Mason 2016) as described in Appendix V.

##### 5.3.3.1..1. Seabed Imagery Analysis

Following the methods described in Section 5.3.2.4..1, digital photographic stills and video footage were successfully obtained along all HA transects and site characterisation stations and subsequently analysed to aid in the identification and delineation of EUNIS habitats and potential Annex I habitats along the survey area. Seabed images were enhanced prior to analysis using the open-source image editing software GNU Image Manipulation Program (www.gimp.org). All seabed imagery analysis was undertaken using the Bio-Image Indexing and Graphical Labelling Environment (BIIGLE[4]) annotation platform (Langenkämper et al. 2017) and in line with JNCC epibiota remote monitoring interpretation guidelines (Turner et al. 2016). Analysis of still images was undertaken in two stages. The first stage, "Tier 1", consisted of labels that referred to the whole image being assigned, providing appropriate metadata for the image. Tier 1 labels included information such as substrate type and indicative biotope/EUNIS habitat. The second stage, "Tier 2", was used to assign percentage cover of 'reef' types by drawing polygons to inform the habitat assessment process.

##### 5.3.3.1..2. Annex I Habitat Assessment

Annex I Rocky Reef

A full reef habitat assessment was conducted on all images to determine whether habitats met the definitions of Annex I stony reef, bedrock reef and *S. spinulosa* reef habitats as detailed in Table 26 and Table 27. To note that there are currently no guidelines for determining the quality ('reefiness') of bedrock reef habitats, however some of criteria described in Table 26 can be adopted to assess this feature too, namely extent, patchiness and elevation. Recommendation on the assessment of low resemblance reef were also considered following Golding, Albrecht, & McBreen (2020). The annotation label tree in BIIGLE was assigned major headings for each reef type: stony reef, bedrock reef and biogenic reef. Under each reef type, labels were assigned for each of the categories required to determine whether reef habitat was present as per the tables below.

[4] https://www.biigle.de/

Table 27: Characteristics of bedrock and stony reefs (Irving 2009)

| Characteristic | 'Reefiness' | | | |
|---|---|---|---|---|
| | Not a Reef | Low | Medium | High |
| Composition (proportion of boulders/cobbles (>64 mm or bedrock)) | <10 % | 10-40 % matrix supported | 40-95 % | >95 % clast-supported |
| Elevation | Flat seabed | <64 mm | 64 mm - 5 m | >5 m |
| Extent | <25 m$^2$ | >25 m$^2$ | | |
| Biota | Dominated by infaunal species | >80 % of species present composed of epibiotal species | | |

Table 28: Characteristics of *Sabellaria spinulosa* reef (Gunnay 2007)

| Characteristic | 'Reefiness' | | | |
|---|---|---|---|---|
| | Not a Reef | Low | Medium | High |
| Elevation (cm) | < 2 | 2 - 5 | 5 – 10 | > 10 |
| Extent (m$^2$) | < 25 | 25 – 10,000 | 10,000 – 1,000,000 | > 1,000,000 |
| Patchiness (% Cover) | < 10 | 10 - 20 | 20 – 30 | > 30 |

**Annex I Sandbanks**

Annex I Sandbank habitats are characterised by three descriptors: topography, substrate/vegetation and proximity to known sandbank/similarity in benthic community (Pinder 2020). Topographic features consist of elongated, rounded or irregular 'mound' shapes which may arise from horizontal or sloping plains of sandy sediment at depths of less than 20m (but can include channels or other areas greater than 20m deep). Substrates are mainly composed of sand (≥ 50 %) and may support *Zostera marina* or maerl beds. Where areas of horizontal or sloping sandy habitats are closely associated with known sandbanks (proximity and/or similarity of benthic communities), they are included within the Annex I type. As a result, all geophysical and ground truthing data were reviewed to assess against these descriptors across the entire survey area. Geophysical data were mostly used to determine the topography of features, while ground truthing data were used to assess sediment type and composition and the presence of key flora and fauna. Where areas were deemed to meet some or all the criteria, they were delineated and assigned confidence score of either 'High' or 'Potential'. Specifically, a 'high' confidence score was assigned to features meeting all the above criteria such as displaying the topographic and sedimentary characteristics described above and located in closed proximity to known sandbanks. Conversely, a 'potential' score was attributed to features only meeting some of the above criteria such as having the same physical characteristic of known sandbanks but located in an area where not known sandbanks were recorded.

### 5.3.4. Statistical Analysis

#### 5.3.4.1. Sediment Classification

Sediment PSD statistics for each sample were calculated from the raw sediment data using Gradistat V8.0 (Blott 2010) and converted into Broad Scale Habitats (BSH) (EUNIS Level 3) using the adapted Folk trigon (Long 2006).

### 5.3.5. Determining Habitat Classifications

Habitats were identified and classified in accordance with the EUNIS habitat classification system, in line with JNCC guidance on assigning benthic biotopes (Parry 2019). Classifications were assigned based on the combined analysis of seabed imagery and broad scale habitat (BSH) data derived from the PSD, alongside existing habitat maps (EMODnet). Seabed features were assigned as high-level classification as possible. All habitat / biotope determination was undertaken through consideration of the following:

- Existing habitat mapping (derived from EMODnet)
- Review and interpretation of geophysical data
- PSD analysis results (textual groups, sediment % contribution and mean grain size) (for determination of Broad Scale Habitat (BSH)
- General site imagery
- All habitat classifications were checked by secondary senior environmental scientist as a means to quality control the mapping effort

### 5.3.6. Habitat Mapping

All habitat mapping was undertaken in ESRI ArcPro Version 2.7.1 by a habitat mapping specialist and reviewed by a secondary senior environmental scientist and invloed overlaying EUNIS classifications and habitat assessment scores assigned to each sampling location on the mosaiced SSS and MBES data allowing for delineation of areas representative of similar acoustic signatures aligned to those at each DDC/grab station and along each DDV transect. Each sampling location was assigned to a EUNIS habitat / biotope based on the available data (still images, sediment and macrofauna data). Following this, an Annex I habitat assessment was carried out at each sampling location and where the criteria for Annex I habitats were met (e.g. Table 26 and Table 27), then these locations were additionally assigned as Annex I habitats (this included also Annex I sandbanks). Finally, this classification was overlaid on the mosaiced SSS and MBES data to delineate large scale habitats and features of interest.

# 6. Supporting Information

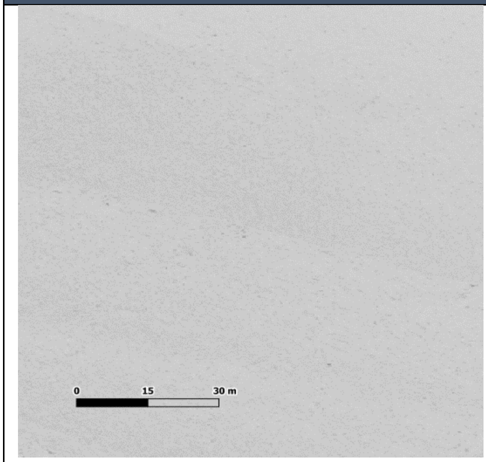
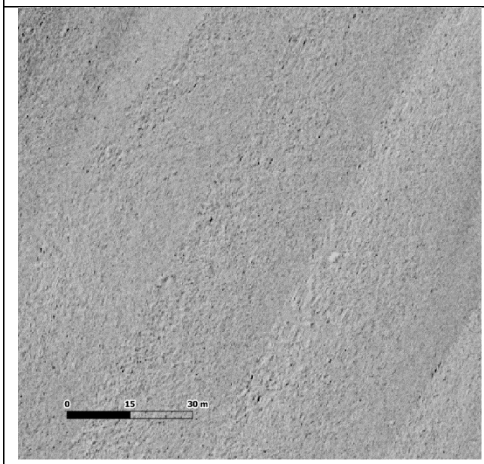
## 6.1. Interpretive Geomodel – Export Cable Route

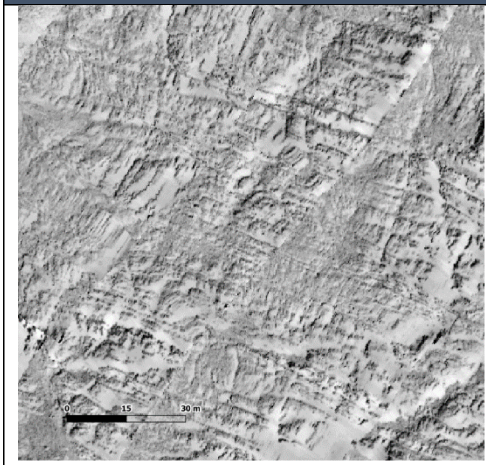
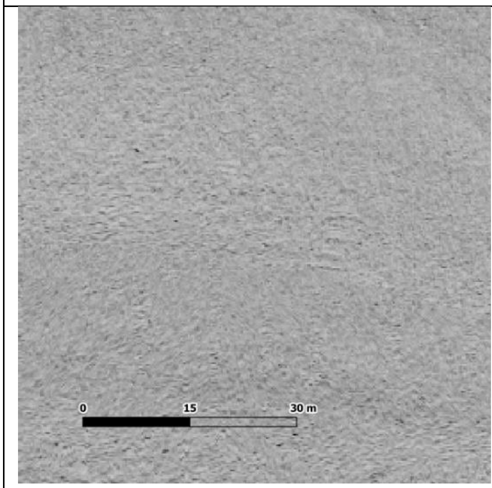
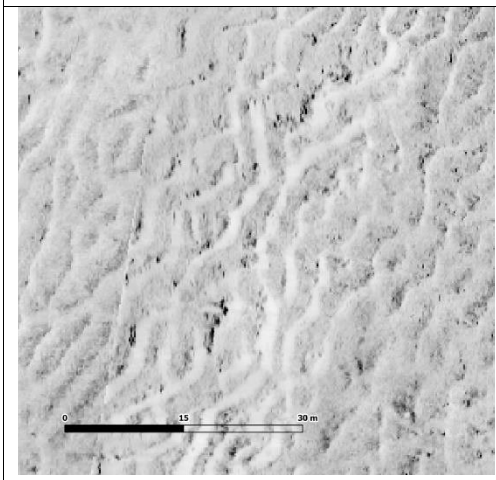
### 6.1.1. Seabed Interpretation – Export Cable Route

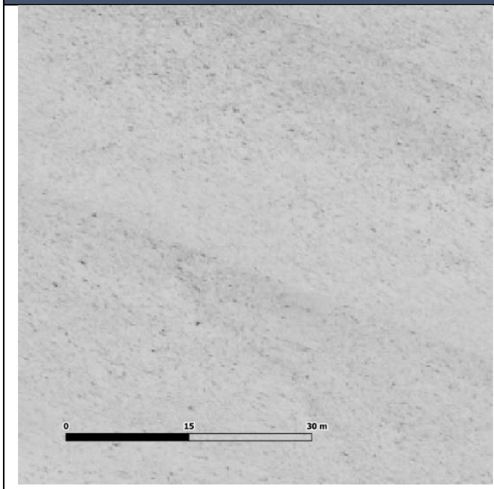
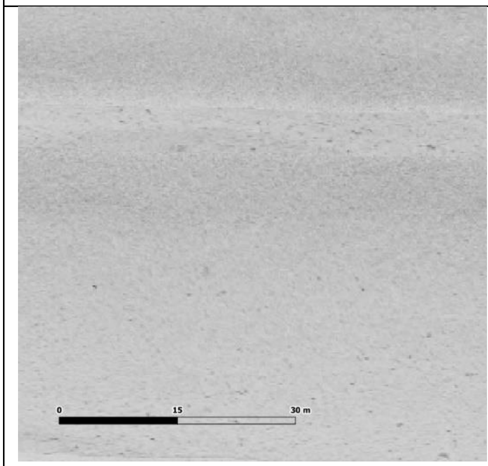
Seven surficial sediment classes have been interpreted along the cable route corridor: ROCK, sandy GRAVEL, muddy sandy GRAVEL, gravelly SAND, SAND, muddy SAND, and sandy MUD. Interpretation has been undertaken using a combination of reflectivity observed on SSS and backscatter, features observed on MBES data, along with localised ground truthing in the form of grab samples. SBP and sparker data aided interpretation of areas of exposed ROCK.

Table 28 shows an example of each classification with their respective descriptions.

Table 29: Surficial sediments Interpretation – Export Cable Route

| Data Example | Description | Sediment Classification |
|---|---|---|
|   | Low reflectivity, uniform sediment | SAND |
|   | Medium reflectivity, moderately textured sediment | sandy GRAVEL |

| Data Example | Description | Sediment Classification |
| --- | --- | --- |
|  | Medium to high reflectivity with angular features, common shadowing, and rugged textured surface | ROCK |
|  | Medium reflectivity, slightly to moderately textured sediment | muddy sandy GRAVEL |
|  | Low to medium reflectivity, slightly to moderately textured sediment | gravelly SAND |

| Data Example | Description | Sediment Classification |
|---|---|---|
|   | Low reflectivity, slightly textured sediment | sandy MUD |
|   | Low reflectivity, weakly to slightly textured sediment | muddy SAND |

The acoustic systems (SSS and MBES) have allowed differentiation of gravelly sediments from sandy/muddy sediments. However, the difference in acoustic reflectivity between many of the sandy/muddy areas inferred from the PSD were not able to be defined as no boundary was clearly defined in the acoustic data, and the difference between the sediment types were relatively minor. This can be seen in the similarity of the sonar imagery for "sandy MUD" and "muddy SAND" presented in Table 28. Therefore, some areas of similar acoustic reflectivity have been assigned different classifications based on the prevailing grab samples taken within an area.

There are some localised conflicts between the seafloor sediment interpretation and the acquired grab samples. These conflicts can be reasoned by the likely graduated nature of change in sediments from other surrounding sediments as well as sample localisation that grab samples inherently have. In some cases, it has been necessary to assign some areas as a mix of "sandy GRAVEL and gravelly SAND" due to the conflict and inconsistency between the grabs and the observed reflectivity, and indeed between the grab samples themselves. Using the sieved photographs of the samples to look for difference between the two sediment types shows that the distinction between the two classes is present but small. In general, there is good alignment between the grab sample results and the final interpreted sediments.

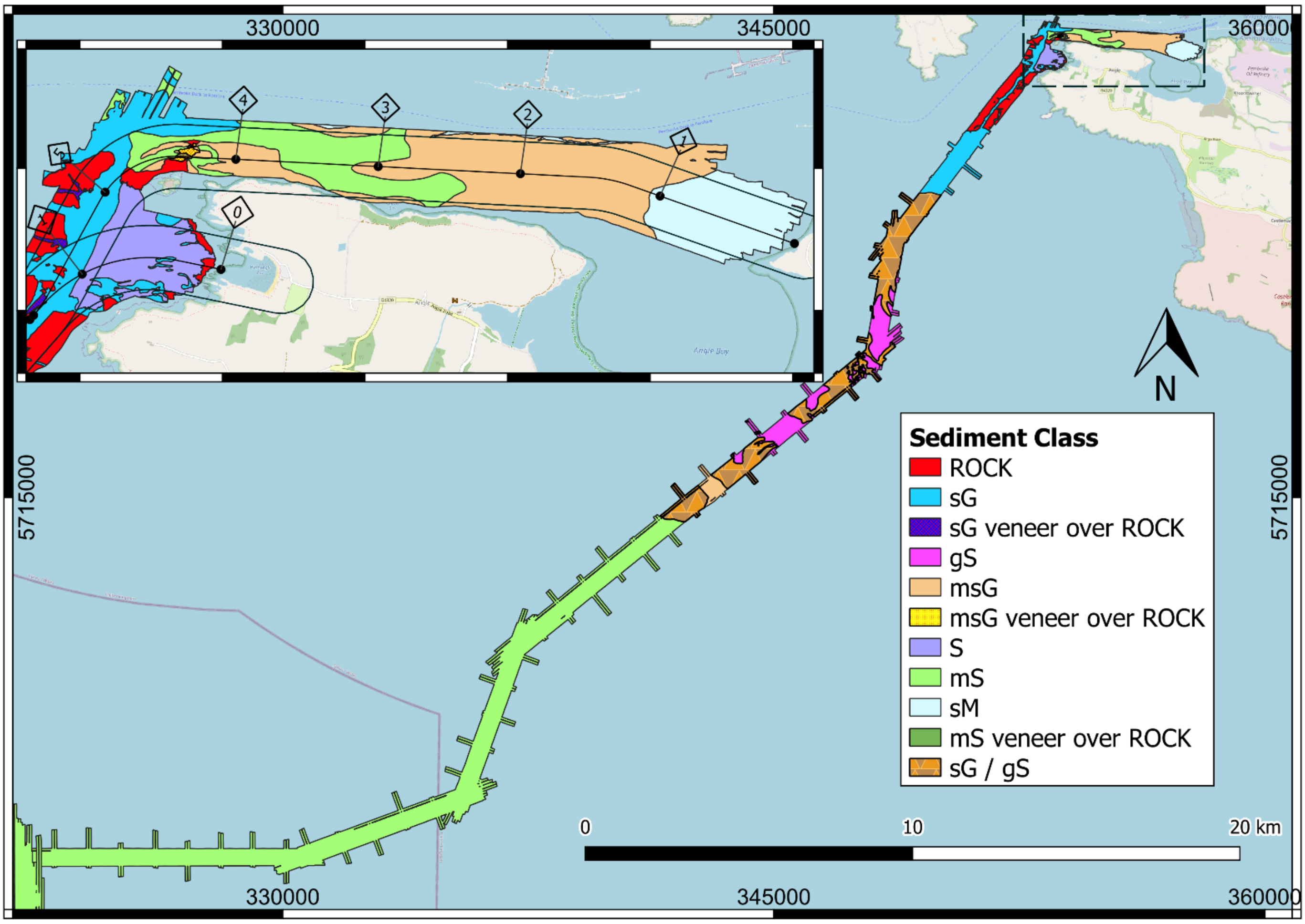



Figure 16: Overview of the sediment classes interpreted over the cable route

Figure 16 provides an overview of the spatial distribution of the sediment classes identified across the cable route survey area. The nearshore data, shown in the zoomed area of Figure 16 features frequent variation between sediment types as well as outcropping and sub-cropping ROCK.

The nearshore section of the centre line from KP0 at Sawdern Point is situated in a zone of sandy MUD, a sediment class which is seen only within this area. The West-East section of the route within Milford Haven Waterway is characterised primarily by finer sediments than the rest of the route. These sediments are considered to be estuarine sediments that have filled the underlying topography that has been eroded into the ROCK. Sandy MUD, muddy SAND and muddy sandy

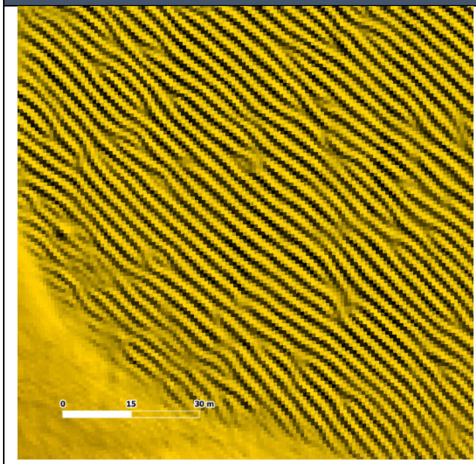
GRAVEL have been interpreted in this area within the Milford Haven Waterway, with areas of outcropping and sub-cropping bedrock appearing as the route veers south into open sea.

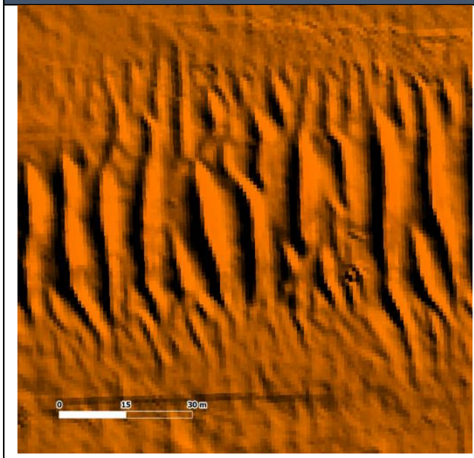
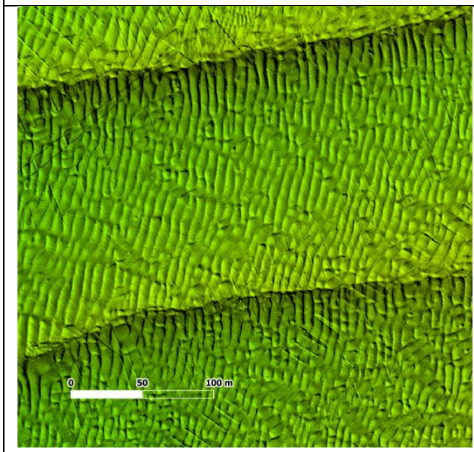
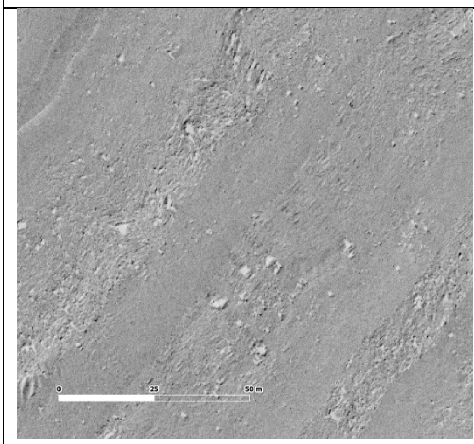
The ROCK between KP5 and 8.5 appears to have been eroded, creating an exposed channel feature which has been backfilled. It is inferred that the back fill is composed of fluvio-estuarine sediments, due to the sub parallel internal reflectors with occasional channel structure observed within the infill sediments reflectors, and the proximity to the estuary at Milford Haven. Highly chaotic fill is not observed reducing the likelihood of glacial till filling the channels. It is likely that the gravels present here on the seabed are derived from erosion of the exposed bedrock and/or of biological origin.

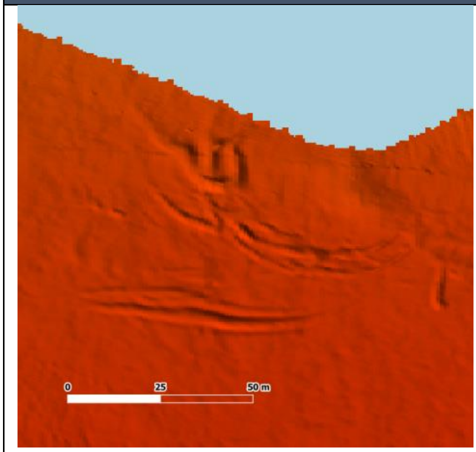
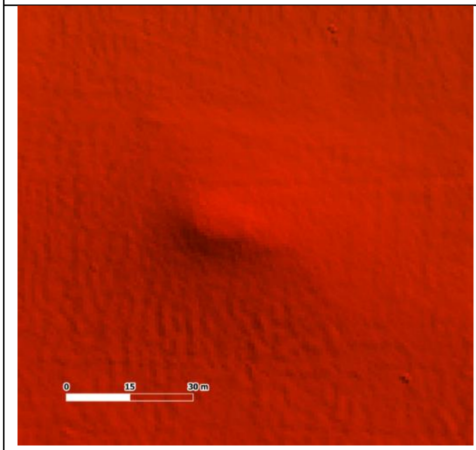
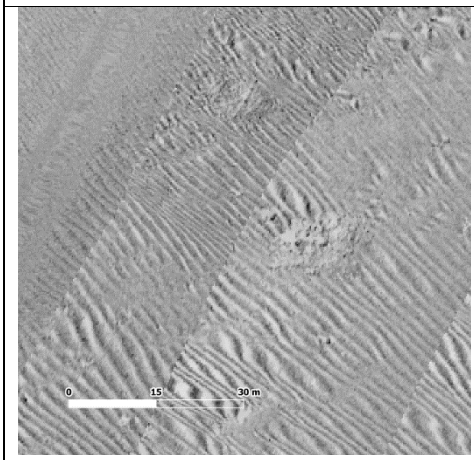
SAND has been interpreted in the proximity of West Angle Bay, concurring with previous literature by Careya et al. 2014. In agreement with the same literature, moving south along the route, coarser sediments have been identified; sandy GRAVEL and gravelly SAND, that extend until KP24. From KP24 onwards, muddy SAND covers the rest of the cable route corridor, hosting extensive areas of mobile sediments including sandwaves.

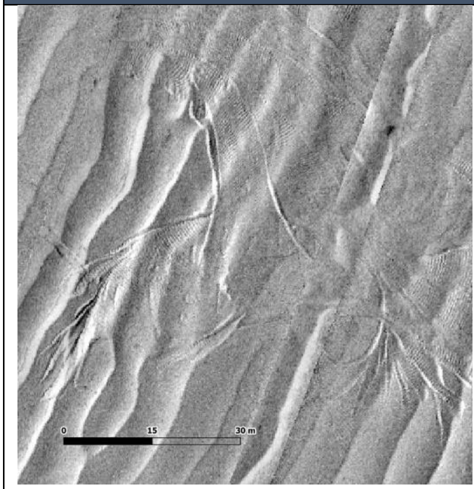
Eight morphological features have been digitised to describe features that have been observed on the seabed: Ripples, Megaripples, Sandwaves, Boulder Fields, Scars, Mounds, Sediment Spills and Anchor Disturbances. Table 29 shows examples of each morphology. Mobile sediments and boulder fields have been identified using SSS and MBES datasets.

Table 30: Seabed morphology interpretation – Export Cable Route

| Data Example | Morphology |
|---|---|
|  | RIPPLES<br>(Mobile sediments with wavelengths <5m and height <0.5m<br>Note that numerous areas of ripples observed within this survey have wavelengths > 5m. Height has been used as the primary differentiator between ripples and megaripples) |

<table>
<tr><th>Data Example</th><th>Morphology</th></tr>
<tr><td>
</td><td>MEGARIPPLES<br><br>Mobile sediments with height between 0.5m to 1.5m and wavelength >5m</td></tr>
<tr><td>
</td><td>SANDWAVES<br><br>Mobile sediments with height greater than 1.5m and wavelength greater than 60m.<br><br>Height has been used as the primary differentiator between megaripples and sandwaves.</td></tr>
<tr><td>
</td><td>BOULDER FIELD<br><br>Areas of boulders in density greater than 10 boulders per 10,000m$^2$ (1 hectare)</td></tr>
</table>

| Data Example | Morphology |
| --- | --- |
|  | SCAR<br><br>Narrow, elongated depression of surface sediment. Likely caused by anthropogenic activity associated with vessel anchorage or fishing activities. |
|  | MOUND<br><br>Isolated and localized increase in seabed depth |
|  | SEDIMENT SPILL<br><br>Isolated patches of what appear to be incongruous sediment overlying the prevalent seabed sediment. Also visible on MBES data where these patches interrupt the continuity of mobile sediments. |

| Data Example | Morphology |
| --- | --- |
|  | ANCHOR DISTURBANCE<br>Anchor lay fan patterns commonly made by slack chain on an anchor disturbing the seabed as tides change. |

### 6.1.2. Subsurface Interpretation – Export Cable Route

Shallow soil interpretation has been based upon British Geological Survey (BGS) Quaternary Sediments charting, using 1:250000 series geological charts.

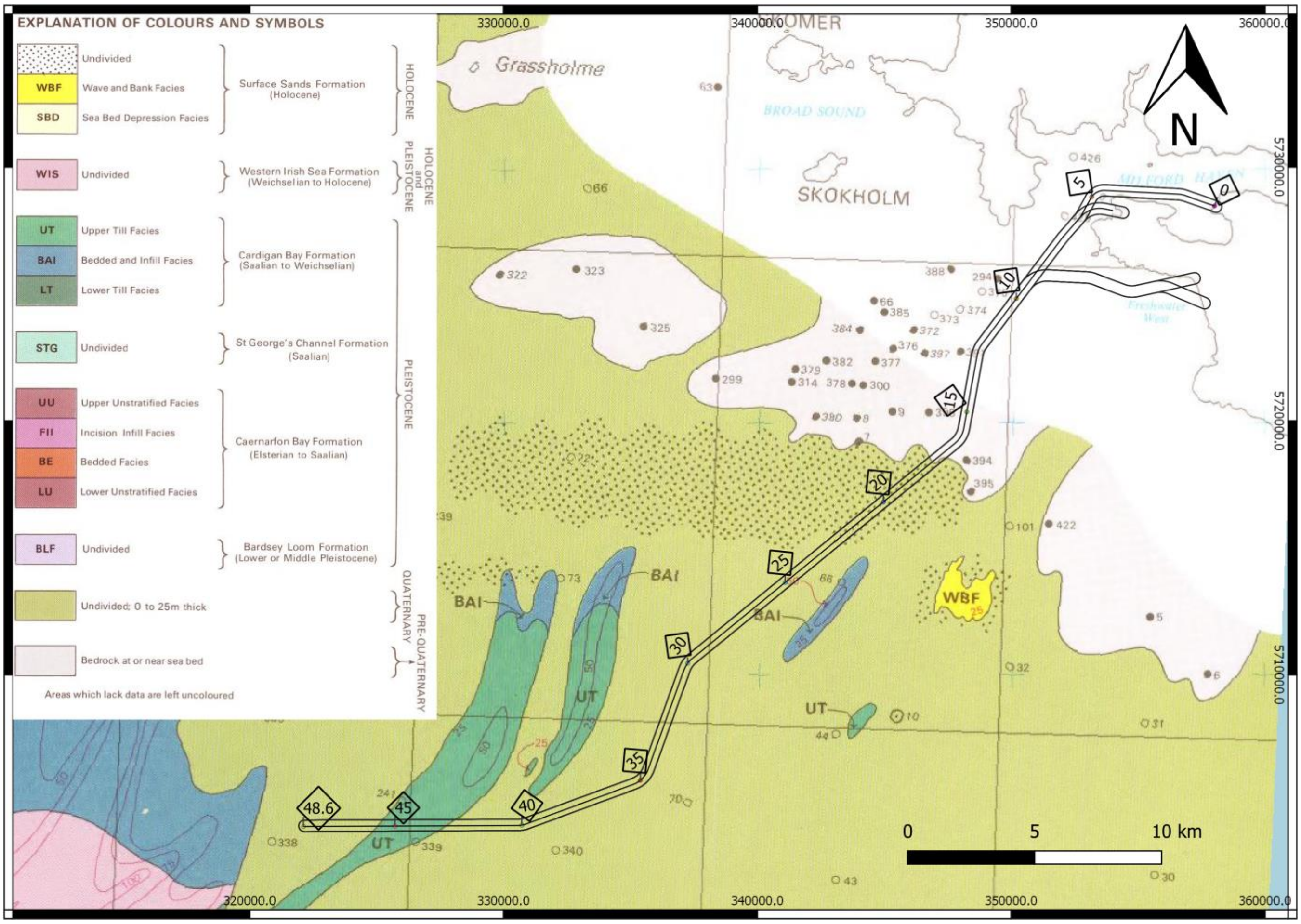



Figure 17: Quaternary geology chart of the survey area ((BGS Quaternary Geology, 1991).)

Figure 17 shows an overview of the expected geological facies present within the survey area. Although the data used to produce this map almost 40 years old and based on data acquired at 10km line spacing, it does provide a regional overview of the expected sediments. Much of the sediment is classified as "Undivided Quaternary deposits", however there are areas of Pleistocene Upper Till Facies of the Cardigan Bay Formation that intersect the cable route between circa KP43 and KP46. It is possible that some of the channel fill sediments are composed of undivided sediments of the Western Irish Sea formation. It is important to note that the resolution of the survey undertaken on this cable route is higher than those used to compile the BGS charting, on which the undivided sediments are classified as sediments <25m thick.

Data interpretation has been undertaken on Innomar parametric echosounder and sparker source sub-bottom profiler datasets. Where possible interpretation has been undertaken on one or other of the data sets dependant on the depth of the horizon. For example, shallow interpretation has favoured the parametric (Innomar) dataset which shows good resolution in the near surface, whereas deeper interpretation was undertaken on the sparker dataset which attained much deeper penetration. This was done to minimise variance in horizon level from interpretation undertaken on both datasets due to the difference in vertical resolution. However, where a horizon either becomes too deep or too shallow for the primary system to detect, then interpretation has continued on the complimentary dataset.

Full details regarding depth and thickness information of each unit at specific KPs can be found in section 7.11 Route Conditions. When a mention of depth to a unit is made, this value always refers to the depth below seabed to the top reflector of the unit.

Three main units and five horizons were identified along the cable route and the results are briefly summarised below in Table 30.

Table 31: Summary of interpreted units and horizons along the cable corridor

| Unit | Horizon | Description |
|---|---|---|
| A | H05 | Base of Recent Sediments |
| B | H04 | Laminar Internal Reflector |
| | H06 | Top of Channel Fill Sediments |
| | H07 | Top of Coarse Channel Fill Sediments |
| C | H10 | Top of Bedrock |

Further discussion and data examples are presented in section 7.7. A schematic drawing of the subsurface interpretation along the centre line is presented in section 6.1.2.4.

#### 6.1.2.1. Unit A – Export Cable Route

This unit of surficial sediment has a range of thickness between 0-15.9m, with an average of 2.3m, making up much of the surface sediment across the cable corridor. Unit thickness is usually dependant on the mobile bedforms that are present on the seabed. In the nearshore between KP0 and KP10.5 it is expected that this unit may be present in isolated areas of sediment veneer.

Further along the cable route this unit has accumulated in places to form mobile bedforms including ripples, megaripples and sandwaves. The base of this unit is represented by the horizon H05, which is observed as a strong and continuous reflector. Some laminar internal reflectors are present above H05, despite the unit being predominantly acoustically featureless. In some areas, reflector H05 is less defined where the underlying sediments are likely very similar. The unit is interpreted to be comprised of SAND with additional components of mud and gravel.

An example of the interpreted reflector for H05 and the surrounding sediments is presented in section 7.7.3.

#### 6.1.2.2. Unit B – Export Cable Route

This unit comprises of a sequence of channel infill sediments that fill eroded channels in the underlying Unit C. The sediment of Unit B has itself been eroded and refilled in multi phases within this unit. It is found across much of the cable route. It has been interpreted as a predominantly fluvial unit. It has been interpreted as a predominantly fluvial unit given observations of reworked channel formation within the unit. Unit B contains two interpreted internal reflectors, H04 and H06 which are further discussed below.

From KP0 at Sawdern Point to KP10 this unit is likely present just beneath the seabed, under a veneer of recent sediments. Unit B sediments up to approximately KP5have been interpreted as fluvio-estuarine sediments that overlie deeper channel fill sediments, interpreted as fluvial sediments. The interpretation as fluvio-estuarine sediments is based on seismic character, discussed in the previous section, and the proximity to the Daugleddau estuary. H04 is an internal reflector representing the sub-parallel sediment deposition that has occurred within the Milford Haven Waterway. The transition between more estuarine sediments and the underlying fluvial sediments is unlikely to be distinct and hence has not be interpreted.

An example of the interpreted reflector for H04 and the surrounding sediments is presented in section 7.7.2.

Moving offshore from KP6 along the route from Sawdern Point an internal horizon to Unit B has been interpreted where a defined layer of much coarser material has formed in the base of the incised channels, possibly derived from the surrounding exposed bedrock. This has been interpreted as an internal reflector, H07 top of coarse channel fill.

An example of the interpreted reflector for H07 and the surrounding sediments is presented in section 7.7.5.

Further offshore from KP26, directly underlying Unit A, a horizon interpreted as the base of the reworked sediment has been picked as H06. This horizon has been interpreted on a generally strong and continuous reflector, with the overlying sediments occasionally displaying parallel and sub-parallel internal reflectors. The horizon is generally flat but occasionally dips down in to the channelised top where the reworked outwash sediment has filled old bathymetric lows. This upper sequence of Unit B, between H05 and H06, has a range of thickness between 0-17.9m and has been interpreted between 0.4-22.7m below seabed. The composition of this sub-unit is expected to be mixed, being composed of eroded material from glacial derived sediments.

Beneath H06 the channel infill sediments of this unit generally appear structureless in the sparker data, however a few weak internal reflectors showing phases of erosion and subsequent channel fill are present. However, the bases of channels are better resolved with stronger reflectance. Where internal reflectors have been observed they are usually characteristic of sediment fill with dipping and truncated reflectors. Deposition of this unit likely took place in a fluvial geological setting. The total range of thicknesses of the channel fill sediments, inclusive of the sediments to H06, is between 0-48m.

An example of the interpreted reflector for H06 and the surrounding sediments is presented in section 7.7.4.

Whilst the BGS charts indicate that the Upper Till Facies are expected in the offshore area where this unit has been interpreted, a clear differentiation between the fluvial channelisation sediments and a glacial till horizon has not been observed. It is likely that all or part of the channel fill sediments of Unit B are composed of sediment associated with glacial till or have been derived from glacial till. This is shown where Unit A thins to the point where coarse sediments and boulders from Unit B start being exposed on the seabed.

#### 6.1.2.3. Unit C – Export Cable Route

It is interpreted that Unit C represents a hard substate, likely ROCK. The top of this unit is distinguished in the data as an undulating reflector with variability in the strength of the reflection. This variability could be owing to weathering sustained on the top surface of the horizon as well as the steeply dipping valley walls. Some internal reflectors are observed, although they are often discontinuous. These internal reflectors are generally inclined and are likely to be significant bedding planes with the bedrock. The depth below seabed to the top of this bedrock ranges from seabed outcrop to a maximum of 51.8m. It can be seen to form a large, exposed channel feature, exposed at the seabed, in the nearshore area of the cable route between KP5.885 and KP8.145. The IGS charting (IGS Solid Geology, 1983), suggests that the bulk of the seabed over the cable route is composed of Pilton Shales, until KP39 where the solid geology is thought to transition to Upper Cretaceous chalk. Within the Milford Haven Waterway there may be a component of Old Red Sandstone present, most likely at the beach landing locations.

An example of the interpreted reflector for H10 and the surrounding sediments is presented in section 7.7.6.

#### 6.1.2.4. Schematic Interpretation

A schematic interpretation along the centre line is presented in Figure 18. It shows the various units defined in the previous section, including all internal horizons that have been interpreted.

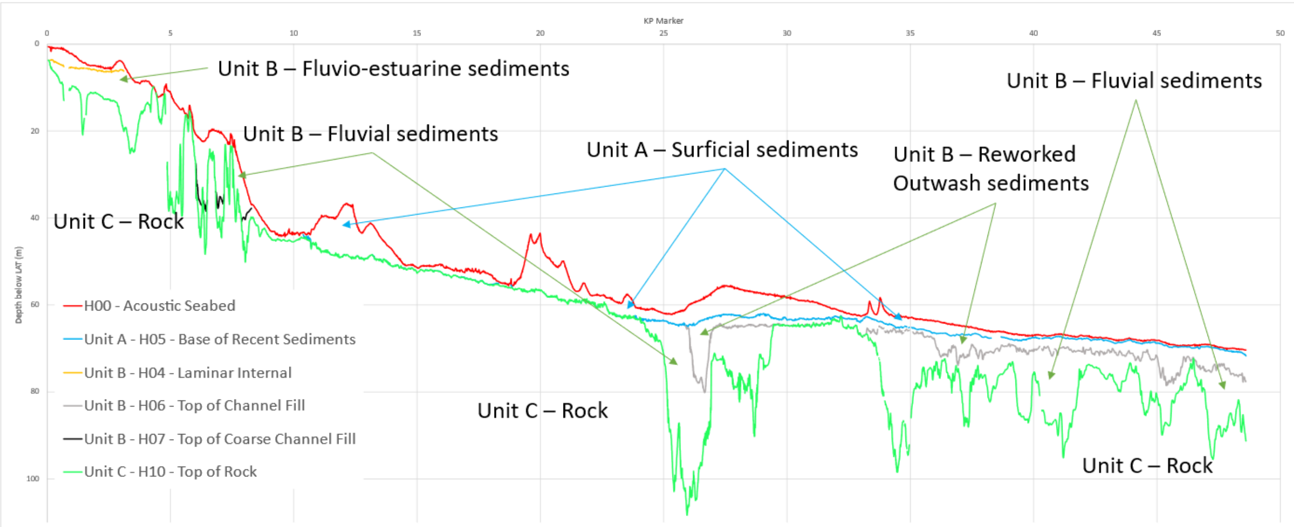


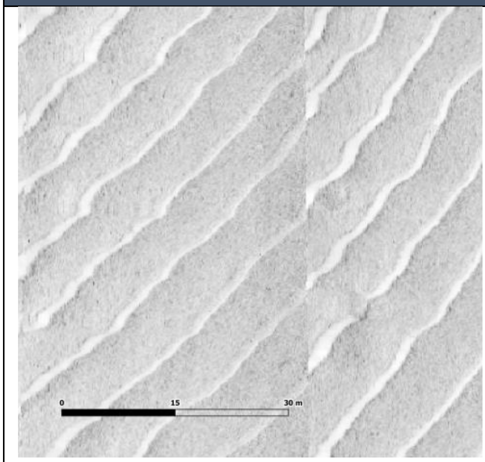

Figure 18: Schematic subsurface interpretation

## 6.2. Interpretive Geomodel – FLOW Site

### 6.2.1. Seabed Interpretation – FLOW Site

Only one surficial sediment class has been interpreted throughout the area array, muddy SAND. Interpretation has been undertaken using a combination of reflectivity observed on SSS and backscatter, as well as features on MBES data, along with localised ground truthing in the form of grab samples. Table 31 shows an example of each classification with its respective descriptions.

Table 32: Surficial sediments interpretation – FLOW Site

| Data Example | Description | Sediment Classification |
|---|---|---|
|  | Low reflectivity, weakly to slightly textured sediment | muddy SAND |

Reconciliation with grab samples obtained in this area has not been completely possible. This is due to the variation in grab results across the array area that do not bear any correlation to the minor variance in acoustic reflectivity of the seabed. Therefore, it has not been possible to define boundaries to constrain these differences in grab results using the acoustic results. The distribution of grab samples and the SSS mosaic are displayed in Figure 36. It shows that there is no substantial change in acoustic reflectivity across the site. There is a small increase in reflectivity towards the north, but this is attributed to increased presence of mobile bedforms, however there is no correlation to grab samples with this minor change in acoustic reflectivity. It also shows that there is little correlation to be made from grab samples from adjacent sites showing that the grabs are not consistently indicating one sediment type over another for a certain region.

Figure 19 shows the distribution of all grab sample results across the WTG area in terms of their interpreted composition as derived from the environmental survey. Muddy SAND is most prevalent, with SAND a close second. The result for gravelly SAND is minor in comparison and is then slightly higher for sandy MUD. It is important to also note the gravel component, when it has been identified, is relatively small. Given the small difference between muddy SAND and sandy MUD and that no coherent regions can be defined from acoustic reflectivity results, the site has been generalised as muddy SAND due to the factors discussed above. It is likely that whilst a small fraction of GRAVEL is present in places, there is not enough material to generate a significant change in reflectivity. With regards to variance between fractions of SAND and MUD, given the lack of contrast in the acoustic reflectivity shown by the SSS, it is likely that the observed variance in grab results are caused by localisation of the sampling and that overall the seabed within the array area is reasonably homogenous in terms of composition. This is reinforced by the ARA from EMODnet shown in Figure 21 and discussed in section 6.3.1, displaying the array site within a single classification.

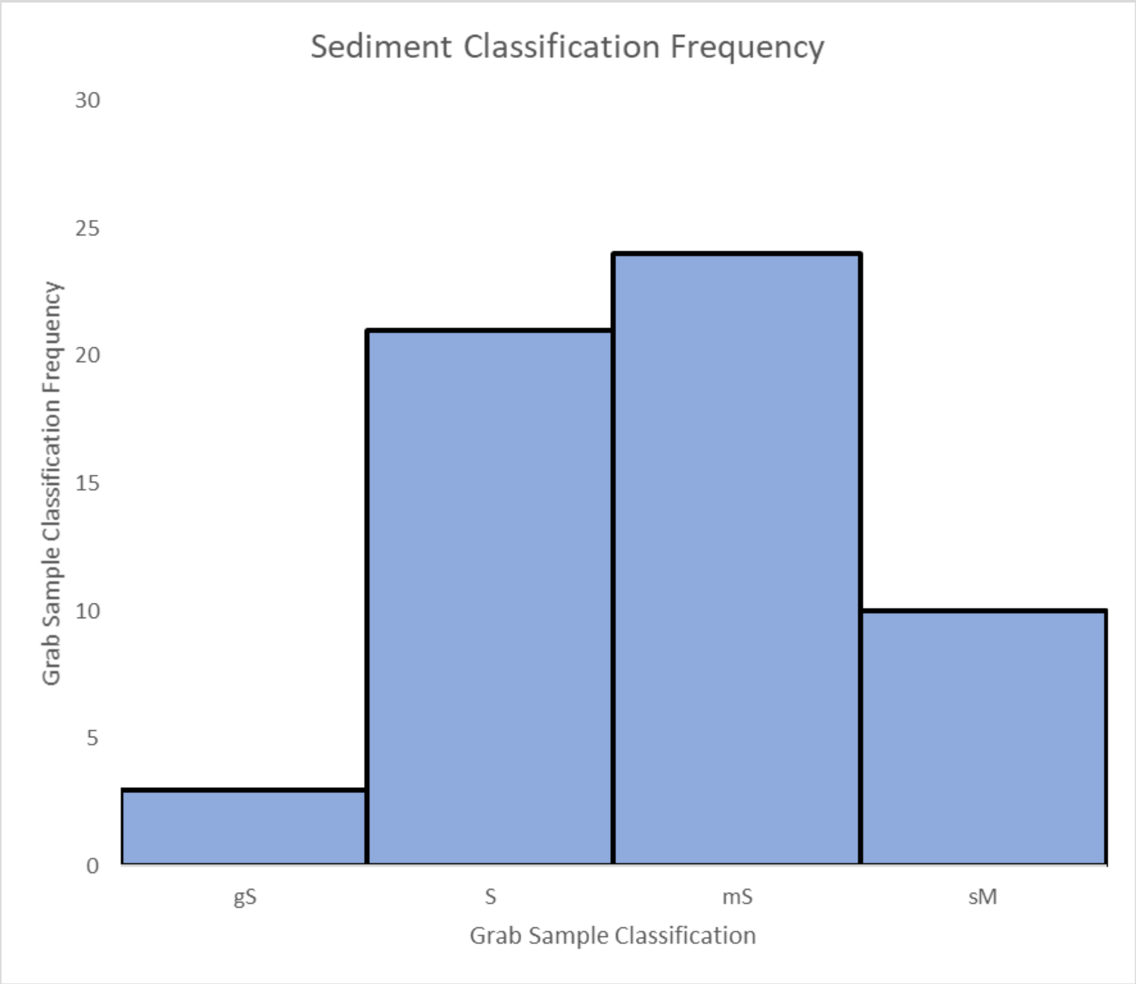
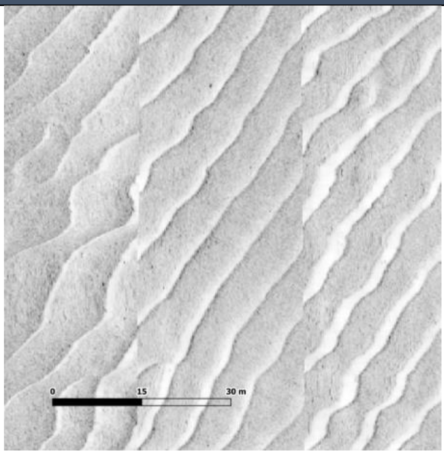
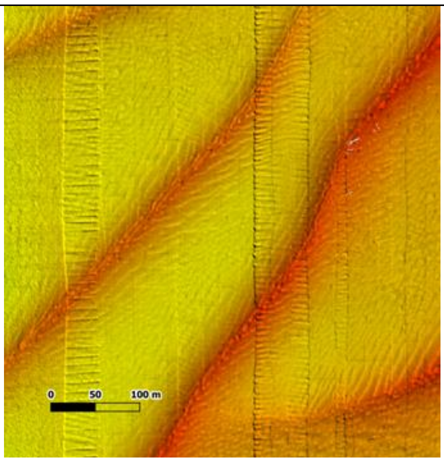
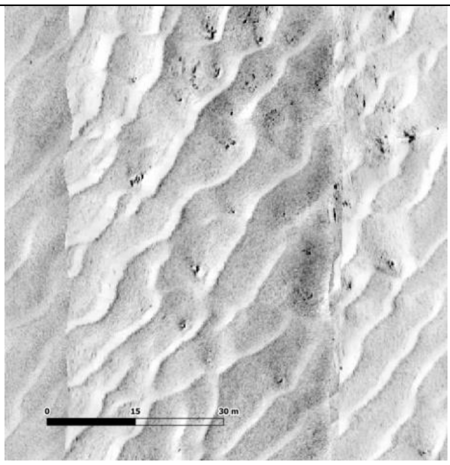


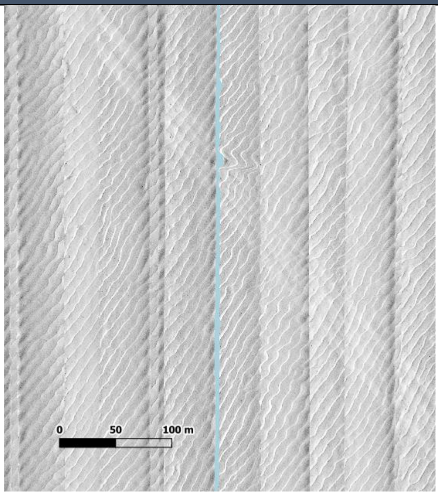

Figure 19: Frequency graph of the classifications of grab samples on the WTG area

Four morphological features have been digitised to describe features that have been observed on the seabed: Ripples, Boulder Fields, Sandwaves/Megaripples and Scars. Table 32 shows examples of each morphology. Mobile sediments and boulder fields have been identified using SSS and MBES datasets.

Seabed scarring may be indicative of trawl-based fishing activities in this area.

Table 33: Seabed morphology interpretation – FLOW Site

| Data Example | Morphology |
|---|---|
|  | RIPPLES<br>Mobile sediments with wavelengths <5m and height <0.5m<br>Note that numerous areas of ripples observed within this survey have wavelengths > 5m. Height has been used as the primary differentiator between ripples and megaripples |
|  | SANDWAVES<br>Mobile sediments with height >1.5m and wavelength >60m<br>MEGARIPPLES<br>Mobile sediments with height between 0.5m to 1.5m and wavelength >5m<br>Height has been used as the primary differentiator between megaripples and sandwaves. |
|  | BOULDER FIELD<br>Areas of boulders in density greater than 10 boulders per 10,000m$^2$ (1 hectare) |

| Data Example | Morphology |
| --- | --- |
|  | SCAR<br>Narrow, elongated depression of surface sediment. |

### 6.2.2. Sub Surface Interpretation – FLOW Site

Shallow soil interpretation has been based upon British Geological Survey (BGS) Quaternary Sediments charting, using 1:250000 series geological charts.

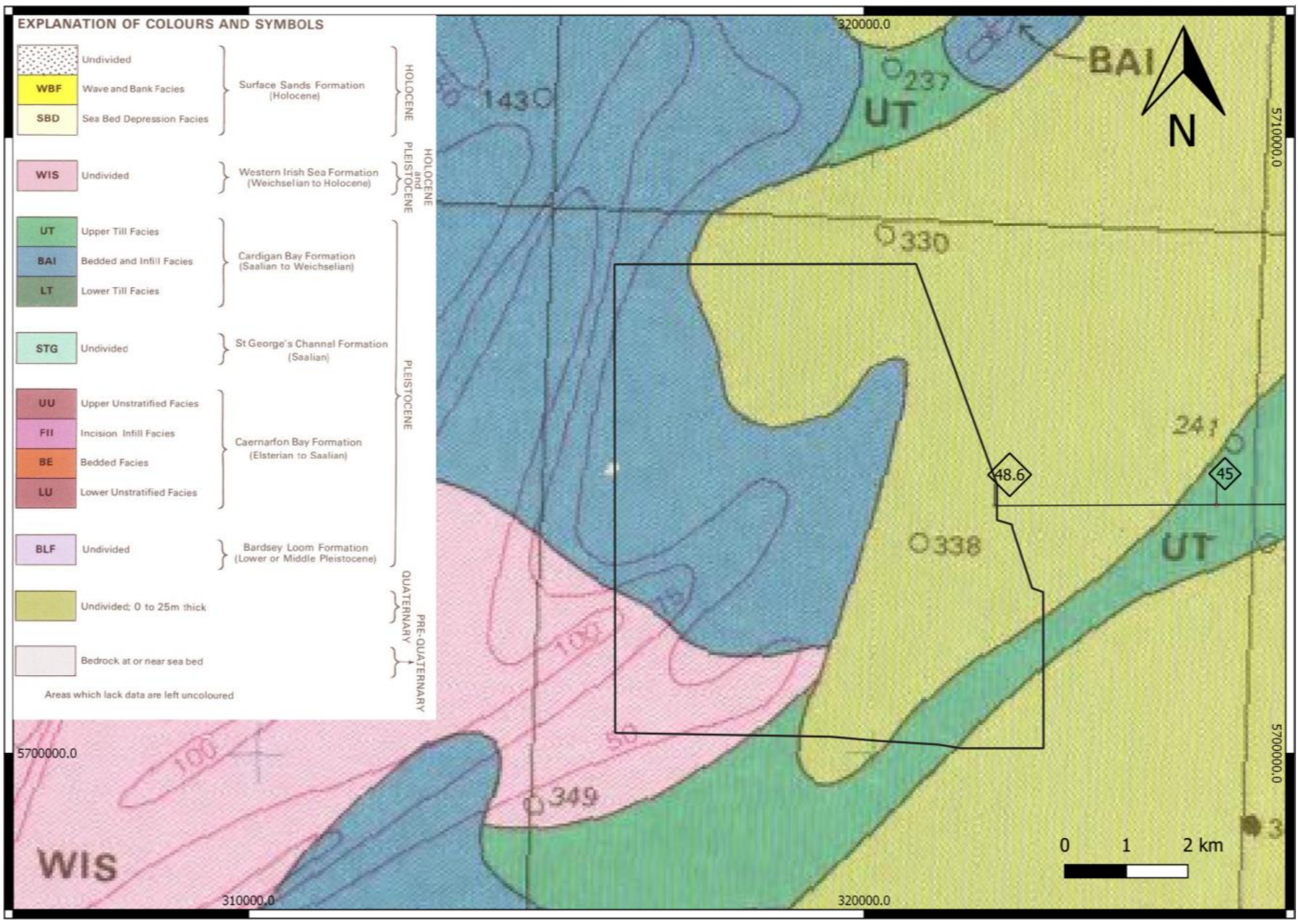



Figure 20: Quaternary geology chart of the FLOW survey area ((BGS Quaternary Geology, 1991)

Figure 20 shows an overview of the expected geological facies present within the overall survey area, including the array area. Although the data used to produce this map almost 40 years old and based on data acquired at 10km line spacing, it does provide a regional overview of the expected sediments. Much of the sediments covered by the acquired data is classified as "Undivided Quaternary deposits", however there is a band of Pleistocene Upper Till Facies of the Cardigan Bay Formation that intersect the array area in the south east. The western side of the proposed array area intersects a unit of Bedded and Infill Facies, of the Cardigan Bay Formation as well as undivided sediments associated with the Western Irish Sea Formation. It is important to note that the resolution of the survey undertaken on this cable route is higher than those used to compile the BGS charting, on which the undivided sediments are classified as sediments <25m thick.

Data interpretation has been undertaken on parametric echosounder and sparker source datasets. Where possible interpretation has been undertaken on one or other of the data sets dependant on the depth of the horizon. For example, shallow interpretation has favoured the parametric (Innomar) dataset which shows good resolution in the near surface, whereas deeper interpretation was undertaken on the sparker dataset which attained much deeper penetration. This was done to minimise variance in horizon level from interpretation undertaken on both datasets due to the difference in vertical resolution. However, where a horizon either becomes too deep or too shallow for the primary system to detect, then interpretation has continued on the complimentary dataset.

Three main units; Unit A, B and C were identified within the array area and the results are summarised in the section below.

Three main units consisting of three horizons were identified along the cable route and the results are briefly summarised below in Table 33.

Table 34: Summary of interpreted units and horizons in the array area

| Unit | Horizon | Description |
|---|---|---|
| A | H05 | Base of Recent Sediments |
| B | H06 | Top of Channel Fill Sediments |
| C | H10 | Top of Bedrock |

Further discussion and data examples are presented in section 7.8. The schematic drawing presented in Figure 18 is valid for the array area from KP30 until the end of the route.

#### 6.2.2.1. Unit A –FLOW Site

This unit of surficial sediment has a thickness of 0-12.3m, making up much of the surface sediment across the array area. The unit displays little signs of dipping, with thickening of the unit due to accumulation of mobile surface sediments. Across the WTG area these sediments have formed ripples, however, in the northern half of the site these sediments have accumulated to form larger megaripples and sandwaves. The base of this unit is demarked by the horizon H05, which is seen to be a strong and continuous subsurface reflector, and contains some laminar internal reflectors, despite being predominantly acoustically featureless. The unit is interpreted to be comprised of SAND with additional components of mud and gravel.

#### 6.2.2.2. Unit B – FLOW Site

This unit comprises of a sequence of channel infill sediments that fill eroded channels in the underlying Unit C. Unit B contains one interpreted internal reflector within the array area, H06 which is further discussed below. The sediment of Unit B has itself been eroded and refilled in multi phases within this unit. It is found across much of the cable route. It has been interpreted as a predominantly fluvial unit given some evidence of reworked channel formation within the unit. An example of these interpreted fluvial channels within Unit B are shown in Figure 82 and discussed in section 7.8.2

From the BGS chart in Figure 20, it is possible that this unit could be comprised of sediment from the Bed and Infill Facies of the Cardigan Bay Formation. In locations north of this survey area, the Bed and Infill Facies are associated with channel fill sediments and proglacial sediments (Mellett et al. 2015). The Western Irish Sea Formation may also be present with the array area, however no clear differentiation between formations, or evidence for the presence of one formation over another, has been identified within the data. It is likely that all or part of the channel fill sediments in Unit B are composed of sediment associated with glacial till or have been derived from glacial till. This is shown where Unit A thins to the point where coarser sediments and boulders from Unit B start being exposed on the seabed. Figure 87 and Figure 88 in sections

7.8.1 and section 7.8.2 respectively, show how the presence of boulders and boulder fields at the seabed appears correlated with the thinning of Unit A.

Across the entire array area, it is interpreted that this unit is present within 5m of the seabed, apart from areas where large sandwaves have formed which have increased the thickness of unit A sediments.

Directly underlying Unit A, a horizon interpreted as the top of channel fill has been picked as H06. This horizon has been interpreted on a generally strong and continuous reflector, occasionally displaying parallel and sub parallel internal reflectors. The horizon is generally flat but occasionally dips down in to the channelised top where the reworked outwash has filled old bathymetric lows. This upper sequence of Unit B, between H05 and H06, has a range of thickness between 0-16.2m and has been interpreted between 0.4-18.2m below seabed. The composition of this sub-unit is expected to be mixed, being composed of eroded material from glacial derived sediments.

Beneath H06 the channel infill sediments of this unit generally appear structureless in the sparker data, however a few weak internal reflectors showing phases of erosion and subsequent channel fill are present. However, the bases of channels are better resolved with stronger reflectance. Where internal reflectors have been observed they are usually characteristic of sediment fill with dipping and truncated reflectors. Deposition of this unit likely took place in a fluvial geological setting. The total range of thicknesses of the channel fill sediments, inclusive of the sediments to H06, is between 0.3-74.3m.

#### 6.2.2.3. Unit C – FLOW Site

It is interpreted that Unit C represents a hard substrate, likely ROCK. The top of this unit is distinguished in the data as an undulating reflector with variability in the strength of the reflection. This variability could be owing to weathering sustained on the top surface of the horizon as well as the steeply dipping valley walls. Some internal reflectors are observed, although they are often discontinuous. These internal reflectors are generally inclined and are likely to be bedding planes within the bedrock. The depth below seabed to the top of this bedrock ranges from 3.7m to a maximum of 82.4m. The IGS charting (IGS Solid Geology, 1983), suggests that the array area sits atop a region of Upper Cretaceous Chalk.

## 6.3. Environmental Key Habitats

### 6.3.1. Existing Habitat Mapping - EMODnet

The Project Erebus survey area comprises of a number of sediment habitats in Milford Haven including EUNIS biotope complexes A5.52 'Kelp and seaweed communities on sublittoral sediment', A5.43 'Infralittoral mixed sediments', A5.33 'Infralittoral sandy mud', A5.26 'Circalittoral muddy sand' and A5.13 'Infralittoral coarse sediment' as well as rocky habitat A4.25 'Circalittoral faunal communities in variable salinity' (Figure 21). At the entrance to Milford Haven rocky habitats A4.214 'Faunal and algal crusts on exposed to moderately wave-exposed circalittoral rock' dominates with A3.21 'Kelp and red seaweeds (moderate energy infralittoral rock)' and A3.11 'Kelp with cushion fauna and/or foliose red seaweeds' fringing the adjacent coastline. Moving offshore, rock habitats transition into circalittoral and offshore sediment habitats including A5.44 'Circalittoral mixed sediment', A5.25 'Circalittoral fine sand' and A5.15 'Deep circalittoral coarse sediment' (Figure 21). To note that some of the rocky and sandy habitats listed above are representative of the Annex I reef and sandbank habitats designated as features of Pembrokeshire Marine (SAC) (see Section 5.4.2.2) (Figure 21).

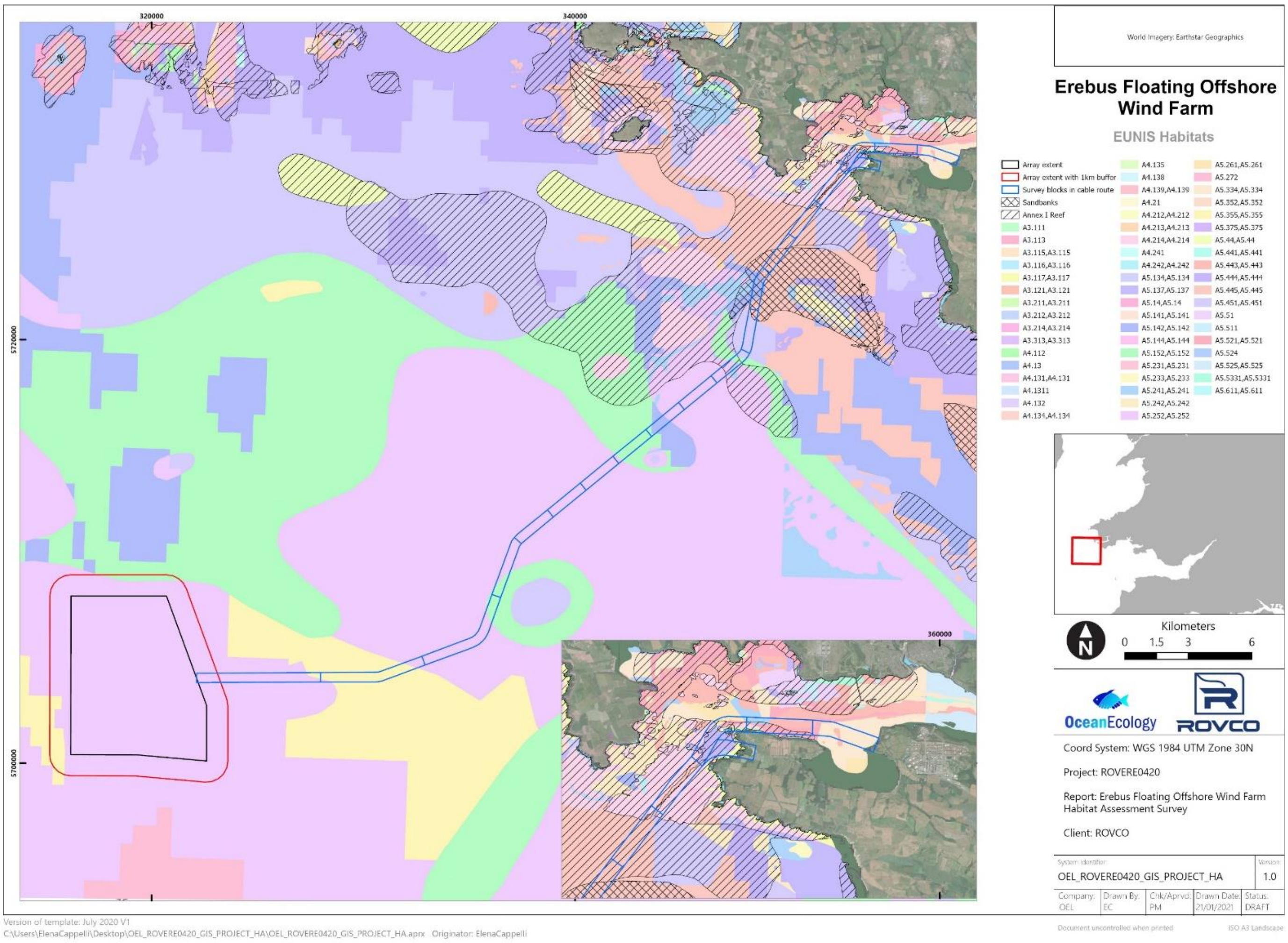



Figure 21: EUNIS Classification mapping from EMODnet and other features of interest across the Project Erebus survey area

### 6.3.2. Nature Conservation

#### 6.3.2.1. Protected Sites

There are several sites that receive designation under various nature conservation legislation which overlap with the survey areas (Figure 1). Under the European Habitats Directive (92/43/EEC) that came into force in 1992 as well as the Environment (Wales) Act 2016 the UK is required to ensure "favourable conservation status" of habitats and species listed by these Directives.

Five nature conservation designations fall within the survey area: The Pembrokeshire Marine SAC, the West Wales Marine SAC, the Angle Peninsula Coast SSSI, the Milford Haven Waterway SSSI and the Skomer, Skokholm and the Seas off Pembrokeshire/ Sgomer, Sgogwm a Moroedd Penfro SPA.

#### 6.3.2.2. Pembroke Marine / Sir Benfro SAC

The Pembrokeshire Marine SAC encompasses marine areas, sea inlets, tidal rivers, estuaries, mud flats, sand flats, lagoons, salt marshes, salt pastures and salt steppes. The SAC was designated primarily to protect Annex I habitats comprising estuaries, large shallow inlets and bays, and reefs, and Annex II species comprising grey seal (*Halichoerus grypus*) and shore duck (*Rumex rupestris*).

#### 6.3.2.3. West Wales Marine / Gorllewin Cymru SAC

The West Wales Marine SAC encompasses marine areas and sea inlets. It was designated to protect the Annex II species, Harbour porpoise (*Phocoena phocoena*).

#### 6.3.2.4. Angle Peninsula Coast / Arfordir Penrhyn Angle SSSI

The Angle Peninsula Coast SSSI is a component part of the Pembrokeshire Marine SAC. It is of special interest for its geology, intertidal rock, sand, and gravel habitats and communities. It encompasses the coastline around the Angle Peninsula to the sandy beach of Freshwater West.

#### 6.3.2.5. Milford Haven Waterway SSSI

The Milford Haven Waterway SSSI is also component part of the Pembrokeshire Marine SAC it encompasses a variety of natural features including estuaries and marine habitats.

#### 6.3.2.6. Skomer, Skokholm and the Seas off Pembrokshire / Sgomer. Sgogwm a Moroedd Penfro SPA

The Skomer, Skokholm and Seas off Pembrokeshire Special Protection Area (SPA) was designated to protect European storm-petrel (*Hydrobates pelagicus*), Manx shearwater (*Puffinus puffinus*), Atlantic puffin (*Fratercula arctica*), lesser black-backed gull (*Larus fuscus*), red-billed chough (*Pyrrhocorax pyrrhocorax*), short-eared owl (*Asio flammeus*), and breeding seabird assemblages. The SPA covers 1,668 $km^2$ of island and sea area off the most south westerly tip of Pembrokeshire, extending beyond the 12 nautical mile boundary.

### 6.3.3. Annex I Habitats Present within the Survey Area

Several important and sensitive habitats are known to be present within the vicinity of and/or intersected by the survey area, these include Annex I habitats that are a primary reason for selection of site:

- Estuaries.
- Large Shallow Inlets and Bays.
- Reefs.

As well as Annex I habitats that are present as a qualifying feature:

- Sandbanks which are slightly covered by sea water all the time.
- Mudflats and sandflats not covered by seawater at low tide.
- Coastal lagoons.
- Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*).
- Submerged or partially submerged sea caves.

#### 6.3.3.1. Sandbanks Slightly Covered by Seawater All the Time

Sandbanks slightly covered by seawater all of the time (hereafter referred to as Sandbanks) consist of sandy sediments that are permanently covered by shallow sea water, typically at depths of less than 20 m. Distinct banks, formed of elongated, round or irregular "mound" shapes arise from horizontal or sloping plains of sandy sediment. The sediment type of these habitats is the key driver of the diversity and type of associated communities, as well as physical, chemical and hydrographic factors (e.g., exposure, temperature, topography, depth, turbidity and salinity). In UK waters this feature is categorised into four sub-types: gravelly and clean sands, muddy sands, eelgrass *Zostera marina* beds and free-living maerl (*Corallinacea)* beds. There are several major sandbanks within the Pembrokeshire Marine SAC and thus near the survey area, including Turbot Bank (19.1 km$^2$) to the south east of the entrance to Milford Haven, St Gowan Shoals (16.05 km$^2$) to the east of Turbot Bank and The Knoll sandbank (5.09 km$^2$) in the vicinity of Skokholm (Figure 21); these sandbanks likely belong to the subtype gravelly and clean sands.

These habitats are typically colonised by burrowing fauna such as worms, crustaceans, bivalve molluscs and echinoderms. Mobile shrimp, gastropods, crabs and fish also inhabit these areas as well as sandeel (*Ammodytes sp*.), a key bird prey species. Where stable coarse sediments are present species of foliose algae, hydroids, bryozoans and ascidians may be present resent that comprise key nursery areas for various fish species. Such areas therefore often comprise key feeding grounds for numerous seabirds[5].

#### 6.3.3.2. Large Shallow Inlets and Bays

The Pembrokeshire Marine SAC includes Milford Haven, one of the best examples of a ria in the UK, and the wide, shallow, predominantly sandy embayment of St Brides Bay. The wide range of environmental conditions supports high community and species diversity (Figure 21). The species-richness of sediment communities throughout Milford Haven is particularly high, with sandy/muddy areas supporting extensive seagrass beds both in the intertidal (*Zostera noltei*) and subtidal (*Zostera marina*).

[5] http://jncc.defra.gov.uk/ProtectedSites/SACselection/habitat.asp?FeatureIntCode=h1110

### *Zostera* (Seagrass) Beds

Seagrass (or eelgrass) beds are biogenic habitats formed by angiosperms adapted to saline conditions. In the UK, two species of seagrass are known to form beds: *Zostera marina* and *Zostera noltei*. The first one is found in fully marine conditions in the intertidal to sublittoral zone, the second species occurs higher on the shore being tolerant to desiccation.

*Zostera* beds around Wales are representative of EUNIS subtidal biotope A2.6111 and EUNIS intertidal biotope A5.5331. Their distribution is limited to a handful of locations three of which are near the Project Erebus survey area: Angle, Littlewick and Longoar Bays, within Milford Haven.

Seagrass beds are identified as a habitat which provides many important ecosystem services (e.g. carbon sequestration, flood/storm defence), and support diverse communities of algae and fauna, including species of conservation concern (e.g. seahorses) and serve as nursery grounds for numerous commercial species. They are classed as vulnerable habitats, sensitive to multiple stressors (e.g. pollution, climate warming, increased sediment turbidity). In recognition of their ecological and economic importance, *Zostera* beds are afforded protection under the Habitats Directive as they are encompassed by Annex I habitats:

- Sandbanks
- Estuaries
- Mudflats and sandflats not covered by seawater at low tide
- Large shallow inlets and bays

Specifically, *Zostera* beds are a known part of Annex I features in the Pembrokeshire Marine SAC. Additionally, *Zostera* beds are also on the OSPAR list of threatened and/or declining species and habitats and habitats of principle importance under section 7 of the Environment (Wales) Act 2016.

### Maerl Beds

Maerl beds are formed by calcareous red algae that grow as unattached nodules (occasionally crusts) forming dense but relatively open beds of coralline algal gravel. Beds of maerl form on a variety of sediments and occur on the open coast and in tide-swept channels of marine inlets (the latter are often stony). In fully marine conditions, the dominant maerl is typically *Phymatolithon calcareum* or *Lithothamnion coralloides*. Maerl beds support diverse communities of burrowing infauna, especially bivalves, and interstitial invertebrates including suspension feeding polychaetes and echinoderms.

Only one maerl bed formed by living *P. calcareum* is known in Wales and located in Milford Haven, in the vicinity of the South Hook Liquid Natural Gas Terminal to the north of the Sawdern Point export cable route. Due to their fragility and sensitivity to disturbance but also to their role in enhancing biodiversity, maerl beds are granted protection under the EC Directive on the Conservation of Natural Habitats and Wild Fauna and Flora (92/43/ECC), as Habitats of Principle Importance (Environment (Wales) Act, 2016) and through inclusion on the OSPAR list of threatened and/or declining species and habitats.

#### 6.3.3.3. Reefs

Geogenic Reef

Geogenic reefs can be very variable in terms of both their structure and the communities that they support. They provide a home to many species such as corals, sponges and sea squirts as well as giving shelter to fish and crustaceans such as lobsters and crabs and can be classified as either bedrock or stony reefs. Based on existing habitat mapping derived from EMODnet, rocky habitats including bedrock and stony reefs are thought to occur within in the nearshore sector of the Project Erebus export cable route survey area but have not been recorded further offshore or across the array area (Figure 21).

Stony Reef

Stony reef habitats occur when stable hard substrata, namely cobbles and boulders >64 mm in diameter arise from the surrounding habitat, creating a habitat colonised by a variety of species. Numerous SAC sites have been designated in UK waters to protect stony reef habitats and associated communities. Such communities can be highly diverse, supporting assemblages of various coral, sponges, ascidians, fish and crustaceans. These associated communities vary dramatically according to environmental variables and may incorporate species that occupy a range of trophic levels. The complexity of habitat created by stony reefs often supports a higher abundance of mobile fauna such as echinoderms and various crabs, hermit crabs, and squat lobsters, as well as fish species for which these species represent key prey items.

Bedrock Reef

Similar to stony reef, Annex I bedrock reef habitat occurs where soft (e.g. clay) or hard bedrock arises from the surrounding seabed, providing a stable habitat for attachment for a diverse range of epibiota. Bedrock reefs and associated biological communities can be highly variable due to the diverse nature of these habitats in terms of topography, structural complexity, and exposure to tidal streams. In the photic zone communities associated with bedrock reefs are often dominated by attached algae, and often support various invertebrate species such as corals, sponges and sea squirts. These epibiotic communities further increase structural complexity and represent key prey items that in turn attract more mobile and commercially valuable species such as fish and crustaceans.

Biogenic Reef

Sabellaria Reef

Sabellaria reefs are biogenic habitats formed by sedentary filter-feeding polychaete worms belonging to the family *Sabellariidae*. Two species are found in Wales, the honeycomb worm (*Sabellaria alveolata*) and the Ross worm (*Sabellaria spinulosa*). Both are gregarious species and can form biogenic reef colonies that can cover hundreds of thousands of square meters of seabed (Jenkins et al. 2018) and similarly large areas of intertidal lower shore (Dubois et al. 2002).

Biogenic reefs formed by *Sabellaria* spp. are thought to benefit wider ecosystem functioning. Their structures are topographically complex, with features such as standing water, crevices and consolidated fine sediments providing microhabitats for other organisms and high levels of biodiversity (Limpenny et al. 2010, Pearce et al. 2011). The associated communities can vary according to local conditions of salinity, water movement, depth and turbidity (Natural England & Countryside Council for Wales 2009). The extent and distribution of *S. alveolata* reefs are thought to be increasing in Wales (Mercer 2016) whilst it is thought that the extent of *S. spinulosa* reefs are potentially underestimated (NRW 2019).

Despite this, no known *Sabellaria* spp. reefs have previously been recorded in Milford Haven and/or across the wider Project Erebus survey area.

Due to their historic losses, sensitivity to anthropogenic disturbance and biological importance, *Sabellaria* spp. reefs are afforded protection under several conservation policies and legislation. *S. spinulosa* reefs are listed on the OSPAR List of Threatened and/or Declining Species and Habitats whilst *S. alveolata* reefs are listed as a Priority Habitat under Section 7 of the Environment (Wales) Act 2016 (previously NERC S42 lists) within the category of 'Littoral Rock'. Reefs formed by both species are also considered within the Marine Protected Area network feature list for Wales (Carr et al. 2016) and are considered as Water Framework Directive (WFD) higher sensitivity habitats as 'Polychaete reefs'.

# 7. Results

## 7.1. Export Cable Route Overview

Data collected on the cable route has been interpreted and reported using the centre line of the centreline used for data acquisition. KP markers have been generated from this centre line with KP0 as the most shoreward location at Sawdern Point. All bathymetric depths are reported as referenced LAT using the VORF model. Figure 22 shows an overview of the main cable route with bathymetry data gridded at 1m resolution, for more detail please Appendix XV.

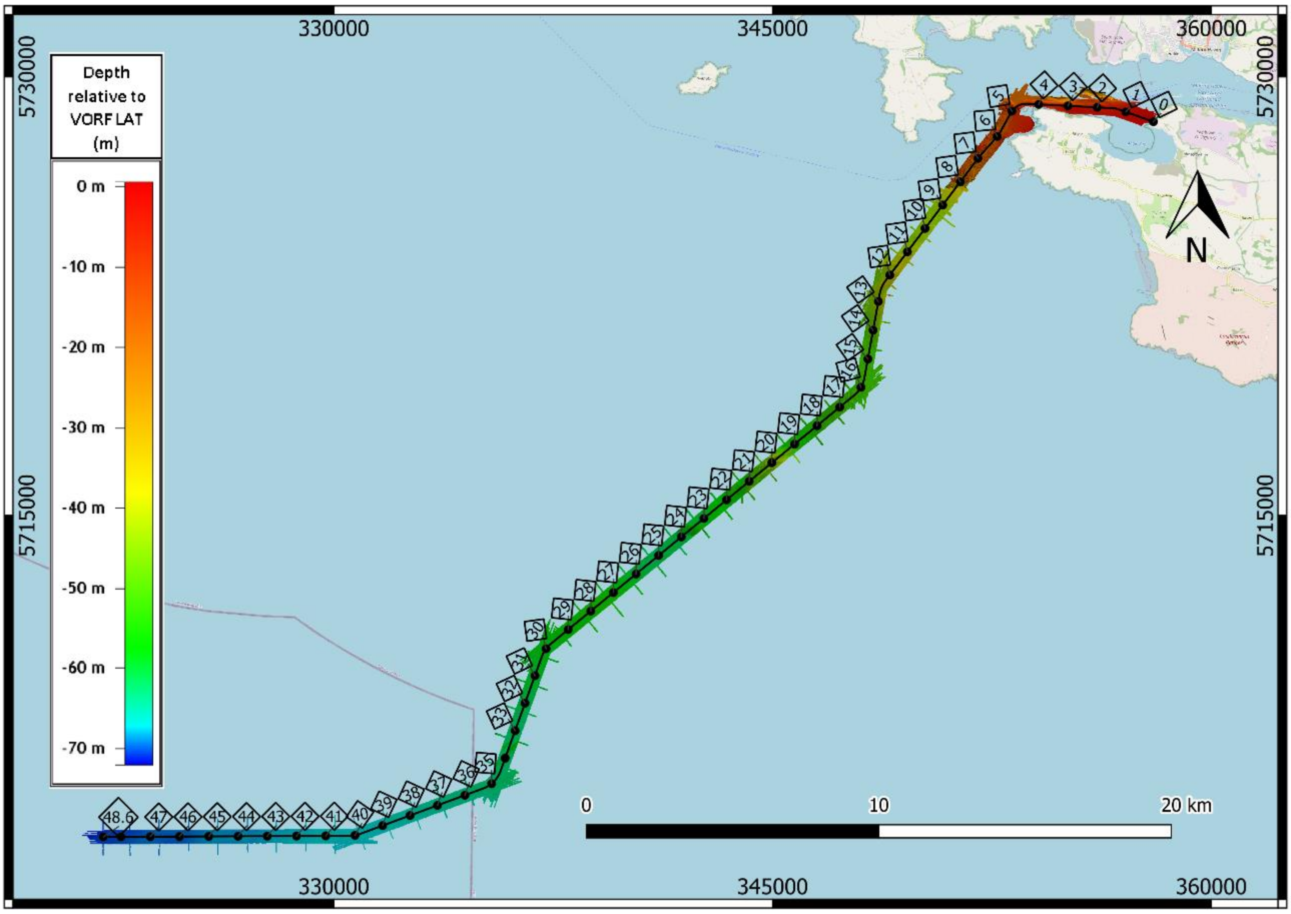



Figure 22: Overview for cable route with bathymetry

A profile of the bathymetry referenced to VORF LAT along the centre line is shown in Figure 23, along with a plot of the gradients present along the line of the centre line. The bathymetry along the centre line varies between -0.62m at KP0.055 to -70.65m at KP48.6. The steepest gradient along the centre line, of 11.9˚, occurs at KP5.749 where the route crosses the start of the bedrock outcrop forming the exposed channel surrounding the centre line observed between approximately KP5.7 and KP8.3. Gradients along the centreline, avoiding bedrock outcrops, are usually less than 3˚, however peak gradient reaches 5.6˚ at an intersection with a sandwave at KP33.747. The high variability in gradients encountered, from approximately KP10 to the end of the cable route, are the product of mobile bedforms. Between KP10 and KP24, higher observed gradients are the due to the presence of sandwaves.

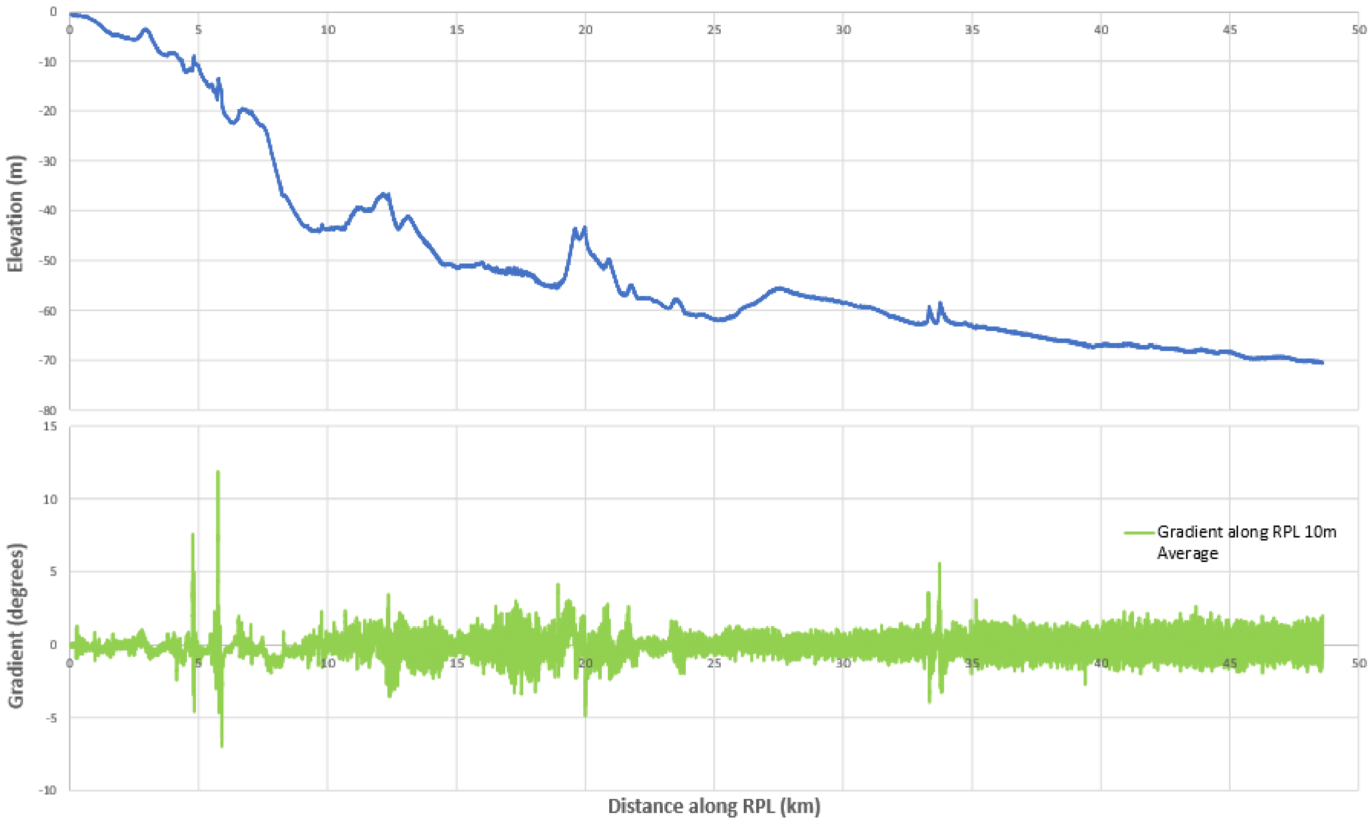



Figure 23: Seabed elevation and gradient profiles along the cable route centreline

Figure 24 shows the average slope values present on the route which have been smoothed by a 10m and 50m average. These values represent the maximum slope value sampled at each point along the centre line, which are not necessarily aligned in the direction of the centre line as opposed to the gradient values displayed in Figure 23 which show slope in the direction of the centre line. This plot allows for identification of gradient changes that exist at, and around, the centre line giving an indication of surrounding seabed conditions. As expected, there is good correlation between the gradient along the centre line and the slope, however some features are exaggerated on the slope profile indicating that variability of gradient around the centre line is greater than simply looking at the gradient along profile. Apart from outcrops of bedrock, which show very short and steep changes in gradient and slope, both plots indicate that high gradients and slopes have primarily been generated by mobile bedforms.

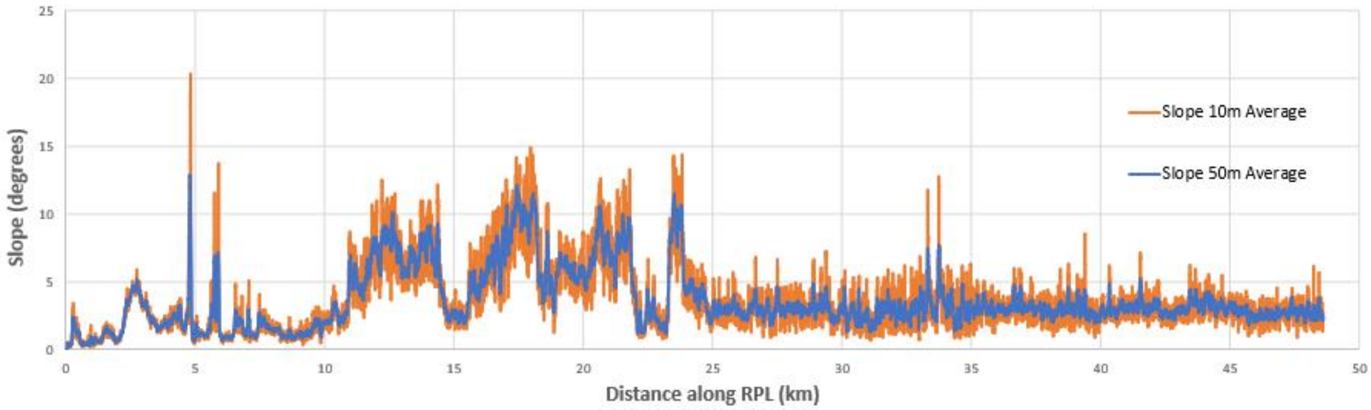



Figure 24: Seabed slope profiles along the cable route centreline

Seabed slopes around the centre line, avoiding areas of outcropping bedrock, vary between 0.2˚ and 14.9˚, with most of the variation associated with mobile bedforms. The slopes greater than 5˚ are primarily present between KP10 and KP25, and also briefly between KP33 and KP34, where large sandwaves and megaripples exist. Maximum slopes perpendicular to sandwaves crests within the survey corridor can reach 7˚ but are usually less than 4˚.

### 7.1.1. Surficial Geology – Export Cable Route

Details of seabed sediment and morphological features encountered along the cable route are present in 6.1.

A full breakdown of changes in the surficial geology along the centre line are listed in section 7.11.

Following sections highlight key surficial features identified on the route.

## 7.2. West Angle Bay (WA1) Landfall Option

### 7.2.1. Route Overview

Data collected on West Angle Bay (WA1) has been interpreted and reported using the centre line used for data acquisition. KP markers have been generated from this centre line with KP0 as the most shoreward location with the route joining the main cable route centre line at KP6.04. Figure 25 shows an overview of the WA1 landfall with bathymetry data gridded at 0.5m resolution.

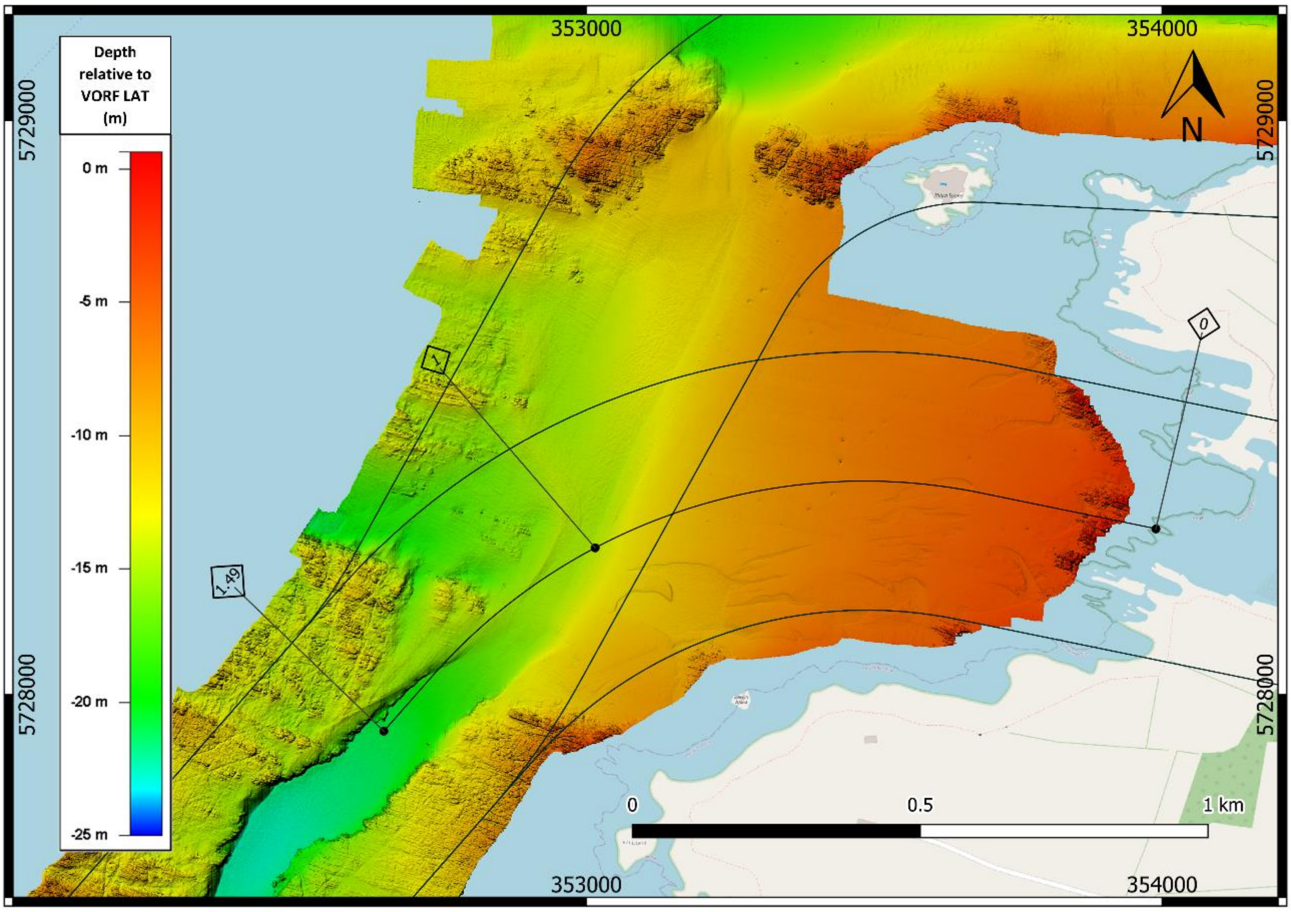



Figure 25: Bathymetric overview of the WA1 Centre Line

A profile of the bathymetry referenced to VORF LAT along the centre line is shown in Figure 26; along with a plot of the gradient along the centre line. The bathymetry along the centre line varies between -1.5m at KP0.082 to -20.8m KP1.49. Gradients on the centre line start relatively high as the centre line crosses an area of outcropping bedrock, with a range of gradients between -6.3 to 5.5˚ being found up to KP0.19. A smaller change in gradient of -3.44˚ is seen at KP0.327, where the centre line transitions into a small sandy GRAVEL filled depression. A final significant variation in gradient of -5.27˚ is found at KP13.43 and is caused by an area of outcropping bedrock at the start of the exposed channel area.

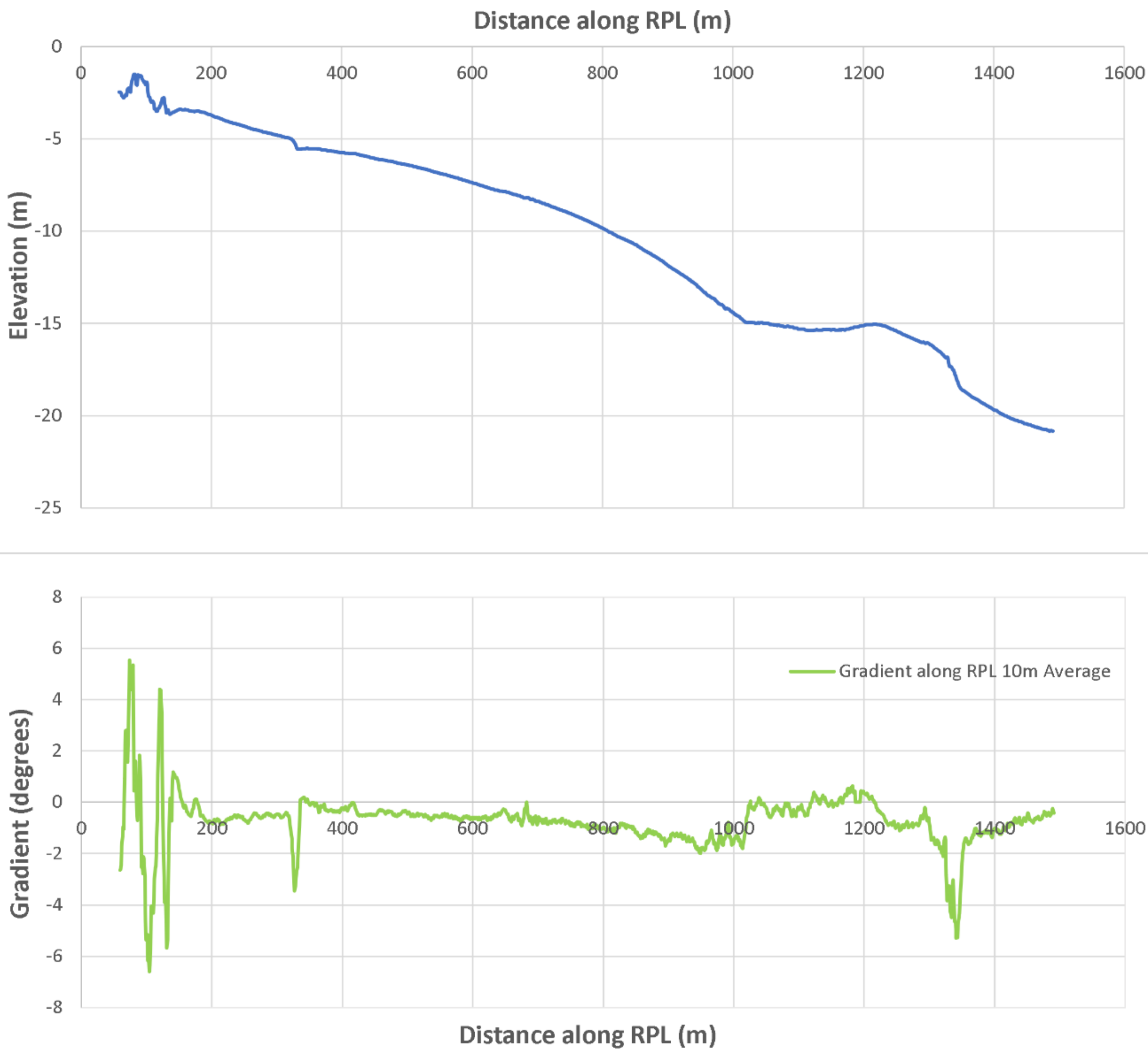



Figure 26: Seabed elevation and gradient profiles along the WA1 Centre Line

Figure 27 shows the average slope values present on the WA1 centre line which have been smoothed by a 10m and 50m average. These values represent the maximum slope value sampled at each point along the centre line, which are not necessarily aligned in the direction of the centre line. This plot allows for identification of gradient changes that exist at and around the centre line giving an indication of surrounding seabed conditions. As expected, there is a good correlation between the gradient along the centre line and the slope, however some features appear exaggerated on the slope profile, indicating that variability of gradient around the centre line is greater than simply looking at the gradient along profile.

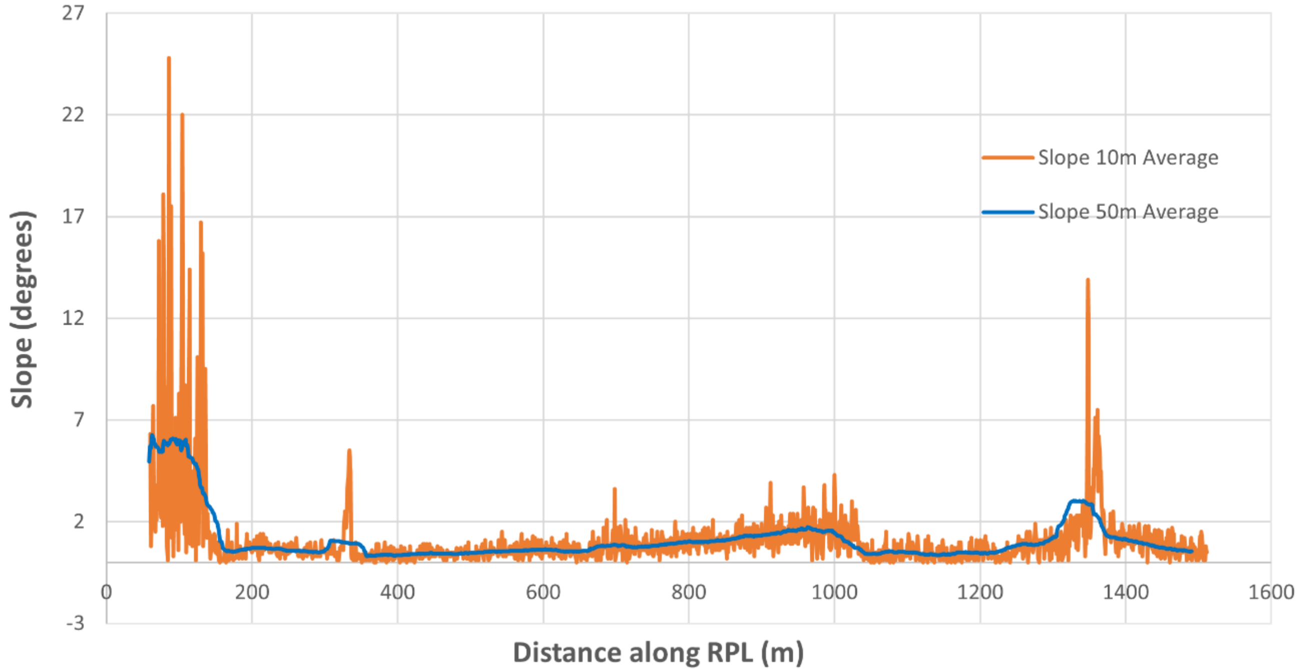



Figure 27: Seabed bathymetric slope profile along the WA1 Centre Line

Both plots show that high gradients/slopes along this centre line have primarily been generated by discrete areas of outcropping bedrock or changes in the composition of the seabed.

### 7.2.2. Surficial Geology

Details of seabed sediment and morphological features encountered along WA1 are presented in section 6.1.1.

A full breakdown of changes in the surficial geology along the centre line are listed in Section 6.1.2.

Figure 28 provides an overview of the different sediment classes encountered along the WA1 centre line. The shoreward end of the centre line is characterised by outcropping ROCK in the shallower waters of the bay, before meeting SAND as the centre line transitions offshore. This large area of SAND stretches to approximately KP1, with one instance of an isolated patch of sandy GRAVEL at KP0.330. After KP1, sandy GRAVEL becomes the dominant sediment class along the remaining centre line. The centre line intersects a short section of ROCK outcrop at KP1.324 which continues for just 25m, before transitioning back into sandy GRAVEL for the remainder of the centre line.

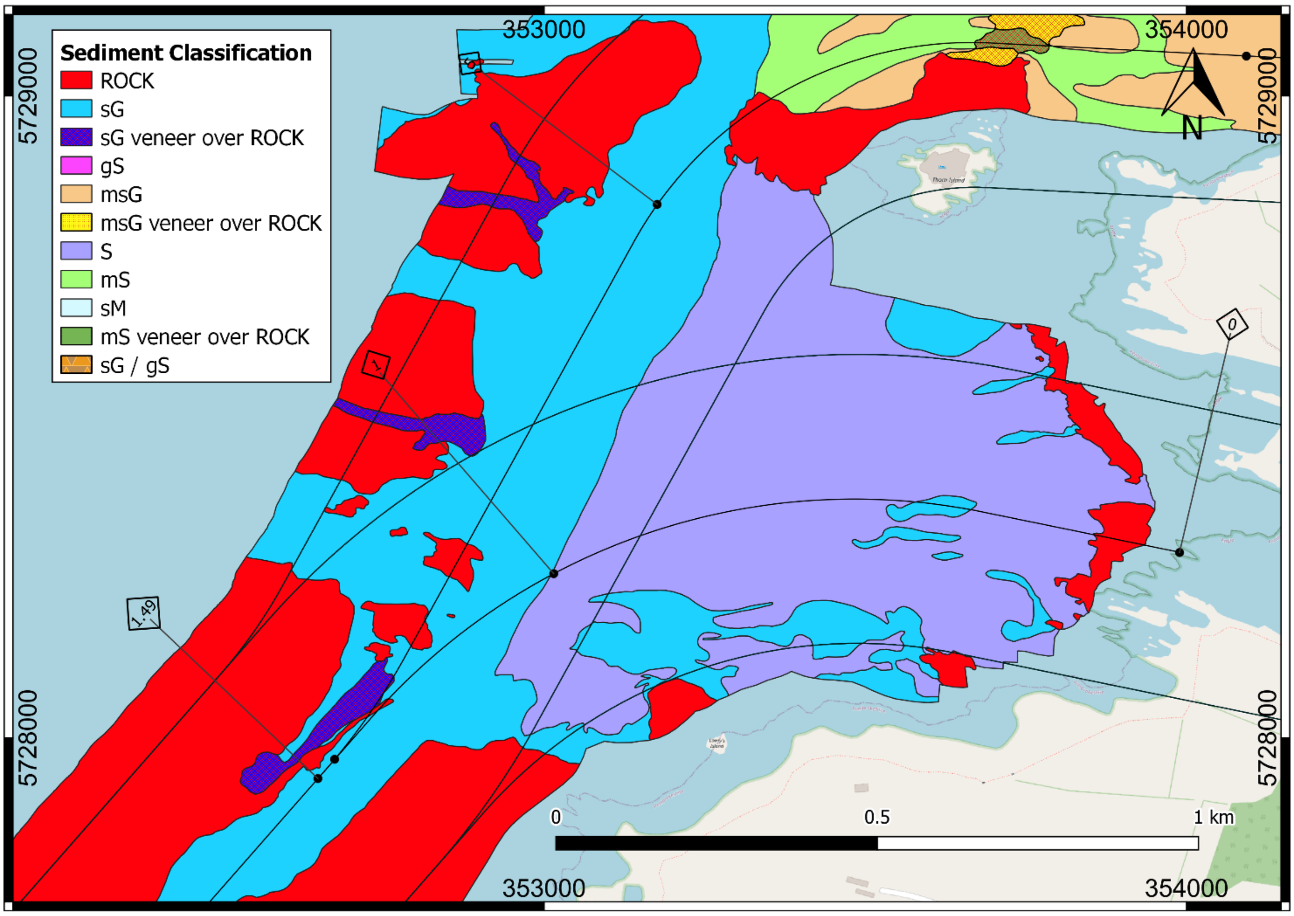



Figure 28: Overview of the sediments encountered across the WA1 centre line

The WA1 centre line crosses a few bedforms. Figure 29 shows the centre line crosses two areas of mobile sediments; both classified as ripples with amplitudes of less than 10cm. The SSS mosaic in the background highlights the large difference in reflectivity of the SAND within the West Angle Bay area and the surrounding coarser sediments.

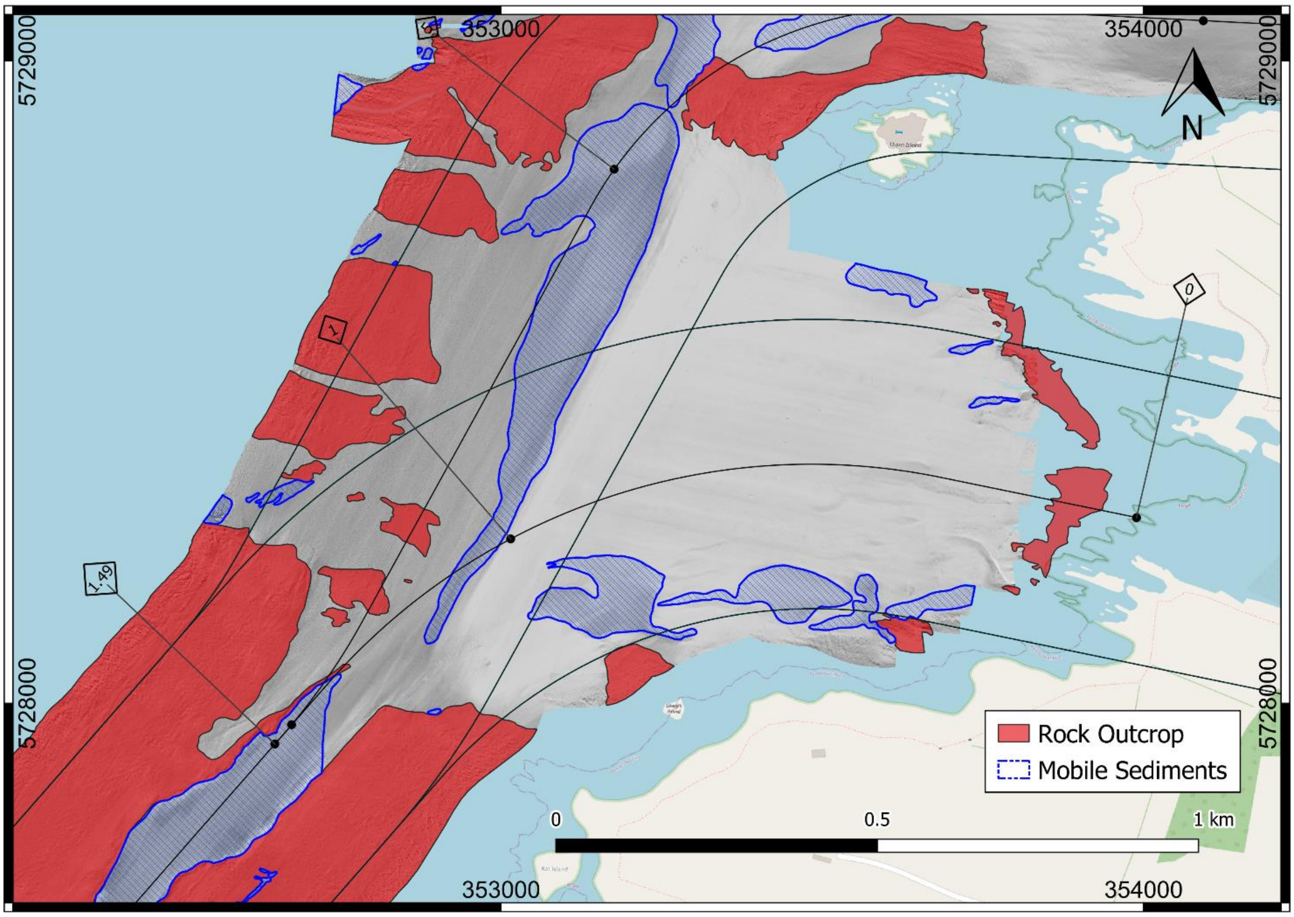



Figure 29: Overview of morphological features with the HF SSS mosaic along with the WA1 centre line

### 7.2.3. Contacts

Due to the short length and proximity of WA1 to the main cable route, contacts for this area are presented as part of section 7.2.5.

Figure 29 gives an overview of the types and distribution of contacts found in proximity to the WA1 centre line. The long linear feature highlighted in the figure is a cable/chain identified on the magnetic and sonar data sets and is discussed in section 7.5.4. This cable is approximately 30m north west of KP1.025. A second significant item of debris, identified as rope/cable/chain, has been identified 7.7m from the centre line at KP1.175, with a length of 36.7m. The magnetometer data shows an anomaly at this contact, indicating ferrous content. As with the nearshore area of the main route, fishing equipment on the seabed has been identified in the vicinity of WA1.

A boulder field with a high density of boulders also intersects the centre line between KP0.203 and KP0.252 (red fill polygon in Figure 30 with a boulder density of 81 boulders per 10000m$^2$. Isolated boulders are also observed across the landfall route.

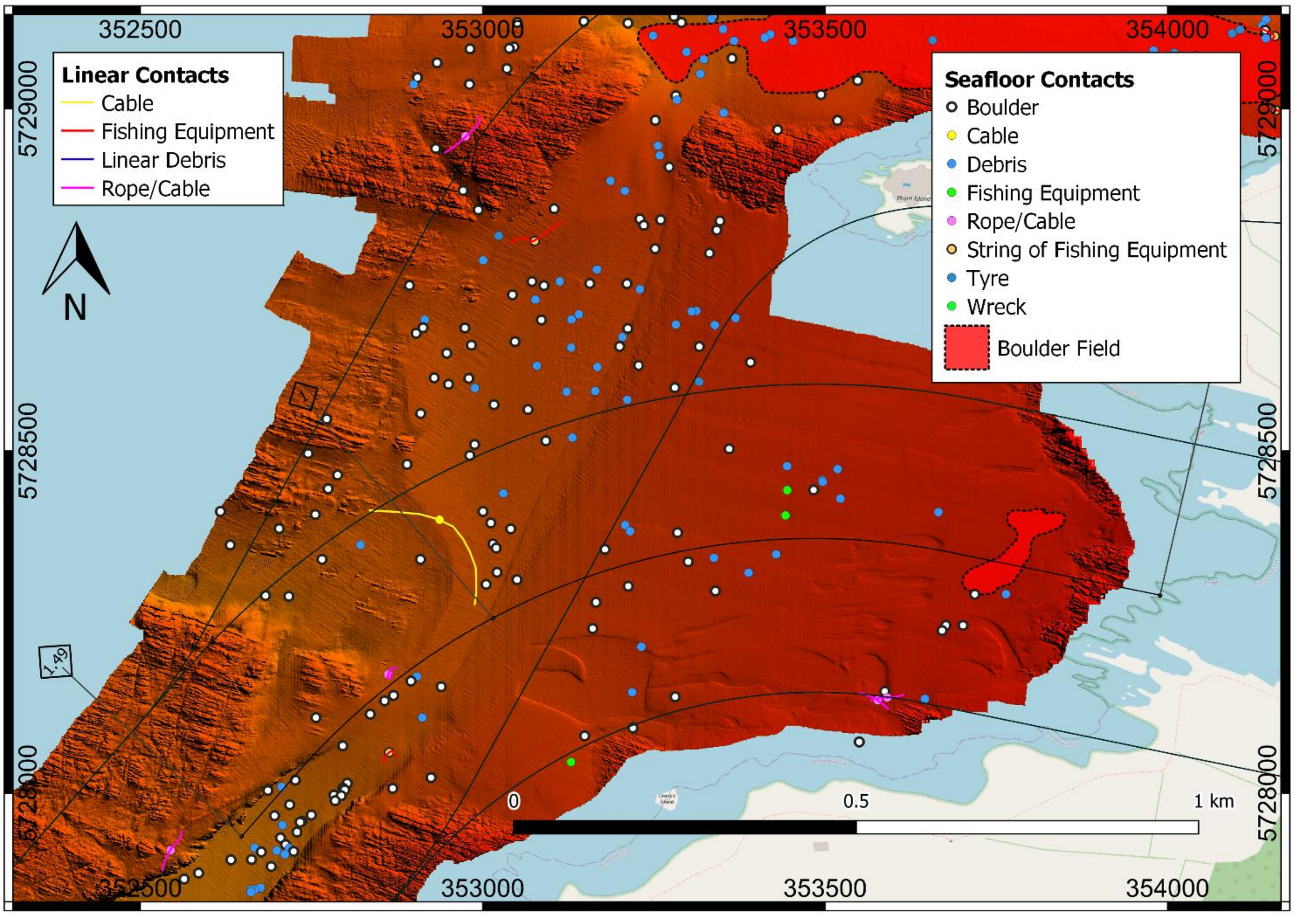


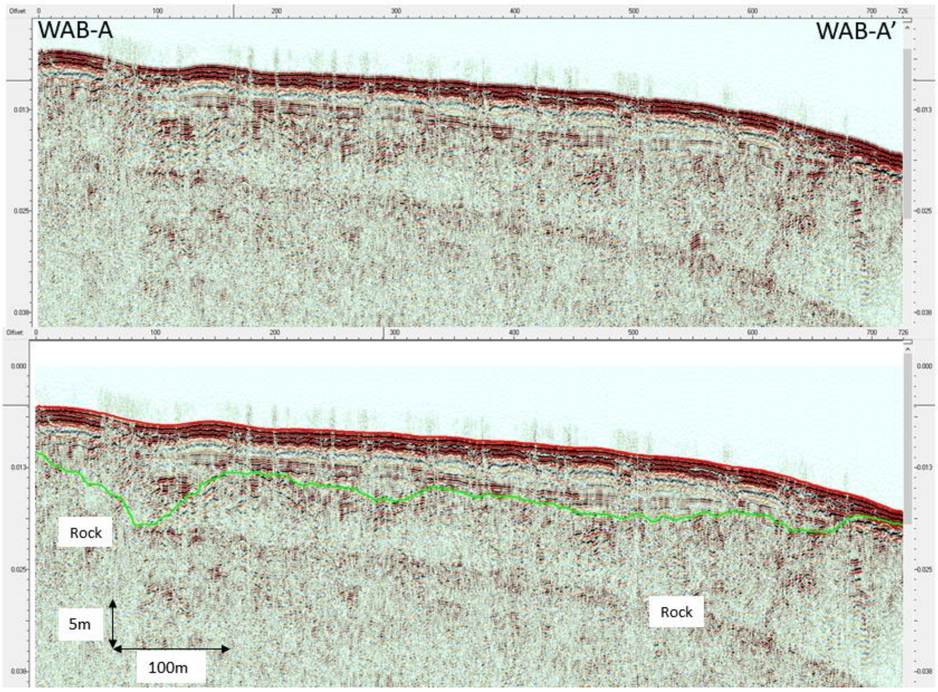

Figure 30: Overview of contacts in the vicinity of WA1 centre line

### 7.2.4. Shallow Soils

#### 7.2.4.1. Route Overview

Two of the horizons listed in "6.1.2 Subsurface Interpretation" have been interpreted on SBP data to at least 10m below the seabed along the WA1 centre line. These are H07, top of coarse channel fill, and H10, top of bedrock. Additionally, a thin veneer of surficial sediments (H05) is expected to exist, although its base was not consistently observed to generate a horizon in this area. A detailed listing of the occurrence of the interpreted units along this centre line has been undertaken in section 7.2.5.

A SBP data example of sparker data along the WA1 centre line is presented in Figure 31. The bedrock is interpreted within the upper 5m of the section, which thins along the centre line until it is uninterpretable within the seabed reflector. The sediments above this show evidence of bedding and are likely composed of fluvio-estuarine sediments. From the surficial geology, it is expected that a veneer of surficial sediment exists across much of the WA1 centre line. In the case of WA1 the main component of this surficial sediment is SAND, likely trapped by the geometry of the bay.



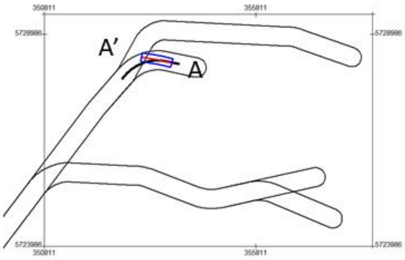




Figure 31: SBP data example from the nearshore section of the WA1 Centre Line

Figure 32 shows the depth below seabed to H10, top of bedrock. The bedrock is present throughout the centre line, apart from isolated patches where there is inadequate coverage of the sparker data. The bedrock appears exposed in the shoreward area but deepens moving along the centre line, forming shallow channel features, before shoaling at the start of the exposed channel. The top of bedrock level varies from outcrop at the seabed to a maximum of 23m below seabed. All values shown are depth to the top of the unit from the seabed.

Additionally, along the WA1 centre line, a very small section of H07 top of coarse sediment fill has been interpreted as the centre line joins the main cable route. This is discussed in section 7.7.5of the export cable route interpretation.

Figure 33 shows the variation in depth below seabed to H10, which represents the top of bedrock along the WA1 centre line. This shows that much of the noted variation in depth to bedrock is due to erosion of the bedrock surface rather than seabed morphology.

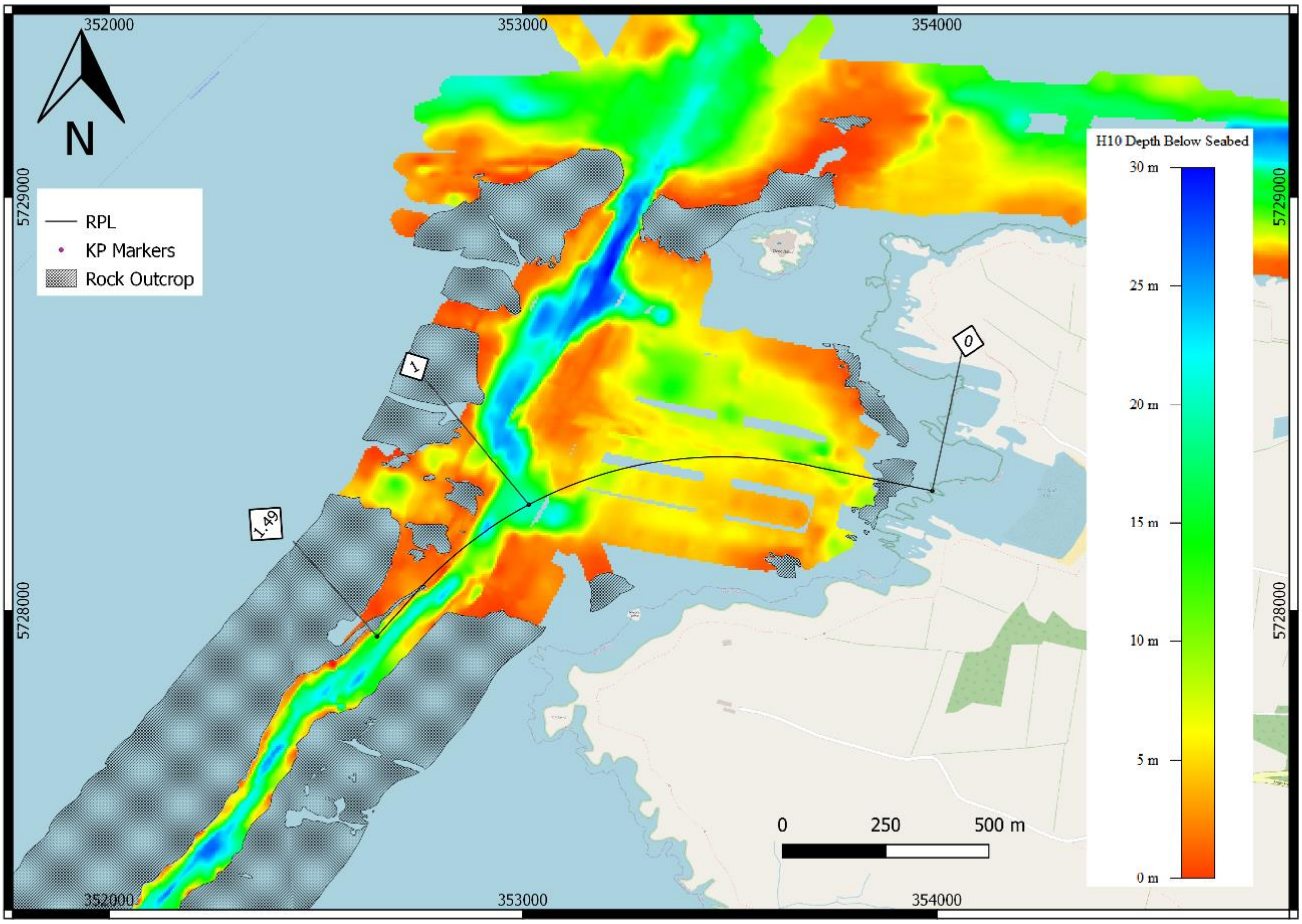



Figure 32: H10 Top of Rock at WA1, depth below seabed grid

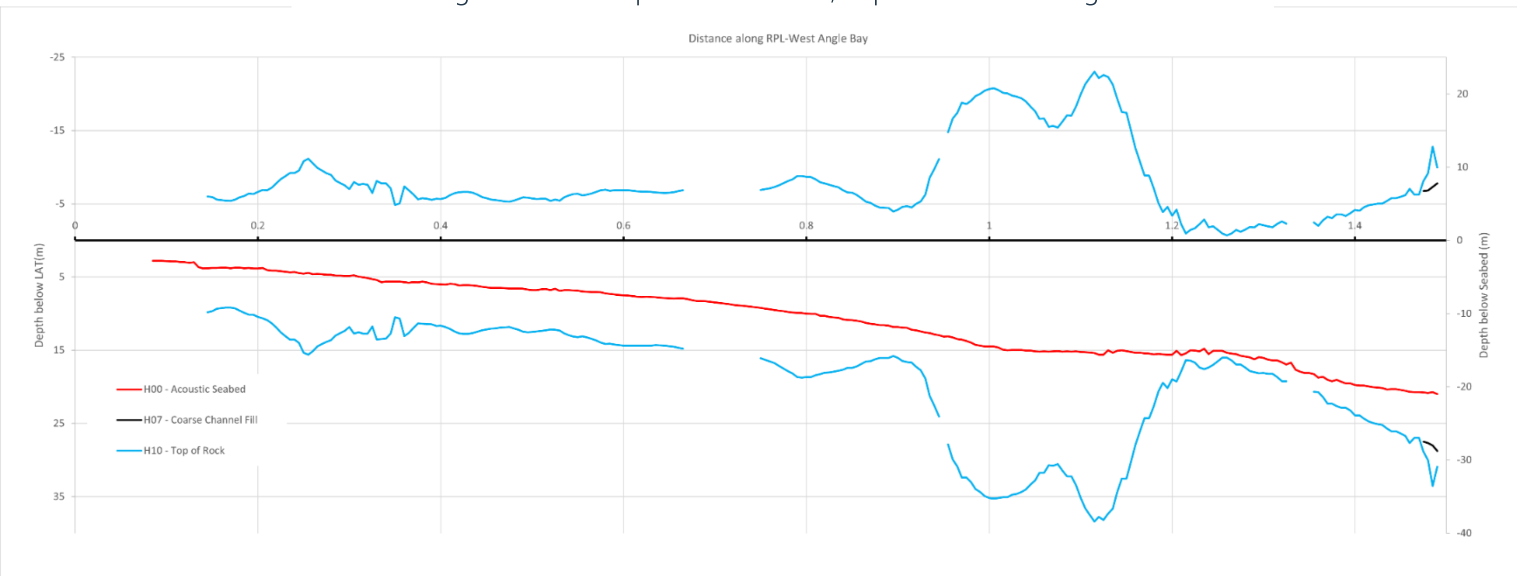



Figure 33: Profile of the WA1 Centre Line SBP interpretation

### 7.2.5. Route Conditions

Table 35: Route condition listing, WA1

| KPStart | KPEnd | SBF | Mobile Features | Obstructions | SBP |
|---|---|---|---|---|---|
| 0 | 0.056 | No SSS or MBES coverage | | | No SBP Coverage |
| 0.056 | 0.135 | ROCK Outcrop | | | No SBP Coverage (A small gap in the bedrock outcrop is present ~70m north of the centre line, however the extent of this has not been completely mapped in the MBES data) |
| 0.135 | 0.203 | SAND | | | H10 is interpreted to undulate between 4.8m to 11.2m between KP0.15 and KP0.665.<br><br>No sparker coverage between KP0.665 and KP0.750 means that continuation of H10 was not possible aver this stretch.<br><br>From KP0.750, H10 deepens slightly from 6.9m to 8.8m, before shoaling again to 3.9m at KP0.895. The bedrock is within 5m of the seabed between KP0.870 KP0.920.<br><br>There is a further gap in coverage of the sparker data between KP0.945 and KP0.955 prevention the continuation of interpretation over this area. |
| 0.203 | 0.252 | SAND with boulder field | | Boulder field density: 81 boulders per 10000m$^2$ | |
| 0.252 | 0.331 | SAND | | | |
| 0.331 | 0.418 | Sandy GRAVEL | | | |
| 0.418 | 1.006 | SAND | | | |
| 1.006 | 1.021 | Sandy GRAVEL | | | |
| 1.021 | 1.107 | Sandy GRAVEL with mobile sediments | Ripples with average wavelengths of 2m and amplitudes of <10cm. | | |
| 1.107 | 1.324 | Sandy GRAVEL | | Metallic debris with length of 36.7m located 7.7m from centre line at KP1.175. | |

| KPStart | KPEnd | SBF | Mobile Features | Obstructions | SBP |
|---|---|---|---|---|---|
| | | | | | Beyond this, H10 deepens into a larger channel feature, reaching its greatest depth noted along the WA1 centre line of 23.0m at KP1.115. From here it shoals to a minimum depth of 0.7m. The bedrock is within 5m of the seabed between KP1.185 and KP1.324. |
| 1.324 | 1.349 | ROCK outcrop | | | Bedrock outcropping |
| 1.349 | 1.490 | Sandy GRAVEL with mobile sediments | Ripples with average wavelengths of 1.9m and amplitudes of <10cm. | | H07, marking the top of the coarse channel fill, is interpreted at a depth of between 6.2- 7.8m and is visible only between KP1.460 and KP1.490. The unit truncates on the bedrock at the flanks of the channel.<br><br>H10 deepens from the outcrop to a maximum depth of 12.8m. It is within 5m of the seabed between KP1.349 and KP1.425. |

## 7.3. FLOW Site Overview

Figure 34 shows an overview of the array area with bathymetry data gridded at 5m resolution.

Across the array area, depth varies from -80.16m within a trough between sandwaves in the northern edge of the array area (317878 E, 5708097 N), to -65.57m on a sandwave crest present in the north eastern quadrant of the array area (321310 E, 5705525 N). The site appears to deepen gently from east to west. Significant changes in depth are associated with mobile bedforms.

The crests of sandwaves are marked in Figure 35, clearly showing that these bedforms are present throughout the whole of the northern half of the array area. The maximum height of one of these sandwaves is 11.5m and they have an average wavelength of around 240m. Some features slightly smaller than the requisite for sandwaves are classified as megaripples and are present within the same area.

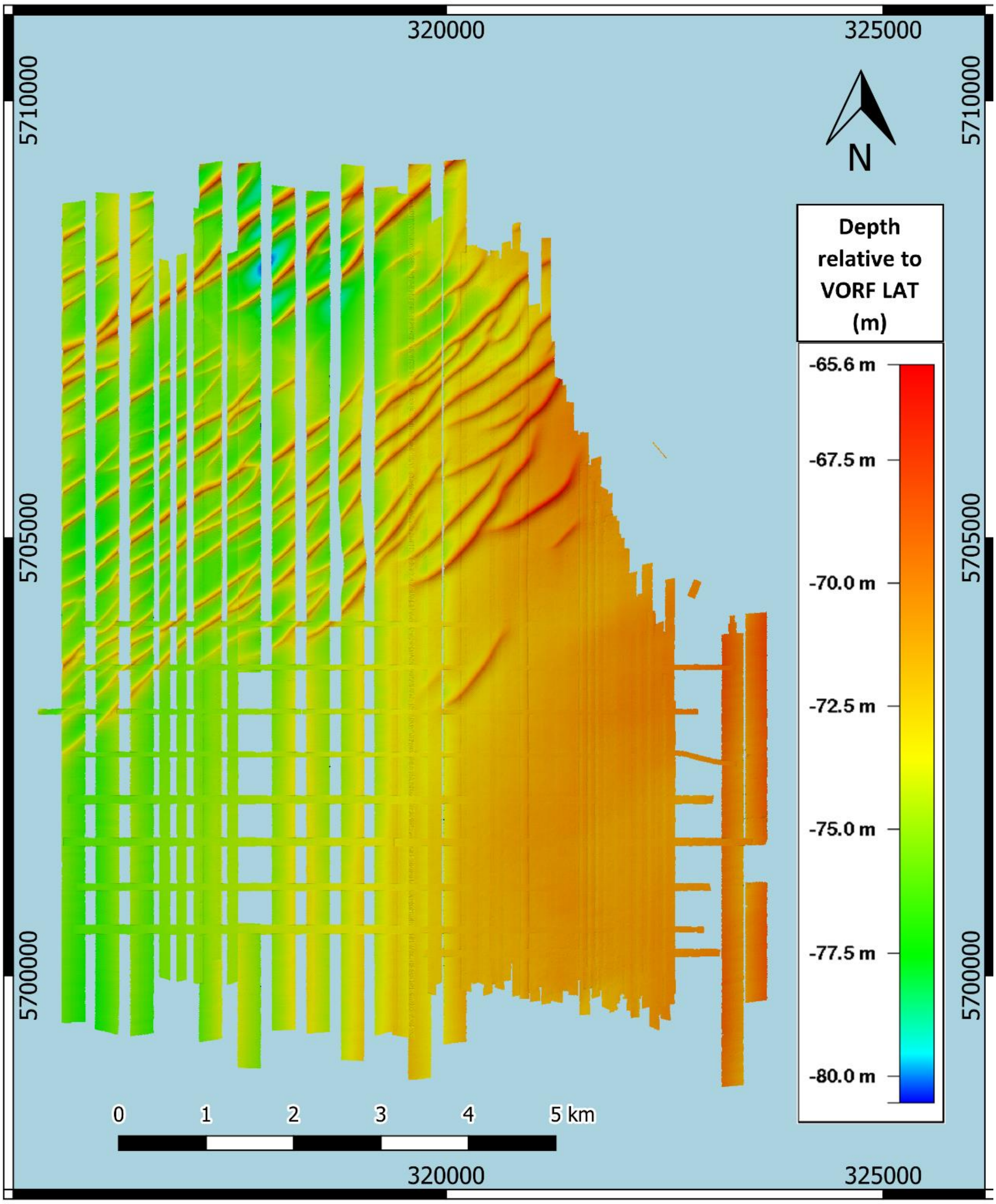



Figure 34: Overview of FLOW Site MBES data gridded at 5m resolution

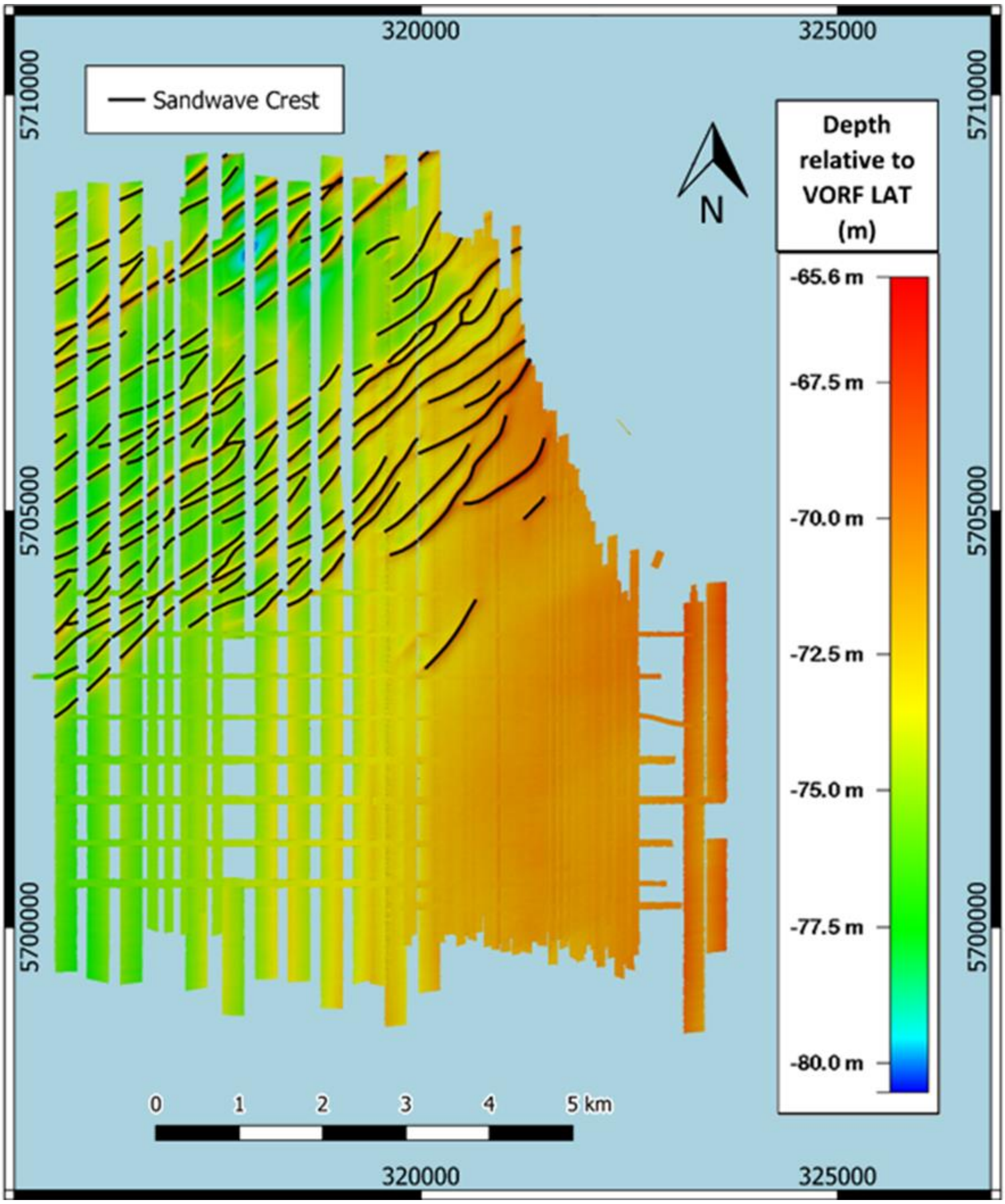



Figure 35: Overview of marked sandwave crests presented on FLOW Site bathymetry

### 7.3.1. Surficial Geology – FLOW Site

Details of seabed sediment and morphological features encountered within the Array area are presented in 5.2.1.

As noted in section 5.2.1, muddy SAND is the sediment class which has been used in the characterisation of the array area. As can be seen in Figure 36, the low frequency (LF) 300kHz SSS mosaic shows little variation in acoustic reflectivity across the area, despite the grab samples indicating the presence of 4 different sediment classes: SAND, sandy MUD, gravelly SAND, and muddy SAND. The absence of any clear variations in reflectivity makes it impossible to digitize boundaries between sediment classes identified in the grabs. Using the most common sediment type present, the site has been generalised as muddy SAND. Additionally, Figure 39 shows the Particle Size Analysis (PSA) results for the array area showing that gravel was a very minor constituent within the three samples that it did appear in. Muddy SAND is also the sediment type classified by

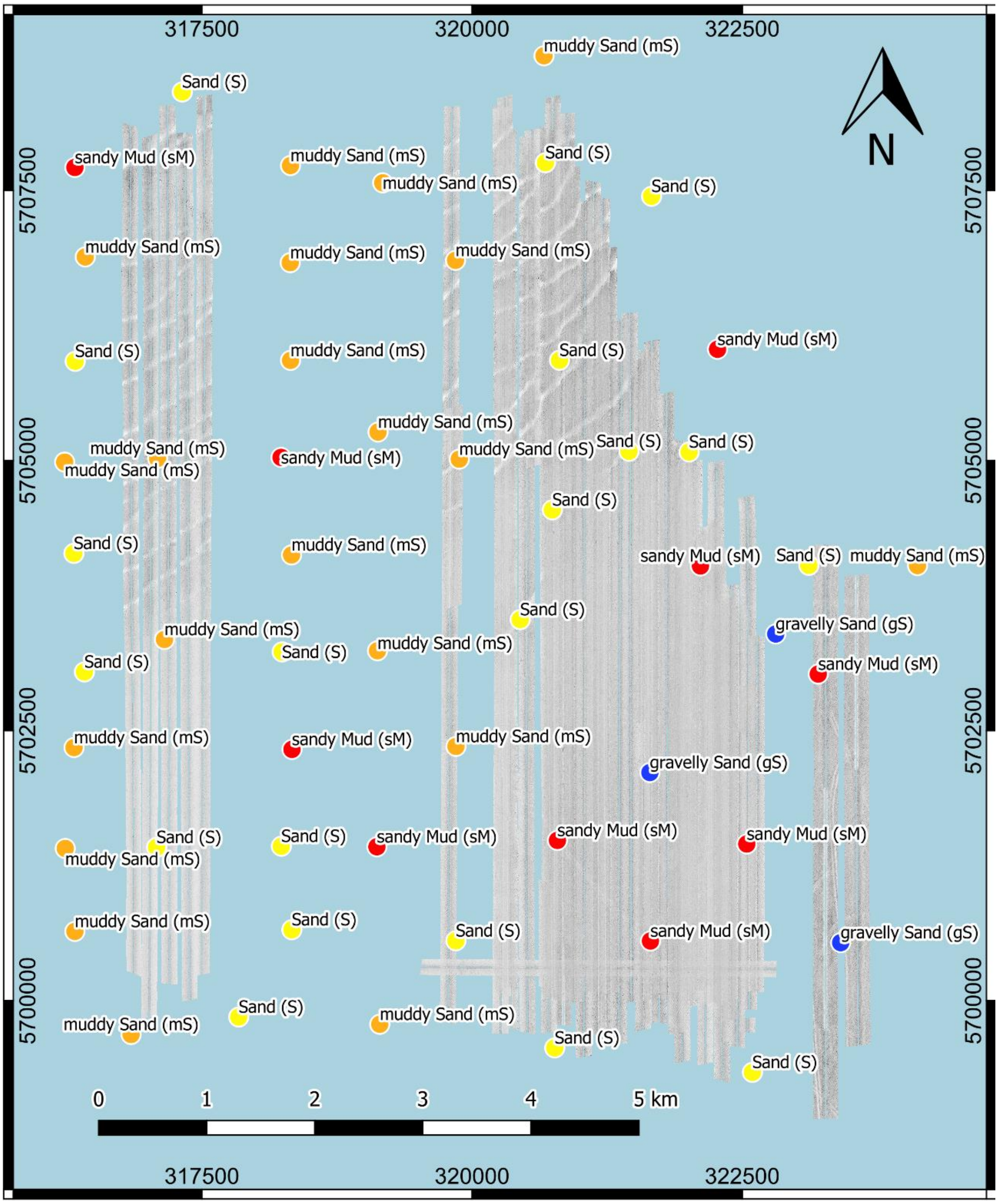



Figure 36: Overview of LF SSS mosaic and grab samples in the array area

the grab samples for the furthest offshore section of the cable route immediately leading into the WTG, allowing continuity of interpretation between the cable route and array areas.

Extensive areas of mobile sediments were identified throughout the site. Ripples with heights of up to 13cm exist across the whole area, but in the northern region of the site they are superimposed onto sandwaves. Sandwaves with an average wavelength of 240m and a maximum height of 11.5m, exist across the northern portion of the array area as shown in Figure 37. The approximate orientation along the crests of mobile bedforms on the array area is approximately south west to north east, indicating current flow perpendicular from the north west and the south east. Figure 37 shows a profile taken across some of the sandwaves present in the array area. The sandwaves appear almost symmetric. There is a very slight tilt indicating the north east face of the sandwaves as the dominant stoss side, however it is very minor, and the symmetry would indicate roughly equal flow in both directions. No evidence of "tearing" of MBES data between datasets acquired at different times on the array has been identified, indicating that no measurable migration has occurred over the timespan of the acquired data.

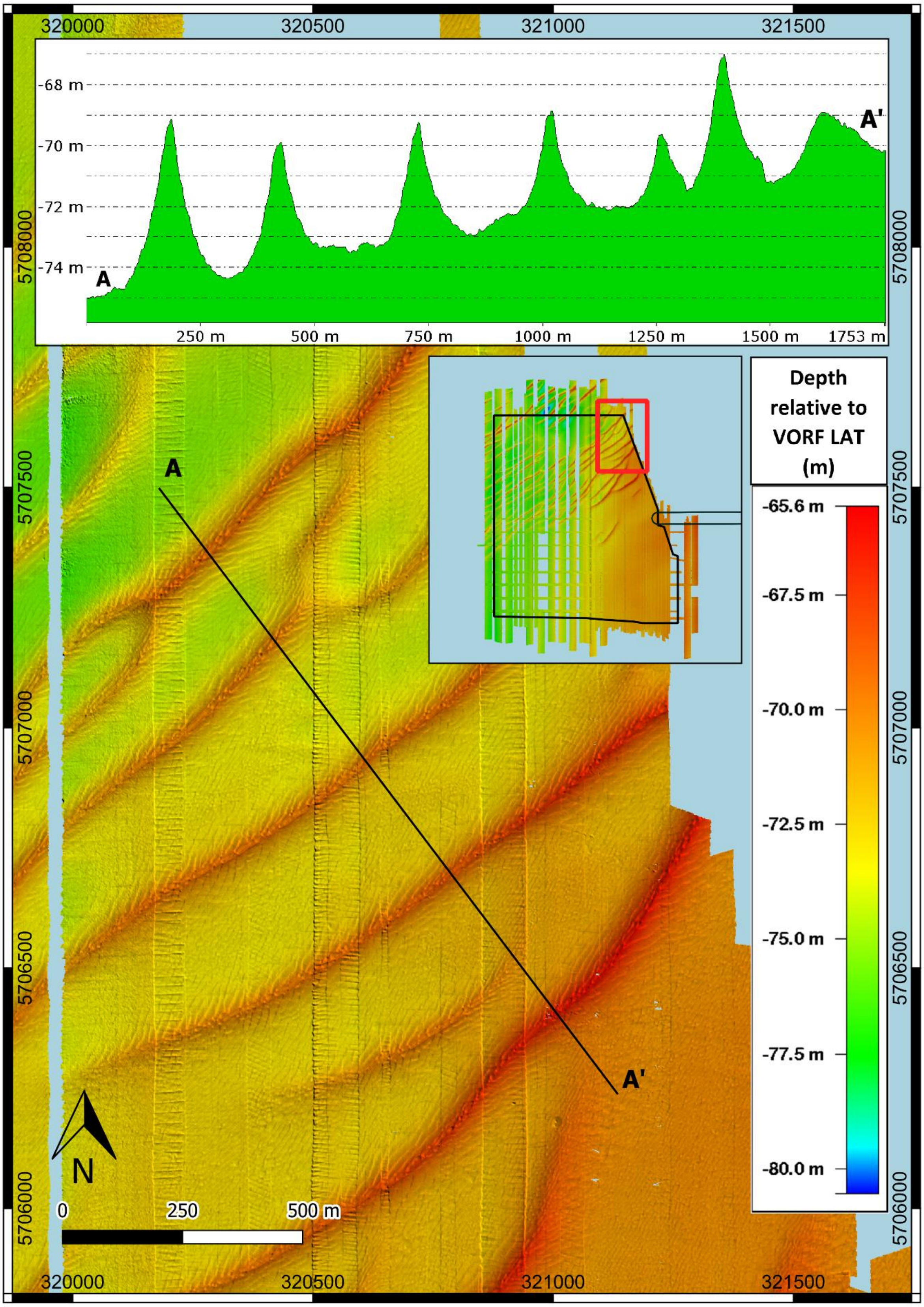



Figure 37: MBES data in the array are with a profile over sandwaves

Boulder fields have also been identified within the array area. The greatest prevalence being in the north-eastern section where sandwave troughs have diminished sediment cover to the point where the underlying reworked outwash material is exposed at the seabed, presenting boulders to the surface. The boulder fields present in the south of the area are associated with general thinning of the unit A sediments. However, it is important to note that boulders appear to be prevalent across the entire array area. An overview of identified boulders and boulder fields can be seen in Figure 38. Interpreted boulder sizes vary from 0.5m with some targets >4m, it is interpreted that these larger boulders may be groups of boulders that could not be discriminated on the SSS data. Boulders less than 0.5m have occasionally been observed. Boulders and other targets are discussed further in Section 7.6.

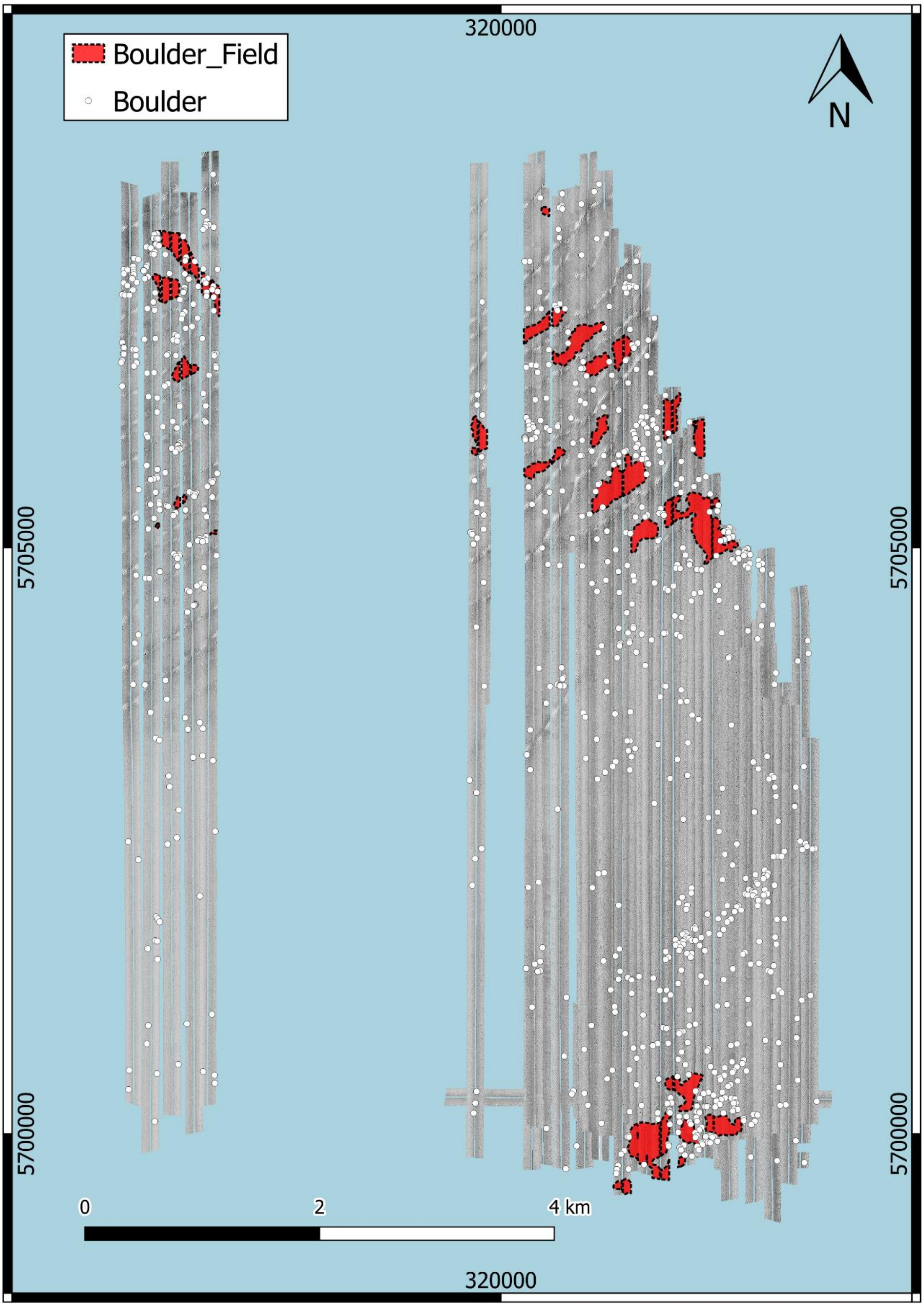



Figure 38: Extent of boulder fields and boulders within the array area.

## 7.4. Particle Size Distribution Data

The composition of sediment data at each grab sampling station throughout the survey area is mapped in Figure 39. Grab sampling logs and sample photos are provided in Appendix VI and VII respectively and full PSD data has been provided in Appendix VIII.

### 7.4.1. Sediment Type

Sediment types at each grab sampling station as classified by the Folk (1954) classification are summarised in Appendix IX and illustrated in Figure 40. Despite some variation in sediment types between stations, the majority of stations were dominated by sand. Mud content was highest close to land and towards the main array. Gravel content was overall low and variable along the cable route. The majority of samples were comprised of sand representing EUNIS BSH A5.2 (Sand and Muddy Sand), while some stations were classified as Gravelly Sand (gS) representing EUNIS BSH A5.1 (coarse sediment) or as Mud and Sandy Mud (EUNIS BSH A5.3); only 5 out of 107 stations were classified as Gravelly Muddy Sand (gmS) representing EUNIS BSH A5.4 (Mixed Sediment).

These sublittoral sediment types could represent 'subtidal sands and gravels' and 'subtidal mixed muddy sediments' listed as habitats of principal importance under Section 7 of the Environment (Wales) Act 2016. To note that these habitats are among the most common habitats found below the MLWS around the coast of the UK.

Most of the sediments recorded were classified as poorly to very poorly sorted (57 % of stations) as a result of the mixed composition of different size fractions of all three principal sediment types (gravel, sand and mud). However, 9 stations (8 %) were classified as moderately well sorted and comprised almost entirely of sand.

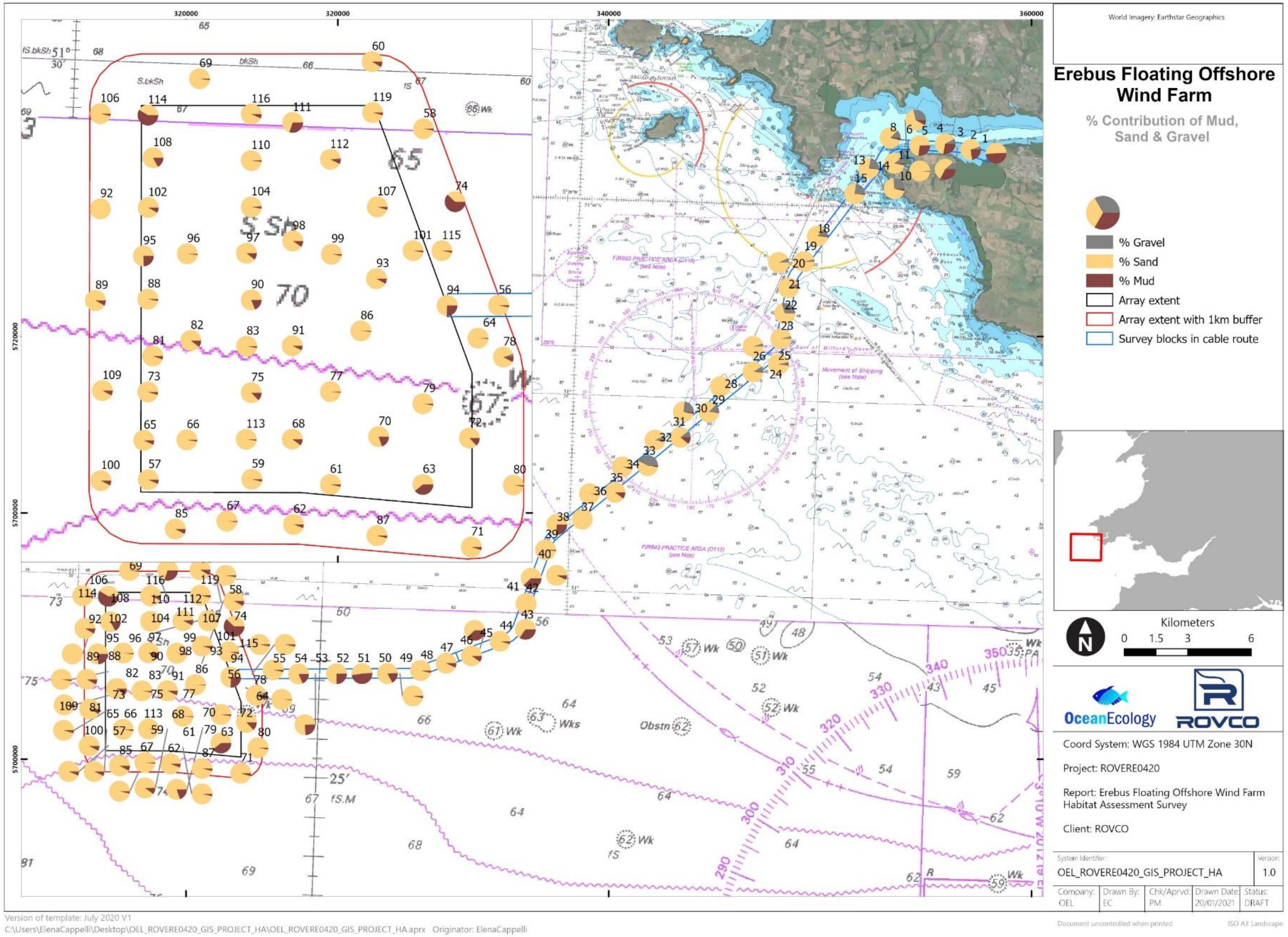



Figure 39: Percentage volume of gravel (G), sand (S) and mud (M) each sampling station during the Erebus FLOW Habitat Assessment Survey

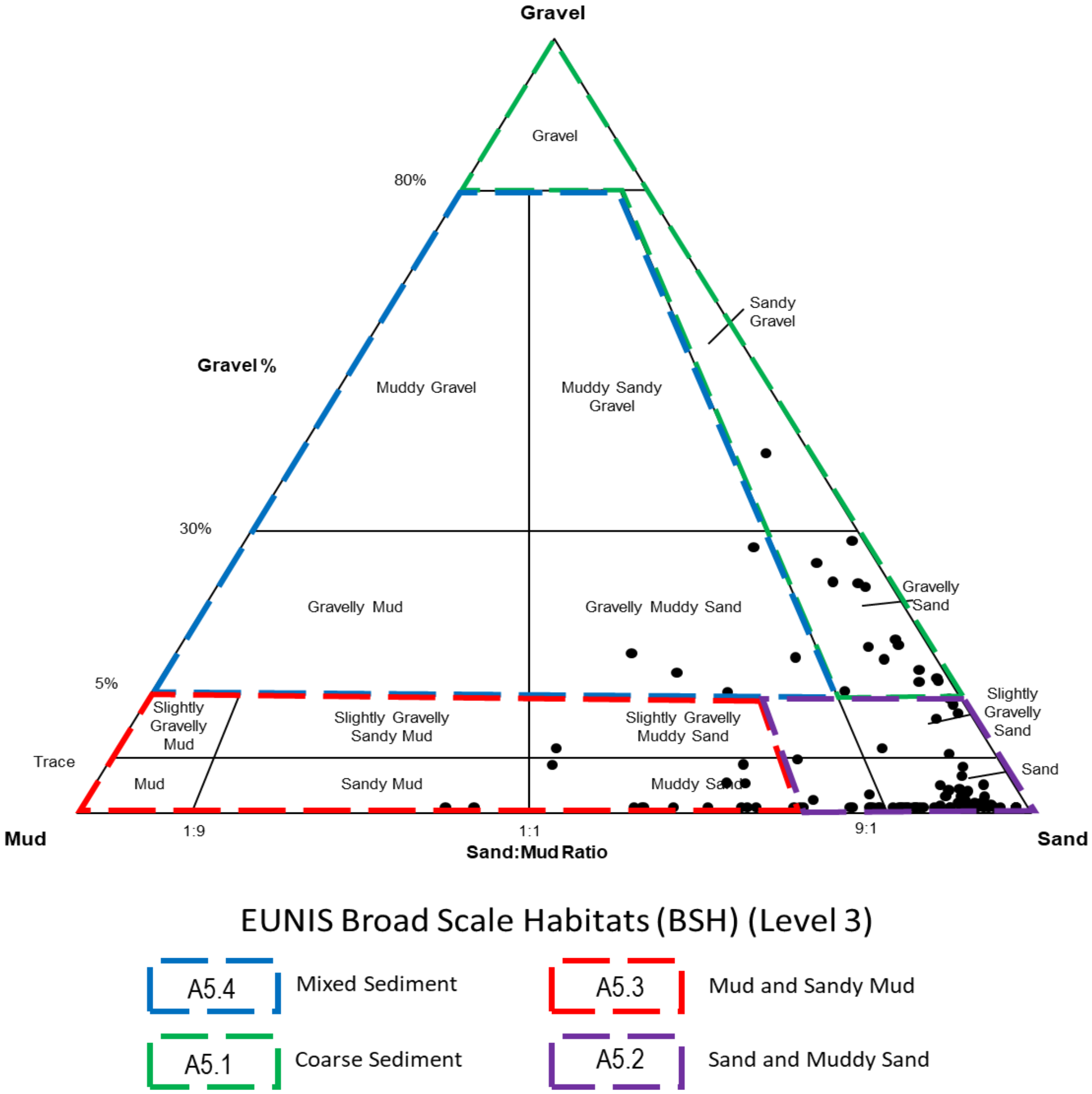



Figure 40: Folk (Folk 1954) triangle classifications of sediment gravel percentage and sand to mud ratio of samples collected during the Project Erebus Offshore Floating Wind Farm survey, overlain by the modified Folk triangle for determination of mobile sediment BSHs under the EUNIS habitat classification system (adapted from Long (2006)).

### 7.4.2. Sediment Composition

The percentage contribution of gravels (> 2 mm), sands (0.63 mm to 2 mm) and fines (< 63 µm) at each station are presented in Figure 40. Sand was the main sediment fraction present at most stations, comprising the largest percentage contribution across the survey area. The mean (± SE) proportion of sand across all stations was 86.7 % (± 1.3), while the mean (± SE) mud and gravel content across the survey area was 10.13 % (± 1.3) and 3.2 (± 0.7) respectively. Sand content was greatest at stations 28, 37, 42 and 92 (cable route stations) and lowest at 74 (main array stations). The mean grain size at sampling stations ranged from 30.82 µm at station 74 (located in the main array) to 1564.8 µm at station 33 (located along the cable route). A summary of PSD data is provided in Appendix VI.

### 7.4.3. Sediment Spills

A number of occurrences of interpreted spilled sediments were identified in the nearshore area of the cable route. These areas are particularly apparent and distinctly different from boulder fields, as they exist in discrete patches of between 10-15m diameter and around 20cm height, with a high density of boulder-like contacts visible. Figure 41 shows the location and nature of these aggregate deposits. Measurements from SSS data show that the boulders present in these features have a range of dimensions from a maximum of approximately 1.5m down to cobble size fragments.

It is possible, given that these features appear to overlie the prevalent seabed sediments, that these deposits have been left by aggregate/dredge vessels that have sailed over this area of the seabed. An SBP line that intersects one of these features shows no evidence of reflectors rising to the surface or a thinning of the sediment already present, hence the interpretation that these features overlie the natural seabed.

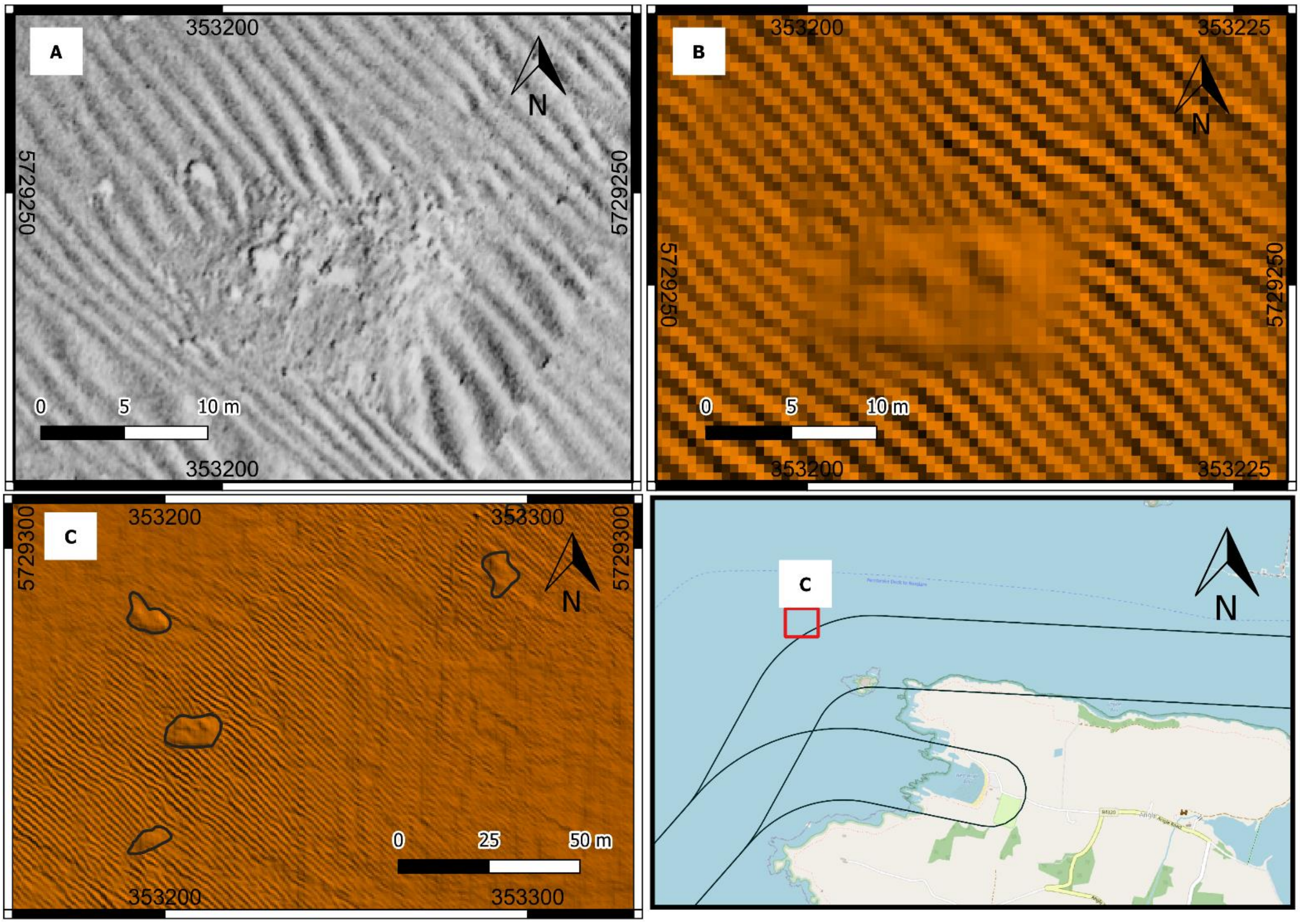



Figure 41: Nature and distribution of interpreted spill sediments

### 7.4.4. Rock Outcrops

Side scan data between KP6 and KP8 are presented in Figure 42. ROCK outcrop is seen extending from approximately 250m north from KP6 to around 400m south from KP8. However, the centre line runs NE-SW down a channel present within an exposed channel that has been eroded into the bedrock surface. Through this exposed channel area there is ROCK present on each side of the centre line. This channel has been filled with estuarine fill sediments with sandy GRAVEL present at the seabed. Ripples (heights less than 0.5m) are present at the edges of the main channel and in smaller channels running through the rock outcrops.

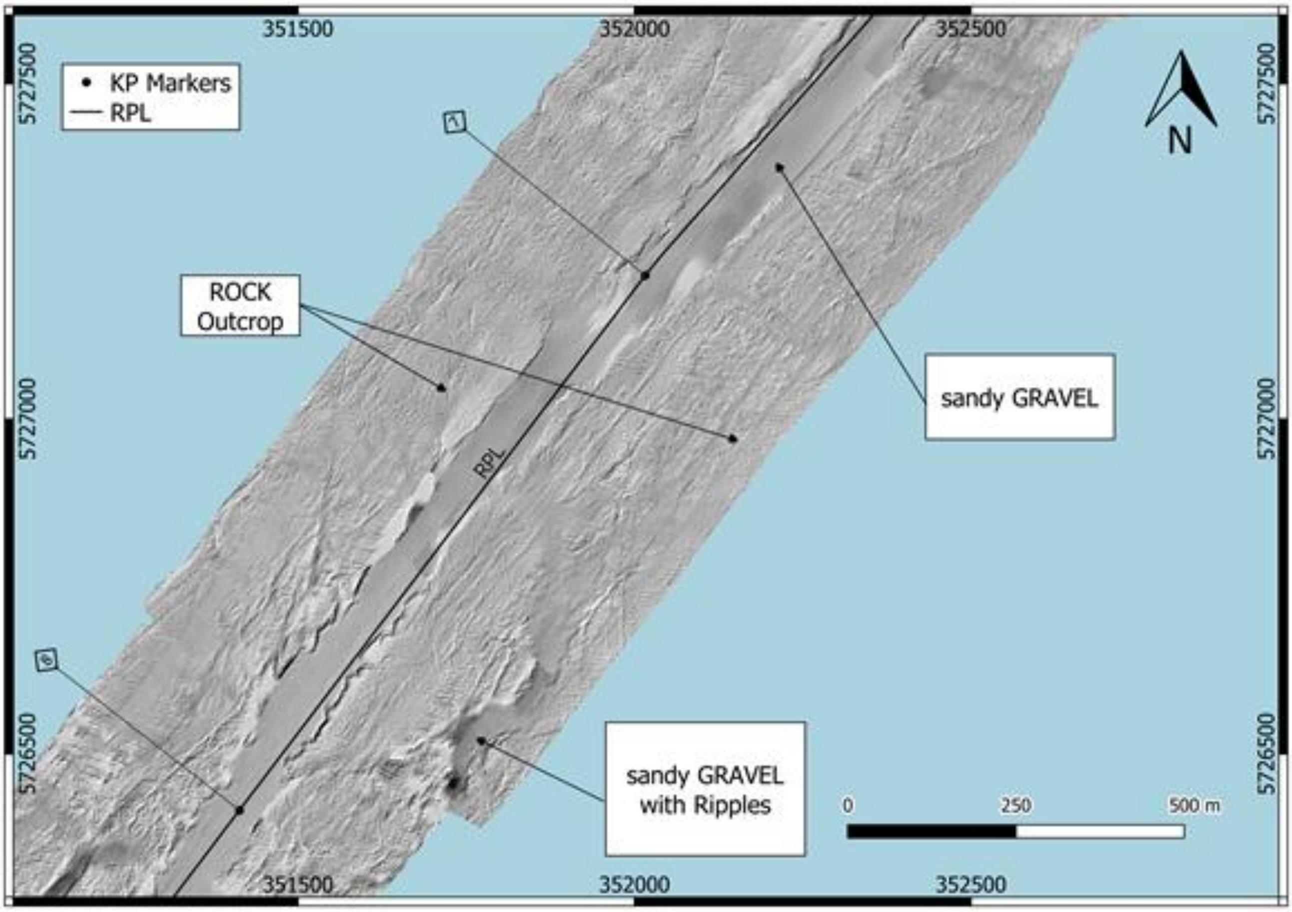



Figure 42: Side scan data example of the sediment filled channel incised in ROCK

Whilst the cable corridor centre line follows this exposed channel for the most part, Figure 43 shows that the centre line intersects areas of outcropping and sub-cropping bedrock around 85m north of KP6 as the planned route brushes past the edge of the exposed channel . Other instances of centre line intersecting bedrock or sub-cropping bedrock shown in Figure 43 include between KP4 and KP5, and on the West Angle Bay landfall, where the centre line runs over exposed bedrock. These areas have been highlighted where ROCK is either observable on the seabed or has been interpreted to be very near the seabed but not observable on SBP data. Areas where ROCK is present along the centre line are fully described in detail within the route listings in section 6.7.

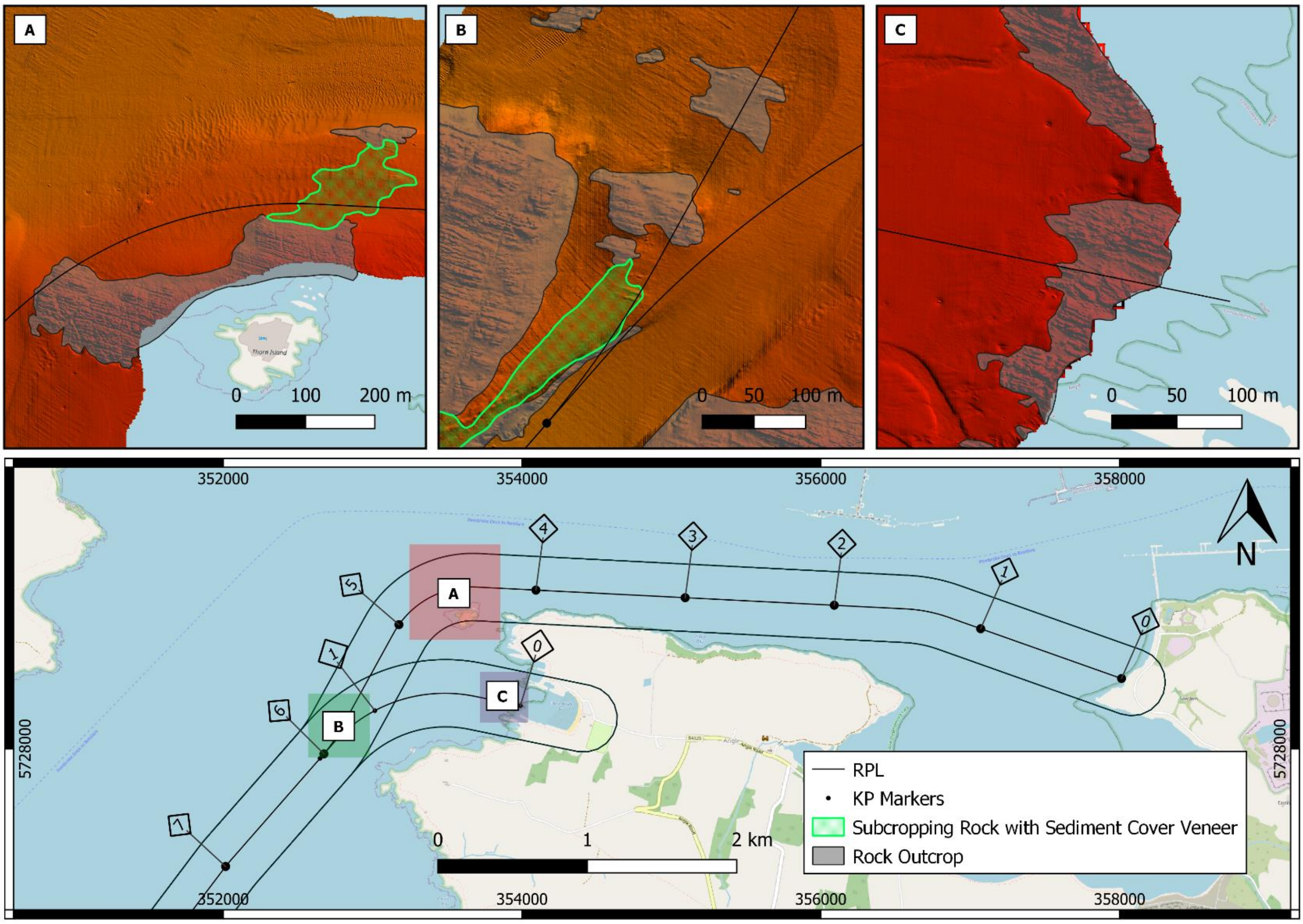



Figure 43: Instances of the Centre Line intersecting with outcropping or sub-cropping ROCK

### 7.4.5. Mobile Bedforms

Ripples, megaripples and sandwaves have all been identified along the main cable route. The relative sizes and classification methods for mobile bedforms have been described in Table 29. The presence of mobile bedforms can be indicative of seabed currents and/or wave motion within the area. However, no significant evidence has been observed of mobile bedforms migrating within the timeframe of the survey operations. In general, the observed ripples and megaripples have crests orientated approximately south west to north east. Sandwaves crests are generally orientated from south west to north east. However, variation along the route has been observed. Table 35 presents a summary of the key characteristics of sandwaves present along the cable corridor.

Table 36: Summary of Sandwave Features along the Cable Corridor

| KP Range | Average Crest Orientation | Symmetry | Average Stoss Direction | Maximum Amplitude | Wavelength |
|---|---|---|---|---|---|
| KP11 to KP13 | 64° | Slightly Asymmetric | 334° | 2.9m | Variable, 40-100m |
| KP16 to KP18 | 33° | Slightly Asymmetric | 123° | 3.1m | ~70m |
| KP18 to KP22 | Variable, 15-66° | Slightly Asymmetric | Variable, 105-156° | 5.9m | Variable, 45-185m |
| KP22 to KP24 | 67° | Slightly Asymmetric | 337° | 2.5m | Variable, 25-40m |
| KP33 to KP35 | 46° | Asymmetric | 316° | 7.0m | ~230m |

It appears from SBP data that the sediments associated with mobile features are loose surficial sediments. These sediments have formed a mobile layer that migrate over older, more consolidated sediments. The sediments are generally sandy but contain variable content of gravel and/or mud, and in some cases are primarily gravel based. Figure 44 demonstrates an area where these mixed gravelly, sandy sediments also demonstrate mobile bedforms.

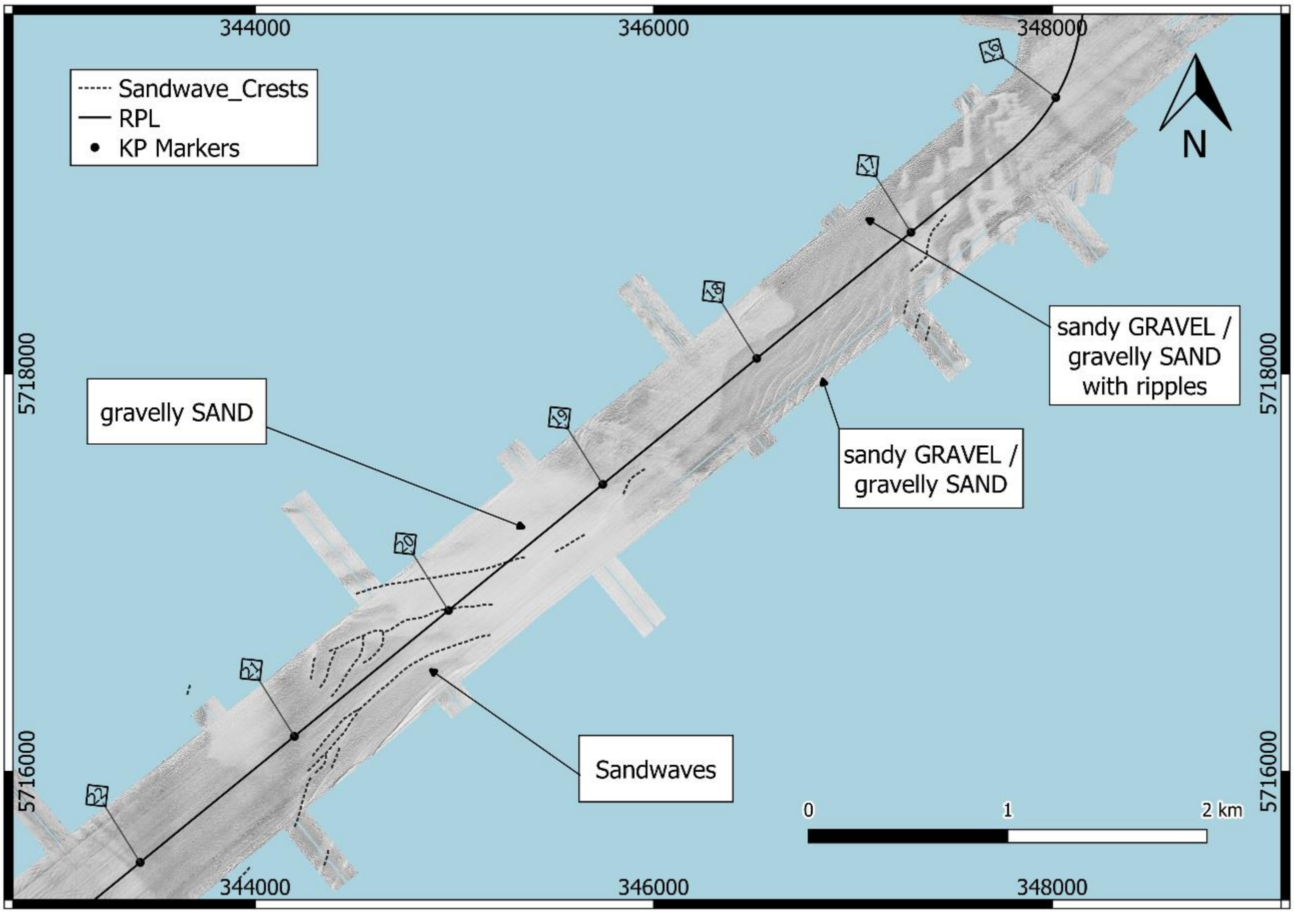



Figure 44: Side scan data example between KP16 and KP22

Sediment type varies intermittently across the section shown in Figure 44 and ripples exist across this whole area and are superimposed on megaripples and sandwaves in places. Isolated patches of gravelly SAND exist between KP16 and KP17, with sediment changes associated within swales between mobile features. Between KP17 and KP19, megaripples exist to the south of the centre line. However, in this case, no bedforms of significant height intersect the centre line.

Figure 45 illustrates the seabed profile along the centre line between KP19 and KP20. Two sandwaves intersect the centre line between KP19 and KP20, both measuring at approximately 2.5m in amplitude.  A third sandwave is present that does not intersect the centre line to the south east.

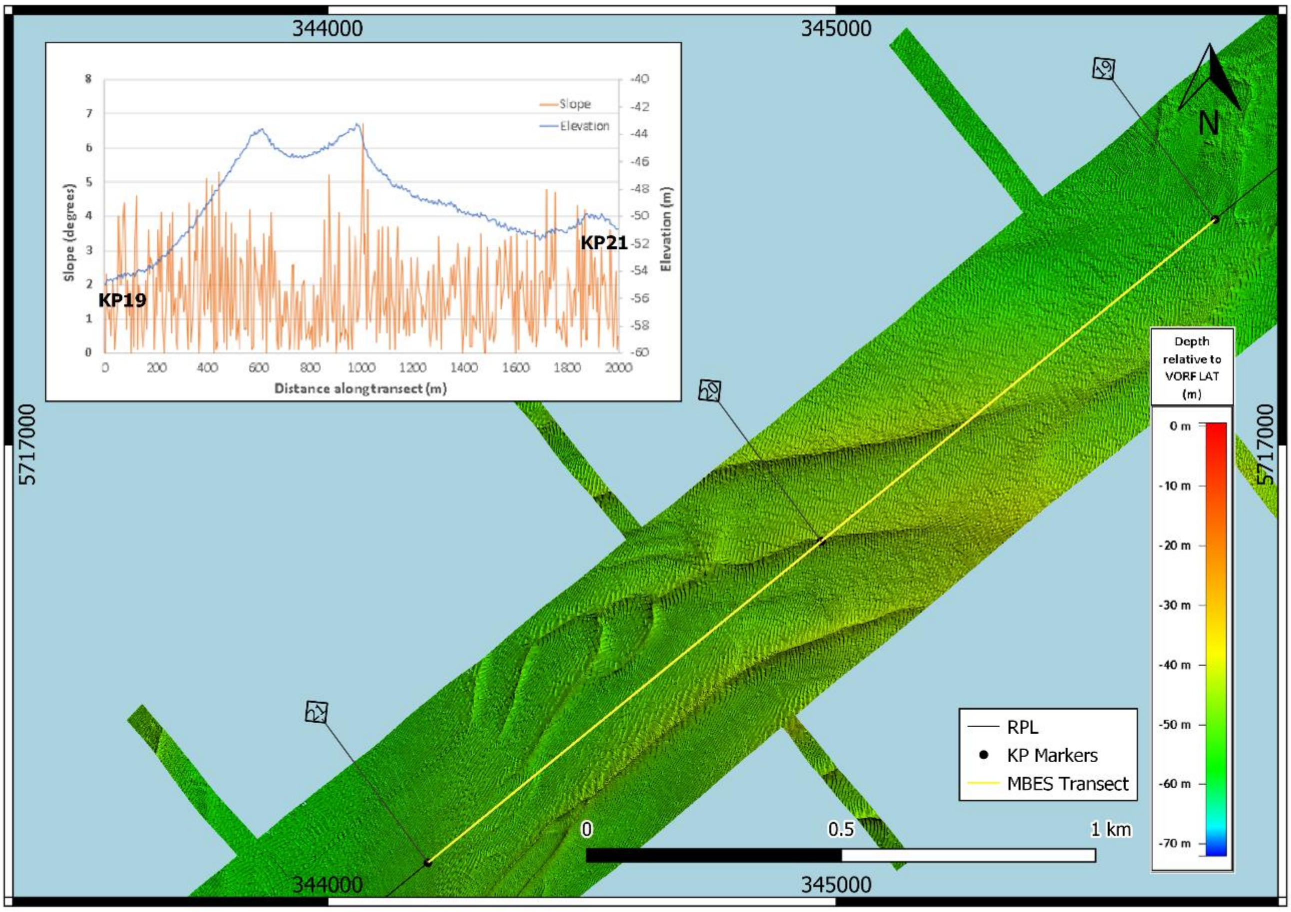



Figure 45: MBES profile across sandwaves between KP19 and KP21

Figure 46 shows second instance of sandwaves intersecting the centre line, with two more sandwaves crossing between KP33 and KP34. The most southern of the two sandwaves has the greatest height, measuring 4.3m in amplitude, whilst the other measures 3.2m. Slopes reach gradients of around 5.5° near the peak of the sandwaves.

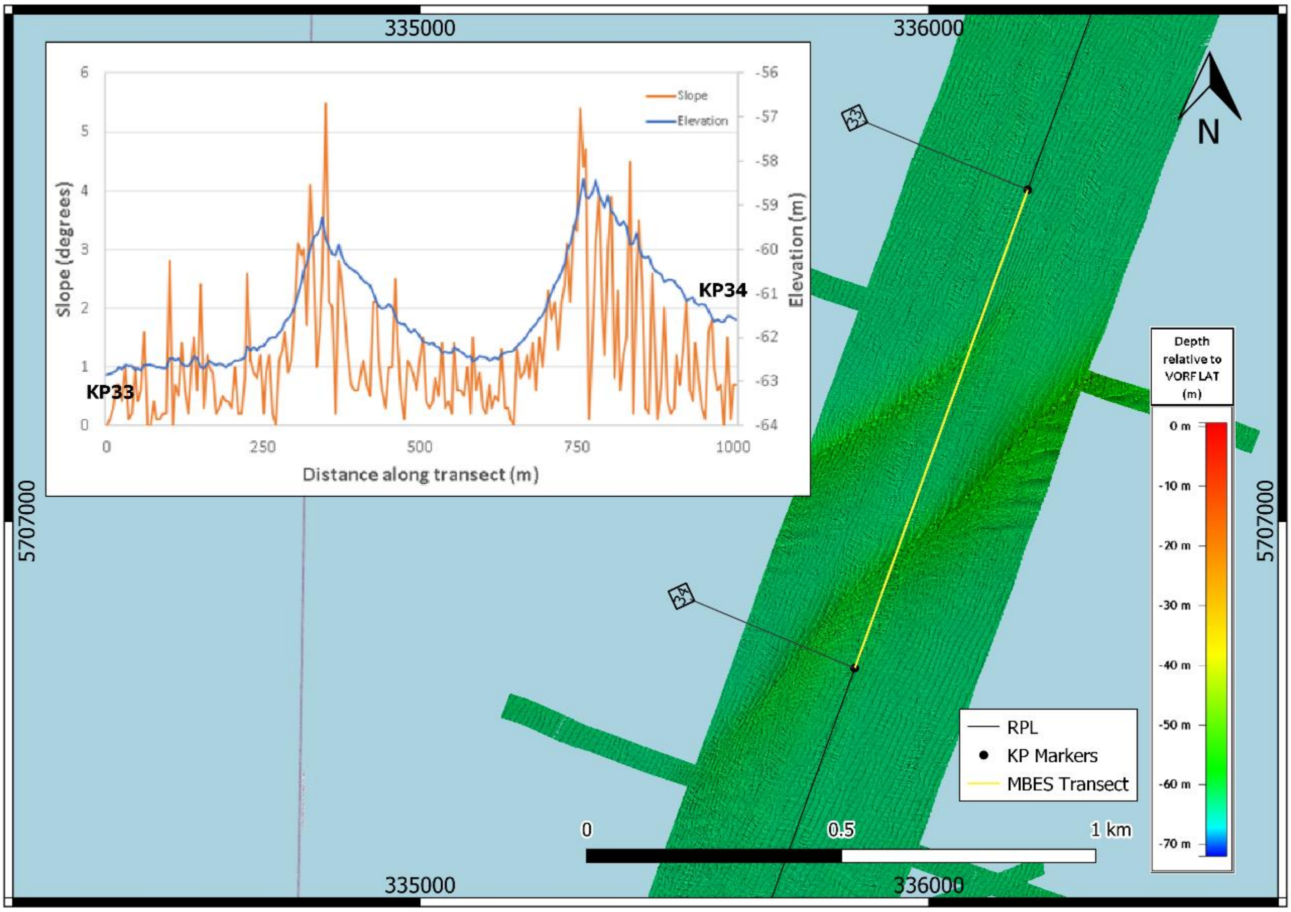



Figure 46: MBES profile across sandwaves present between KP33 and KP34

### 7.4.6. Seabed Imagery

Generally, seabed imagery correlated well with SSS however the ability to delineate between coarser sediments in the central area of the route and those sandier sediments furthest offshore using SSS was limited therefore DDV transects and PSD data were fundamental in determining the sediment / substrate type. The main assessment was conducted using the still images captured during the DDC deployments / DDV transects due to high turbidity levels, which reduces the resolution of analysis from the video imagery. The main habitats identified based on the seabed imagery are presented in Figure 47. Example imagery from each DDC station is presented in Appendix X, along with BSH description, and the EUNIS habitat description. The dive logs for all seabed imagery collected during HA and site characterisation transects are presented in Appendix XI and XII, respectively.

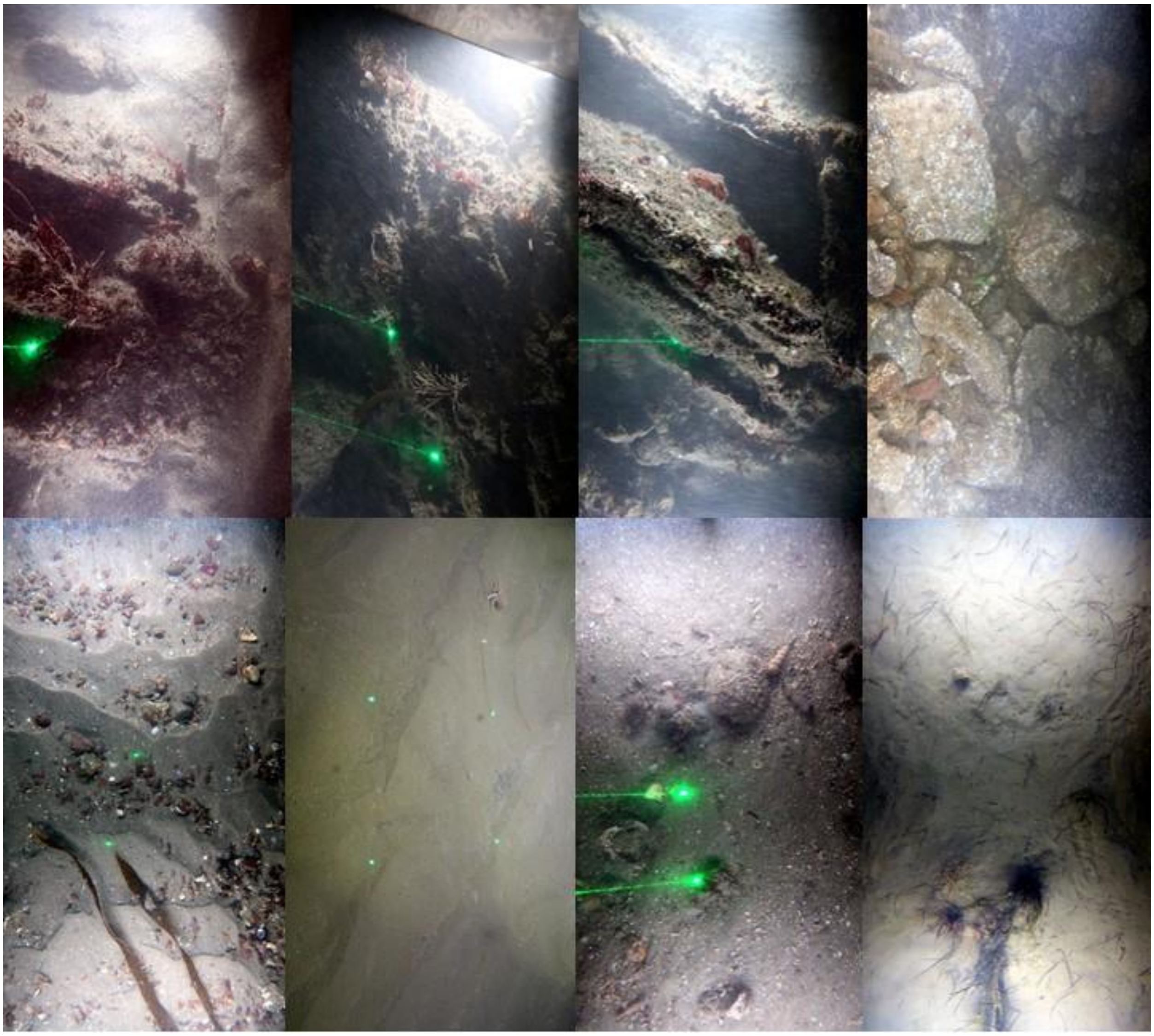


Figure 47: Example seabed imagery collected during the Erebus Floating Offshore Wind Farm Habitat Assessment Survey. Top row left to right: EUNIS biotope A3.12, A3.24, A4.13, A4.214. Second row left to right: EUNIS biotope A5.13, A5.25, A5.43 and A5.53.

## 7.5. Targets – Export Cable Route

1874 seafloor Targets have been identified on SSS and/or MBES datasets. All targets >0.5m in any dimension have been digitised and interpreted. Linear targets that measure >10m in length have also being digitised with a line to represent their extent. Significant targets such as wrecks have been digitised using polygons to represent their extent. Areas where boulders have been identified in densities >10 boulders per 10000m$^2$ have been digitised as a polygon area defining the extents of boulder fields. Table 36 provides a breakdown of the different classifications assigned to these seafloor targets.

Numerous items of debris have been interpreted to be fishing equipment, mainly distinguished by uniformly square shapes or multiple targets appearing in a linear path, often visibly appearing to be connected by rope.

Table 37: Breakdown of interpretation of identified targets on the Export Cable Route

| Interpretation | Quantity |
| --- | --- |
| Boulders | 1423 |
| Debris | 383 |
| Fishing Equipment | 17 |
| String of Fishing Equipment | 46 |
| Wreck | 1 |
| Suspected UXO | 1 |
| Unknown Floating | 3 |

The largest target encountered was 644m in length, interpreted as a string of fishing equipment. However, the largest single object identified was a length of cable 247.7m long that was observed on SSS and MAG datasets. This target is described further in Section 6.3.3. The maximum height of a target encountered on the cable route was a wreck in the nearshore area, measuring 3.4m from seabed. The wreck is further discussed in section 6.3.5.

710 primary magnetic targets have been interpreted on the MAG dataset of which 62 targets have been associated with seafloor targets. Targets with total amplitudes greater than 5nT on a magnetic residual field grid have been identified. Target correlation between seafloor and magnetic targets has been undertaken if targets lie within 5m of each other, or if it is interpreted that a causative body from further away is responsible for the observed magnetic field. Due to the line spacing between magnetometer passes it has not been possible to correlate all objects identified on the seabed with a magnetic target.

Additional to the primary magnetic contacts, 1108 magnetic signatures with amplitudes >5nT within regions of magnetic noise have been identified. Figure 48 shows two areas of interpreted magnetic noise, with a zoomed image on the northern area including the magnetic residual field grid. The grid shows a high proportion of the bounded area having residual magnetic amplitudes of >5nT and <-5nT indicating a reasonable response from these areas. However, they are not discrete, which leave ambiguity to their source and caused problems with interpreting a contact. This is compared with the residual field either side of the bounded area which show more yellow areas which highlight magnetically quiet areas where discrete targets can be identified.

It should be noted that 72 contacts of the 710 primary contacts lie within these magnetic noise areas and have been included in the main contact listing due to size or correlation with an object identified on the seafloor.

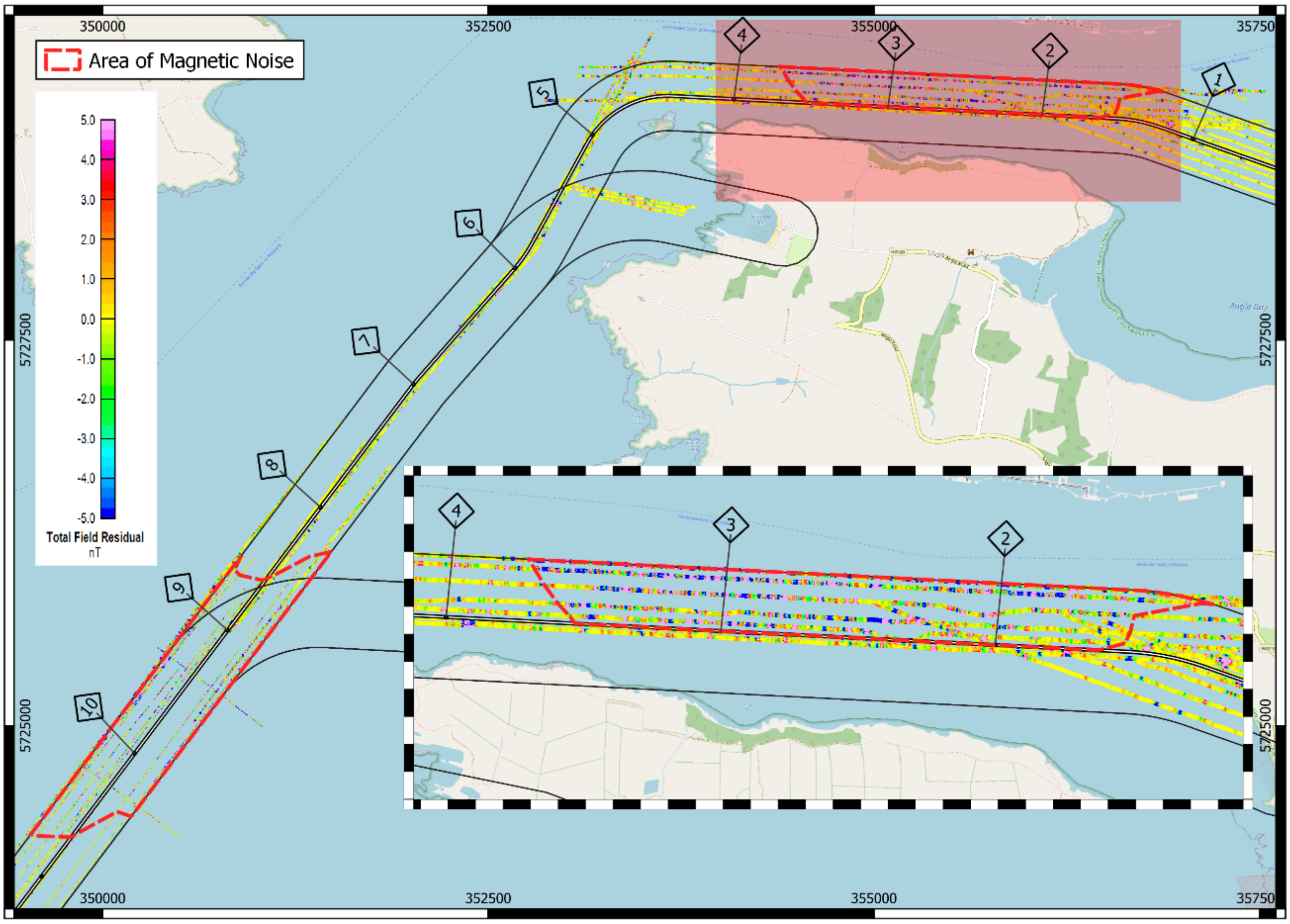



Figure 48: Interpreted areas of magnetic noise

The areas shown in Figure 48 seem to loosely correlate with boulder field areas shown in Figure 49. There is a possibility that the boulders in this area have a magnetic response. The surrounding terrestrial geology indicates the presence of Old Red Sandstone (IGS Solid Geology, 1983). Red Sandstone is known to have a component of iron oxide (BGS, 2015) which may well be generating the observed magnetic responses. Boulder fields present further along the centre line do not present such an issue with magnetic noise, reinforcing the observed locality relative to the Old Red Sandstone.

Given these areas and the current limited coverage of magnetic data, further magnetic survey work may be required.

The following sections highlight key contacts identified on the route.

### 7.5.1. Boulders

An overview of the boulders identified along the cable route is shown in Figure 49.

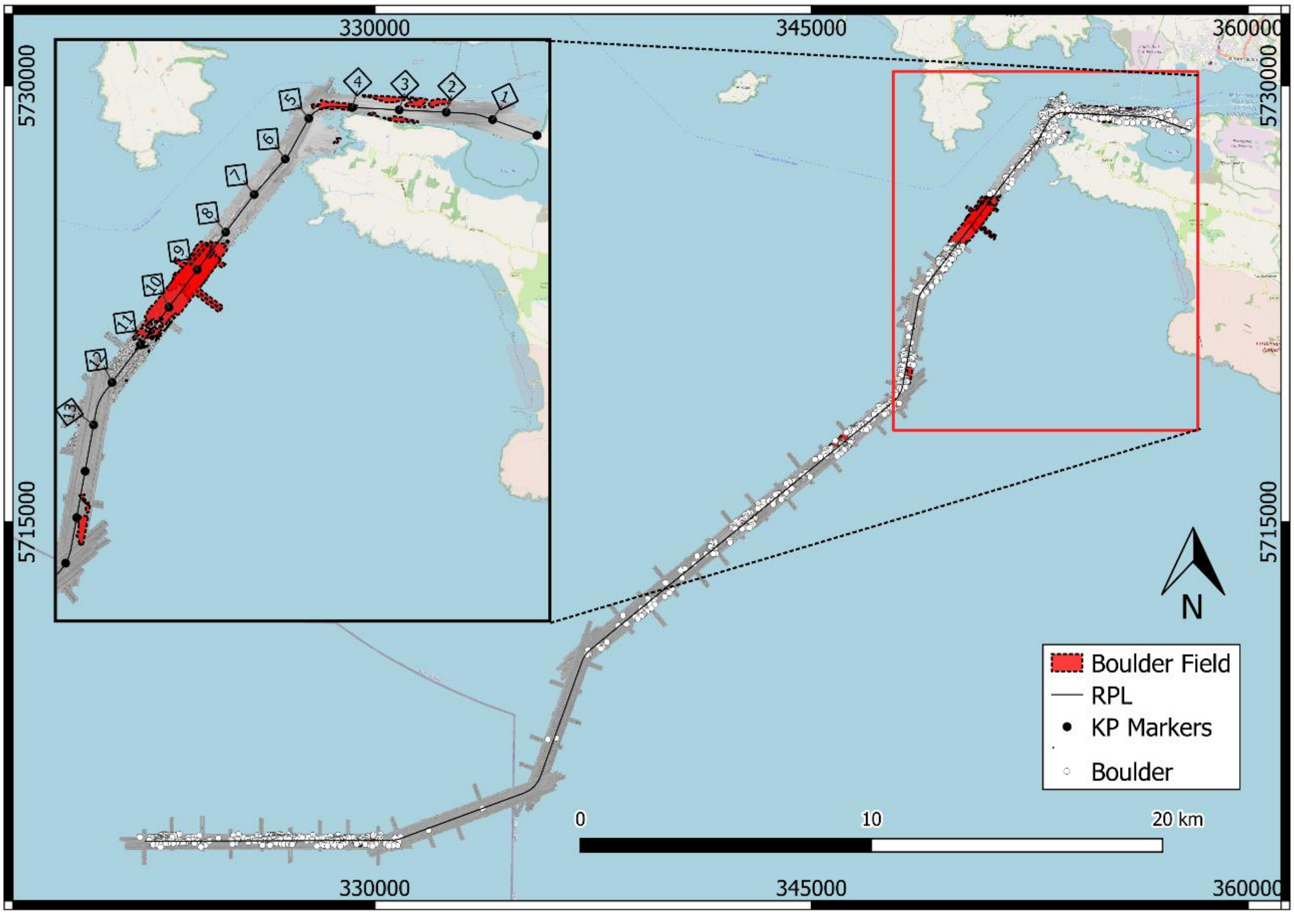



Figure 49: Overview of boulder fields and individual boulders along the cable route

Boulder fields with the largest extent were observed in the northern areas of the cable route, with the largest boulder field existing between KP8 and KP11. The centre line intersects this boulder field, which has an average boulder density of 37 boulders per 10000m$^2$, boulders smaller than 0.5m are included in this density if they were observed within the SSS dataset Other areas of high boulder density are between KP1 and KP6 within Milford Haven Waterway, as well as the far south of the cable route between KP40 and KP48.6. The tallest boulder measured was 2.53m, and the largest boulder measured was 4.54m. Both aforementioned boulders are a significant distance from the centre line.

Table 37 shows the number of boulders present within each size category presented. The single largest dimension has been used to categorise the data. The larger boulders may comprise of a group of boulders that are very close together that could not be identified individually from the SSS data.

Table 38: Distribution of boulder sizes present on the export cable route

| Maximum Boulder Dimension | Frequency |
|---|---|
| 0.5 - 1 | 508 |
| 1.0 -1.5 | 324 |
| 1.5 - 2.0 | 85 |
| 2.0 - 2.5 | 33 |
| 2.5 - 3.0 | 13 |
| 3.0 - 3.5 | 4 |
| 3.5-4.0 | 1 |
| 4.0 > | 2 |

Additional work was undertaken on the boulder field between KP8 and KP11. This significant boulder field intersected a large section of the cable corridor. An estimation of actual density values, based on contacts observable on the SSS mosaic, was made. The resultant product was a heat map showing approximate boulder density within the overall boulder field. This heatmap is presented in Figure 50. Whilst it shows that the majority of moderate density boulder field is unavoidable, it does highlight areas of higher density that can possibly be avoided.

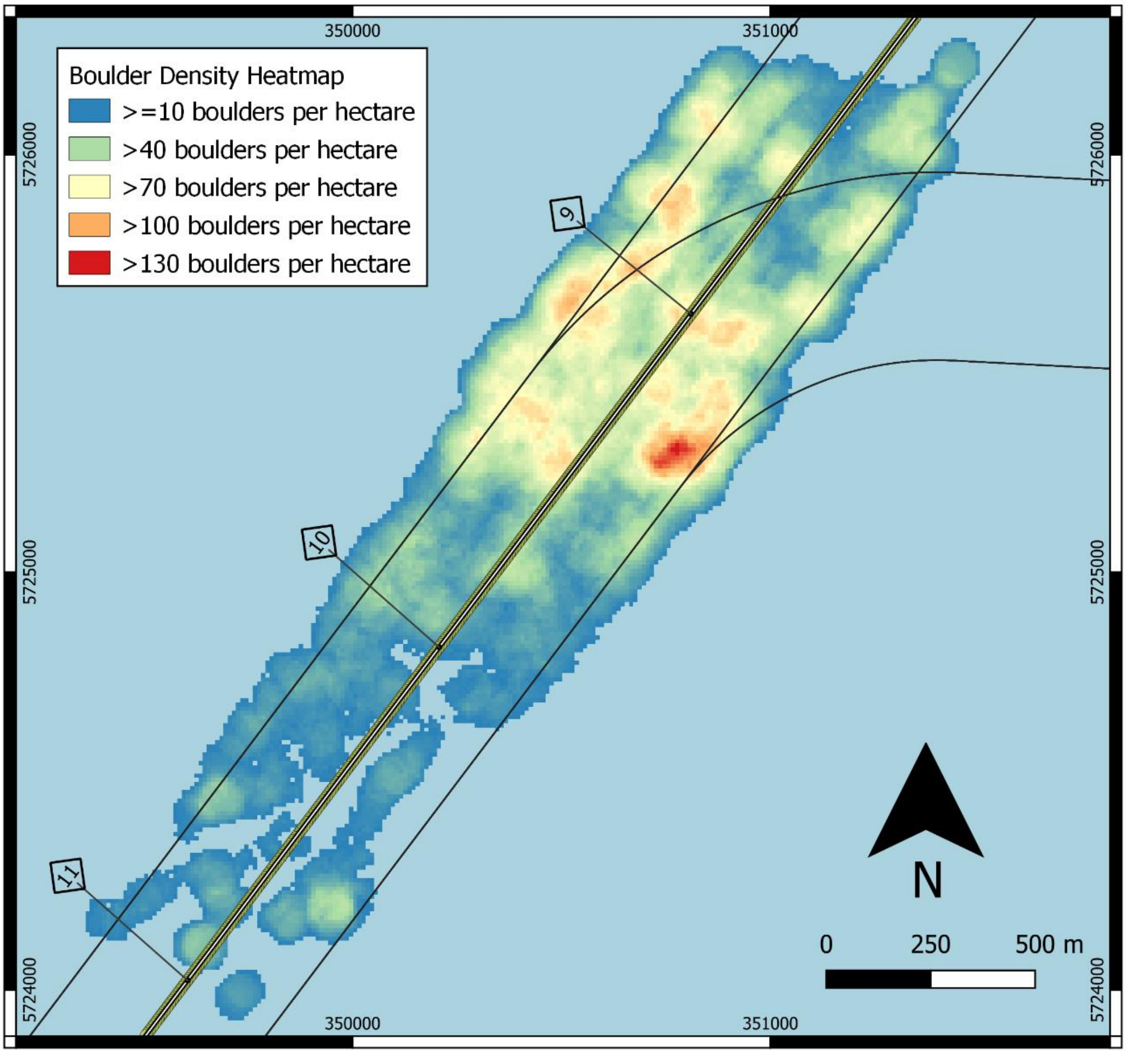



Figure 50: Boulder density heatmap between KP8 and KP11

### 7.5.2. Potential UXO

One potential UXO (pUXO) contact was identified on the cable route. Its position within the cable route and visual appearance in the SSS data can be seen in Figure 51. SFC_SZ_1296 was identified 50m south east of the centre line from KP18.275.

The target could not be correlated with magnetometer data due to line spacing and cannot be verified for ferrous content. The two closest lines detects a faint signature; however, the maximum measured amplitude was 0.8nT which was far less than the picking threshold of 5nT and not much higher than other noise signals present in the calculated residual field. However as mentioned the lines of magnetic data were approximately 10m offset from the target location, which would result in diminished detection. . The object displays characteristics which are similar to those of a moored mine, a large spherical object with a connected linear feature which can be seen. While no associated mine chair was seen, the object is flagged as a pUXO for potential future investigation.

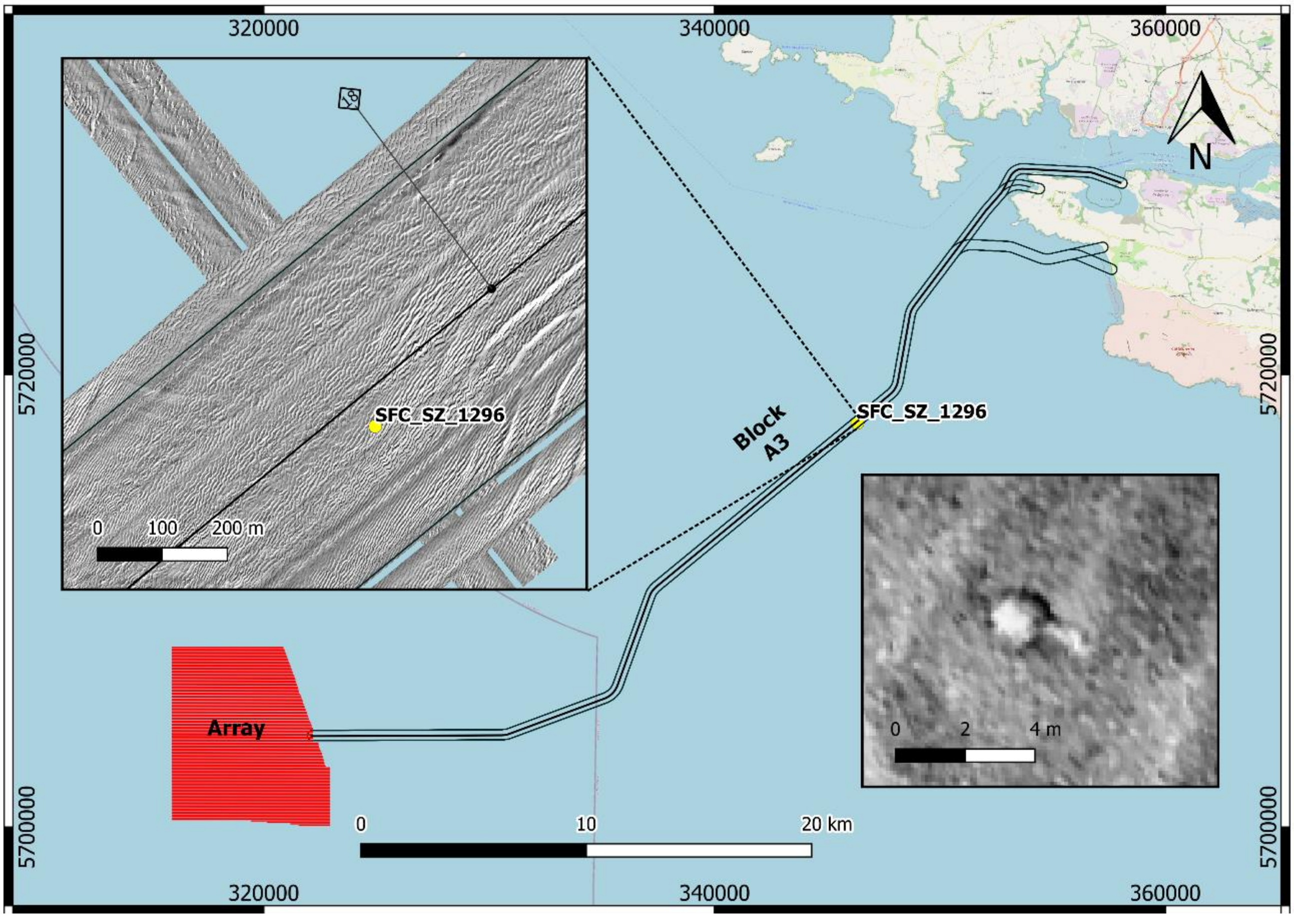



Figure 51: Location of pUXO Target "SFC_SZ_1296"

### 7.5.3. Fishing Equipment

A high density of fishing gear has been identified in the northern portion of the cable route. In Figure 52 the distribution of strings of fishing equipment is shown to be confined largely to Milford Haven Waterway, with a small number of items identified just offshore of the West Angle Bay landfall. Contacts that are visibly distributed in a line have been classified as 'String of Fishing Equipment'. In some cases, the connected line is observed on the sonar data. However, connecting line is not visible in all instances, but it is possible this is due to the orientation of the SSS lines not being optimal to insonify them. Isolated contacts with appearances similar to those seen in these strings have been classified as 'Fishing Equipment'.

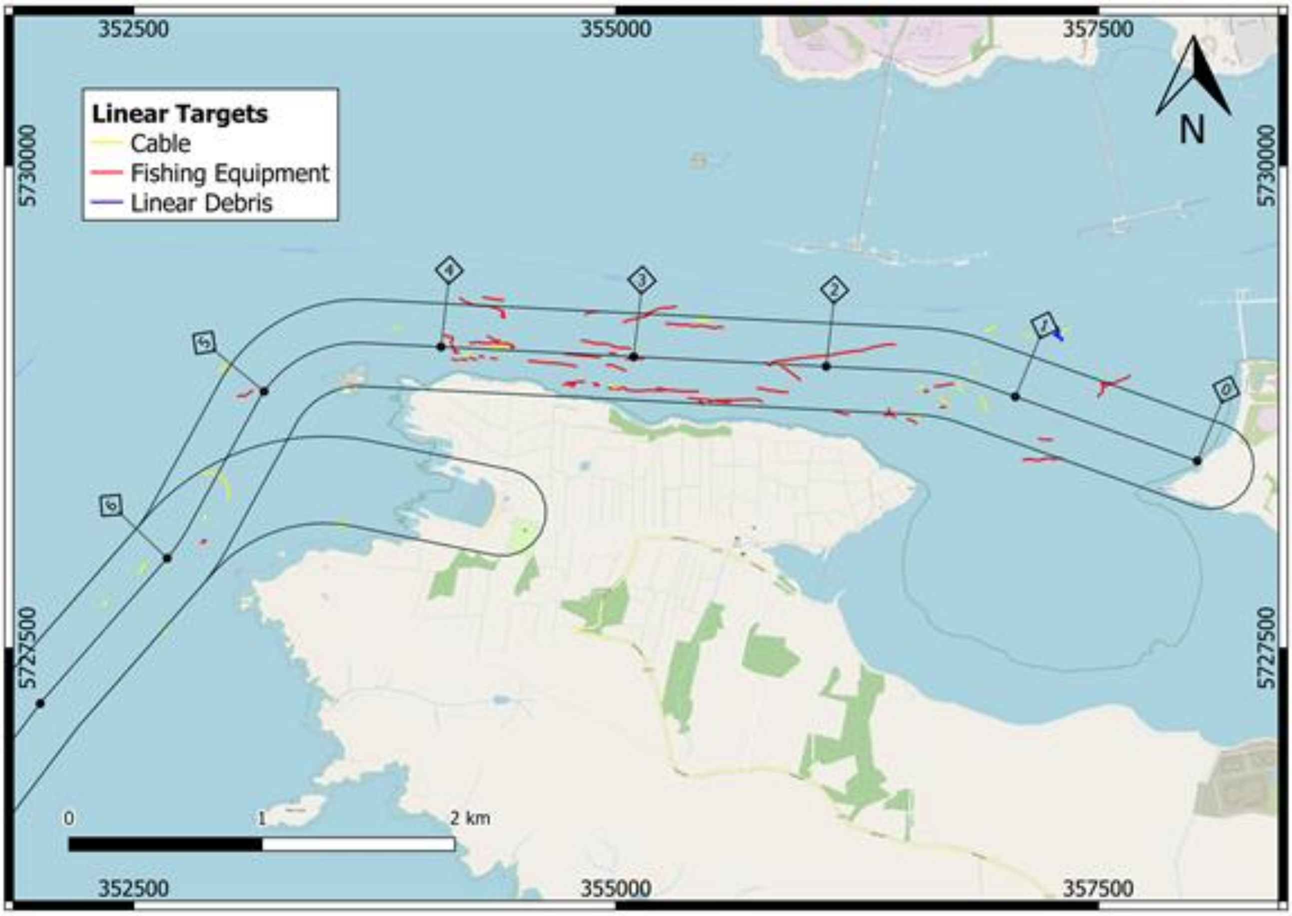



Figure 52: Distribution of linear contacts relative to the Centre Line

Figure 53 illustrates examples of both classifications. The isolated cages, shown in the left-hand image, typically exhibit straight edges and often appear square in shape. They also tend to display a clear and clean shadow. The contact pictured measures 2m x 2m, with 1.2m height.

The right-hand image in Figure 53 shows a string of cages with the shadow of the connecting line clearly visible between each cage. The longest string of fishing equipment identified was 644m (SFC_IS_0474).

There are two instances where linear contacts associated with fishing equipment intersect the centre line; linear feature associated with SFC_IS_0326 at KP3.937, and linear feature associated with SFC_IS_0566 at KP2.307.

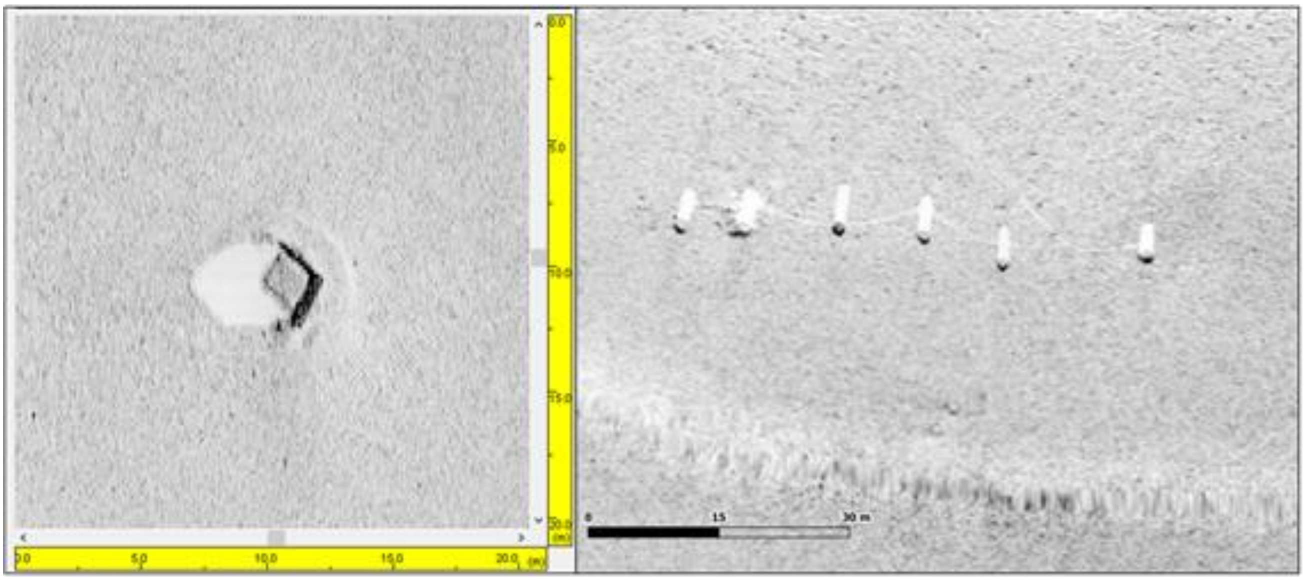



Figure 53: Examples of fishing equipment on SSS imagery

### 7.5.4. Interpreted Cable/Chain

One contact classified as cable or chain (SFC_IS_0870) measures 248m in length and 7cm in height and crosses the centre line at KP5.494. The magnetic residual field and the bathymetry grid of the target is shown in Figure 54.

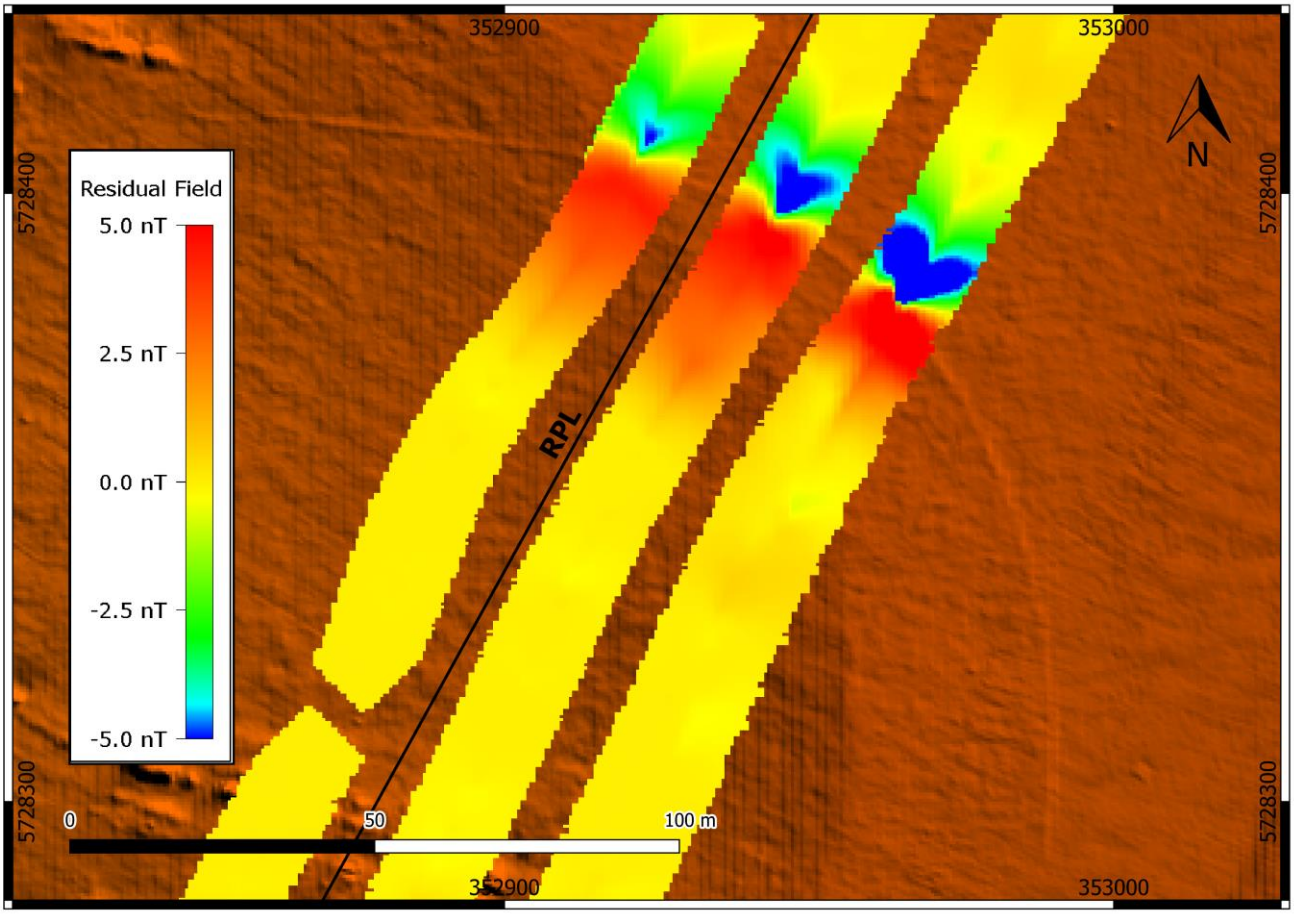



Figure 54: Cable debris intersecting the Centre Line

The presence of a magnetic response indicates ferrous content and leads to the interpretation of a cable or chain rather than rope. Background information does not reveal any known cables crossing the proposed cable route, so it is likely an item of debris.

### 7.5.5. Wreck

One wreck was identified in the nearshore area of data, shown in Figure 55. The wreck lies 80m north of KP2.420 from Sawdern Point. The wreck is observed in SSS, MBES and magnetometer data and has been identified as a known wreck (INSPIRE Wreck ID 12013) from the ADMIRALTY Marine Data Portal. The MBES data reveals that the wreck is 32m long, 14.5m wide and approximately 3.4m proud of the seabed.

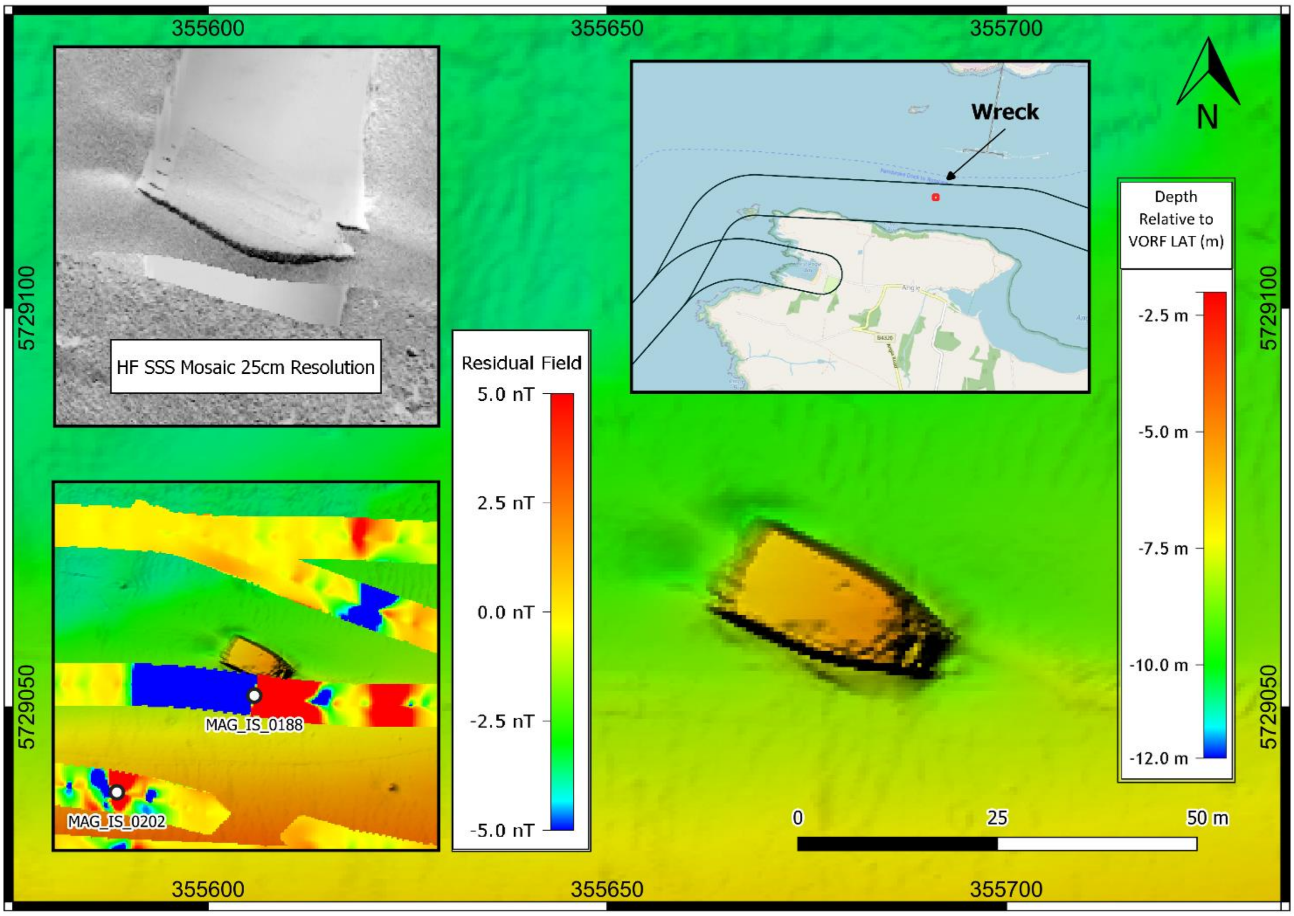



Figure 55: Wreck contact visible in three sensors: MBES, magnetometer and side scan sonar

### 7.5.6. Unknown Floating Objects

There have been three occurrences of unusual reflections and shadows in the SSS data. Due to the offset between the reflection and the shadow it can be determined that these objects are floating above the seabed, hence the term 'Unknown Floating' in the contact listing. It is possible that these features are caused by floating debris or marine life. These targets all feature a large shadow, without an obvious reflector. An example of this can be seen in Figure 56. The gap from reflector to shadow indicates these objects are floating. The reflectors of these targets have all been measured at around 6m in length.


Figure 56: Unknown floating object in SSS data (SFC_SZ_1519), shown on line A5_008

## 7.6. Targets – FLOW Site

1138 targets have been identified on SSS and/or MBES datasets withing the FLOW site area. All targets >0.5m in any dimension have been digitised and interpreted. Linear targets that measure >10m in length have also being digitised with a polyline to represent their extent. Areas where boulders have been identified in densities >10 boulders per 10000m$^2$ have been digitised as a polygon area defining the extents of boulder fields. Table 4 provides a breakdown of the different classifications assigned to these seafloor targets.

Table 39: Breakdown of interpretation of identified targets within the FLOW site

| Interpretation | Quantity |
|---|---|
| Boulders | 970 |
| Debris | 148 |
| Wreck | 1 |
| Unknown (MBES only target) | 19 |

Debris have been classified where target shape/size indicate possible anthropogenic origins or where targets have been associated with a magnetic target. Some items of debris have been able to be further classified specifically as tyres where the size, shape and double shadow have been observed on SSS data. In the case of targets that have only been identified from bathymetry data, where SSS data coverage was not achieved in the array area, it has not been possible to determine any interpretative details therefore they have been listed as unknown.

The largest seafloor target identified is 51.4m long with a measured width of 0.3m. and has been interpreted as a section of rope/cable discarded on the seabed. The wreck observed in the data is very small (5.5m primary dimension) but has an odd shape. Details of this contact can be found in section 3.4.2.

An overview of the distribution of seafloor contacts identified can be seen in Figure 57.

200 magnetic contacts have been interpreted on the MAG dataset of which four contacts have been associated with seafloor targets. Contacts with total amplitudes greater than 5nT on a magnetic residual field grid have been identified. Contact correlation between seafloor contacts and magnetic contacts has been undertaken if targets lie within 5m of each other, or if it is interpreted that a causative body from further away is responsible for the observed magnetic field. Due to the line spacing between magnetometer passes it has not been possible to correlate all objects identified on the seabed with a magnetic contact.

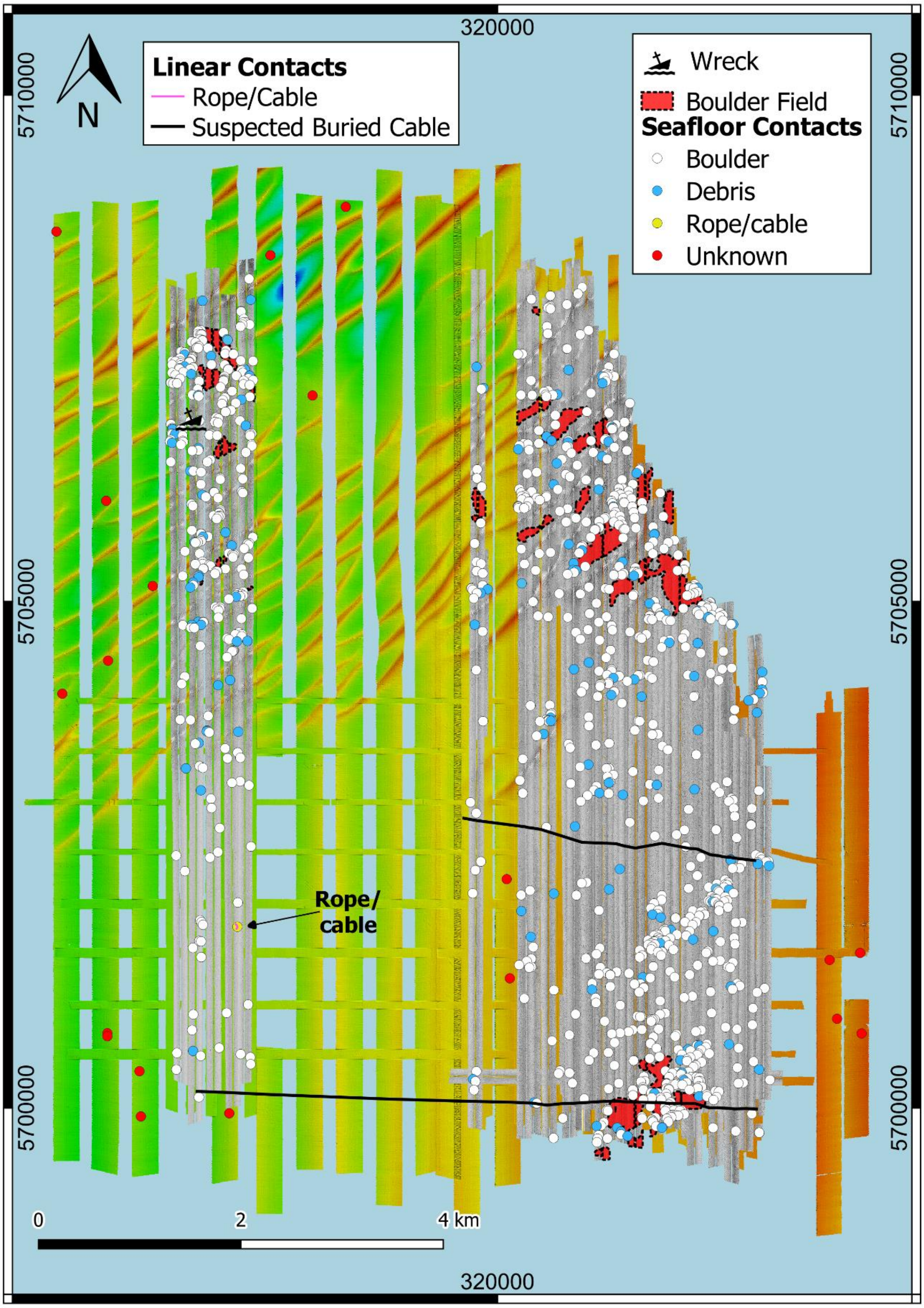



Figure 57: Overview of seafloor and linear contacts identified in the array area

### 7.6.1. Boulders

Figure 57 shows that boulders have been identified across the array area, where SSS data has been acquired, Table 39 shows the number of boulders present within each size category presented. The single largest dimension has been used to categorise the data. The larger boulders may comprise of a group of boulders that are very close together that could not be identified individually from the SSS data.

Table 40: Distribution of boulder sizes present on the array area

| Maximum Boulder Dimension (m) | Frequency |
|---|---|
| 0.5 - 1 | 508 |
| 1.0 -1.5 | 324 |
| 1.5 - 2.0 | 85 |
| 2.0 - 2.5 | 33 |
| 2.5 - 3.0 | 13 |
| 3.0 - 3.5 | 4 |
| 3.5-4.0 | 1 |
| 4.0 > | 2 |

### 7.6.2. Suspected Buried Cables

Two linear contacts have been interpreted from the magnetic dataset. These have not been observed on any other data and are hence considered to be buried. Cross checks with SBP data did not show any correlations, however this does not rule out buried features.

Figure 58 shows the location and extent of these two linear contacts with the magnetic residual field. The alignment of a number of contacts is unlikely unless there is a common causative body, leading to these interpretations. Confidence is higher in the southern cable interpretation as the magnetic targets present larger more consistent targets that are identifiable across all acquired data. The northern cable, whilst having some significant magnetic amplitudes, is less consistent in targets picked and target amplitudes and is also lost over a gap in the dataset near the middle of the site.

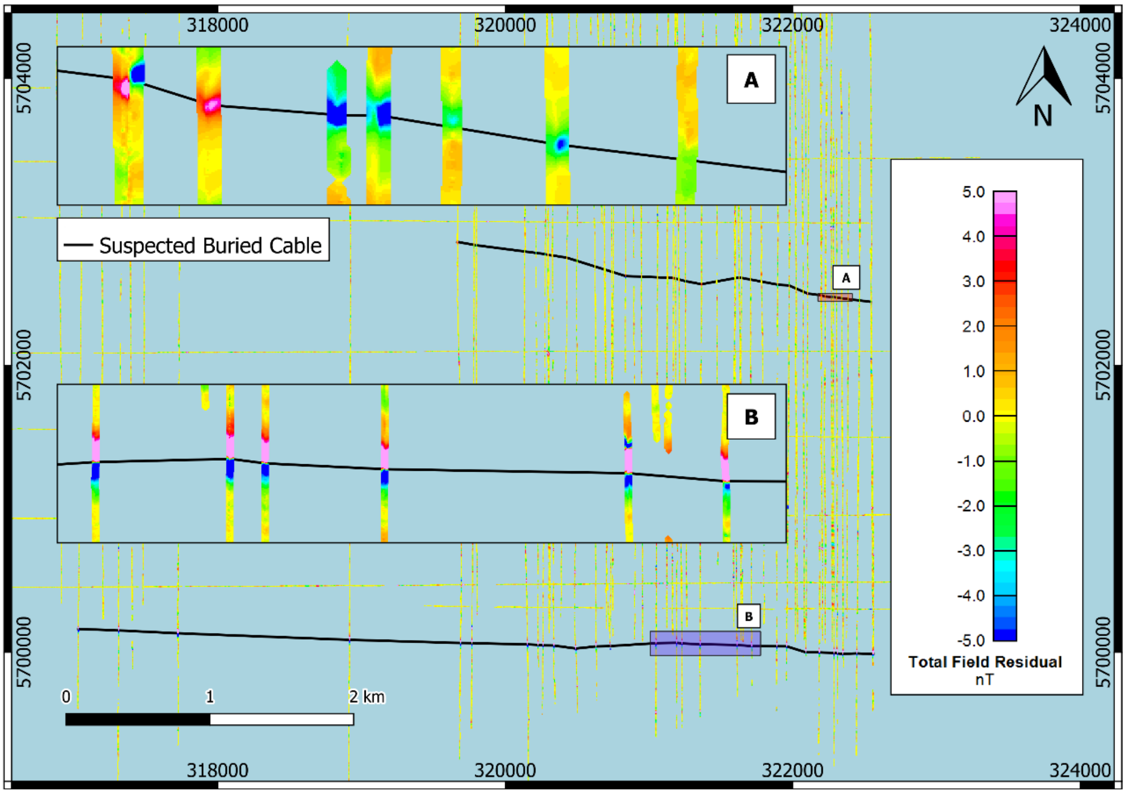



Figure 58: Overview of suspected buried cable contacts with magnetic anomaly data overlaid

No cable crossings have been found to correlate to these suspected cables using the EMODnet subsea cable database.

### 7.6.3. Suspected Wreck

The suspected wreck present in the array area has been interpreted due to its odd shape and size. Measuring 5.5m in length it is not likely to be a vessel, however it is much larger than an expected item of general debris. The initial reflection and subsequent shadowing suggest that the object is a cylindroid with a tapered section approximately two-thirds the way along the object where the object thins briefly. With a measured height <30cm, it is unclear if this object is partially buried and maybe larger than it appears on the surface. The target lies on the edge of a sandwave to the north so it is possible that it is partially buried beneath the flank of the bedform. The closest magnetic survey line is 90m east, which is too far to identify any correlation to magnetic data.

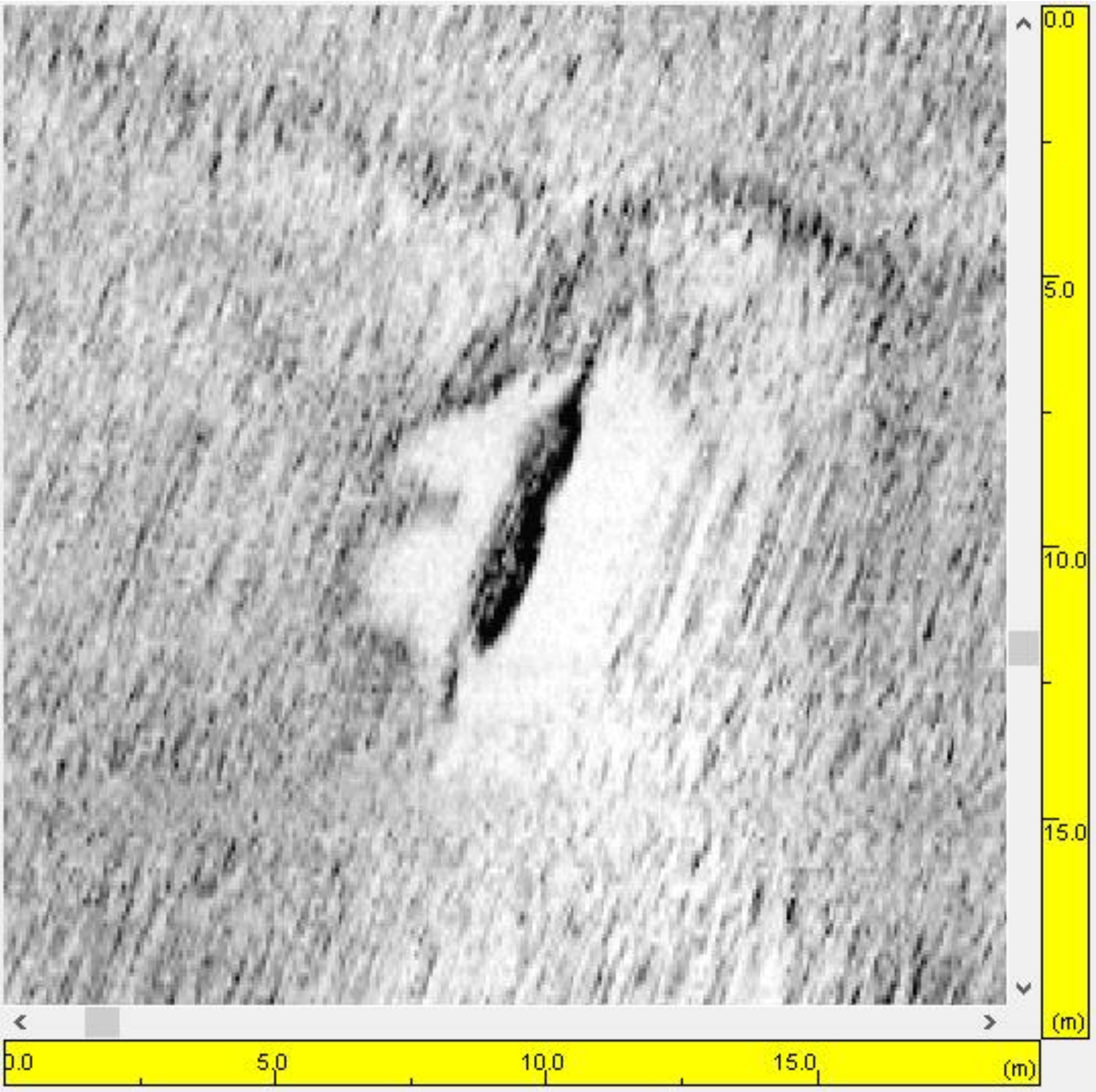



Figure 59: Suspected wreck identified on SSS data

## 7.7. Shallow Soils – Export Cable Route

The three units described in "5.1.2 Subsurface Interpretation" have been interpreted on SBP data to at least 10m depth below seabed along the cable route corridor. In most cases penetration allowed interpretation further than this. A detailed listing of the occurrence of the interpreted units along the centre line has been undertaken in section 6.7.

A profile of interpretation undertaken on the cable route is presented in section 7.7.7. Figure 77 visually summarises the SBP route conditions interpreted along the centre line in terms of depth to LAT and depth below seabed.
This section presents data examples and interpretation present along the cable route corridor.

### 7.7.1. Route Overview

Figure 60 shows an example of parametric echosounder (Innomar SBP) data along the centre line starting from Sawdern Point between approximately KP0 and KP4. H10 (Unit C - top of bedrock) is interpreted in green, H04 (Unit B - laminar internal) is interpreted in blue and acoustic blanking due to suspected shallow gas is highlighted in yellow. It is interpreted that a thin veneer of Unit A sediments exists on the surface throughout the nearshore of the centre line, however no consistently interpretable basal horizon is noted in the data.

Beneath this veneer exists a unit of subparallel bedded sediments, interpreted as SAND, the base of which is represented by H04. H04 remains flat with changes in thickness of the unit resulting from accumulation of overlying sediments, before terminating against the seabed above. There is no notable change in seabed characteristic noted where this unit outcrops, suggesting it is of similar composition to the overlying sediment. This unit is not observed again offshore from the point at which it appears to terminate at the seabed.

Below H04 exists a thickness of heavily laminated sediments, showing distinct and continuous internal strata. These sediments can be seen to fill depressions and channelisation in the underlying bedrock formations, with the reflectors at the base of the unit being visibly brighter than at the top. This suggests that sediment grain size could be fining upwards, with the coarser sediments making up the base of the channels. This is consistent with the interpreted deposition of these sediments within a fluvial setting. Acoustic blanking within this unit is observed, thought to be the result of trapped shallow gas, and is noted overlying the thickest sequences of channel infill.

The bedrock is seen to dip along the route, forming several large channels. The base of these channels are not always resolvable within the dataset, despite the bedrock being marked by a strong reflector for much of the section. This is likely due to the limit of penetration of the parametric system. However, the presence of acoustic blanking has also obscured interpretation in some of these areas. The bedrock is not seen to outcrop within this section of the cable route (KP0 – KP4).

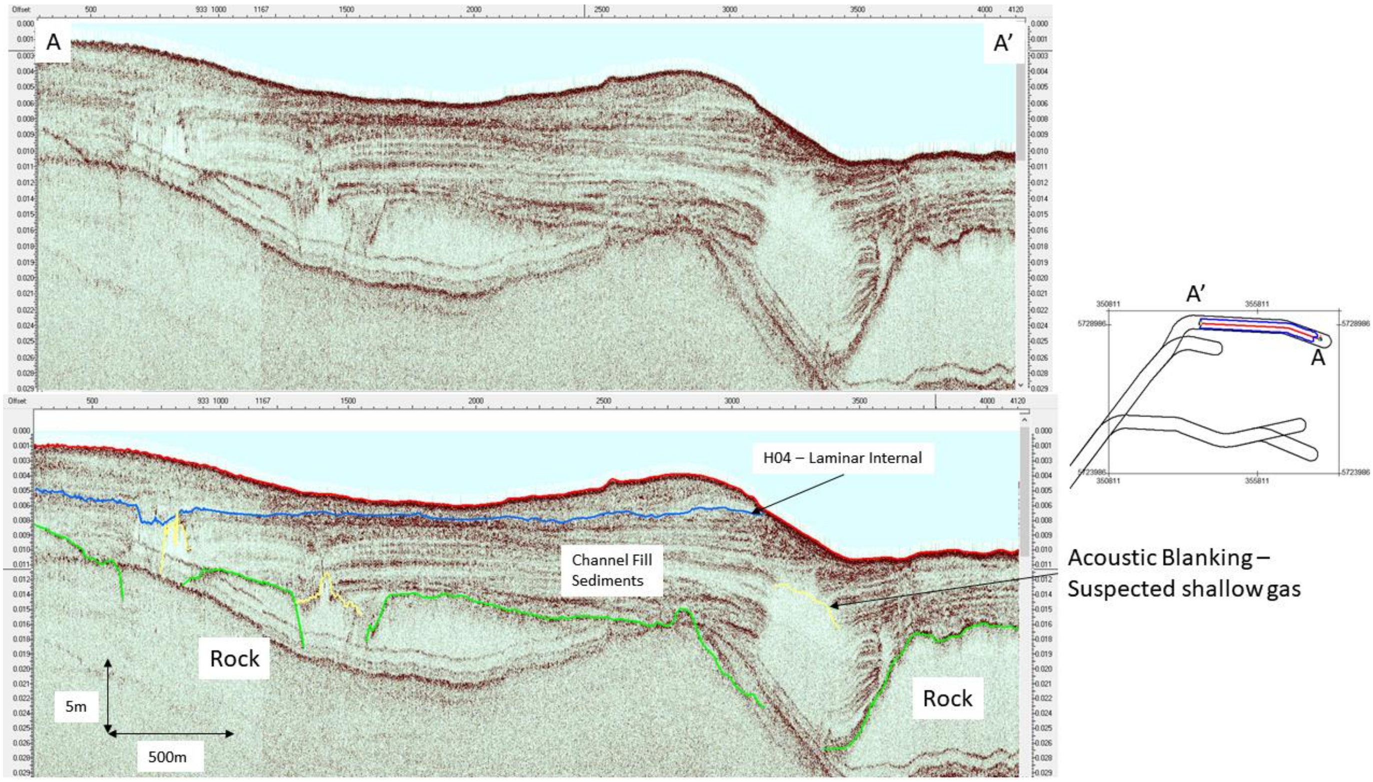



Figure 60: Parametric echosounder data example between KP0 and KP4

Figure 61 shows an example of sparker data along the centre line between KP2 and KP6 on the approach between Sawdern Point and the entrance to West Angle Bay. H10 is interpreted in green and H07 (top of coarse channel fill) in black. Throughout the nearshore region of the cable route, it is interpreted that a thin veneer of Unit A sediments exists, however these have not been consistently observed in the nearshore data to allow the interpretation of a coherent horizon.

Beneath this veneer are coarser fluvial sand and gravel deposits, associated with Unit B, which infills channels eroded into the underlying bedrock. Where the veneer of recent sediment dissipates, and the fluvial unit becomes more exposed, the seabed sediments are observed to be coarser and are often associated with large numbers of seafloor boulders. The top of the interpreted coarse channel fill horizon can be observed with distinctively higher amplitude reflectors in the deeper parts of the incised channels.

The bedrock outcrops at several points along this nearshore section. The bedrock reflector itself is acoustically weak, possibly due to weathering and the typically high incidence angle on the channel edges. The expected higher amplitudes from the bedrock appear where the horizon is less chaotic and gently sloping. Acoustic blanking is observed in Figure 61 and is interpreted to be the result of shallow gas accumulation.

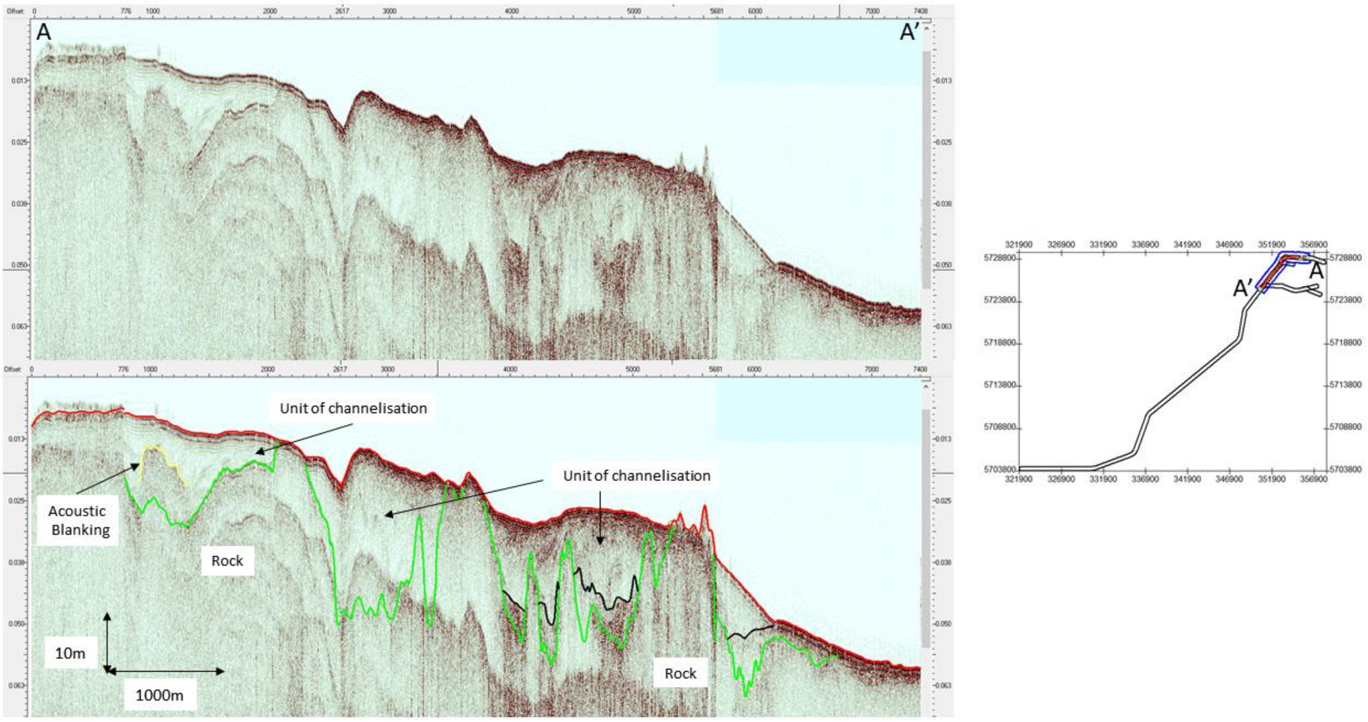



Figure 61: Sparker data example between KP2 and KP6

Figure 62 shows an example of sparker data along the centre line between KP6 and KP30. H05 (Unit A - base of surficial sediments) is interpreted in blue, H06 (Unit B - top of channel fill) in black, H10 (Unit C - top of bedrock) in green. For much of the section, the bedrock is interpreted to be close to the seabed running simultaneously with the base of surficial sediments, which form mobile features that migrate along the bedrock surface in this area.

Further offshore, the bedrock deepens as it is incised by a channel feature, infilled by fluvial sediment. The overlying surficial sediments thicken more consistently from this point. The depth of this channel below the seabed reaches a maximum of 47.7m.

Within the channel fill sediments exist a strong internal reflector marked by H06. It is interpreted that this horizon marks the final preserved instance of channel erosion within the channel fill sediments. Figure 62 shows a strong flat reflector interpreted as H06, towards the southern extent of the example, which is truncated by a channel to the north. It is interpreted that sediments above H06 have been deposited after a hiatus or change in depositional setting and not subjected to any further fluvial erosion. Sediments above H06 are interpreted to be the reworked glacial material that has filled the underlying erosional surface without being exposed to fluvial processes. It is possible that this layer is a result of marine transgression which has reworked the existing channel fill and possibly added eroded material from nearby glacial material.

Figure 63 shows an example of sparker data along the centre line, continuing from Figure 62 between KP30 and KP48.6 which is the end of the cable route. Horizons shown in this figure are the same as described in Figure 62. Here the top of bedrock is initially observed to form a short-lived plateau before undulating heavily, forming multiple channels filled with interpreted fluvial deposit.

At the edge of the channel, the infill sediments truncate on the bedrock, leaving a layer of the reworked sediments above H06 overlying the bedrock covered by a small thickness of surficial sediments. In places the surficial sediments thin to a veneer, and in other parts of the route away from the centre line the veneer thins completely thus exposing the coarse and often boulder laden sediment that comprises the interpreted reworked outwash sediments to the seabed. The channel infill sediments in this area can be observed to be largely acoustically featureless and chaotic.

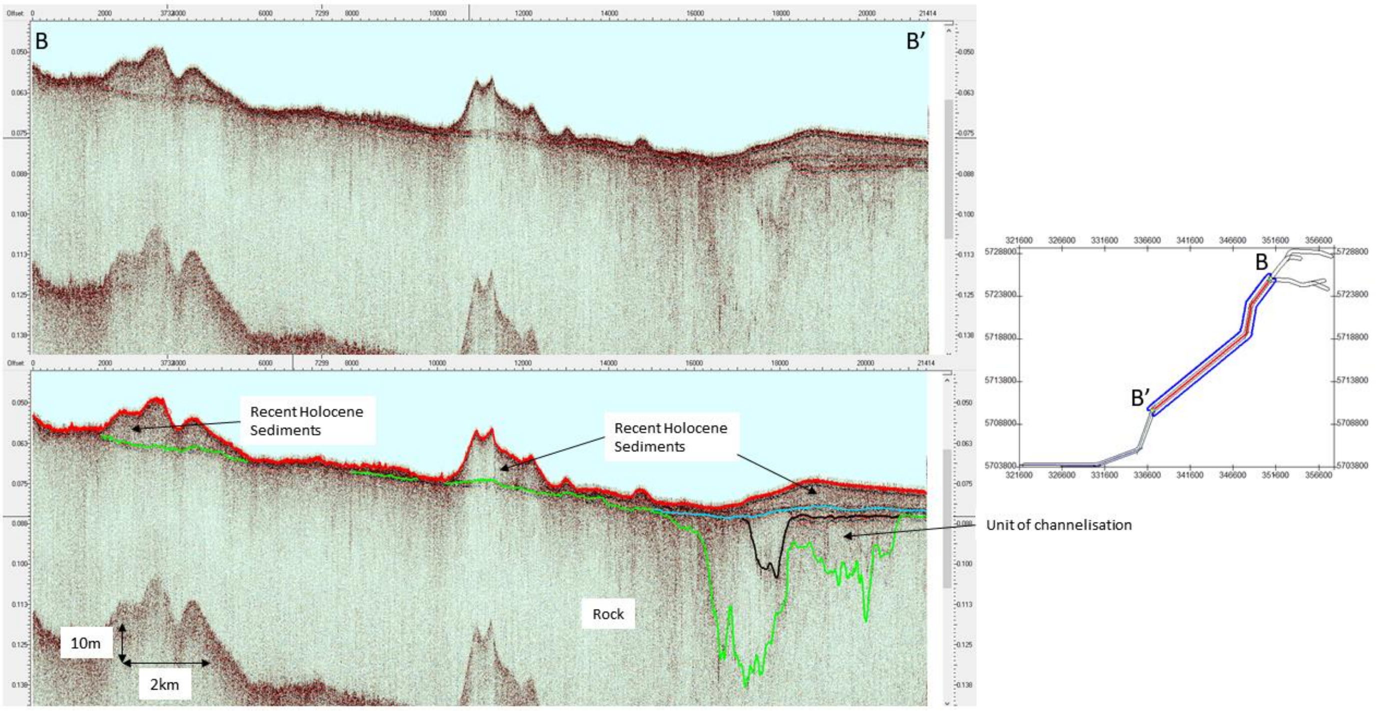



Figure 62: Sparker data example between KP6 and KP30

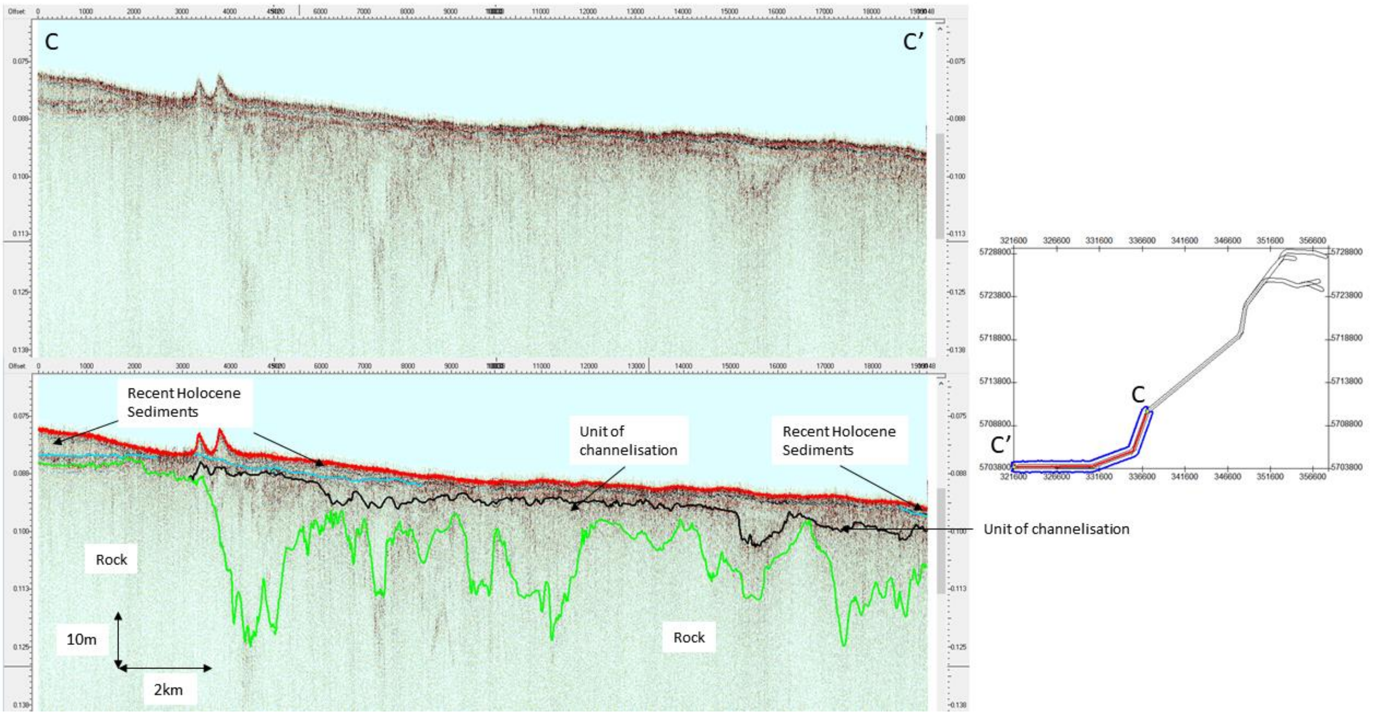



Figure 63: Sparker data example from the offshore section of the cable route

### 7.7.2. Unit B - H04 Laminar Internal

H04 represents an internal reflector that was continuously observed in the nearshore portion of the survey corridor. Figure 64 shows the depth and extent of the interpretation for this horizon. It has been interpreted near the top of a sequence of parallel to sub-parallel reflectors that have been interpreted as estuarine deposits from the river flowing into Milford Haven Waterway. This internal reflector is isolated to the nearshore region of the cable route, with a depth range from 0 – 5.9m. Some areas of the unit are poorly imaged, relating to acoustic blanking due to suspected shallow gas. The unit truncates on the seabed above with a maximum westward extent of KP3.235. A data example of the interpreted reflector and the surrounding sediments is shown in Figure 65.

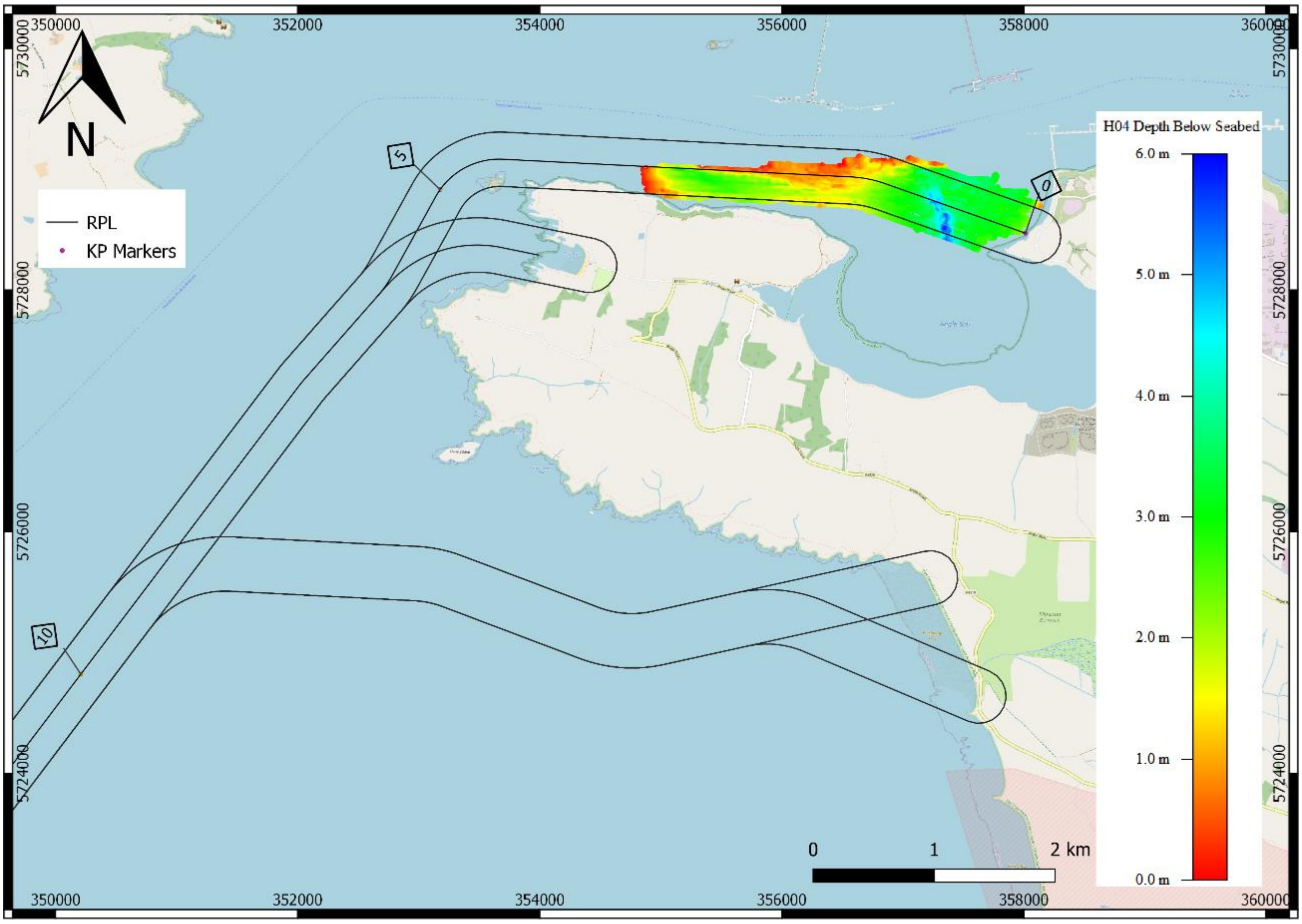



Figure 64: H04 Laminar Internal, depth below seabed grid

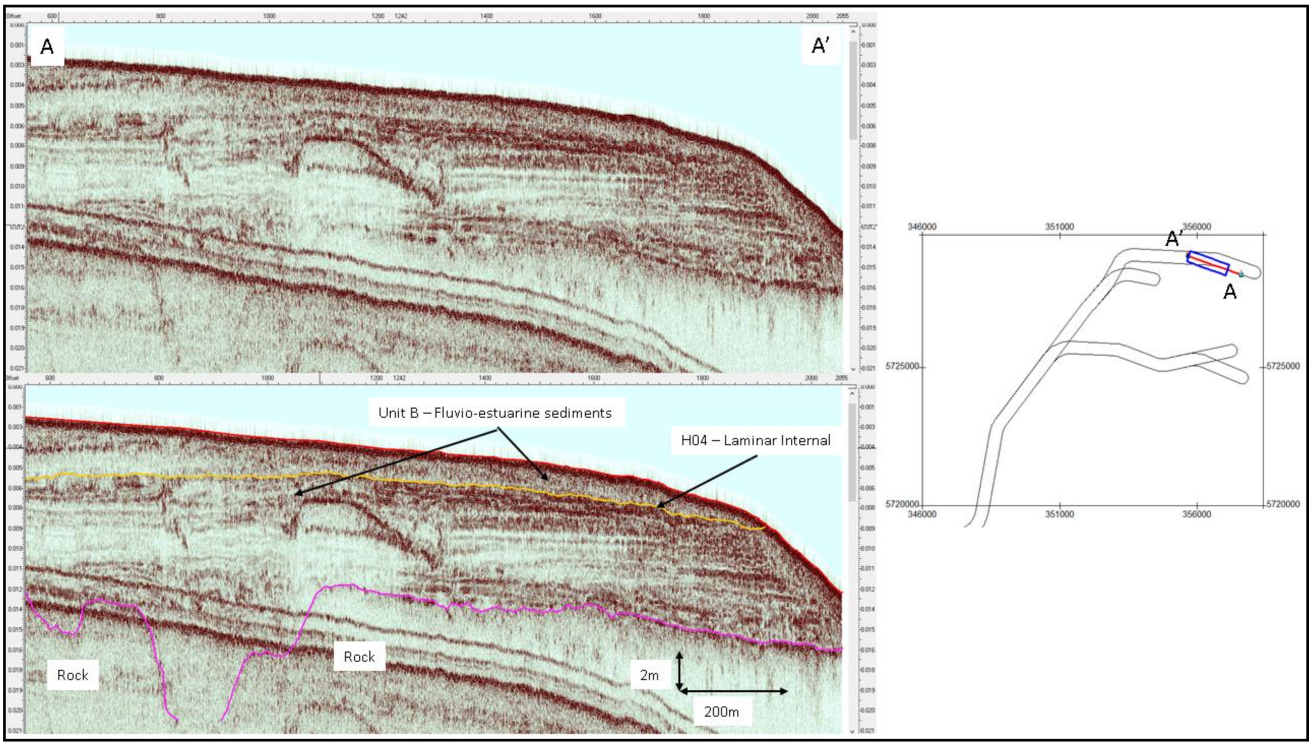



Figure 65: SBP data example showing interpretation of H04

### 7.7.3. Unit A - H05 Base of Surficial Sediments – Export Cable Route

H05 represents the base of surficial sediments, which in places has accumulated into mobile bedforms. Figure 66 shows the depth and extent of the interpretation for this horizon. Increases in the unit thickness of these surficial sediments are attributed to accumulations of larger scale mobile sediments such as sandwaves rather than deepening of the basal reflector. Generally, across the extent of this horizon some form of bedforms are present. Depth below seabed to the base of the recent marine sediments range from veneer to a maximum of 15.9m. Whilst the extent of interpretation is limited from approximately KP10 to the end of the cable route, it is expected that intermittent veneers of surficial sediments are present from KP10 in the nearshore, however a continuous reflector for this has not been observed.

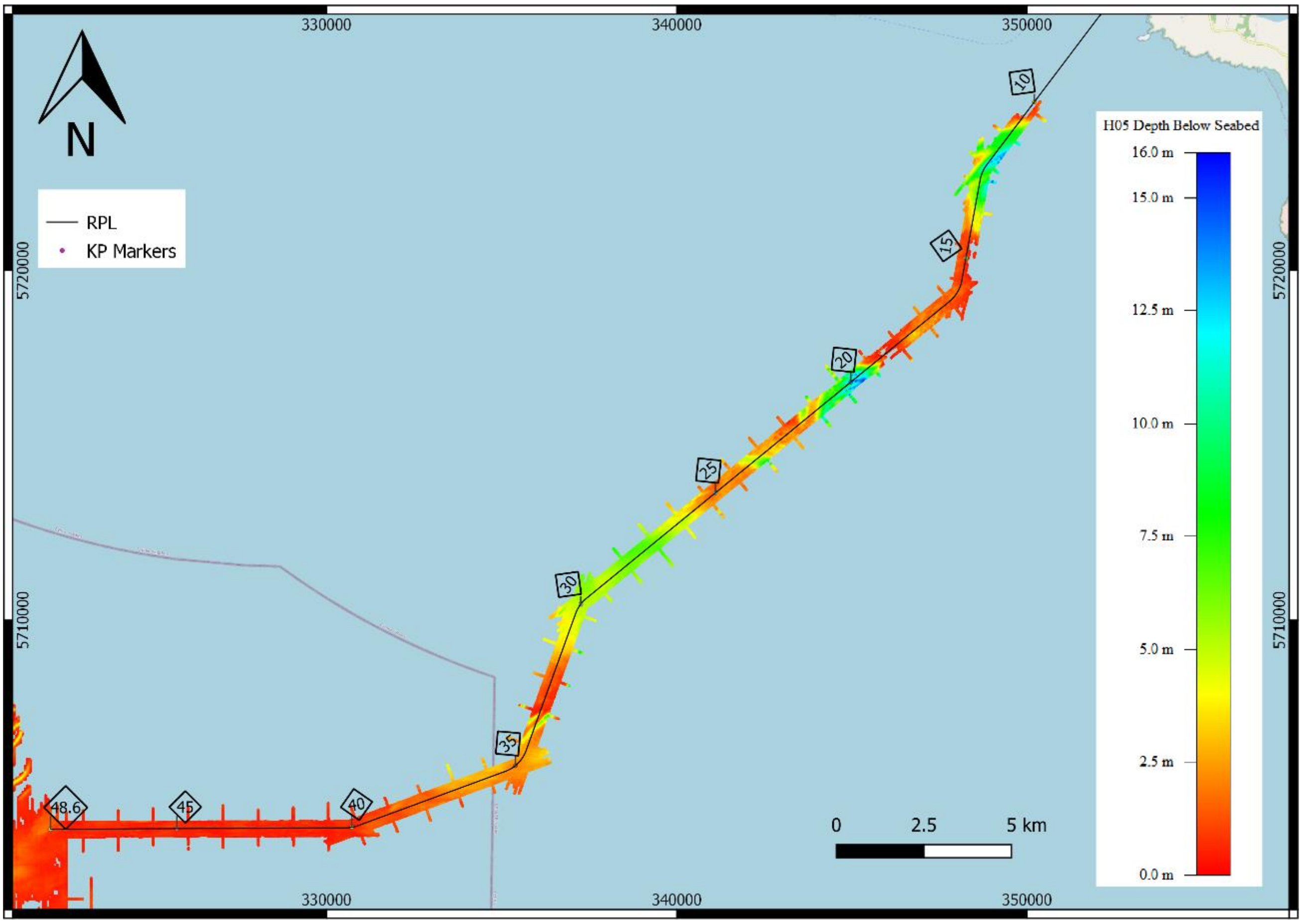



Figure 66: H05 Base of Surficial Sediments, depth below seabed grid

Areas where H05 is seen to terminate on the seabed tend to relate to regions of increased seafloor boulder density. This is due to the exposure of the underlying coarse reworked sands and gravels of the reworked sediments defined by H06 which appear to include numerous boulders. Examples of this are present between KP14 and KP20 which are shown in Figure 67 where the H05 reflector becomes uninterpretable as it approaches the seabed indicated by the gaps in the grid. At these locations there is strong correlation with the interpretation of boulder fields.

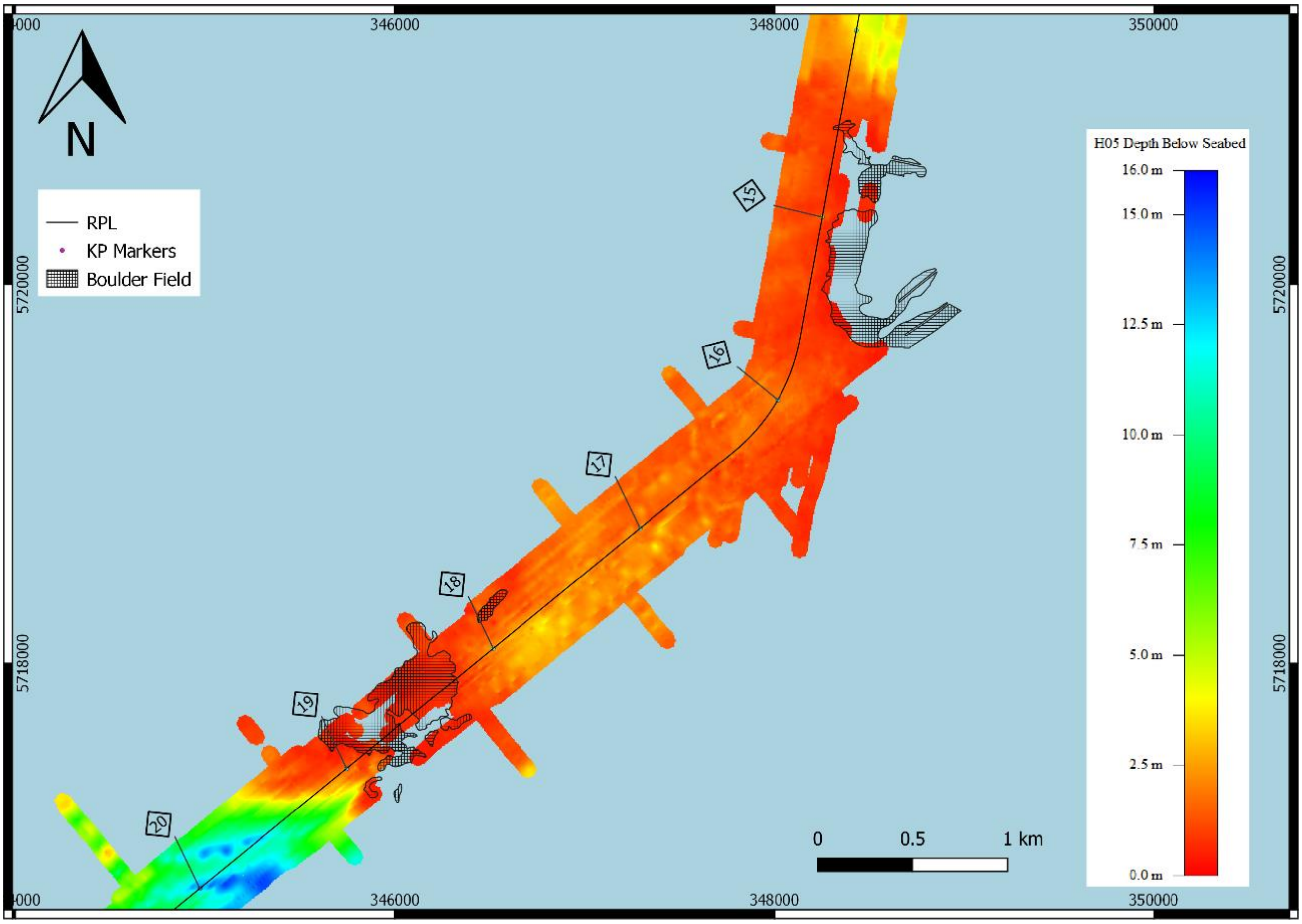



Figure 67: H05 Base of Surficial Sediments, interpretation limits on depth below seabed grid

A data example of the interpreted reflector and the surrounding sediments is shown in Figure 68.

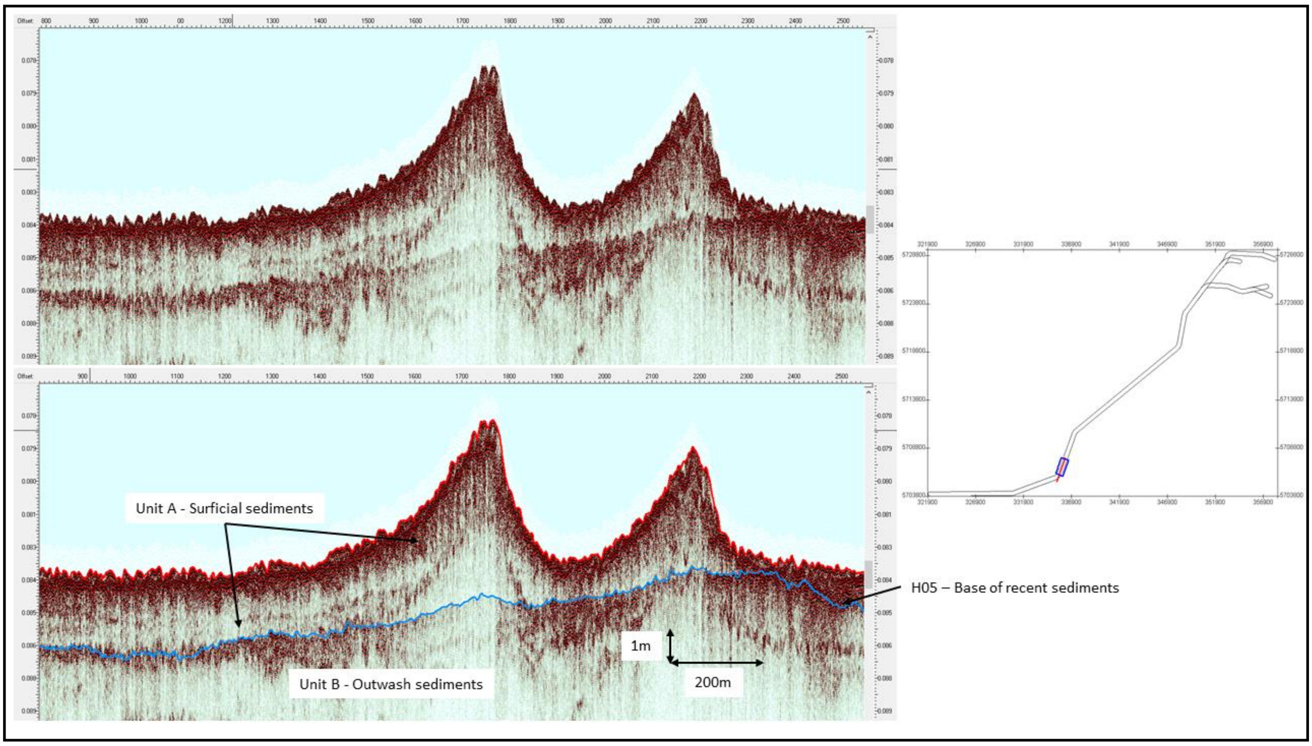



Figure 68: SBP data example showing interpretation of H05

### 7.7.4. Unit B - H06 Top of Channel Fill – Export Cable Route

H06 represents the top of channel fill that marks the interface between the underlying channel fill sediments and reworked material interpreted above. It is likely composed of reworked till material given its coarse composition as interpreted from areas of exposure. Figure 69 shows the depth and extent of the interpretation for this horizon. This unit shows a generally very gently undulating surface, but the sediment has filled some deeper channel features in places. The horizon terminates against the base of the surficial sediments at KP25.915.

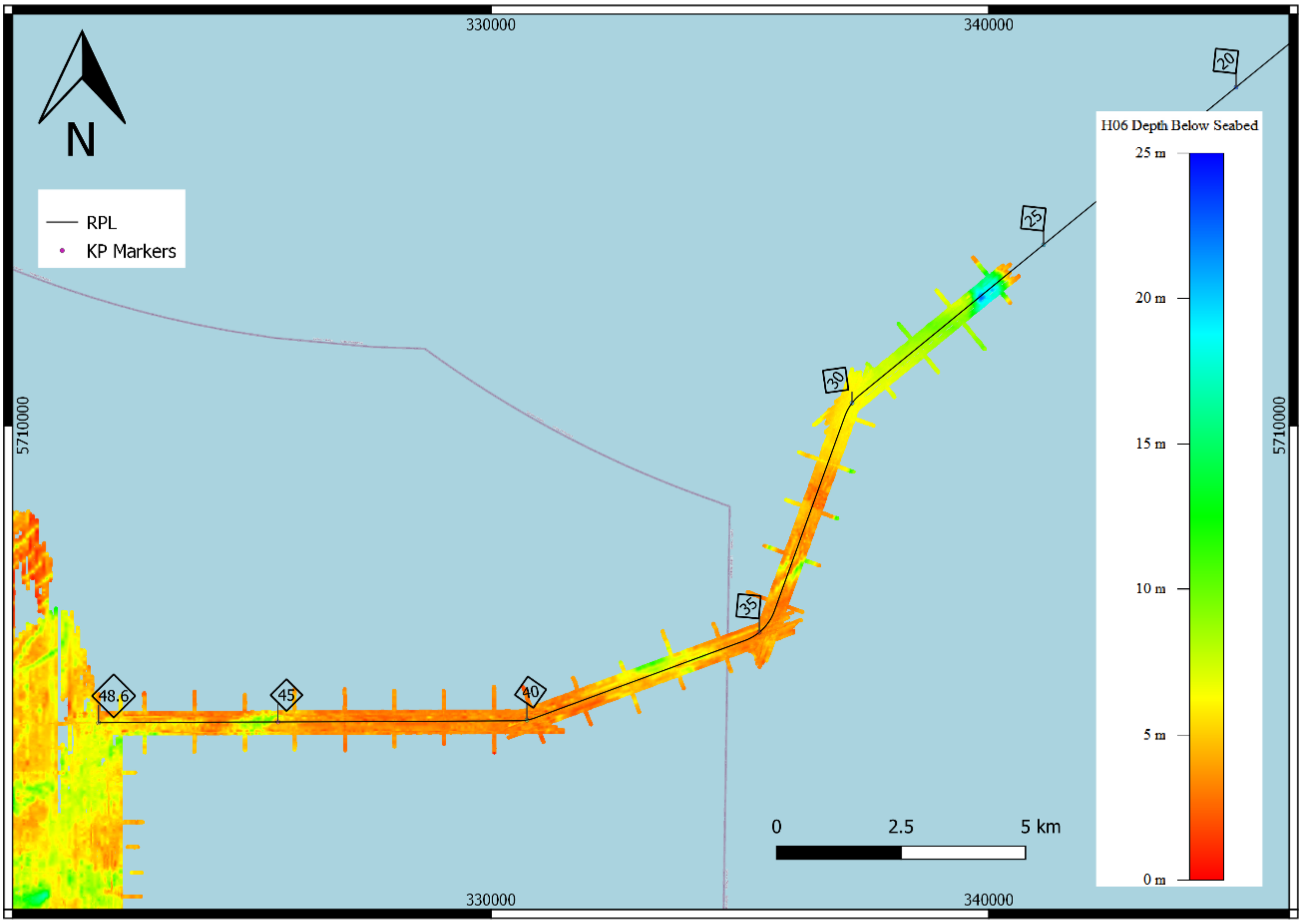



Figure 69: H06 Top of Channel Fill, depth below seabed grid

A data example of the interpreted reflector and the surrounding sediments is shown in Figure 70.

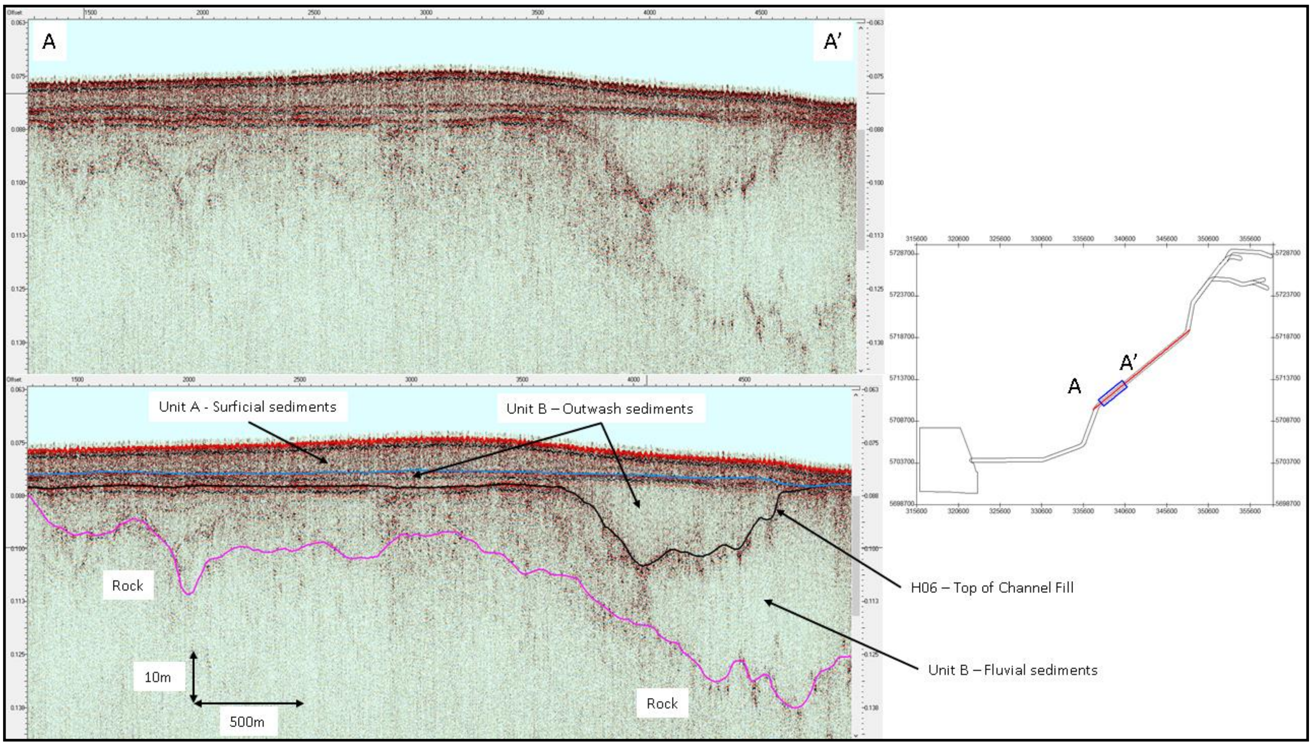



Figure 70: Sparker data example showing interpretation of H06

### 7.7.5. Unit B - H07 Top of Coarse Channel Fill

H07 represents the top of coarse channel fill that identifies a horizon of high amplitude reflections within the large, exposed channel. Figure 71 shows the depth and extent of the interpretation for this horizon. This unit terminates against the flanks on all sides of the exposed channel and appears to be confined only to this channel. It is possible that this sediment is composed of coarse material derived from the bedrock surrounding this channel.

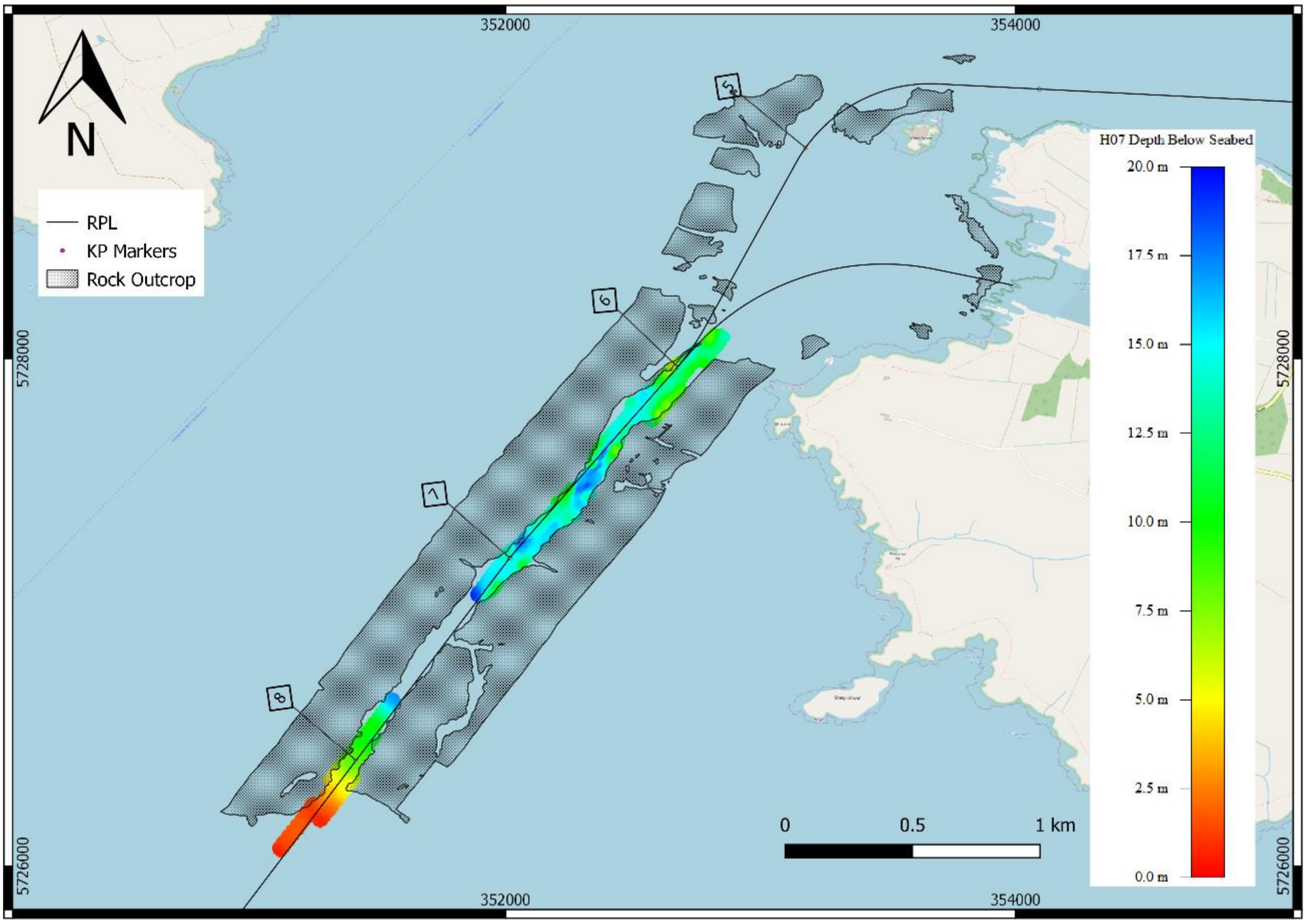



Figure 71: H07 Top of Coarse Chanel Fill, depth below seabed grid

A data example of the interpreted reflector and the surrounding sediments is shown in Figure 72.

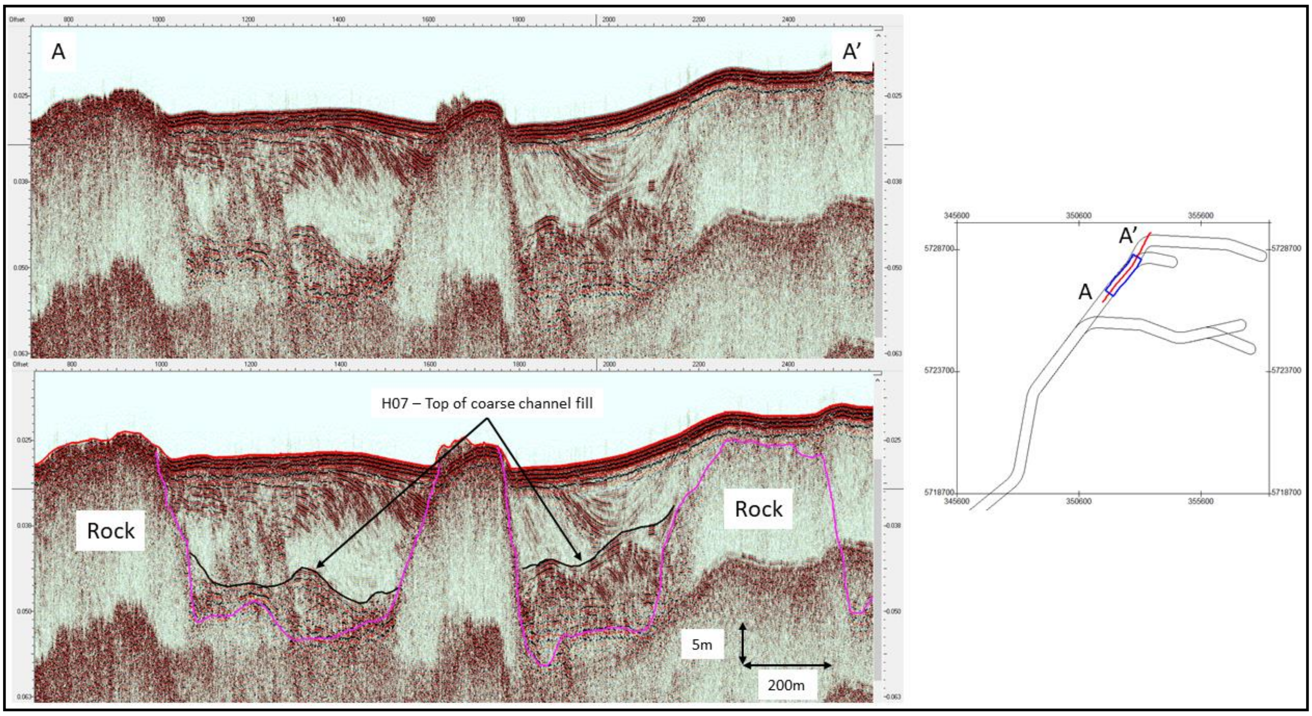



Figure 72: Sparker data example showing interpretation of H07

### 7.7.6. Unit C - H10 Top of Bedrock

H10 represents the top of bedrock. Figure 73 shows the depth and extent of the interpretation for this horizon. The depth to the bedrock ranges from surface outcrop to a maximum depth of 51.8m below seabed. It has been possible to map the top of bedrock across most of the survey corridor with few exceptions such as acoustic blanking or limited data quality or penetration. The top of bedrock has been interpreted as a highly erratic surface in most areas due to numerous channel incisions into its surface. The bulk of the bedrock from the landfalls to KP39 is thought to be composed of Pilton Shale, with a possible minor component of Old Red Sandstone(IGS Solid Geology, 1983). From KP39 the IGS Solid Geology chart suggests a change in bedrock to Cretaceous Chalk, however this transition is not observed in either the SBP or Sparker datasets. Given the low resolution of the IGS Solid Geology Chart the transition at KP 39 is only indicative.

Figure 74 shows the same depth below seabed grid but with the colour scale adjusted to highlight areas where bedrock is within 5m of the seabed in red. As the figure shows there are extensive areas within the offshore route which are further described in detail as part of the route listings in section 6.7.

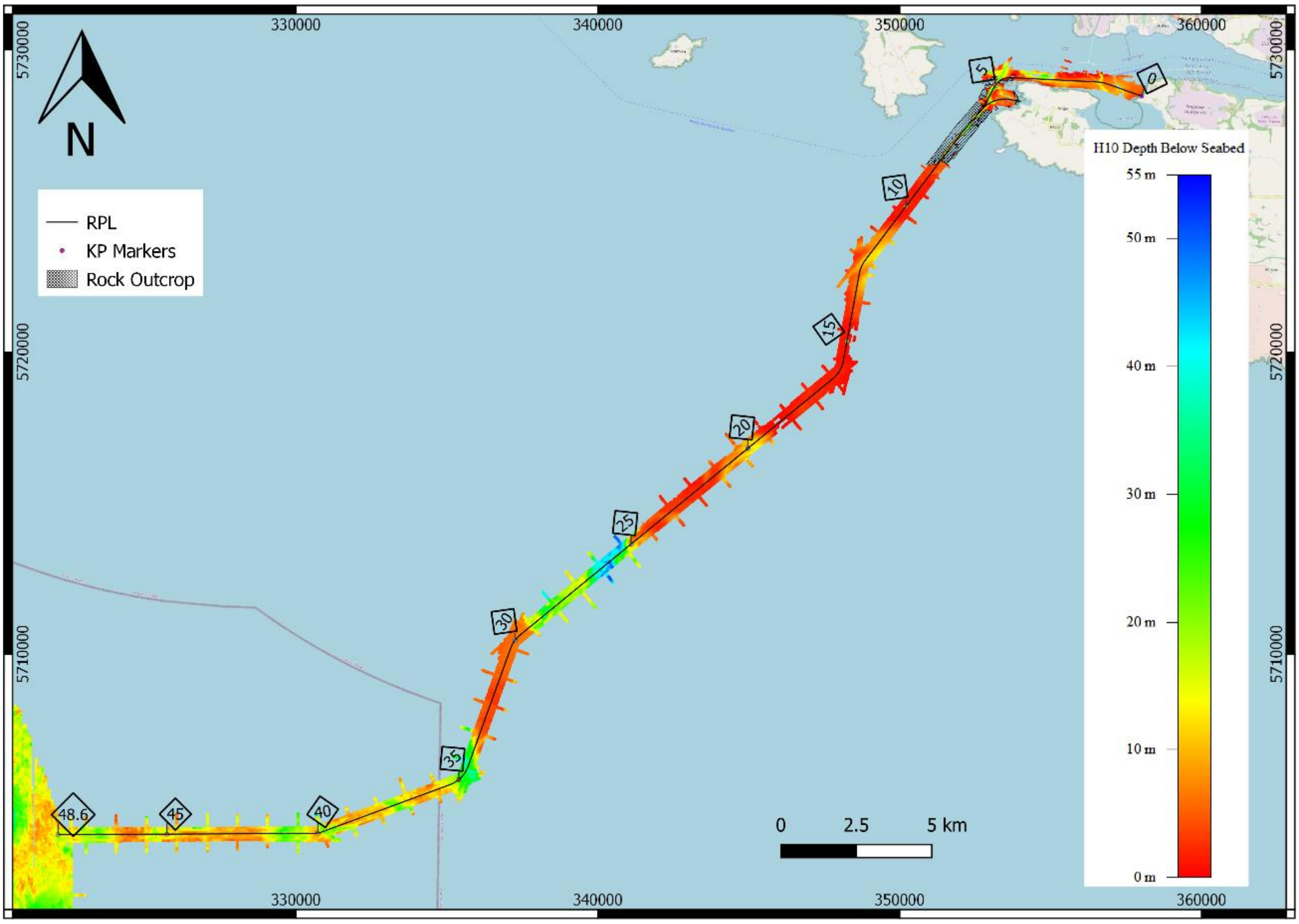



Figure 73: H10 Top of Rock, depth below seabed grid

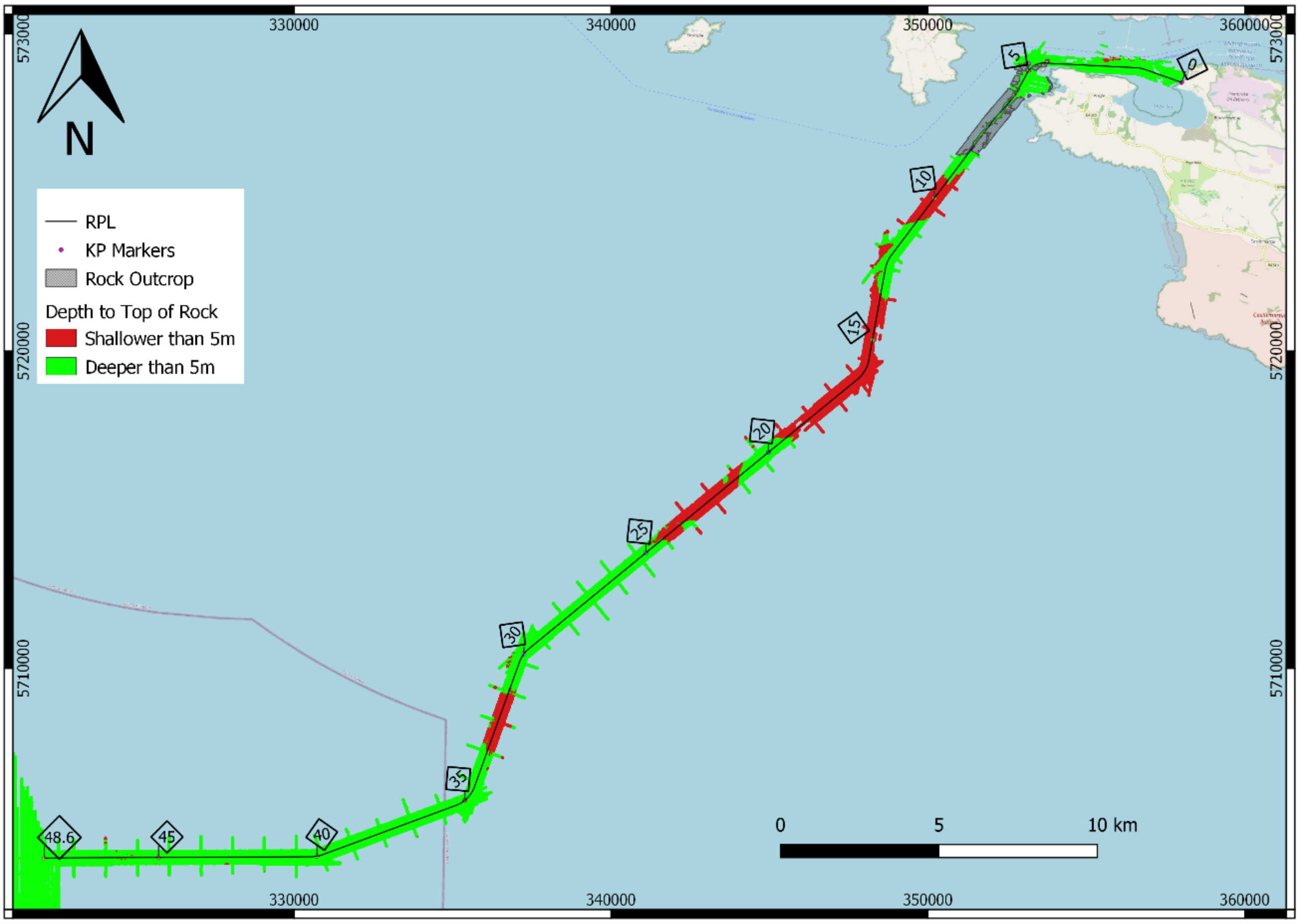



Figure 74: H10 Top of Bedrock, <5m depth below seabed grid

Figure 75 shows the depth below seabed to the bedrock, focused on the exposed channel feature between KP5.920 and KP8.140. Channels within this feature reaches a maximum depth of 27.1m below seabed, with the bedrock outcropping at the flanks. The deeper parts of this channel are filled with coarse material, the top of which is demarked by the horizon H07. Maximum thickness of coarse channel fill is 14.3m.

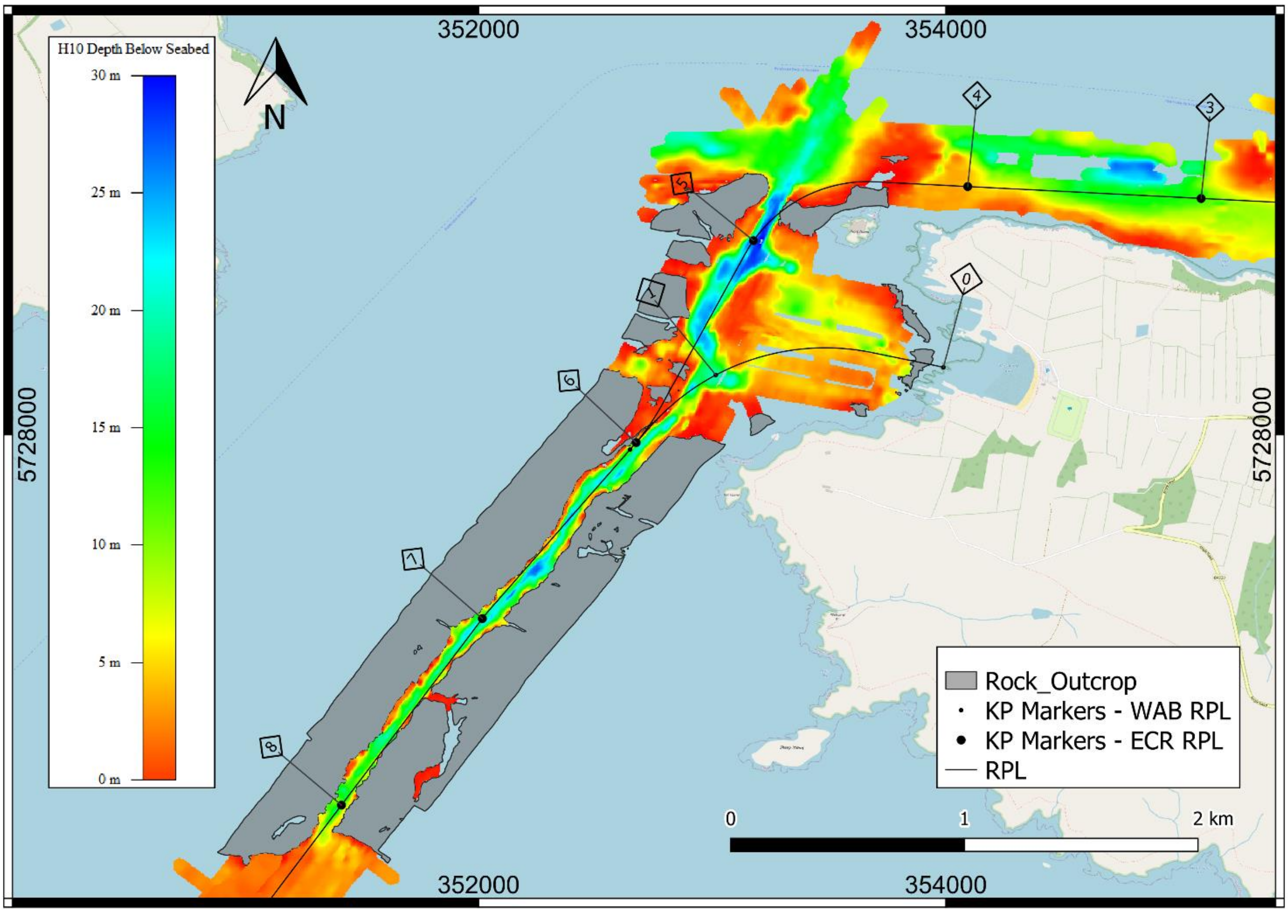



Figure 75: H10 Top of Rock at the exposed channel feature, depth below seabed grid

A data example of the interpreted reflector and the surrounding sediments is shown in Figure 76.

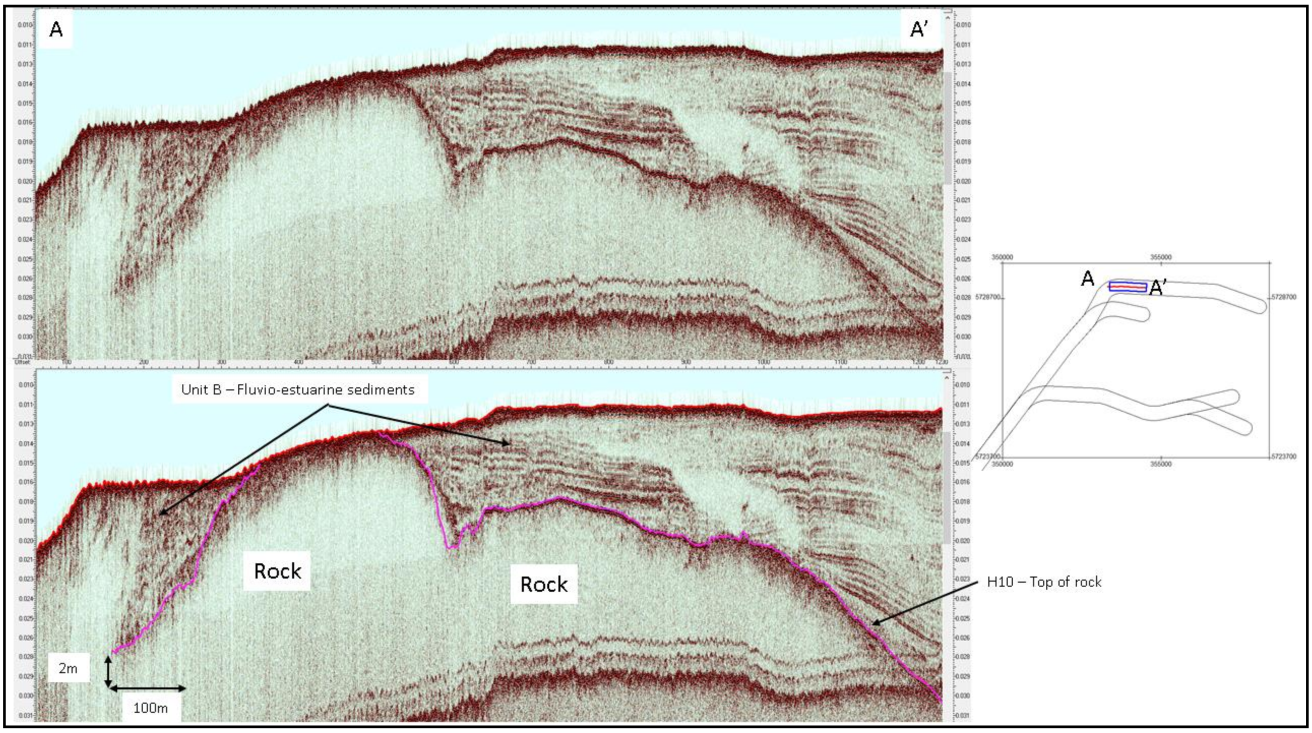



Figure 76: Sparker data example showing interpretation of H10

### 7.7.7. Centre Line Interpretation Profile

Figure 77 shows the variation in both depth below LAT and depth below seabed, for all interpreted horizons described in this section. The top section shows depth relative to seabed whilst the lower panel shows all horizons relative to LAT.

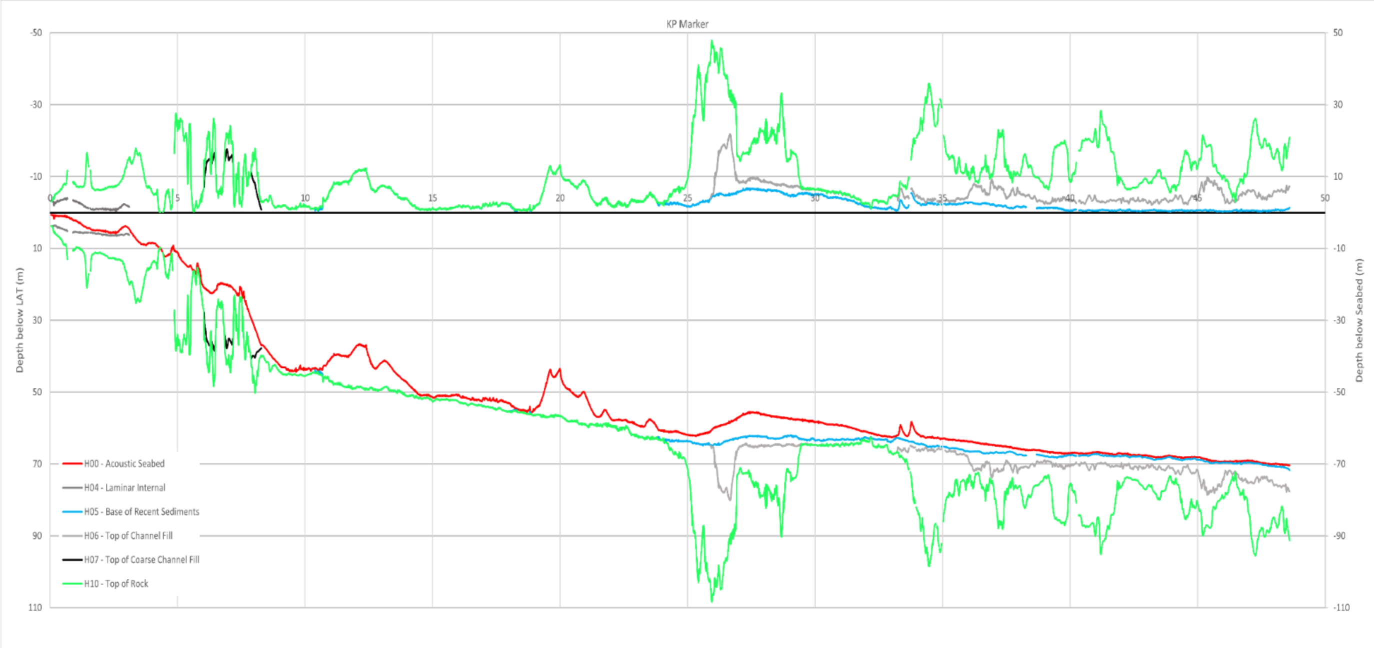



Figure 77: Profile of the main cable route centre line SBP interpretation

### 7.7.8. Subsurface Features – Acoustic Blanking

A few areas of acoustic blanking have been noted within the survey corridor, some of which cross the centre line. Acoustic blanking has only been observed nearshore of KP6. Two distinct types of blanking have been observed in different locations. The map shown in Figure 78 highlights the parts of the cable corridor that have been affected by acoustic blanking in the data. The two types are identified as shallow gas and a high amplitude reflector, with the shallow gas being widespread from KP0.5 up to KP4 and the high amplitude reflector horizon only present just outside the survey corridor between KP5 of the main route and the WA1 landfall option.

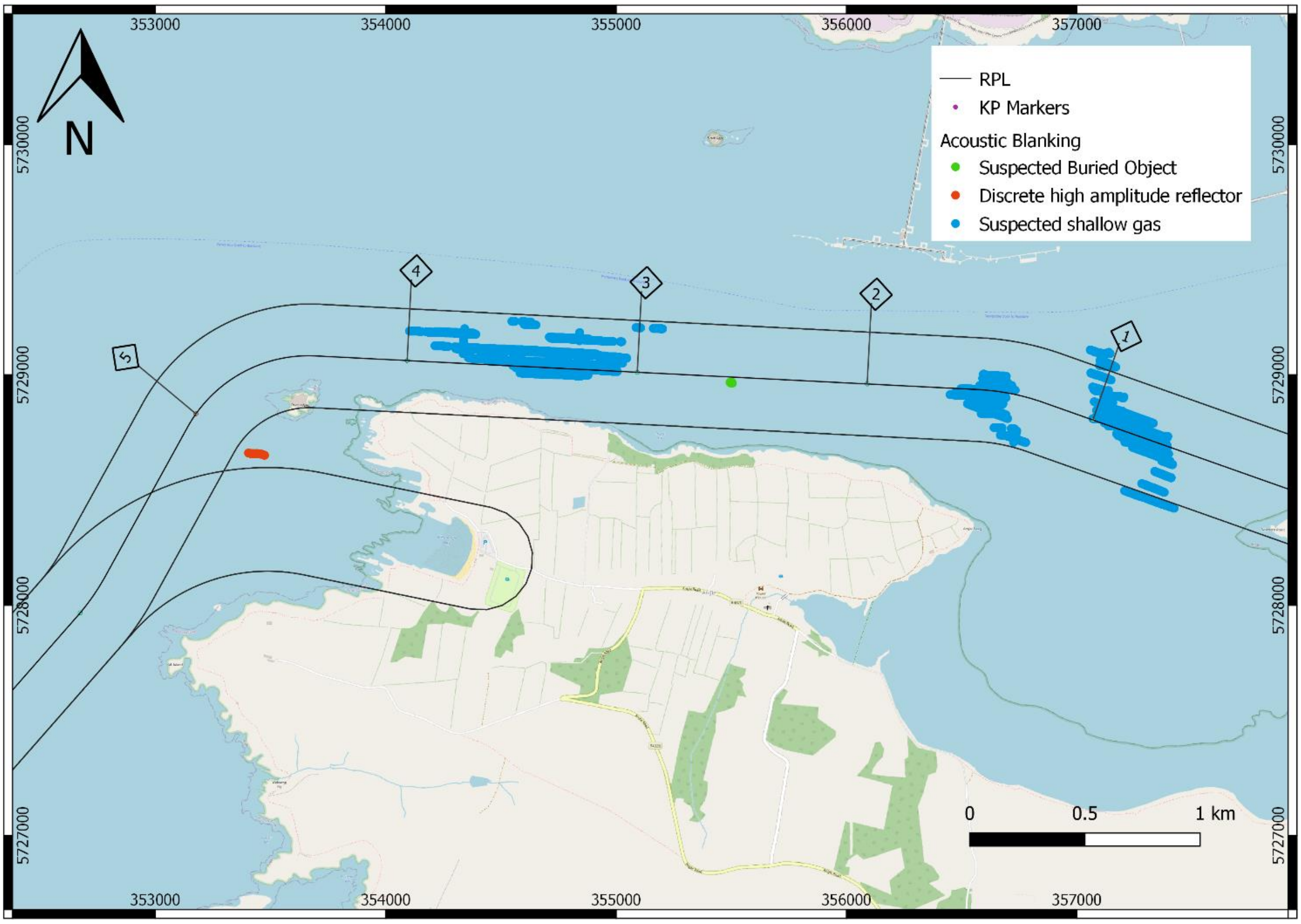



Figure 78: Overview of acoustic blanking extents

Figure 79 shows a prominent diffuse reflector under which interpretation is unable to continue as all the seismic energy appears to be lost. The type of blanking is likely attributable to an accumulation of shallow gas.

Figure 80 shows the blanking reflector is not so diffuse compared to the example in Figure 79. It appears as a very strong reflector where it is distinguishable from the seabed.

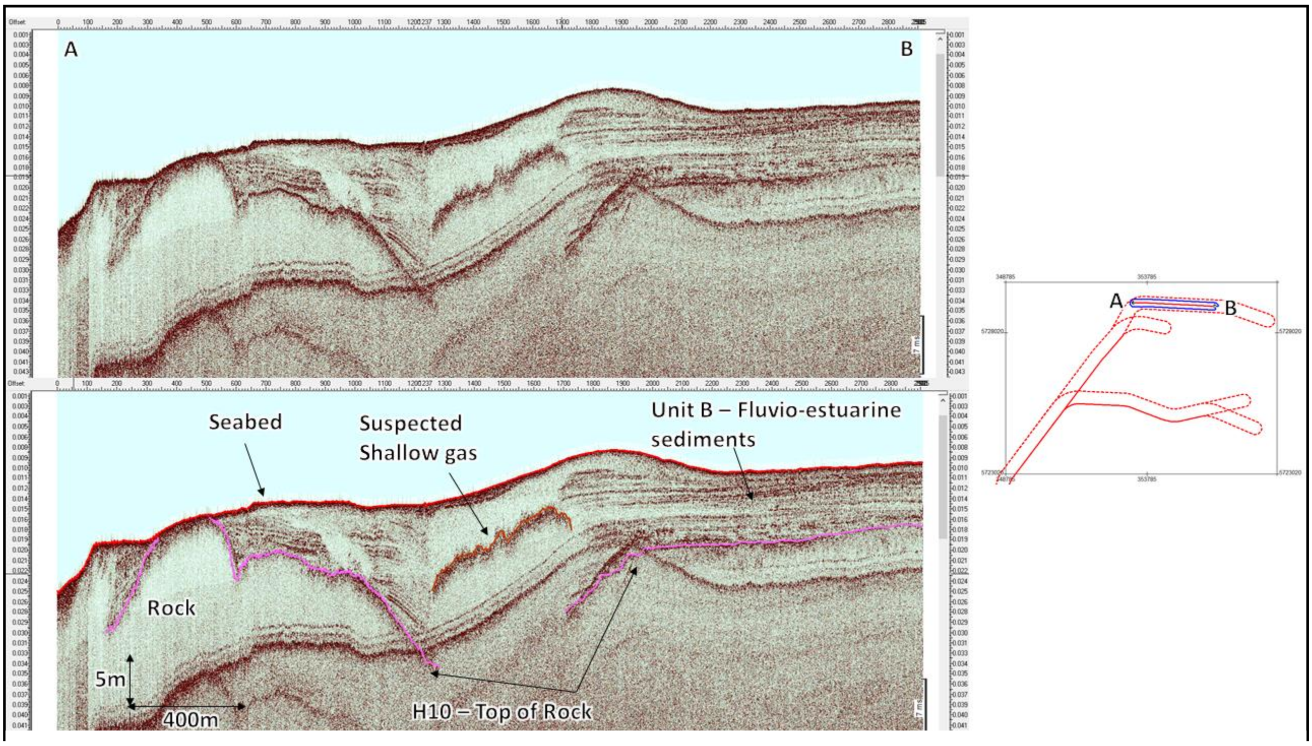



Figure 79: SBP acoustic blanking data example (line: B_CL)

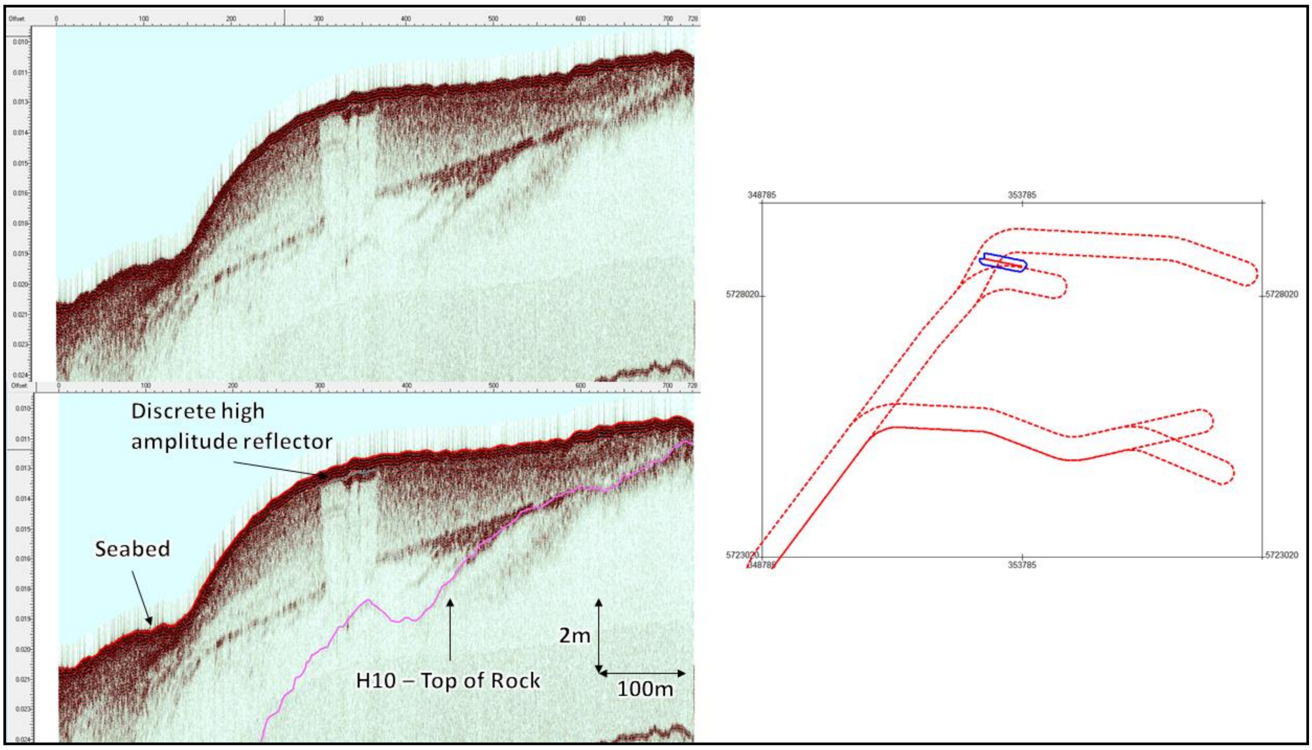



Figure 80: SBP Acoustic blanking data example (line: A_250)

### 7.7.9. Subsurface Features – Suspected Buried Object

An anomaly on the SBP data has been identified approximately 20m south of KP2.595 along the main cable route centre line. Figure 81 shows examples of the anomaly in two SBP lines and on the bathymetry data. In the bathymetry data it appears as an unexpected slightly raised surface in a sub linear shape. This coincides with a short but sharp burst of acoustic blanking in the SBP data, the top of which appears to be just below the seabed. It is highly likely that something very hard or something acoustically opaque is buried at this location. It is unlikely that such a small target with definition on the seabed bathymetry is associated with shallow gas or other organic sources of acoustic blanking.

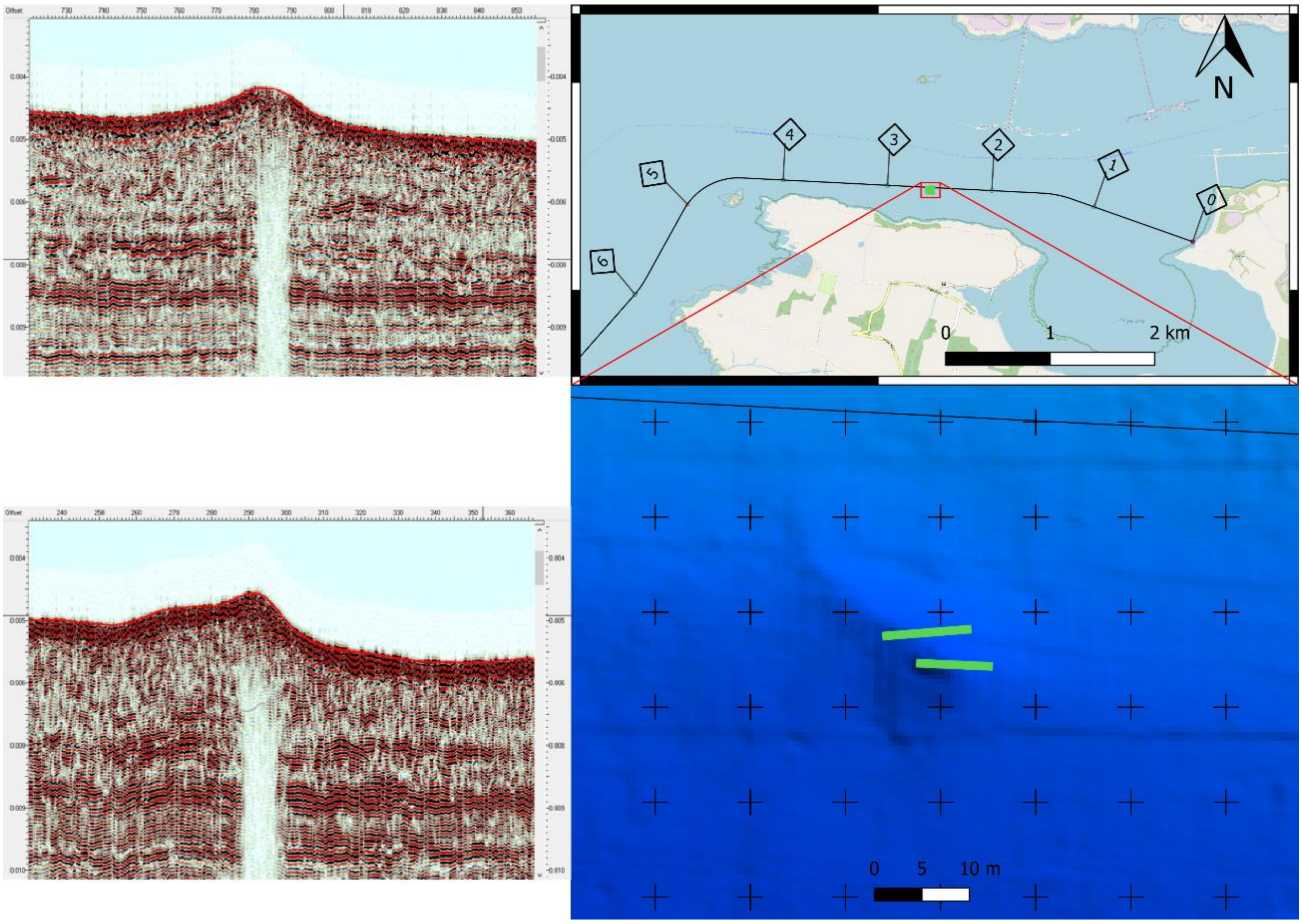



Figure 81: Suspected buried object on SBP and MBES data

## 7.8. Shallow Soils – FLOW Site

The three units described in section 6.2.2have been interpreted on SBP data to at least 20m depth below seabed within the array area. In most cases penetration allowed interpretation further than this.

An example of sparker data and parametric echosounder data running south to north, collected within the WTG area are shown in Figure 82 and Figure 83 respectively. H10 (Top of bedrock) is interpreted in pink, H06 (top of channel fill) is interpreted in black and H05 (base of recent sediments) is interpreted in blue.

Unit A sediments are seen to form mobile bedforms, including sandwaves and megaripples. The erosional base of these morphological features is marked by H05. Whilst the majority of the larger bedforms are present in the northern half of the site, the surficial sediments are still present in the south and present as a generally thinner layer of ripples. In some areas the surficial sediments have become so thin that they are no longer resolvable on either sparker or parametric echosounder and hence are interpreted to only form a veneer on the seabed.

Beneath this unit of surficial sediments is a layer of reworked sediment, displaying sub-parallel internal reflectors, with high reflectance. Within sandwave troughs and towards the southern side of the site, the surficial sediments thin to the extent that an observable increase in boulder density is noted. The base of the reworked sediments is interpreted as H06. It is interpreted that this reworked  sediment is derived from the erosion of glacial sediments.

H06 marks the change from reworked sediments to fluvial channel fill sediments. This horizon stays fairly level across the site, with small variations where the overlying reworked sediment has filled depressions in the palaeosurface. Beneath H06, multiple phases of channelisation can be observed. This is shown in Figure 82 as the faint, chaotic and steeply dipping internal reflectors. In Figure 83 these are seen as the deeper reflectors that begin to fade with loss of acoustic penetration. No outcrop of this unit is seen within the section.

The bedrock is seen to undulate across the section and is frequently incised by channelisation. These channels are filled by the overlying coarse fluvial material. Some southerly dipping internal reflectors can be seen within the bedrock, although they appear to be poorly resolved and discontinuous. The internal reflectors are bedding planes in the regional bedrock, likely to be Cretaceous Chalk as indicated on the IGS Solid Geology chart.

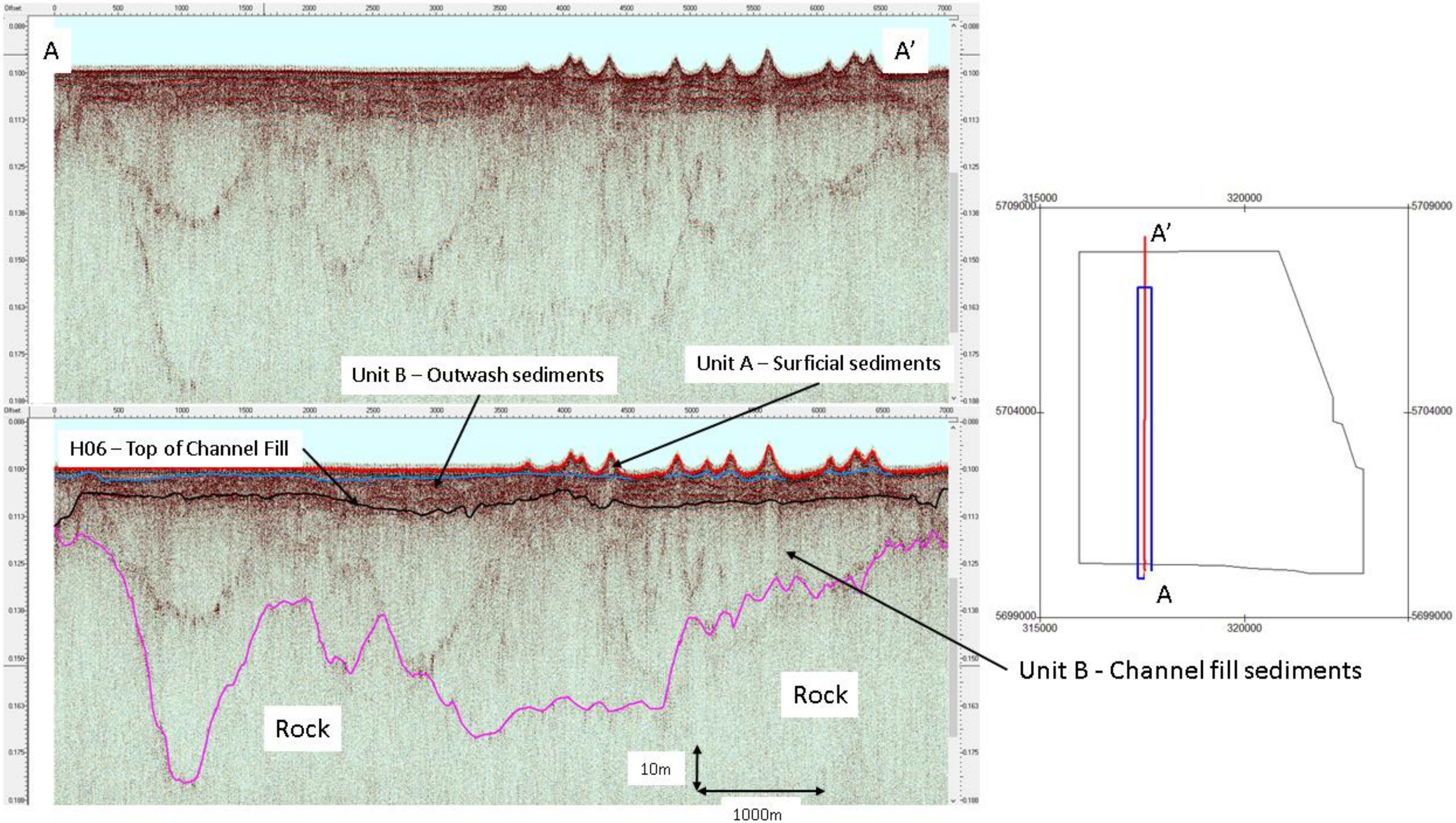



Figure 82: Sparker data example and profile interpretation running S-N of the Array area

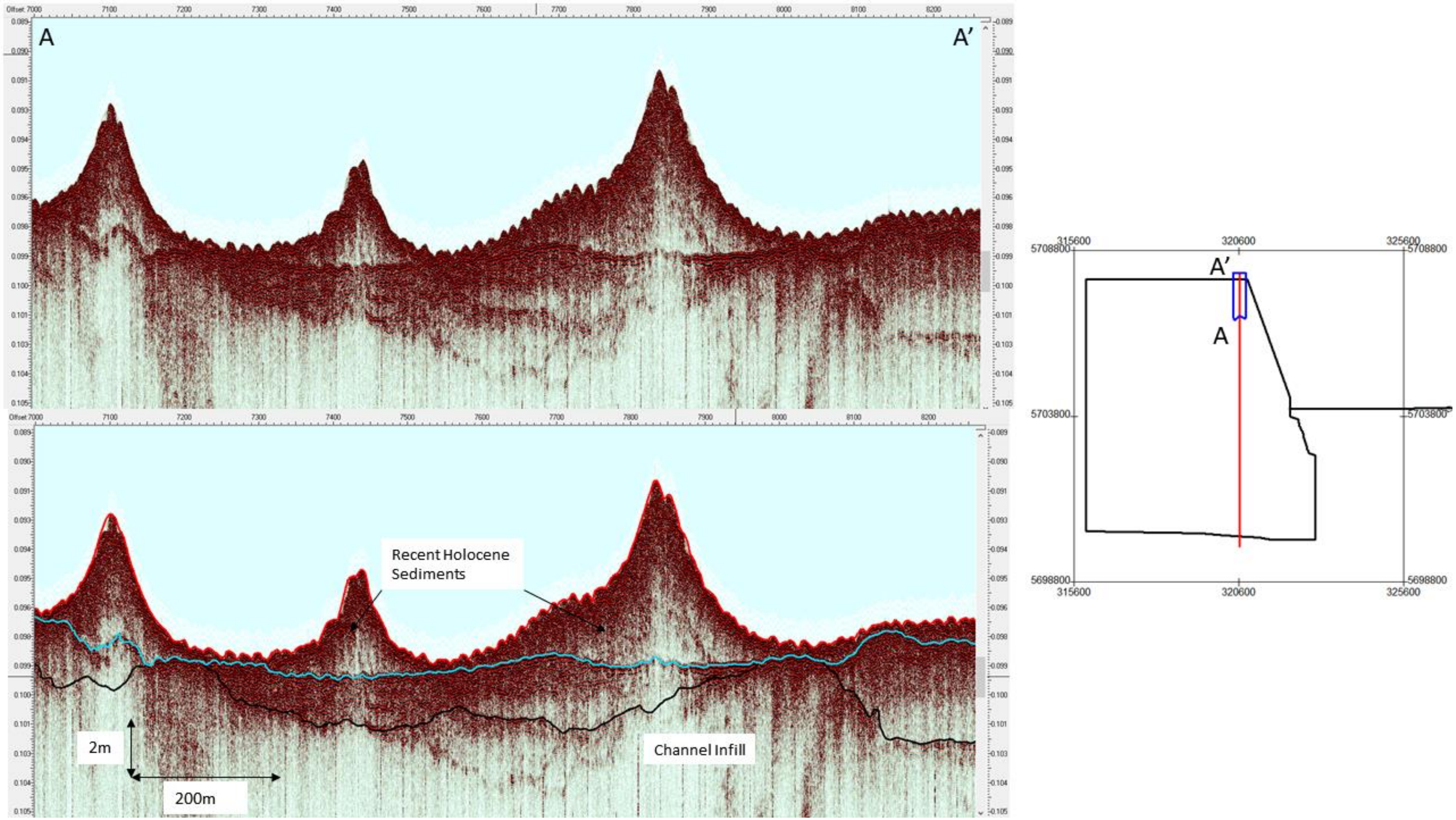


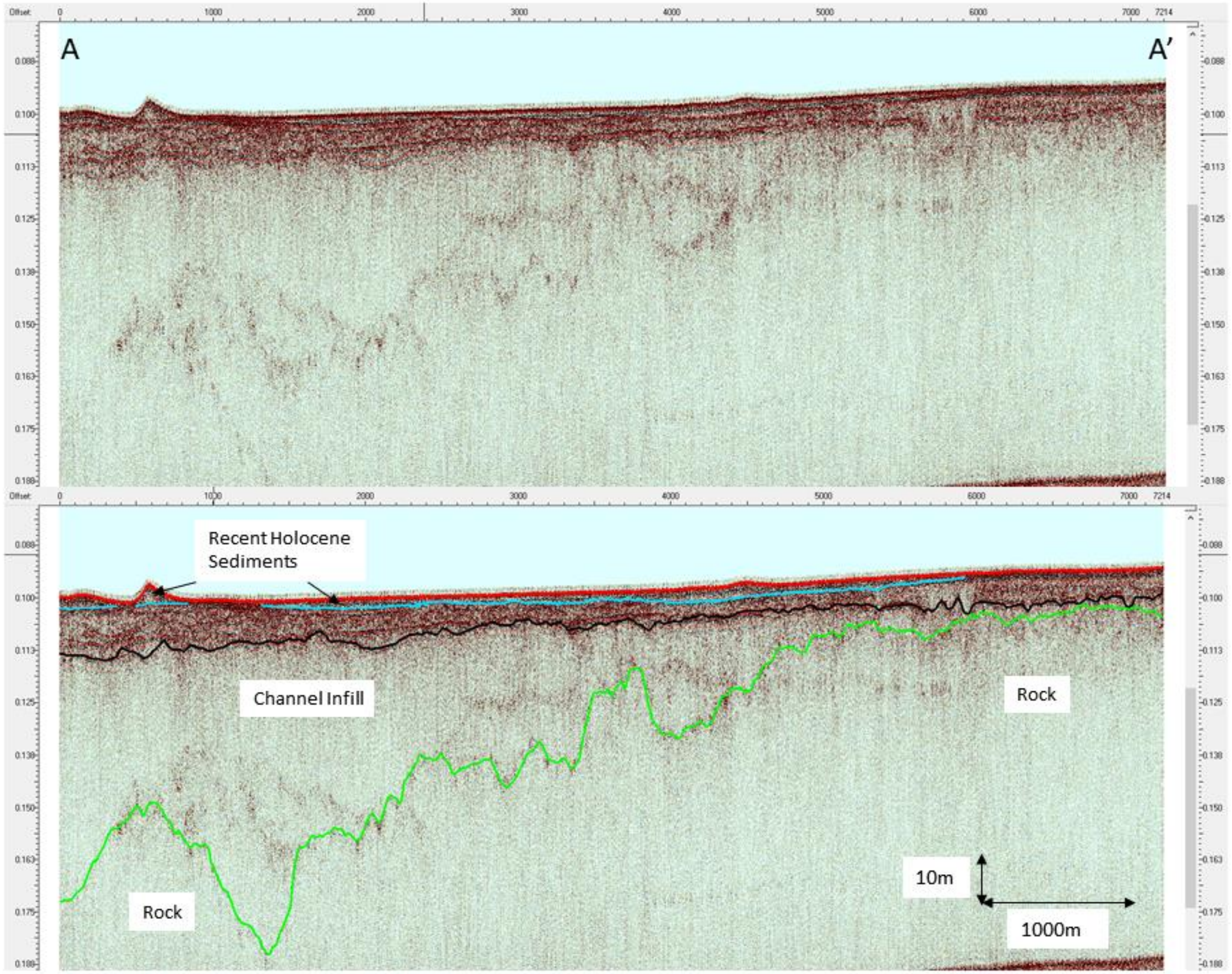

Figure 83: Parametric data example and profile interpretation running S-N of the Array area

A second example of sparker data collected west to east, within the Array area is shown in Figure 84. H10 (Unit C – top of bedrock) is interpreted in green, H06 (Unit B – top of channel fill) is interpreted in black and H05 (Unit A - base of recent sediments) is interpreted in blue.

To the west of the site, the surficial sediments have accumulated into a sandwave. Moving eastwards of the sandwave there are minor changes in thickness of the surficial sediments, but it generally remains thin throughout. Beneath this, the layer of reworked sediments can be seen on a strong, slightly undulating reflector. This high reflectivity unit maintains a moderately constant thickness, thickening slightly to the west.

Multiple phases of erosion and subsequent channel fill can be seen within the fluvial unit of sediments beneath H06 as weak minor internal reflectors, but generally the sediment fill remains mostly structureless.

The top of the bedrock is observed to deepen in an east west direction, with intermittent incised channels which have been infilled with coarse fluvial sediments. Some horizontal internal reflectors to the bedrock are very faintly observable on the right on Figure 84.



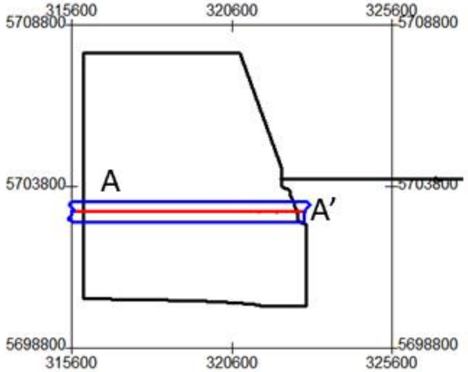




Figure 84: Sparker data example and profile interpretation running W-E of the array area

### 7.8.1. Unit A - H05 Base of Surficial Sediments – FLOW Site

Figure 85 shows the gridded interpretation for H05. H05 shows a deepening relative to LAT towards on the north west. Depth below LAT to the base of surficial sediments can be seen to vary from 69.5m to 82.0m, a range of 12.5m across the entire array area. The thickness of Unit A across the site varies from a thin surface veneer to a maximum of 12.3m seen beneath a sandwave in the central northern region of the array area.

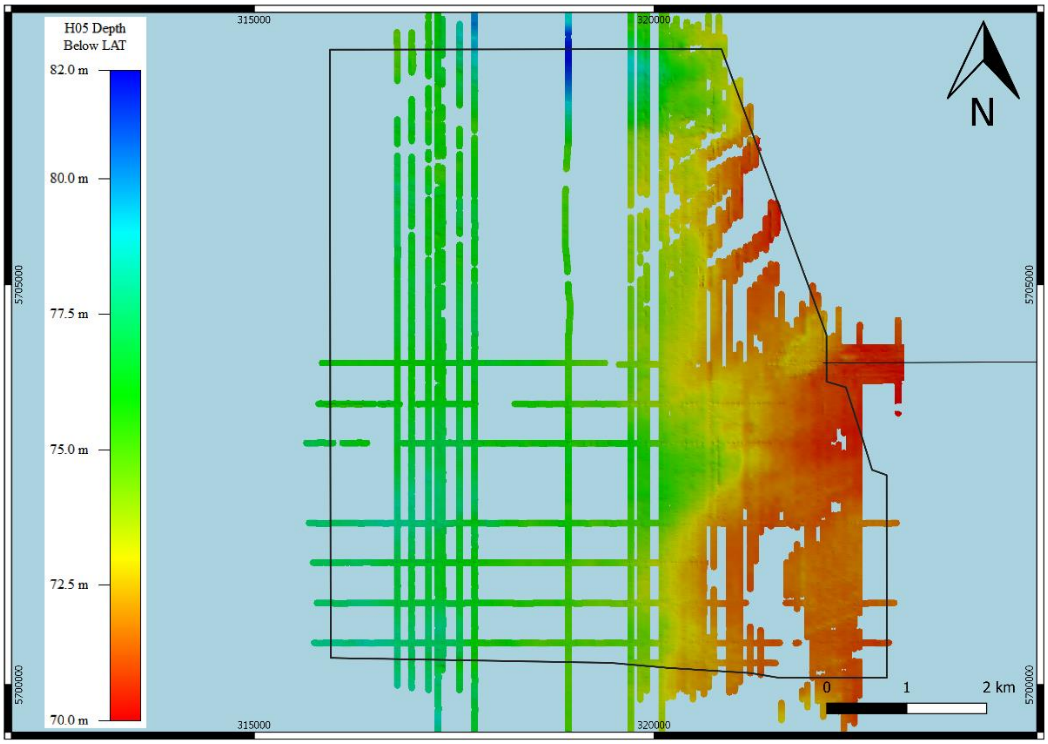



Figure 85: Gridded depth below LAT to base of Unit A - FLOW Site

In the troughs of consecutive sandwaves, the surficial sediments have thinned, exposing the interpreted reworked deposits beneath. These exposures often result in an increase in the number of seafloor boulders. This is demonstrated in Figure 87, which shows the depth below seabed to H05 and also displays boulder locations and boulder field areas. The correlation between thickness of surficial sediments and presence of boulders is clear. Where veneers occur, there are usually boulder fields present. This is important as it highlights the boulder nature of the sediments that overlie H06.

This layer of boulder laden sediments below H05 and above H06 has been interpreted as reworked sediment of the last outwash cycle of eroded glacial material associated with the underlying fluvial system that channelised and filled the geology below. Figure 86 shows the calculated thickness of this layer. It is seen to thin to the north east, with a thickening of the unit to the south being the result of a deepening of the H06 horizon within the data where deeper palaeosurfaces have been filled.

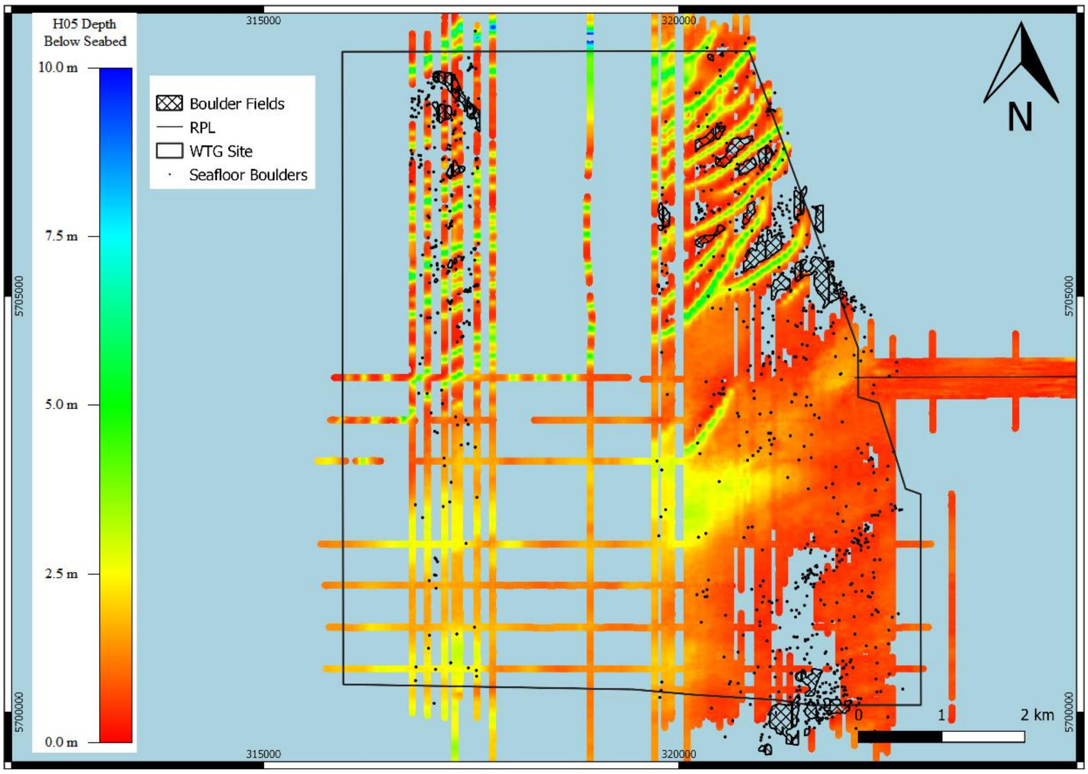



Figure 86: Gridded depth below seabed to H05

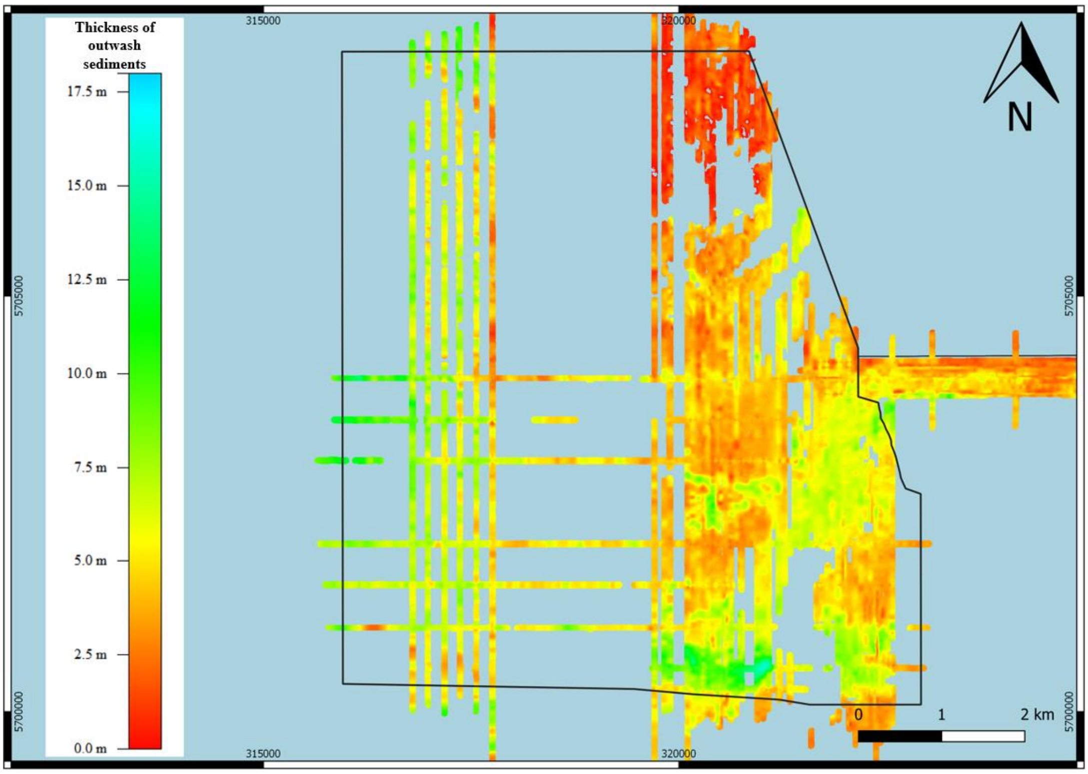



Figure 87: Gridded thickness of the reworked outwash sediments above H06

### 7.8.2. Unit B - H06 Top of Channel Fill – FLOW Site

H06 represents the top of channel fill that marks the interface between the underlying fluvial sediments and the overlying reworked sediments. The composition of the sediments above H06 is partial observed from areas of seabed where the overlying Unit A sediments thin. This is present across the array area in Figure 86 and in a zoomed section in Figure 88. Where surficial sediments are observed to thin and increase in boulder density also correlates indicating the source of the boulders is like from within the sediments overlying H06 and beneath H05.

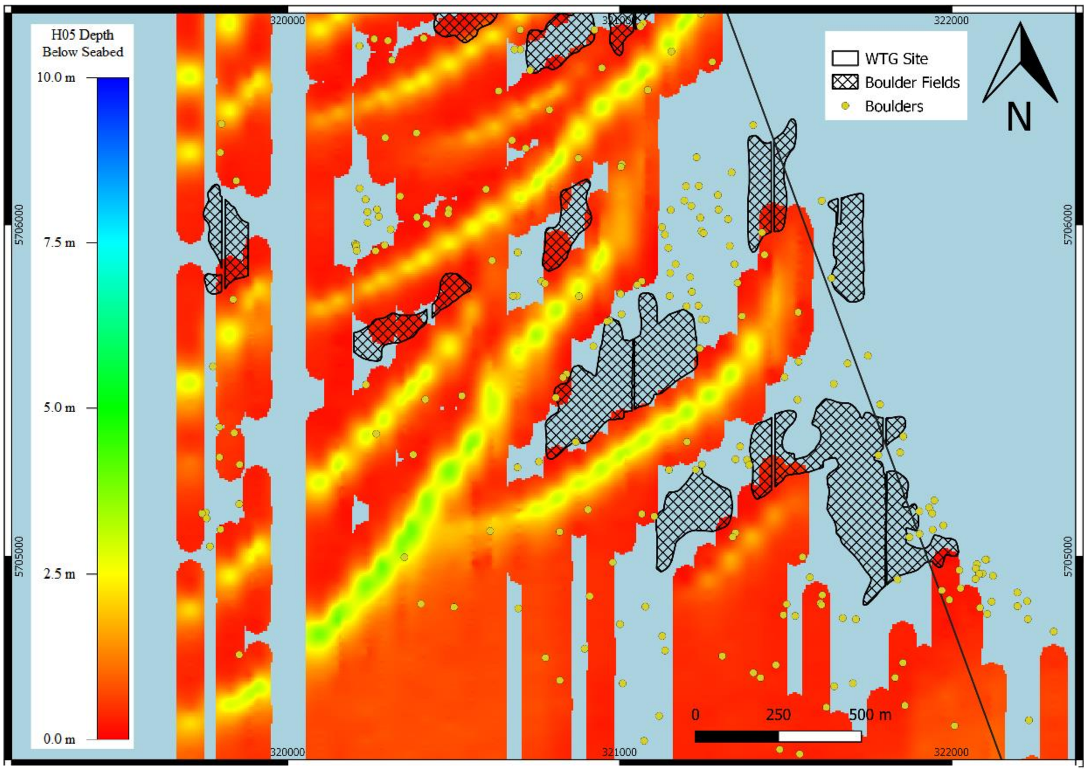



Figure 88: Gridded depth below seabed showing thickness of recent sediment cover with boulders and boulder fields

The underlying interpreted fluvial sediments show typical characteristics of fluvial fill sediments with numerous phases of erosion and subsequent sediment fill. It is likely to have a component of reworked till material. The extent of interpretable coverage and distribution of depths below seabed can be seen in Error! Reference source not found.. Depth below seabed to H06 ranges from 0.4m to 18.2m, with no definitive outcrop noted within the array area given it comes very close to the seabed in places.

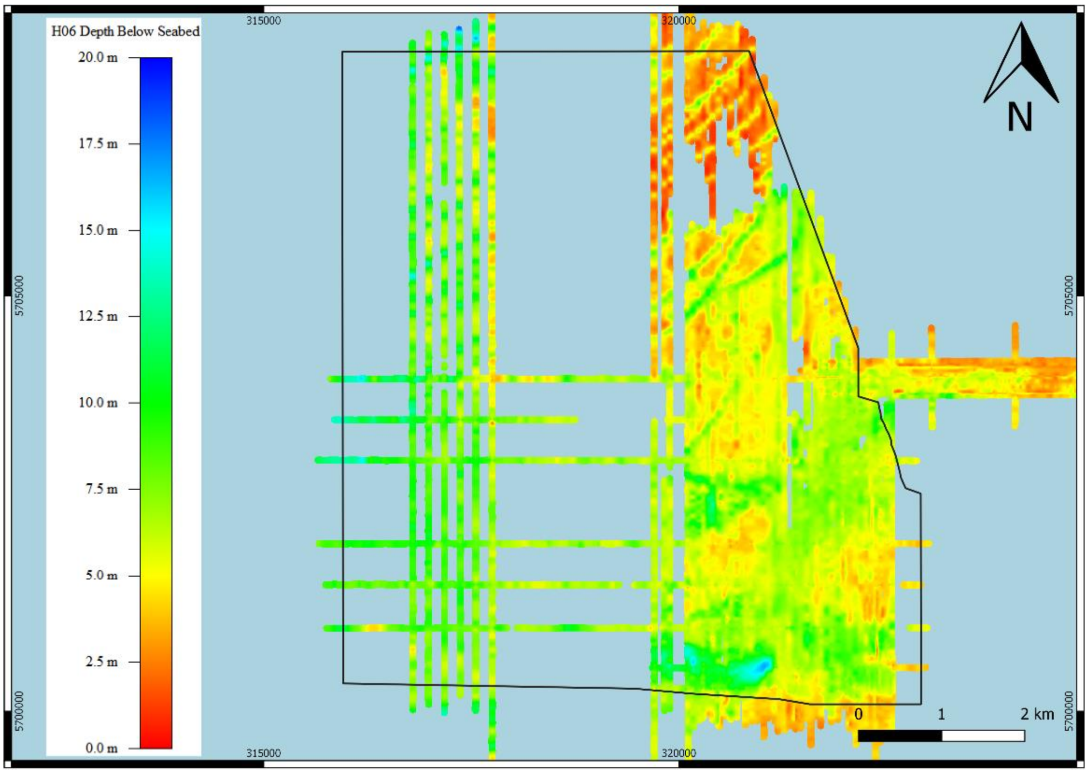



Figure 89: Gridded depth below seabed to H06

### 7.8.3. Unit C - H10 Top of Bedrock

H10 represents the top of bedrock. Figure 90. shows the depth and extent of the interpretation for this horizon. Depth below seabed to H10 ranges from 3.7m in the south east of the array area to a maximum depth of 82.4m within a channel feature to the west. Erosion and surface weathering of the bedrock often makes it difficult to resolve within the dataset.

Figure 91 shows the same depth below seabed grid (as Figure 90) but with the colour scale adjusted to highlight areas where bedrock is within 20m of the seabed in orange and areas within 10m of the seabed highlighted in red. As the figure shows, much of the site to the east has bedrock interpreted to be within 20m of the seabed, but only a small region is seen within 10m.

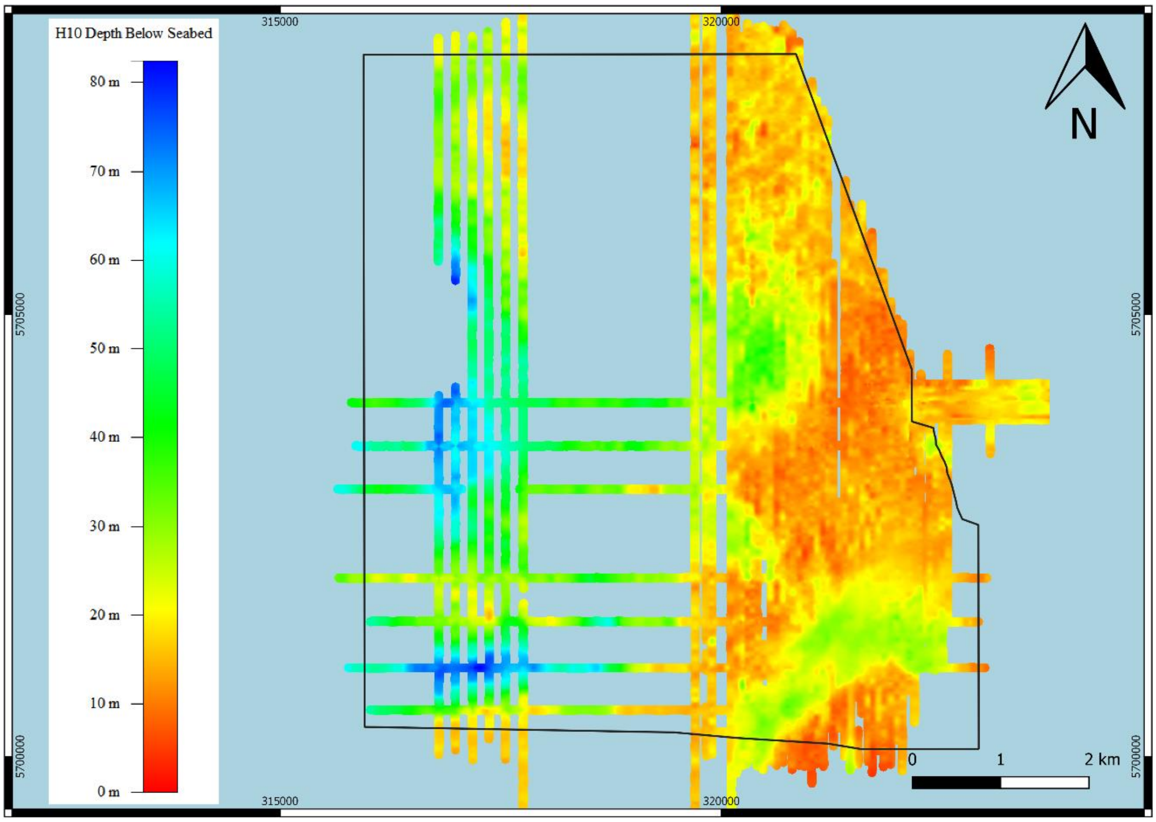



Figure 90: Gridded depth below seabed to H10

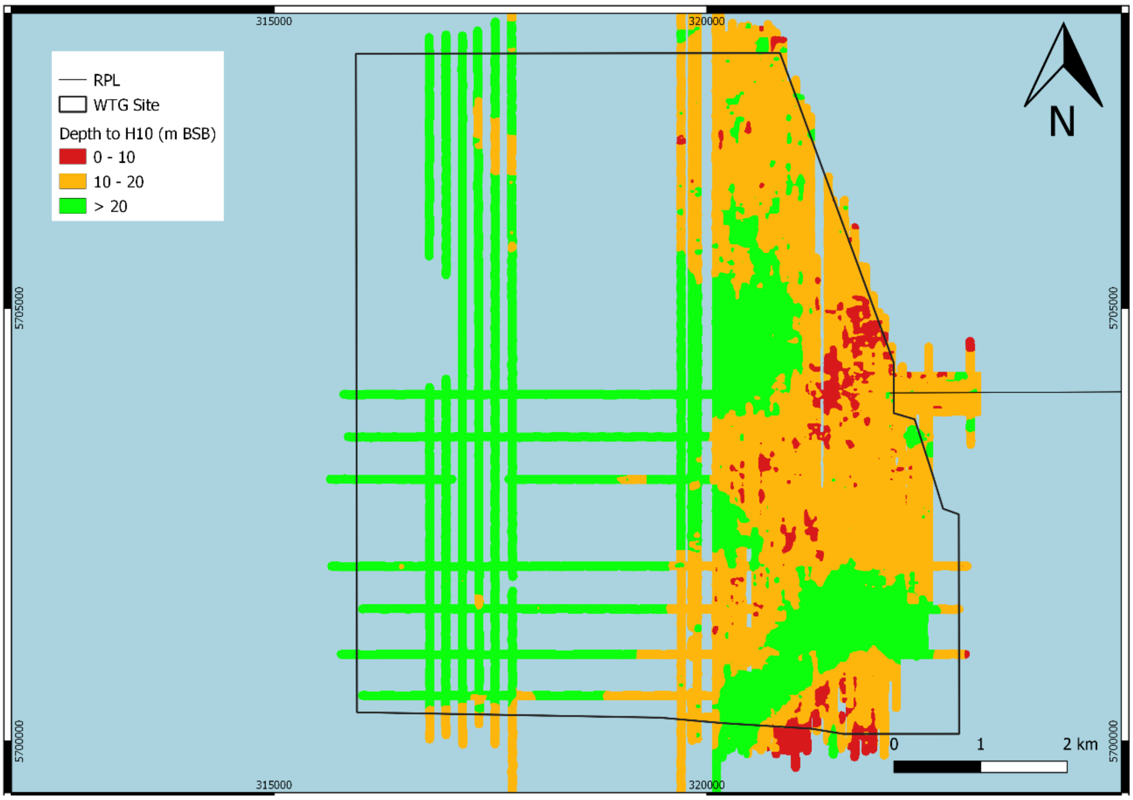



Figure 91: Gridded depth below seabed to H10, categorised by depth

## 7.9. Habitat Mapping

To map the principal habitats that occur throughout the Project Erebus survey areas, a full interrogation of available geophysical data in combination with review of DDV imagery collected at dedicated HA transect locations and site characterisation DDC locations was undertaken. PSD data were also used to support this data and better understand the sediment type within the wider habitat types (see paragraph 7.4 for PSD results). The main habitats identified across the Project Erebus survey area at which seabed imagery or grab samples were obtained comprised primarily of fine sand characterised as the EUNIS classification A5.251 '*Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand' and A5.351 '*Amphiura filiformis*, *Kurtiella* (*Mysella) bidentata* and *Abra nitida* in circalittoral sandy mud' in the offshore section of the cable route and in the main array.

Stations located on the cable route within the Milford Haven Waterway were characterised by various EUNIS biotopes including A5.143 '*Protodorvillea kefersteini* and other polychaetes in impoverished circalittoral mixed gravelly sand', A5.334 '*Melinna palmata* with *Magelona* spp. and *Thyasira* spp. in infralittoral sandy mud', and A5.433 '*Mysella bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment'. The INNS *Crepidula fornicata* were present at ST03, however more dense aggregations of this species are found further up the estuary (Bohn et al. 2015). With only few key species present, this station remained listed as a level 4 EUNIS classification.

Stations located on the outer fringes of the Milford Haven Waterway and the nearshore area of the cable route were best represented by the EUNIS classifications A5.14 'Circalittoral coarse sediment', A5.25 'Circalittoral fine sand' and A5.44 'Circalittoral mixed sediments'. Low faunal abundances of key species were present in grab samples collected at these locations. These stations therefore remained as a level 4 classifications.

The distribution and extent of the habitats/biotopes identified across the Project Erebus survey area based on all the available data are presented in Figure 92 to Figure 94. Descriptions of each of these habitat/biotope types, for which shapefiles have been created for mapping purposes (provided as Appendix XIII), are presented in Table 41, along with the corresponding EUNIS classification assigned to each. Example seabed images of all dominant habitats/biotopes observed during the survey are also provided in Appendix X.

## 7.10. Habitats of Conservation Importance

### 7.10.1. Annex I Geogenic Reef

Annex I Stony Reef

A full reef habitat assessment was conducted on all images to determine whether habitats met the definitions of Annex I reef (stony and bedrock) habitats as detailed in Table 26. It is noted that where stony and bedrock reefs were recorded along the same transects, they were deemed to form mosaic habitats meaning it was difficult to differentiate between the two reef types given the lack of clear boundaries in the acoustic data. Areas of Annex I stony reef were present across the survey area, mostly along the nearshore section of the cable route (Figure 92). In total, 13 transects showed evidence of stony reef, with 4 transects (T_004, T_005, T_008 and T_009) deemed to be representative of medium resemblance stony reef, 4 transects (T_006, T_018, T_020 and T_098) of low resemblance stony reef and the remaining transects (T_003, T_007, T_010, T_019 and T_099) mix of low and medium resemblance stony reefs (Table 41). Coverage of this habitat type was most extensive at transects T_003 and T_007. Annex I bedrock reef was identified along 11 transects from T_003 to T_010, T_016, T_017 and T_026 (Table 41). Coverage of this habitat type was most extensive in the area covered by transects T_007 to T_010.

Annex I Bedrock Reef

Annex I bedrock reef was identified along 11 transects from T_003 to T_010, T_016, T_017 and T_026 (Figure 95 and Table 41). Coverage of this habitat type was most extensive in the area covered by transects T_007 to T_010. Transect locations are as shown in Figure 11and Figure 12. It is noted that in the shallow subtidal area close to the landfall location at West Angle Bay (survey block WA01) Annex I bedrock was identified as a continuous structure extending from the subtidal to the intertidal zone. The EUNIS habitat for this area encompassing the shallow subtidal zone and the intertidal zone was assessed to be A3.2 based on Unmanned Aerial Vehicle (UAV) imagery and acoustic data (Figure 94; for details on intertidal habitats see OEL 2021). Transect T_013 located in proximity of the West Angle Bay landfall did not show evidence of Annex I bedrock as the extent of the feature observed in the seabed imagery was not large enough to qualify as Annex I (grey dots in Figure 94); nevertheless a few images of kelp on sublittoral rock were recorded at the beginning of the transect, which indicates that this rocky feature extends towards the intertidal zone rather than offshore.

Table 41 Main EUNIS classifications (and MNCR 04/05 correlations) identified within the Erebus Floating Offshore Wind Farm.

| EUNIS Level 4 | EUNIS Level 5 | MNCR Code | EUNIS Description |
|---|---|---|---|
| A5.13 | A5.137 | SS.SCS.ICS.SLan | Dense *Lanice conchilega* and other polychaetes in tide-swept infralittoral sand and mixed gravelly sand |
| A5.14 | A5.143 | SS.SCS.CCS.Pkef | *Protodorvillea kefersteini* and other polychaetes in impoverished circalittoral mixed gravelly sand |
| | - | SS.SCS.CCS | Circalittoral coarse sediment |
| A5.25 | - | SS.SSa.CFiSa | Circalittoral fine sand |
| | A5.251 | SS.SSa.CFiSa.EpusOborApri | *Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand |
| A5.26 | - | SS.SSa.CMuSa | Circalittoral muddy sand |
| A5.33 | A5.334 | SS.SMu.ISaMu.MelMagThy | *Melinna palmata* with *Magelona* spp. and *Thyasira* spp. in infralittoral sandy mud |
| A5.35 | A5.351 | SS.SMu.CSaMu.AfilMysAnit | *Amphiura filiformis*, *Mysella bidentata* and *Abra nitida* in circalittoral sandy mud |
| A5.43 | - | SS.SMx.IMx | Infralittoral mixed sediments |
| A5.44 | A5.443 | SS.SMx.CMx.MysThyMx | *Mysella bidentata* and *Thyasira spp*. in circalittoral muddy mixed sediment |
| | - | SS.SMx.CMx | Circalittoral mixed sediments |

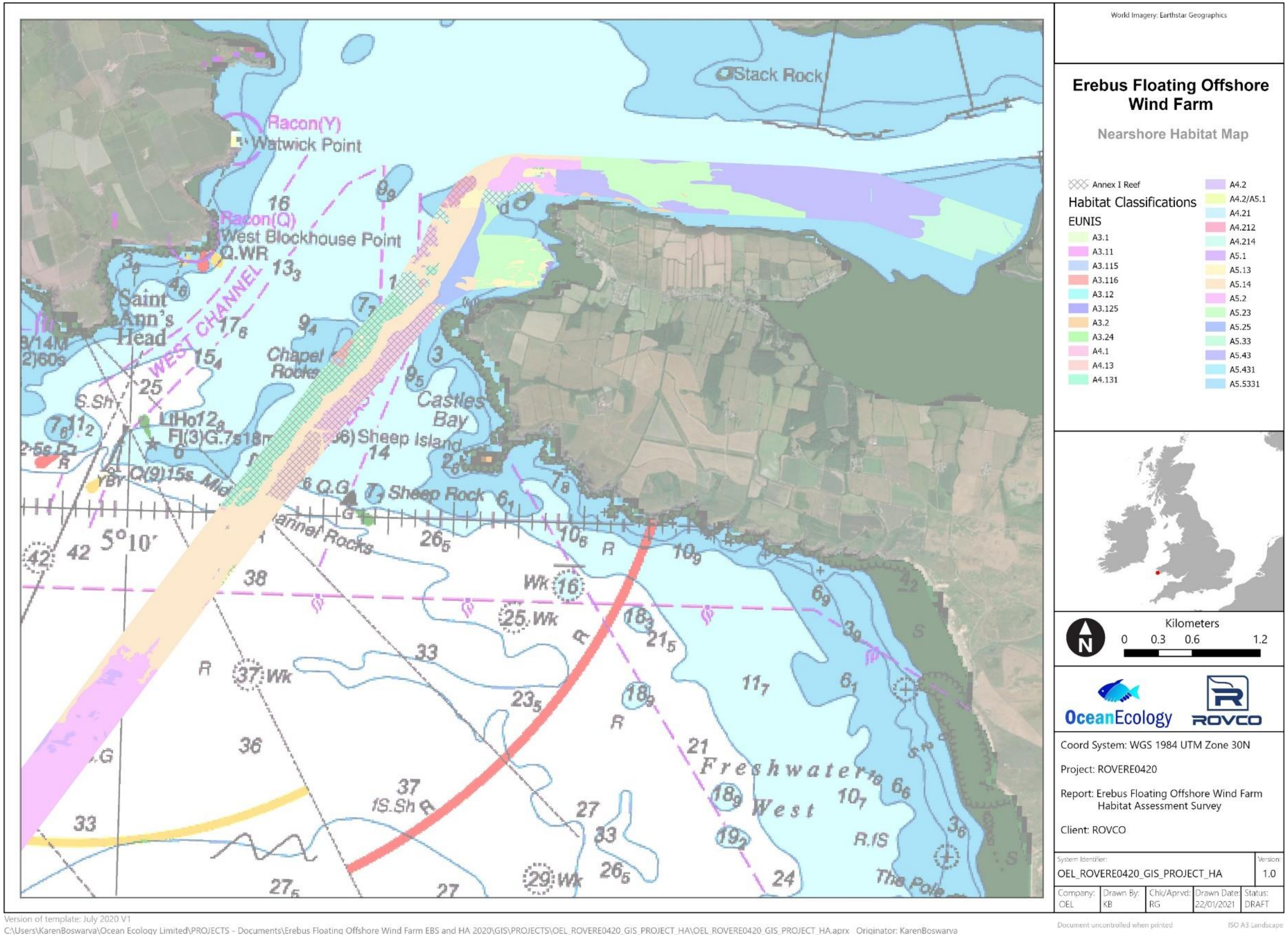



Figure 92: EUNIS habitat/biotope and Annex I reef mapping across the nearshore section of the Project Erebus survey area

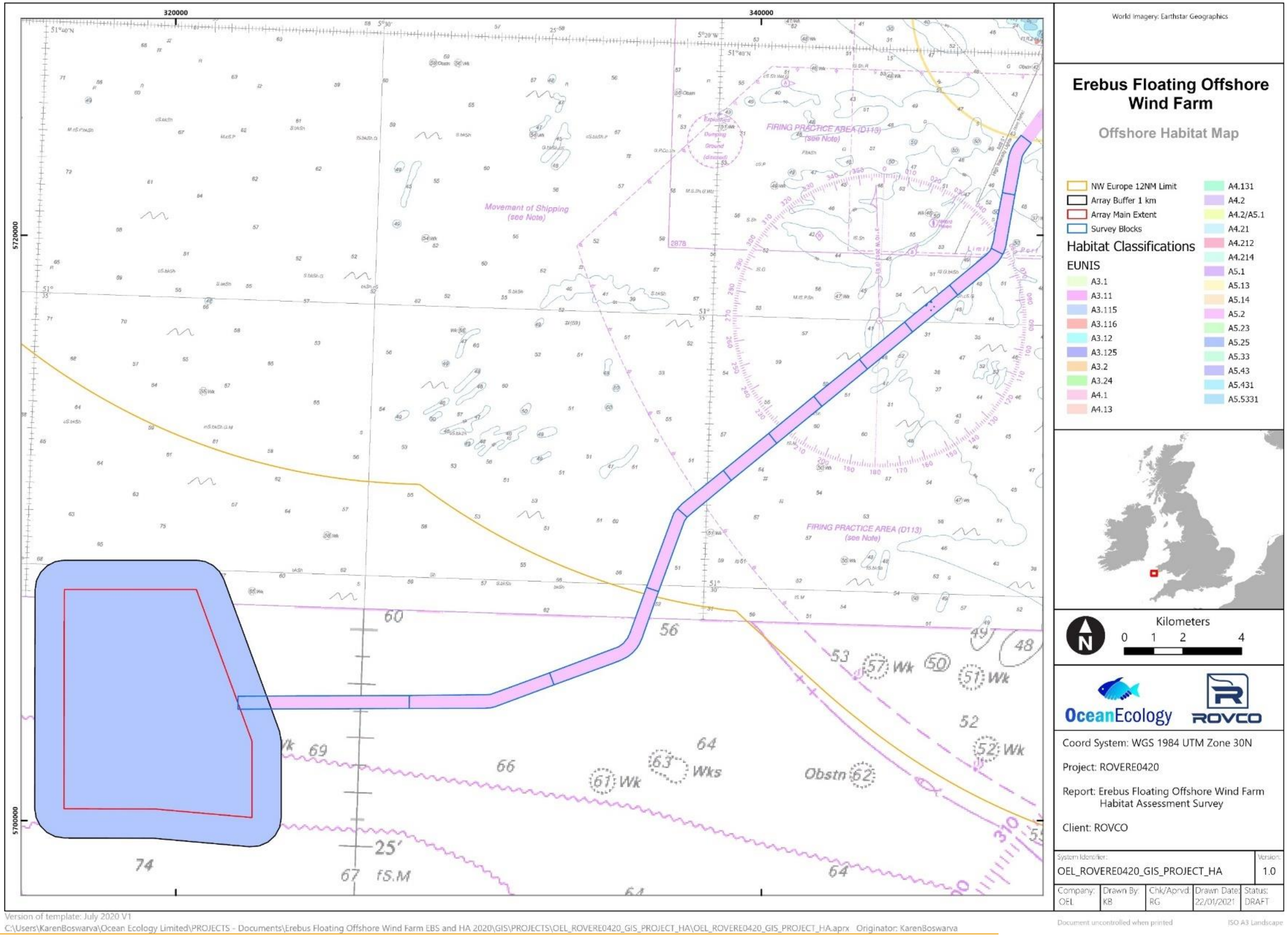



Figure 93: EUNIS habitat/biotope and Annex I reef mapping across the offshore section and array area of the Project Erebus survey area

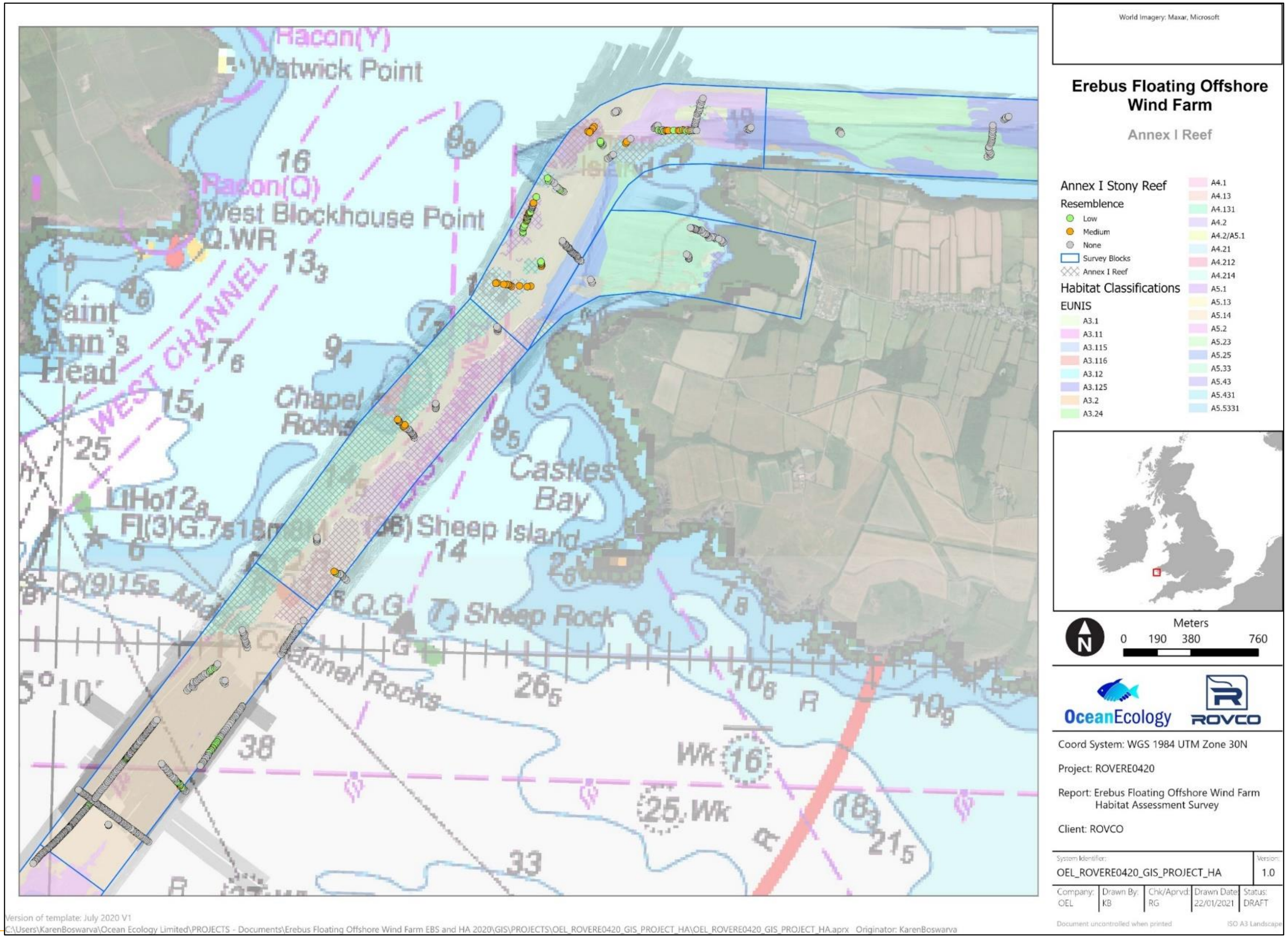



Figure 94: Annex I reef assessment across the Project Erebus survey area highlighting acoustic data and areas of non-reef

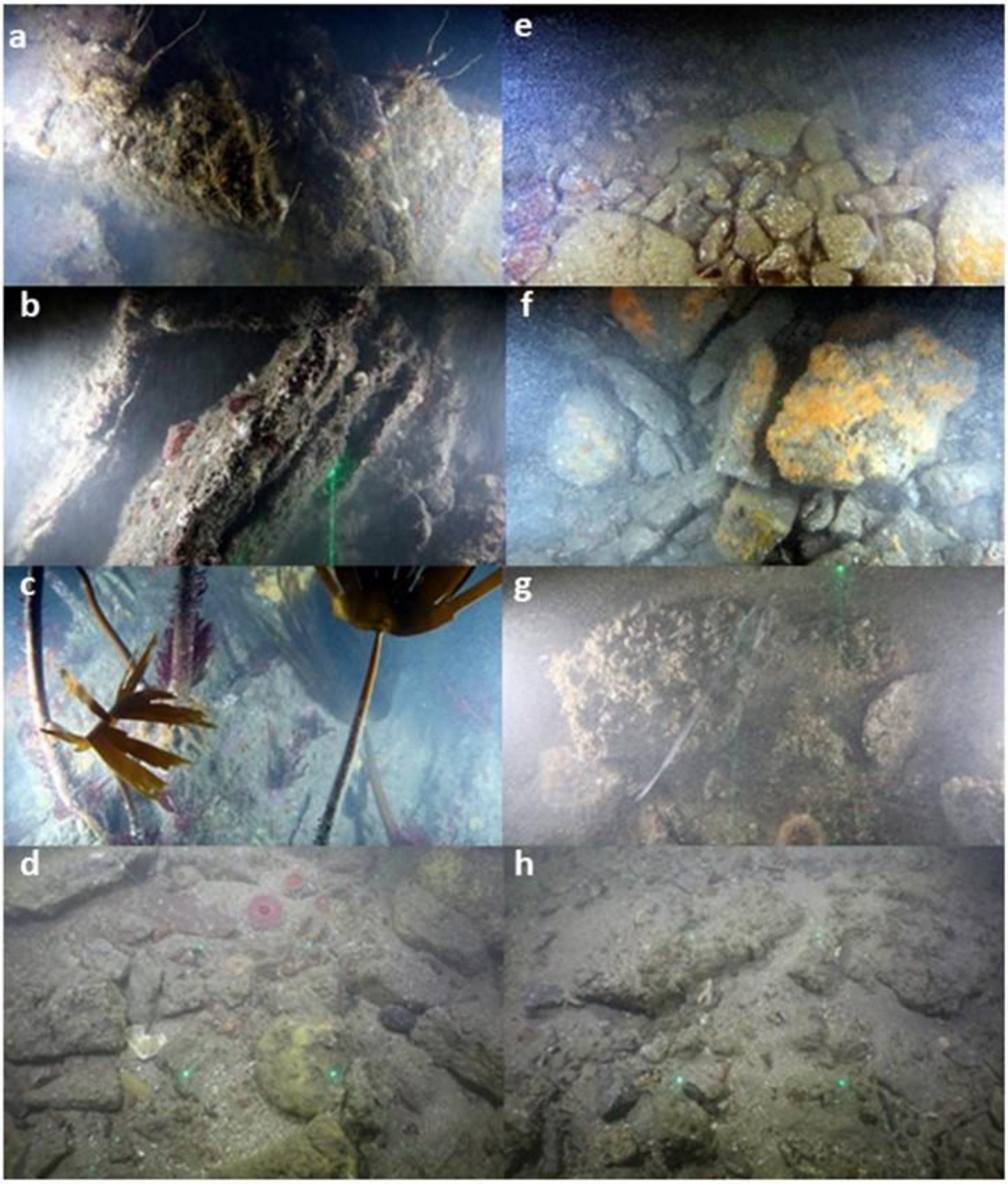



Figure 95: Example imagery showing bedrock reef (a-c), low resemblance stony reef (d, g and h) and medium resemblance stony reef (e and f). The distance between laser point is 10 cm.

Table 42: Summary of Annex I rocky reef assessment for each transect along which reef was observed

| Station | Stony Reef | | | Bedrock |
|---|---|---|---|---|
| | Not a Reef | Low | Medium | |
| T_003 | 6 | 8 | 7 | 6 |
| T_004 | 7 | - | 2 | 9 |
| T_005 | - | - | 5 | 17 |
| T_006 | 7 | 4 | - | 3 |
| T_007 | 9 | 14 | 5 | 13 |
| T_008 | - | - | 11 | 12 |
| T_009 | 16 | - | 5 | 18 |
| T_010 | 8 | 2 | 1 | 16 |
| T_016 | 23 | - | - | 4 |
| T_017 | 14 | - | - | 7 |
| T_018 | 21 | 4 | - | - |
| T_019 | 21 | 5 | 1 | - |
| T_020 | 92 | 3 | - | - |
| T_026 | 37 | - | - | 1 |
| T_098 | 74 | 5 | - | - |
| T_099 | 35 | 10 | 1 | - |

### 7.10.2. Annex I Biogenic Reef

No Annex I biogenic reef habitat was observed across the survey area following reef qualifying criteria set out by Gubbay (2007). A small patch of stony reef was observed along transect T_018 with one image showing *S. spinulosa* tube aggregations; however, this area was not deemed to meet the Annex I reef qualifying criteria due to its limited extent (Figure 96). Similarly, across transect T_026 an image showing an area of mixed sediment supporting *S. spinulosa* was noted however its extent was also very limited and therefore was not deemed to meet the Annex I reef qualifying criteria (Figure 96).

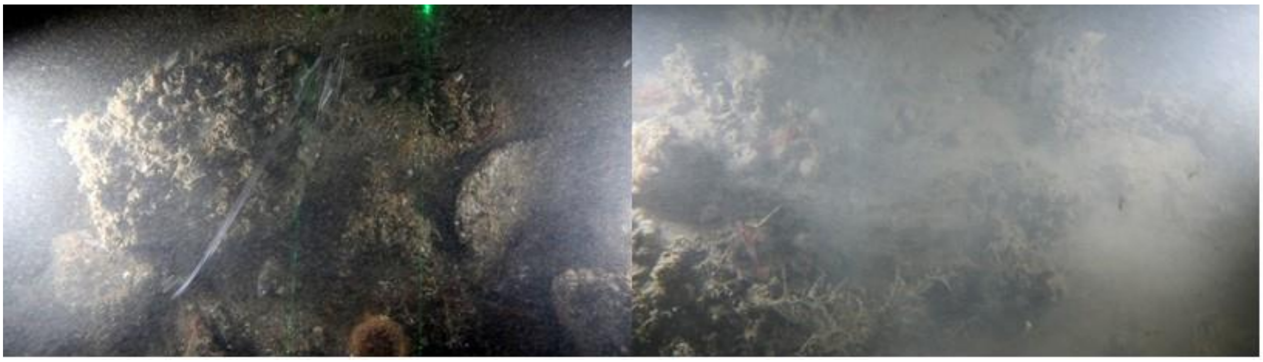


Figure 96: Two seabed images collected along the nearshore cable route depicting Sabellaria spinulosa tube aggregations. Left: EUNIS biotope A4.221 - Sabellaria spinulosa encrusted circalittoral rock (T_018); Right: EUNIS biotope A5.611 - Sabellaria spinulosa on stable circalittoral mixed sediment (T_026).

### 7.10.3. Annex I Sandbanks

Two areas of sandy habitat were identified as likely Annex I Sandbank habitats covering a combined area of 2.6 $km^2$ ofthe export cable route in consideration of the descriptors described by Pinder (2020). The first was assigned a 'High' confidence score given its topographic and sedimentary characteristics as well as the fact that it intersects, and forms part of, the known Turbot Bank Annex I sandbank feature. The second area was found further along the export cable corridor and was deemed to meet the topographic and sedimentary criteria but was assigned a 'Potential' confidence score due to the lack of known adjacent sandbanks. Pinder (2020) (Figure 97).

### 7.10.4. Seagrass Beds

*Zostera marina* shoots were recorded along transect T_001 extending to the shallow subtidal area of the Sawdern Point landfall (Figure 98). This area coincided with subtidal macrophyte dominated sediment and was deemed to be representative of EUNIS biotope A5.5331 '*Zostera marina / angustifolia* beds on lower shore or infralittoral clean or muddy sand'. Shoot density was generally low although several discrete patches of dense shoots were observed. Like many terrestrial plants, seagrasses senesce in the autumn and winter with storms causing dying shoots and leaves to break off and become redistributed. Given the time of the year the survey was undertaken, it is likely that the observation of low-density shoots is indicative that this area supports a seagrass bed which at the time was in a state of senescence. The majority of the plant biomass would have therefore been below the sediment surface at the time of the survey in the form of the system of rhizomes and roots whereas the more visible shoots are lost. It is noted that seagrass beds are habitats of principal importance for the purpose of maintaining and enhancing biodiversity in Wales under Section 7 of the Environment (Wales) Act 2016.

### 7.10.5. Maerl Beds

No maerl beds were observed across the survey area however a discrete patch of a mixture of live maerl and dead maerl rubble was observed in one seabed image taken at EBS station 003. This was not deemed to be representative of a distinct bed due to its limited extent but was recorded in relatively close proximity to the known bed in the vicinity of the South Hook Liquid Natural Gas Terminal to the north of the Sawdern Point export cable route (Figure 99). It is noted that maerl beds are habitats of principal importance for the purpose of maintaining and enhancing biodiversity in Wales under Section 7 of the Environment (Wales) Act 2016.

### 7.10.6. Other Notable Species

Notable species include species in the list of invasive non-native species (INNS) as well as protected species under different legislations. Aggregations of the slipper limpet *Crepidula fornicatea, and INNS*, were observed along transect T_014 located on mixed sediments which were deemed to be representative of the EUNIS biotope A5.431 '*Crepidula fornicata* with ascidians and anemones on infralittoral coarse mixed sediment'.

Shells of the native oyster *Ostrea edulis* were observed along transects T_020, T_097, T_098 and T_099 in the nearshore section of the export cable route corresponding to the EUNIS biotope complex A5.14 'Circalittoral coarse sediment'. Of these, the majority were not deemed to be alive (20 out of 27 images) however it was difficult to clearly assess this based on images only (Figure 100). The presence of *O. edulis* is notable given that the beds they can form are protected as

Habitats of Principle Importance (Environment Wales Act, 2016) and through inclusion on the OSPAR list of threatened and/or declining species and habitats. The presence of alive or dead *O. edulis* may be indicative of a previous or nearby bed in the area.

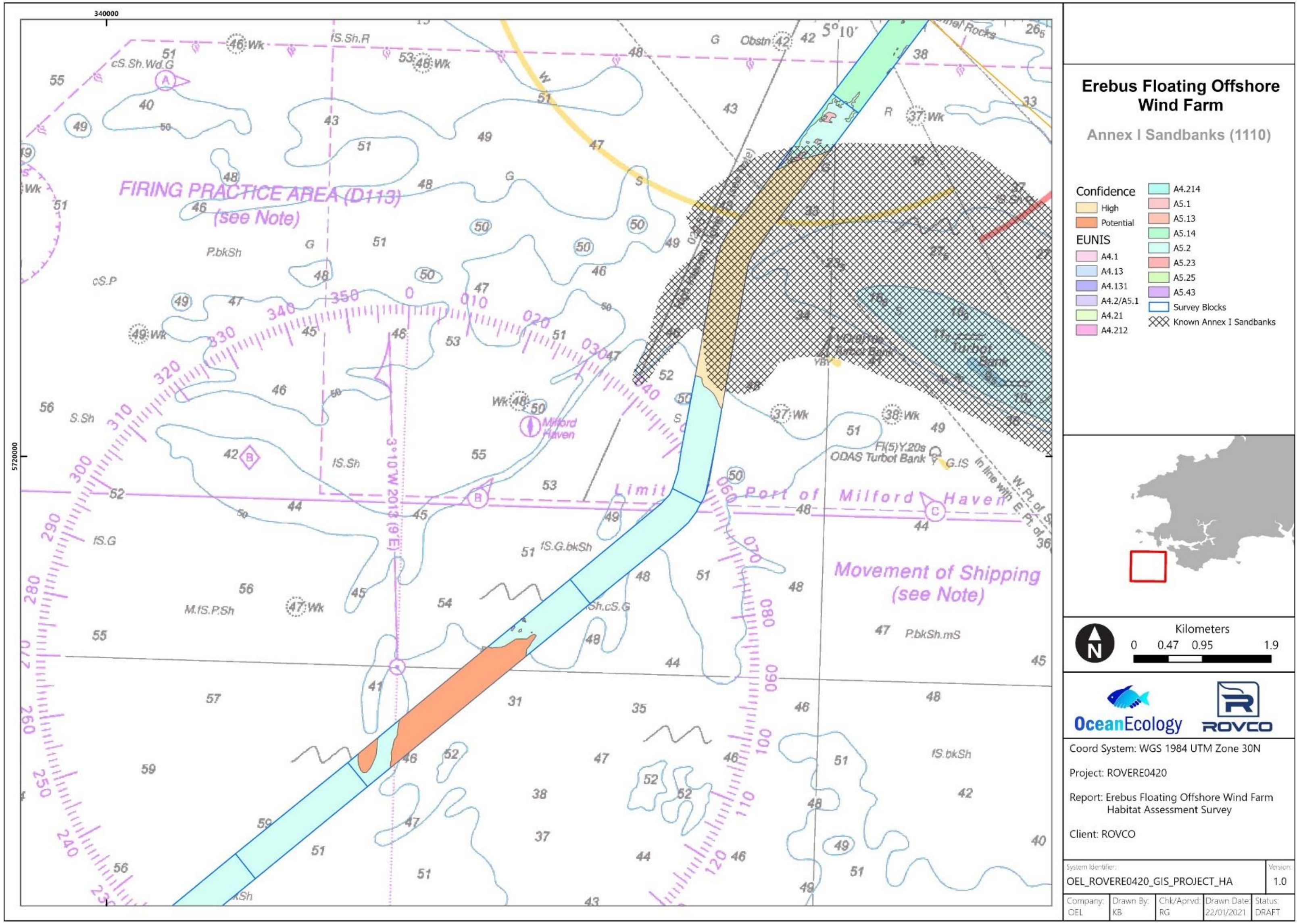



Figure 97: Annex I sandbank mapping across the nearshore section of the Project Erebus survey area

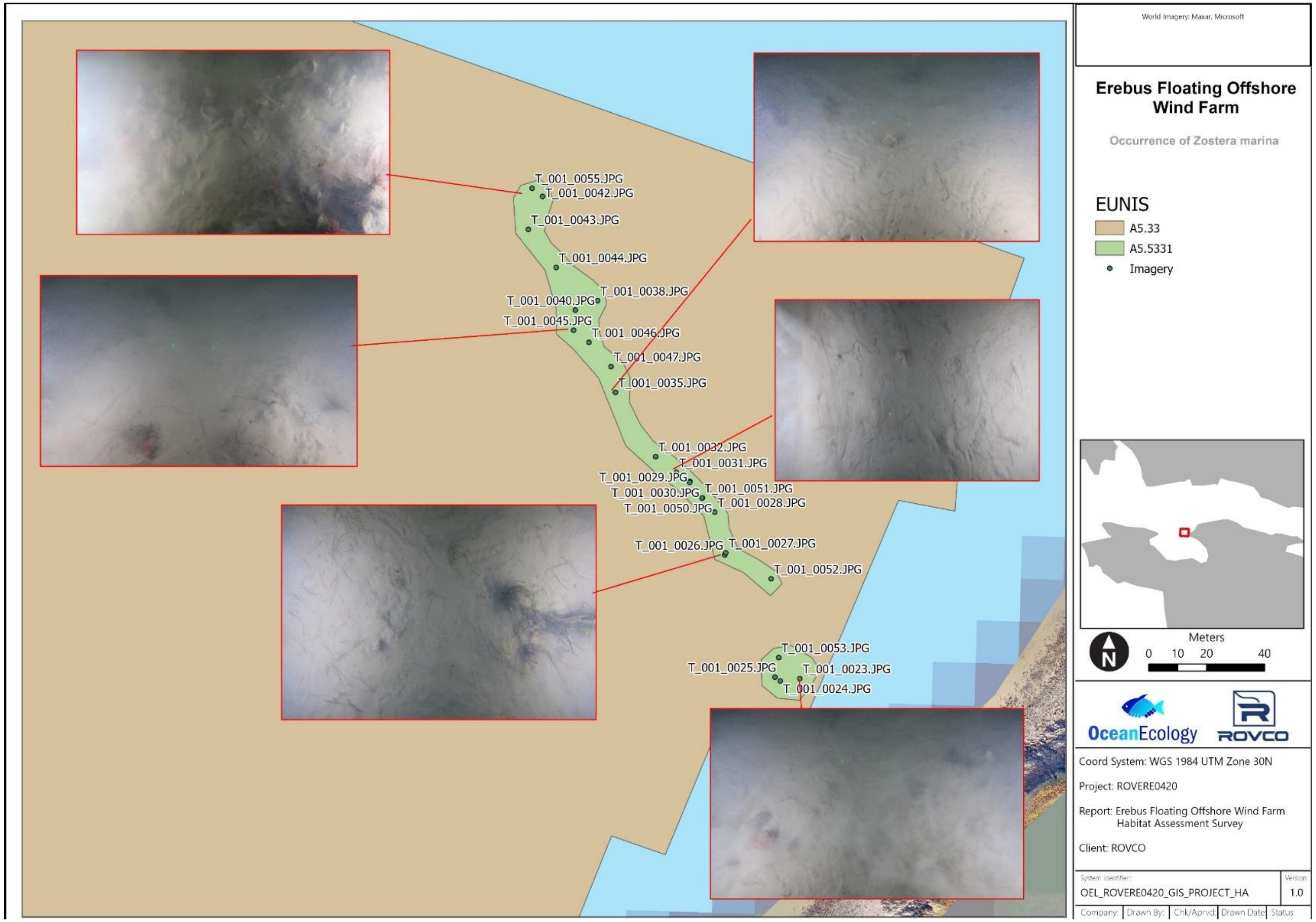



Figure 98: Zostera marina recorded across Transect T_001 in the vicinity of the Sawdern Point landfall location

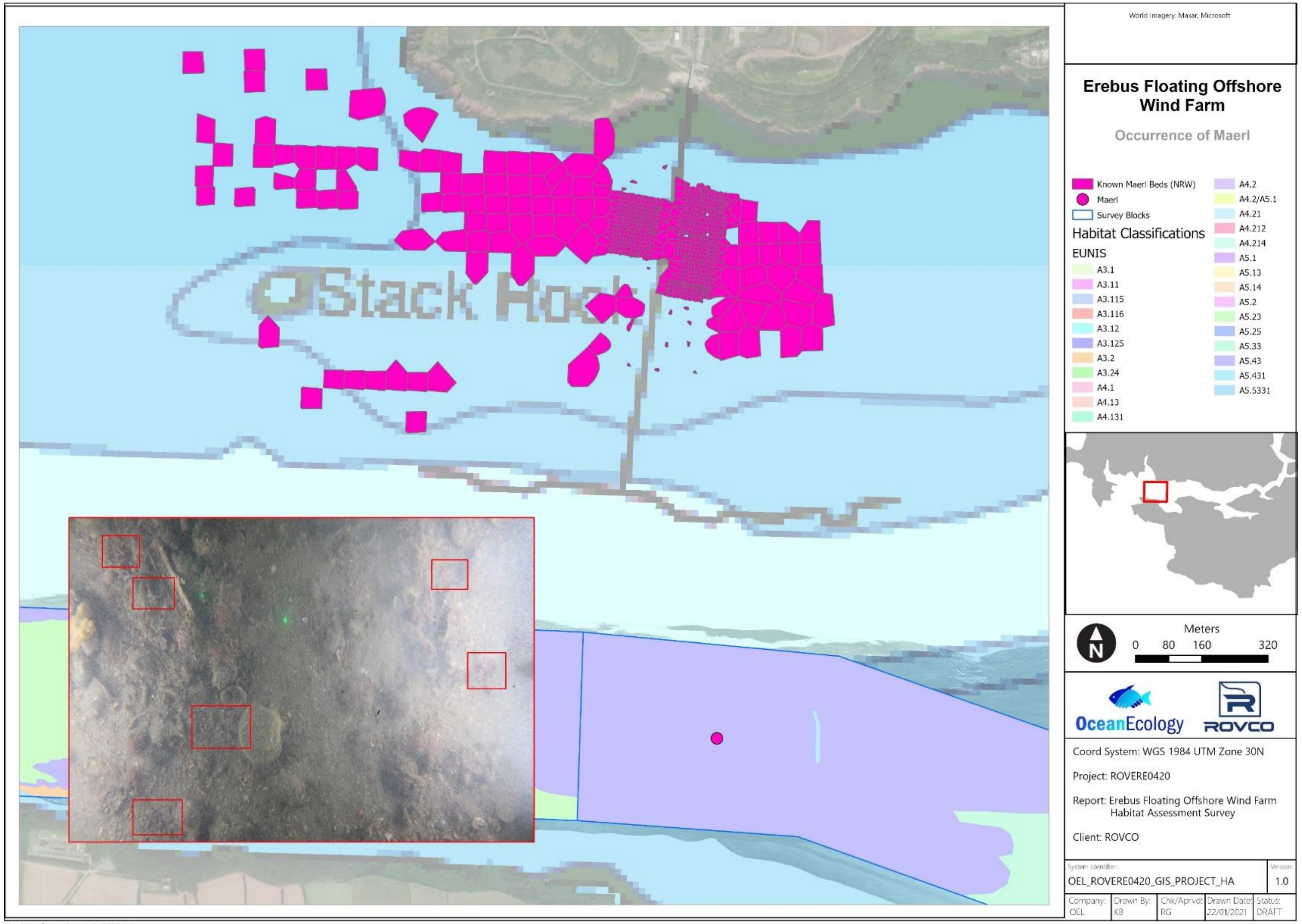



Figure 99: Occurrence of Maerl recorded at EBS station 003

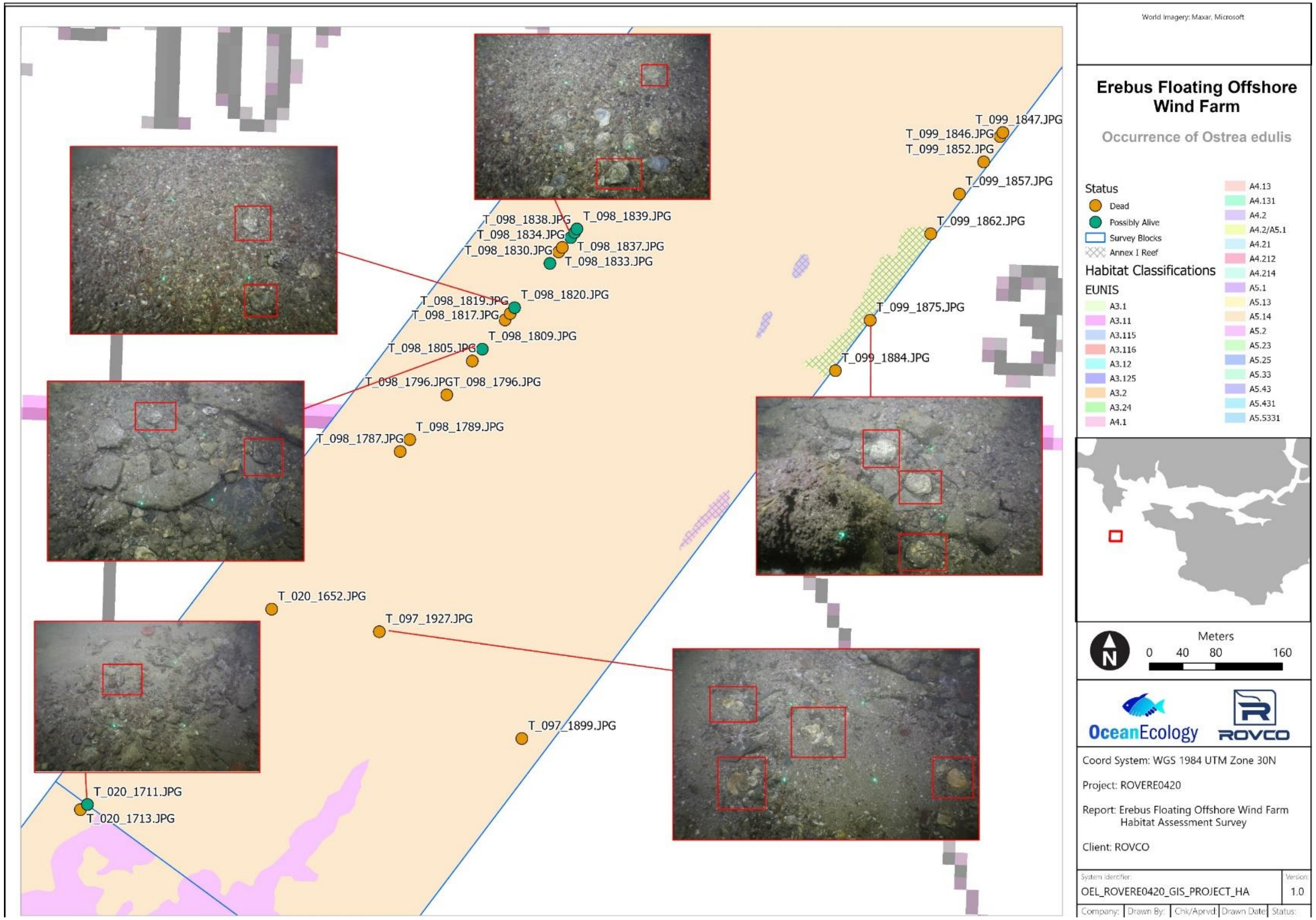



Figure 100: Occurrence of *Ostrea edulis* observed along transects T_020, T_097, T_098 and T_099.

### 7.11. Route Conditions

Table 42 lists changes in seafloor sediments along the centre line whilst also highlighting key features that cross or are in close proximity to the planned cable route. Subsurface interpretation is described in sections, specifically highlighting when bedrock becomes <5m below seabed including areas of exposure. Subsurface depths mentioned in the table are all relative to seabed, unless explicitly stated otherwise.

Table 43: Route condition listing, Sawdern Point and Export Cable Route

| KP Start | KP End | SBF | Mobile Features | Obstructions | SBP |
|---|---|---|---|---|---|
| 0.001 | 0.027 | No SSS coverage. | | | No SBP Coverage |
| 0.027 | 0.081 | No SSS coverage. | | | H04 slightly increasing in depth along the route from 2.1 to 2.9m<br><br>H10 within 5m of the seabed, maximum depth of 5.3m, minimum depth of 3.3m. |
| 0.081 | 0.244 | Sandy MUD | | | |
| 0.244 | 0.606 | Sandy MUD with mobile sediments | Ripples with average wavelength of 10m and maximum amplitude of 25cm | | H04 continuing to increase in depth along the route from 2.9 to 5.2m at KP0.805 where the horizon begins to shoal gently to 2m.<br><br>Acoustic blanking has been observed on SBP data between KP0.65 and KP0.955 and again at KP0.99 to KP1.005. These have been interpreted to be caused by the build-up of shallow gas. Interpretation beneath this feature has been limited.<br><br>H10 increases along the route, forming a channel between KP0.640 to KP0.915. Due to acoustic blanking, the |
| 0.606 | 1.070 | Sandy MUD | | | |
| 1.070 | 1.294 | Muddy sandy GRAVEL | | | |

| KP Start | KP End | SBF | Mobile Features | Obstructions | SBP |
|---|---|---|---|---|---|
| | | | | | base of this channel is not entirely resolved in the data. Depth BSB to H10 ranges from 5.3m – 11.7m. |
| 1.294 | 1.872 | Muddy sandy GRAVEL with mobile sediments | Ripples with average wavelength of 4m and maximum amplitude of <10cm. | Linear contact SFC_IS_0624 rope/cable present 1.46m from KP1.536 | Acoustic blanking has been observed on SBP data between KP1.395 and KP1.6 and again at KP3.08 to KP3.55. These have been interpreted to be caused by the build-up of shallow gas. Interpretation beneath this feature has been limited.<br><br>H04 continues to shoal and undulates between 0.5 and 2.6m below seabed. At KP3.235 H04 terminates on the seabed and is not seen for the remainder of the cable route.<br><br>H10 deepens to form a channel feature between KP1.345 and KP1.660, maximum depth the base of channel along the centre line is 16.6m. Some further shallow gas is present in the channel, making the base unresolvable at times.<br><br>Beyond this channel, the bedrock deepens progressively offshore from 6.8m to 17.8m. |
| 1.872 | 1.929 | Muddy sandy GRAVEL | | | |
| 1.929 | 1.945 | Muddy sandy GRAVEL with mobile sediments | Ripples with average wavelength of 4m and maximum amplitude of <10cm. | | |
| 1.945 | 2.269 | Muddy sandy GRAVEL | | | |
| 2.269 | 2.578 | Muddy sandy GRAVEL with mobile sediments | Ripples with average wavelength of 4.5m and maximum amplitude of 10cm. | SFC_IS_0566 String of Fishing Equipment crosses centre line at KP2.308. Wreck located 79.6m north of centre line at KP2.419. | |
| 2.578 | 3.166 | Muddy sandy GRAVEL | | SFC_IS_0526 String of Fishing Equipment present 8.91m from KP2.951. SFC_IS_520 present 6.93m from KP3.010. | |
| 3.166 | 3.689 | Muddy SAND | | SFC_IS_0492 String of Fishing Equipment present 4.38m from KP3.354. | |
| 3.689 | 3.909 | Muddy sandy GRAVEL | | | |

| KP Start | KP End | SBF | Mobile Features | Obstructions | SBP |
|---|---|---|---|---|---|
| 3.909 | 4.127 | Muddy sandy GRAVEL with boulder field | | SFC_IS_0326 String of Fishing Equipment crosses centre line at KP3.938.<br><br>Boulder field density: 64 boulders per 10000m$^2$ | From KP3.550 the depth to bedrock decreases progressively, reaching a depth of 5m below seabed at KP4.070. From here it continues to shoal, before sub-cropping from KP4.307 |
| 4.127 | 4.177 | Muddy SAND with boulder field | | Boulder field density: 64 boulders per 10000m$^2$ | |
| 4.177 | 4.301 | Muddy sandy GRAVEL with boulder field | | Boulder field density: 64 boulders per 10000m$^2$ | |
| 4.301 | 4.307 | Muddy SAND with boulder field | | Boulder field density: 64 boulders per 10000m$^2$ | |
| 4.307 | 4.320 | Muddy SAND veneer over ROCK with boulder field | | Boulder field density: 64 boulders per 10000m$^2$ | H10 sub-cropping near seabed. No interpretable horizons noted beneath |
| 4.320 | 4.344 | Muddy SAND veneer over ROCK with boulder field and mobile sediments | Ripples with average wavelength of 7m and maximum amplitude of 12cm. | Boulder field density: 64 boulders per 10000m$^2$ | |
| 4.344 | 4.370 | Muddy SAND veneer over ROCK with boulder field | | Boulder field density: 64 boulders per 10000m$^2$ | |
| 4.370 | 4.422 | Muddy SAND veneer over ROCK with boulder field and mobile sediments | Ripples with average wavelength of 7m and maximum amplitude of 12cm. | Boulder field density: 64 boulders per 10000m$^2$ | |
| 4.422 | 4.424 | Muddy SAND with boulder field and mobile sediments | Ripples with average wavelength of 7m and maximum amplitude of 12cm. | Boulder field density: 64 boulders per 10000m$^2$ | H10 deepens to form a channel, Maximum depth to channel bottom is 6.5m, before returning to the seabed and outcropping from KP4.756. |
| 4.424 | 4.444 | Muddy SAND with boulder field | | Boulder field density: 64 boulders per 10000m$^2$ | |

| KP Start | KP End | SBF | Mobile Features | Obstructions | SBP |
|---|---|---|---|---|---|
| 4.444 | 4.691 | Muddy SAND with boulder field and mobile sediments | Ripples with average wavelength of 7m and maximum amplitude of 12cm. | Boulder field density: 64 boulders per 10000m$^2$ | |
| 4.691 | 4.702 | Muddy SAND with mobile sediments | Ripples with average wavelength of 7m and maximum amplitude of 12cm. | | |
| 4.702 | 4.756 | Muddy SAND | | | |
| 4.756 | 4.834 | ROCK | | SFC_IS_0538 item of debris 2.35m max dimension located 0.91m from KP4.758. | Bedrock outcropping on seabed |
| 4.834 | 4.849 | Sandy GRAVEL | | | H10 depth increases along the route from outcropping to a maximum depth of 27.4m at KP4.945. From here it undulates, remaining deeper than 5m until it begins to shoal at KP5.550. From here it shoals further before outcropping at KP5.605. |
| 4.849 | 4.869 | Sandy GRAVEL with mobile sediments | Ripples with average wavelength of 2m and maximum amplitude of <10cm. | | |
| 4.869 | 4.877 | Sandy GRAVEL | | | |
| 4.877 | 5.085 | Sandy GRAVEL with mobile sediments | Ripples with average wavelength of 2m and maximum amplitude of <10cm. | | |
| 5.085 | 5.146 | Sandy GRAVEL | | | |
| 5.146 | 5.250 | Sandy GRAVEL with mobile sediments | Ripples with average wavelength of 2m and maximum amplitude of <10cm. | | |
| 5.250 | 5.605 | Sandy GRAVEL | | SFC_IS_0870 cable/metallic debris | |

| KP Start | KP End | SBF | Mobile Features | Obstructions | SBP |
|---|---|---|---|---|---|
| | | | | cross centre line at KP5.494. | |
| 5.605 | 5.663 | ROCK | | | Bedrock outcropping on seabed |
| 5.663 | 5.741 | Sandy GRAVEL | | | H10 briefly deepens to a maximum of 2m before shoaling again |
| 5.741 | 5.786 | ROCK | | | Bedrock outcropping on seabed |
| 5.786 | 5.841 | Sandy GRAVEL | | | H10 briefly deepens to a maximum of 2m before shoaling again |
| 5.841 | 5.902 | Sandy GRAVEL veneer over ROCK | | | Bedrock sub-cropping on seabed |
| 5.902 | 5.917 | ROCK | | | Bedrock outcropping on seabed |
| 5.917 | 6.526 | Sandy GRAVEL with mobile sediments | Ripples with average wavelength of 1.9m and maximum amplitude of <10cm. | | H10 remains within 5m of the seabed until KP5.970 beyond which it deepens to form large channels filled with coarse sediments. The top of these infill sediments is demarked by H07. On the flanks of these channels, the bedrock returns to within 5m of the seabed between KP6.585 and KP6.605, with a minimum recorded depth of 4.1m BSB. |
| 6.526 | 6.646 | Sandy GRAVEL | | | |
| 6.646 | 6.654 | Sandy GRAVEL with mobile sediments | Ripples with average wavelength of 1.9m and maximum amplitude of <10cm. | | |
| 6.654 | 6.859 | Sandy GRAVEL | | | H10 increases in depth to a maximum of 24.0m. It remains at a depth greater than 5m, until between KP7.200 and KP7.260 where it reaches a minimum depth of |
| 6.859 | 7.033 | Sandy GRAVEL with mobile sediments | Ripples with average wavelength of 1.9m and maximum amplitude of <10cm. | | |

| KP Start | KP End | SBF | Mobile Features | Obstructions | SBP |
|---|---|---|---|---|---|
| 7.033 | 7.077 | Sandy GRAVEL | | | 1.5m. From here it deepens further, before again shoaling to a depth of 4.2m at KP7.415, then outcropping on the seabed from KP7.480. |
| 7.077 | 7.48 | Sandy GRAVEL with mobile sediments | Ripples with average wavelength of 1.9m and maximum amplitude of <10cm. | | |
| 7.48 | 7.492 | ROCK | | | Bedrock outcropping on seabed |
| 7.492 | 8.277 | Sandy GRAVEL with mobile sediments | Ripples with average wavelength of 1.9m and maximum amplitude of <10cm. | | H10 remains at or within 5m of the seabed until KP7.560, where it increases in depth to a maximum of 17.5m at KP8.049, marking the base of a channel feature. Shoaling again from this point, it returns to within 5m of the seabed at KP8.210. Onwards from this point along the centre line it remains fairly constant and shallow, with a depth below seabed ranging from 0.9m to 4.7m. |
| 8.277 | 8.282 | Sandy GRAVEL with mobile sediments | Ripples with average wavelength of 1.9m and maximum amplitude of <10cm. | Boulder field density: 37 boulders per 10000$m^2$. Maximum density:131 per 10000$m^2$ | |
| 8.282 | 9.077 | Sandy GRAVEL | | Boulder field density: 37 boulders per 10000$m^2$. Maximum density:131 per 10000$m^2$ | |
| 9.077 | 9.09 | Sandy GRAVEL with mobile sediments | Ripples with average wavelength of 3m and maximum amplitude of <10cm. | Boulder field density: 37 boulders per 10000$m^2$. Maximum density:131 per 10000$m^2$ | |
| 9.09 | 9.894 | Sandy GRAVEL | | Boulder field density: 37 boulders per 10000$m^2$. Maximum density:131 per 10000$m^2$. | |
| 9.894 | 10.272 | Sandy GRAVEL with mobile sediments | Ripples with average wavelength of 8m and maximum amplitude of 11cm. | Boulder field density: 37 boulders per 10000$m^2$. Maximum density:131 per 10000$m^2$ | |
| 10.272 | 10.591 | Sandy GRAVEL with mobile sediments | Ripples with average wavelength of 8m and | | |

| KP Start | KP End | SBF | Mobile Features | Obstructions | SBP |
|---|---|---|---|---|---|
| | | | maximum amplitude of 11cm. | | |
| 10.591 | 10.599 | Sandy GRAVEL with mobile sediments | Ripples with average wavelength of 8m and maximum amplitude of 11cm. | Boulder field density: 29 boulders per 10000m$^2$ | From KP10.591, the base of the surficial sediments, H05, becomes resolvable within the dataset. This basal horizon quickly merges onto the H10 top of bedrock horizon below as the surficial sediments lie directly onto the bedrock surface. The thickness of H05 thickens significantly forming a sediment bank spanning from KP10.665 to KP14.420 which at its peak is 12.1m thick.<br><br>H10 remains within 5m of the seabed until KP10.910 where the increasing thickness of the overlying surficial sediments increased to a maximum of 12.1m at KP12.3980. After which it again returns to within 5m of the seabed at KP13.595. From here it shoals to a minimum depth of 0.7m below the seabed at KP14.508. The surface of the top of bedrock dips relative to LAT, increasing in depth further along the centre line. |
| 10.599 | 10.738 | Sandy GRAVEL with mobile sediments | Ripples with average wavelength of 8m and maximum amplitude of 11cm. | | |
| 10.631 | 10.738 | Sandy GRAVEL / gravelly SAND with mobile sediments | Ripples with average wavelength of 8m and maximum amplitude of 11cm. | | |
| 10.738 | 10.812 | Sandy GRAVEL / gravelly SAND with mobile sediments | Ripples with average wavelength of 8m and maximum amplitude of 11cm. | Boulder field density: 62 boulders per 10000m$^2$ | |
| 10.812 | 10.902 | Sandy GRAVEL / gravelly SAND with mobile sediments | Ripples with average wavelength of 8m and maximum amplitude of 11cm. | | |
| 10.902 | 10.918 | Sandy GRAVEL / gravelly SAND with mobile sediments | Ripples with average wavelength of 8m and maximum amplitude of 11cm. | Boulder field density: 61 boulders per 10000m$^2$ | |
| 10.918 | 11.106 | Sandy GRAVEL / gravelly SAND with mobile sediments | Ripples with average wavelength of 4.5m and maximum amplitude of 30cm. | | |
| 11.106 | 11.149 | Sandy GRAVEL / gravelly SAND with mobile sediments | Ripples with average wavelength of 4.5m and maximum amplitude of 30cm. | Boulder field density: 24 boulders per 10000m$^2$ | |
| 11.149 | 14.508 | Sandy GRAVEL / gravelly SAND with mobile sediments | Ripples with average wavelength of 4.5m and maximum amplitude of 30cm. | | |

| KP Start | KP End | SBF | Mobile Features | Obstructions | SBP |
|---|---|---|---|---|---|
| | | | Sandwaves present on south side of centre line between KP11.820 and KP12.295 with wavelength of 200m and maximum height of 2.1m. Orientation NE-SW. | | |
| 14.508 | 14.531 | Sandy GRAVEL / gravelly SAND with mobile sediments | Ripples with average wavelength of 4.5m and maximum amplitude of 30cm. | Boulder field density: 24 boulders per 10000m$^2$ | H05 continues to overlie H10 with peak thickness of 2.9m. Thickness variations across this stretch are primarily governed by the height of mobile bedforms including sandwaves.<br><br>H10 remains close to the seabed, undulating slightly. Depth below seabed ranges from 0.6m to 2.9m. The surface of the top of bedrock dips relative to LAT, increasing in depth further along the centre line. |
| 14.531 | 14.569 | Sandy GRAVEL / gravelly SAND with mobile sediments | Ripples with average wavelength of 4.5m and maximum amplitude of 30cm. | | |
| 14.569 | 16.044 | Gravelly SAND with mobile sediments | Ripples with average wavelength of 4.5m and maximum amplitude of 30cm. | | |
| 16.044 | 16.126 | Sandy GRAVEL / gravelly SAND with mobile sediments | Ripples with average wavelength of 5.5m and maximum amplitude of 40cm. | | |
| 16.126 | 16.296 | Gravelly SAND with mobile sediments | Ripples with average wavelength of 7m and maximum amplitude of 60cm. | | |
| 16.296 | 16.441 | Sandy GRAVEL / gravelly SAND with mobile sediments | Ripples with average wavelength of 7m and maximum amplitude of 60cm. | | |
| 16.441 | 16.457 | Gravelly SAND with mobile sediments | Ripples with average wavelength of 7m and maximum amplitude of 60cm. | | |

| KP Start | KP End | SBF | Mobile Features | Obstructions | SBP |
|---|---|---|---|---|---|
| 16.457 | 16.461 | Sandy GRAVEL / gravelly SAND with mobile sediments | Ripples with average wavelength of 7m and maximum amplitude of 60cm. | | |
| 16.461 | 16.478 | Gravelly SAND with mobile sediments | Ripples with average wavelength of 7m and maximum amplitude of 60cm. | | |
| 16.478 | 16.536 | Sandy GRAVEL / gravelly SAND with mobile sediments | Ripples with average wavelength of 7m and maximum amplitude of 60cm. | | |
| 16.536 | 16.614 | Gravelly SAND with mobile sediments | Ripples with average wavelength of 7m and maximum amplitude of 60cm. | | |
| 16.614 | 16.744 | Sandy GRAVEL / gravelly SAND with mobile sediments | Ripples with average wavelength of 7m and maximum amplitude of 60cm. | | |
| 16.744 | 16.841 | Gravelly SAND with mobile sediments | Ripples with average wavelength of 7m and maximum amplitude of 60cm. | | |
| 16.841 | 16.942 | Sandy GRAVEL / gravelly SAND with mobile sediments | Ripples with average wavelength of 7m and maximum amplitude of 60cm. | | |
| 16.942 | 17.007 | Gravelly SAND with mobile sediments | Ripples with average wavelength of 7m and maximum amplitude of 60cm. | | |
| 17.007 | 17.099 | Sandy GRAVEL / gravelly SAND with mobile sediments | Ripples with average wavelength of 7m and maximum amplitude of 60cm. | | |

| KP Start | KP End | SBF | Mobile Features | Obstructions | SBP |
|---|---|---|---|---|---|
| 17.099 | 17.77 | Sandy GRAVEL / gravelly SAND with mobile sediments | Megaripples with average wavelength of 130m and maximum amplitude of 1.2m. | | |
| 17.77 | 18.222 | Sandy GRAVEL / gravelly SAND with mobile sediments | Ripples with average wavelength of 7m and maximum amplitude of 30cm. | | |
| 18.222 | 18.25 | Gravelly SAND with mobile sediments | Ripples with average wavelength of 7m and maximum amplitude of 30cm. | | |
| 18.25 | 18.547 | Gravelly SAND with mobile sediments | Ripples with average wavelength of 7m and maximum amplitude of 30cm. | Boulder field density: 45 boulders per 10000m$^2$<br><br>Suspected UXO 50m south east of centre line from KP18.270. | H05 thins up until KP18.340 at which point it is no longer interpretable. The loss of surficial sediment cover correlates to the appearance of a boulder field exposing the reworked glacial deposits beneath. At KP18.775 the H05 horizon becomes interpretable again with thicknesses up to 1.4m.<br><br>H10 remains between 0.5 to 2.1m below the seabed, continuing to dip seaward relative to LAT. |
| 18.547 | 18.573 | Gravelly SAND with mobile sediments | Ripples with average wavelength of 7m and maximum amplitude of 30cm. | | |
| 18.573 | 18.631 | Sandy GRAVEL / gravelly SAND with mobile sediments | Ripples with average wavelength of 7m and maximum amplitude of 30cm. | | |
| 18.631 | 18.872 | Sandy GRAVEL / gravelly SAND with mobile sediments | Ripples with average wavelength of 7m and maximum amplitude of 30cm. | Boulder field density: 45 boulders per 10000m$^2$ | |
| 18.872 | 19.032 | Sandy GRAVEL / gravelly SAND with mobile sediments | Ripples with average wavelength of 7m and maximum amplitude of 30cm. | | H05 increases in thickness again from KP18.925 forming another bank of sediment hosting sandwaves. The |

| KP Start | KP End | SBF | Mobile Features | Obstructions | SBP |
|---|---|---|---|---|---|
| 19.032 | 20.165 | Gravelly SAND with mobile sediments | Ripples with average wavelength of 8m and maximum amplitude of 30cm.<br><br>Sandwaves with average wavelength of 370m and maximum amplitude of 2.5m. ENE-WSW orientation. | | maximum thickness occurs at KP19.970 at 13.1m below seabed.<br><br>H10 continues to undulate <5m beneath the seabed whilst continuing to dip seaward relative to LAT. The depth exceeds 5m from KP19.282 until KP21.173, where the surficial sediments have formed a bank, beyond which it thins to a minimum depth of 1.8m. |
| 20.165 | 22.059 | Sandy GRAVEL / gravelly SAND with mobile sediments | Ripples with average wavelength of 8m and maximum amplitude of 30cm.<br><br>Sandwaves with average wavelength of 370m and maximum amplitude of 2.5m.<br><br>Not present in data from KP21.270. Orientation NE to SW. | | |
| 22.059 | 22.123 | Muddy sandy GRAVEL with mobile sediments | Ripples with average wavelength of 5m and maximum amplitude of <10cm. | | Both H05 and H10 dip seawards together relative to LAT with the surficial sediments continuing to lie directly on top of the bedrock. Thicknesses of surficial sediments between 1.4m and 5.7m below seabed are observed. |
| 22.123 | 22.181 | Muddy sandy GRAVEL with mobile sediments | Ripples with average wavelength of 5m and maximum amplitude of <10cm. | Area of trawl scars | |
| 22.181 | 22.67 | Muddy sandy GRAVEL | | Area of trawl scars. | |
| 22.67 | 22.675 | Sandy GRAVEL | | | |
| 22.675 | 23.099 | Sandy GRAVEL with mobile sediments | Ripples with average wavelength of 5m and | | |

| KP Start | KP End | SBF | Mobile Features | Obstructions | SBP |
|---|---|---|---|---|---|
| | | | maximum amplitude of <10cm. | | |
| 23.099 | 23.101 | Sandy GRAVEL with mobile sediments | Ripples with average wavelength of 5m and maximum amplitude of <10cm. | Boulder field density: 12 boulders per 10000m$^2$ | |
| 23.101 | 23.131 | Sandy GRAVEL with mobile sediments | Ripples with average wavelength of 5m and maximum amplitude of <10cm. | | |
| 23.131 | 23.145 | Sandy GRAVEL with mobile sediments | Ripples with average wavelength of 5m and maximum amplitude of <10cm. | Boulder field density: 12 boulders per 10000m$^2$ | |
| 23.145 | 23.906 | Sandy GRAVEL with mobile sediments | Ripples with average wavelength of 5m and maximum amplitude of 30cm.<br><br>Sandwaves present in data to south of centre line from KP23.225 to KP23.830. The do not cross the centre line. Average wavelength 40m, maximum amplitude 1.2m. Orientation ENE to WSW. | | |
| 23.906 | 33.244 | Muddy SAND with mobile sediments | Ripples with average wavelength of 8.5m and maximum amplitude of 40cm.<br><br>Sandwaves between KP33.250 to 34.050. Orientation NE-SW. Average wavelength | | H05 separates from the top of the bedrock unit, H10, at KP24.044, marking a separation between the surficial sediments on the surface and the channel fill sediments beneath. Initially the thickness of sediment increases to a peak of 6.83m at KP27.320 on a bank of sediment. This is followed by |

| KP Start | KP End | SBF | Mobile Features | Obstructions | SBP |
|---|---|---|---|---|---|
| | | | 420m, maximum amplitude 4m. | | a brief shoal at KP33.184 where thickness reaches 0.5m.<br><br>H06, representing the top of the channel infill sediments and the base of a layer of reworked outwash sediments is observed to split from H05 at KP25.890. It initially deepens rapidly to fill a paleochannel, before returning to approximately 8.2m below seabed. Maximum depth at the base of this channel is 21.4m at KP26.654, shoaling to 6.4m offshore, where it truncates against the bedrock below at KP29.660.<br><br>H10 appears as an eroded surface on the bedrock. Multiple erosional channel features are present incised into the bedrock, with a maximum interpreted depth of 47.5m. For much of the section, the depth to bedrock remains deep within these channels, however from KP31.080, the bedrock is interpreted to be within 5m of the seabed, with a minimum interpreted depth of 1.2m at KP32.195. |
| 33.244 | 40.769 | Muddy SAND with mobile sediments | Ripples with average wavelength of 8.5m and maximum amplitude of 40cm.<br><br>Sandwaves between KP33.250 to 34.050. | | After initially shoaling, H05 thickens beneath by two sandwaves encountered at KP33.327 and KP33.764. Thickness of sediment then gradually decreases moving along the centre line to a minimum thickness of 0.3m |

| KP Start | KP End | SBF | Mobile Features | Obstructions | SBP |
|---|---|---|---|---|---|
| | | | Orientation NE-SW. Average wavelength 420m, maximum amplitude 4m. | | H06 remains eroded away until KP33.244, where it is interpreted once more and undulates along the centre line, with the depth ranging from 2.3m to 9.3m.<br><br>H10 remains within 5m of the seabed until KP33.260, beyond which it begins to undulate once more, following deep erosional channels, but remaining deeper than 5m. |
| 40.769 | 40.966 | Muddy SAND with mobile sediments | Ripples with average wavelength of 17m and maximum amplitude of 40cm. | Boulder field density: 12 boulders per 10000m$^2$ | For the remainder of the route, H05 remains thin, with depths ranging from 0.1m to 0.9m. |
| 40.966 | 43.542 | Muddy SAND with mobile sediments | Ripples with average wavelength of 17m and maximum amplitude of 40cm. | | H06, is observed undulating but stable beneath H05, along the top of channel features. Depths to this horizon range from 2.2m to 9.8m. |
| 43.542 | 44.021 | Muddy SAND with mobile sediments | Ripples with average wavelength of 17m and maximum amplitude of 40cm.. | Boulder field density: 14 boulders per 10000m$^2$ | |
| 44.021 | 48.604 | Muddy SAND with mobile sediments | Ripples with average wavelength of 17m and maximum amplitude of 40cm. | | H10 mostly remains deeper than 5m below the seabed, forming large channels, infilled with coarse sediment. The maximum interpreted depth below seabed is 28.3m at the base of one of these channel features. Between KP46.350 and KP46.510 H10 returns to within 5m of the seabed, with a minimum interpreted depth of 3.1m. Beyond this it continues to deepen and form further channelisation. |

# 8. Discussion

## 8.1. EUNIS Habitats/Biotopes

The main habitats identified across the survey area at which seabed imagery and grab samples were obtained comprised primarily of the EUNIS classifications A5.251 '*Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand' and A5.351 '*Amphiura filiformis*, *Mysella bidentata* and *Abra nitida* in circalittoral sandy mud' in the offshore section of the cable route and in the main array.

Stations located on the cable route within the Milford Haven Waterway were characterised by various EUNIS biotopes including A5.143 '*Protodorvillea kefersteini* and other polychaetes in impoverished circalittoral mixed gravelly sand', A5.334 '*Melinna palmata* with *Magelona* spp. and *Thyasira* spp. in infralittoral sandy mud', and A5.433 '*Mysella bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment'. Stations located on the outer fringes of the Milford Haven Waterway and the nearshore area of the cable route were best represented by the EUNIS biotope A5.14 'Circalittoral coarse sediment', A5.25 'Circalittoral fine sand' and A5.44 'Circalittoral mixed sediments'.

Overall, the habitat identified across the Project Erebus survey area using a combination of geophysical data, seabed imagery, and sediment and macrofauna samples for ground truthing reflect the existing EMODnet broad scale habitat mapping while providing a more refined assessment of the habitats and biotopes present across the survey area, including key features and designated habitats.

## 8.2. Annex I Habitats

Annex I bedrock and stony reef habitats were identified in areas of the cable route, mostly along the nearshore sections around the entrance to Milford Haven. Annex I bedrock was also identified in the shallow subtidal area close to the West Angle Bay landfall (survey block WA01). Here sublittoral fringe rock extended to the infralittoral zone forming a continuous feature which can be assigned as Annex I reef (JNCC 2015). Interestingly, transect T_013 located in proximity of West Angle Bay did not show evidence of Annex I reef habitats (grey dots on Figure 94) as none of the seabed images with rocky substrates covered an area large enough to qualify as an Annex I reef. Nevertheless, these few images showing kelp on bedrock in the shallower part of the transect (T_013) proved that the rocky shore observed in the intertidal zone continues in the sublittoral zone hence forming an Annex I reef habitat (JNCC 2015; OEL 2021). Based on the data presented in this report, the stony reefs were assessed to be of both low and medium resemblance (as per Irving (2009)). In general, where stony and bedrock reefs were recorded along the same transects, they were deemed to form mosaic habitats meaning it was difficult to differentiate between the two reef types given the lack of clear boundaries in the acoustic data. These features were deemed to form part of the designated Annex I 'reef' feature of the Pembrokeshire Marine SAC, which, overall, is currently deemed to be in an 'Unfavourable' conservation status (NRW 2018). This is largely because of the impacts of the high levels of nutrients in the water column within the Milford Haven waterway and high levels of chemicals such as tributyltin compounds (TBT), mercury and its compounds and brominated diphenylether (BDPE) on the structure and functioning of the feature. Despite this, the rocky shores of the Milford Haven Waterway are considered to be in good condition (NRW 2018).

Two areas of sandy habitat were identified as likely Annex I Sandbank habitats along the export cable route. The first was assigned a 'High' confidence score given its topographic and sedimentary characteristics as well as the fact that it intersects, and forms part of, the known Turbot Bank Annex I sandbank feature which is currently deemed to be in an 'Unfavourable' conservation status (NRW 2018). The second area was found further along the export cable corridor and was deemed to meet the topographic and sedimentary criteria but was assigned a 'Potential' confidence score due to the lack of known adjacent sandbanks. It should be noted that this 'potential' sandbank feature is located outside the Pembrokeshire Marine SAC and does not therefore constitute part of the designated Annex I Sandbank feature of the SAC.

No Annex I biogenic reef habitat was observed across the survey area. Only two images were recorded showing *S. spinulosa* tube aggregations which were not deemed to meet the Annex I reef qualifying criteria.

### 8.3. Other Features of Interest

The presence of low-density *Z. marina* shoots along transect T_001 extending to the shallow subtidal area of the Sawdern Point landfall suggest that a seagrass meadow may be present in this area. To note that shoots of *Z. marina* were also observed in the intertidal area on the very lower shore at the northern end of Sawdern Point (OEL, 2021). Like many terrestrial plants, seagrasses senesce in the autumn and winter with storms causing dying shoots and leaves to break off and become redistributed. Given the time of the year the survey was undertaken, it is likely that the observation of low-density shoots is indicative that this area supports a seagrass bed which at the time was in a state of senescence. The majority of the plant biomass would have therefore been below the sediment surface at the time of the survey in the form of the system of rhizomes and roots whereas the more visible shoots are lost. Due to the low shoot density, the characteristic acoustic signature of dense seagrass beds was not evident, nor was there any clear evidence upon review of the aerial imagery collected as part of the Project Erebus intertidal surveys that overlapped with the acoustic data. As such the mapping produced for this area was assigned a low confidence score with further survey work required during the period of peak biomass (August/September) to confirm the presence/absence of a meadow and increase the confidence in the mapping. If a seagrass bed were to be present in the area, this would be protected as a Habitat of Principal Importance under Section 7 of the Environment (Wales) Act 2016.

No beds of maerl or native oysters were observed across the survey area although there were observations of discrete patches of live and dead maerl at one location (EBS station 003) and occasional native oysters at numerous locations along the cable route. The presence of *O. edulis* is notable given that the beds they can form are protected as Habitats of Principle Importance (Environment Wales Act, 2016) and through inclusion on the OSPAR list of threatened and/or declining species and habitats. The presence of alive or dead O. edulis may be indicative of a previous or nearby bed in the area. The full distribution of this species across the survey area will be assessed and presented in the EBS report following completion of the macrobenthic sample analysis.

The INNS slipper limpet (*C. fornicata)* was recorded forming aggregations along transect T_014 in the nearshore section of the export cable route. *C. fornicata* is an invasive non-native species (INNS) that originated from the eastern USA and has been present in the UK for over a century. Initially confined to the south and south-east coast of England, it is now common in Europe. In Wales *C. fornicata* has been first found in the Menai Strait (McMillan 1938) and currently has reached locally high abundances in Milford Haven close to the survey area (Bohn et al. 2013).

## 8.4. WA1 Landfall Discussion

The bathymetry along the WA1 landfall centre line varies between -1.5m at KP0.082 to -20.8m KP1.49. Gradients on the centre line start relatively high as the centre line crosses an area of outcropping bedrock, with a range of gradients between -6.3 to 5.5˚ being found up to KP0.19. A significant peak in gradient of -5.27˚ is found at KP13.43 and is caused by the edge of an area of outcropping bedrock. A small gap in the bedrock outcrop at the nearshore extent of the survey data is present ~70m north of the centre line, however the extent of this has not been completely mapped in the MBES data. This gap could present a routing opportunity if the extent of the gap and be determined into the intertidal zone.

Due to the proximity and short length of the landfall to the main route, the contact figures have been included in the reporting for the main route. Boulders, debris and fishing equipment have all been identified in the WA1 landfall corridor. Significant contacts close to or intersecting the cable have been reported in the route listings.

Three classifications for surface geology have been interpreted along the WA1 landfall cable route: SAND, sandy GRAVEL, and ROCK. Areas of mobile bedforms and boulder fields have also been interpretated and observed to intersect the centre line. Mobile bedforms have been interpreted as ripples.

Two major subsurface units have been interpreted along this cable route. Unit B is present at the surface and fills channels present in the underlying bedrock that composes unit C. The sediments of Unit B are expected to be fluvio-estuarine in nature. This unit overlies the Unit C bedrock that is observed to outcrop at the start of the exposed channel feature as the WA1 landfall centre line joins the main cable route centre line. At this point a brief area of coarse channel infill is observed to exist as an internal reflector to Unit B. Whilst Unit A has not been consistently observed in the SBP data it is expected to be present in a veneer of SAND at the seabed.

## 8.5. Sawdern Point and Export Route Discussion

The bathymetry along the Sawdern Point landfall option and the subsequent export cable route centre line varies between -0.62m LAT at KP0.055 to -70.65m LAT at KP48.6. The largest gradient along the centre line, of 11.9˚, occurs at KP5.749 where the centre line intersects an outcrop of ROCK. Further areas of gradient exceeding 5˚ are observed where large sandwaves have formed at KP33.747. Variability in gradients observed along the route are primarily generated by bedrock outcrops or mobile bedforms.

In total, 1874 targets >0.5m have been identified on SSS and MBES across the entire survey dataset. Items identified include boulders, debris, fishing equipment, a wreck and a suspected UXO object. Targets <0.5m have occasionally been observed. In total 710 magnetic targets have been interpreted. Of these targets, 62 have been associated with SSS targets. In some areas it has not been possible to identify discrete magnetic targets due to geological magnetic noise. Additionally, a suspected buried object has been identified on the SBP dataset near KP2.595. Significant contacts close to or intersecting the centre line have been reported in the route listings.

Seven classifications for surface geology have been interpreted along the main cable route: ROCK, sandy GRAVEL, muddy sandy GRAVEL, gravelly SAND, SAND, muddy SAND, and sandy MUD. Areas of mobile bedforms and boulder fields have also been interpretated and observed to intersect the centre line. Mobile bedforms range from ripples to sandwaves.

Additional items of morphology have also been identified in the cable corridor including scars, mounds, sediment spills and anchor disturbance patterns.

Three major subsurface units have been interpreted along the cable route. Unit A is comprised of recent surficial sediments that form mobile bedforms at the seabed and overlie the units beneath. The surficial sediments are primarily observed from approximately KP10.5 onwards. Unit A is expected to be present closer inshore but in isolated areas of veneered sediment. Unit B includes reworked sediments and fluvial channel fill that have infilled channels that have been incised into Unit C which is interpreted to be the bedrock. In the nearshore it is expected that the Unit B sediments will be more estuarine is nature. Unit B sediments are expected to be coarser than Unit A sediments and often correlate with boulder fields where completely exposed at the seabed. The bedrock of unit C is exposed at the seabed at various locations within the cable corridor between approximately KP4.24 and KP8.465. with additional areas of shallow bedrock <5m below seabed present intermittently along the route.

## 8.6. FLOW Site Geophysical Discussion

The bathymetry within the array area varies from -86.54m, within a sandwave trough, to -65.57m, on a sandwave crest. Bathymetry generally deepens to the north west along a gentle slope superimposed by mobile bedforms ranging from ripples to sandwaves.

In total, 1138 targets >0.5m have been identified on SSS/MBES data across the WTG survey area. Items identified include boulders, debris, and a suspected wreck. Targets <0.5m have occasionally been observed. Contacts identified solely from the multibeam data are also included, however, as no finer detail is visible for these contacts an interpretation for them cannot be made. The suspected wreck is small with a length of 5.5m and may be a particularly large item of debris, however it possesses peculiar shape as observed on SSS data.

In total 200 magnetic targets have been interpreted. Of these targets, four have been associated with SSS targets. Two long linear chains of magnetic contacts have led to the interpretation of possible buried cables within the southern half of the array area. The plotted positions of these linear contacts do not correlate to any existing infrastructure on the EMODnet database.

The array area has been generally classified as muddy SAND. Whilst ground truthing shows variance from gravelly SAND to sandy MUD, there is little change in acoustic reflectivity across the area. Grab samples appear to vary with little correlation to surrounding samples. Hence the area is likely a mix of primarily sandy sediments with some muddy components and a very small fraction of gravel in localised areas, the boundaries of which are not observed in the acoustic datasets.

The entire array area has areas of mobile bedforms. Ripples are present in the south which evolve into megaripples and sandwaves to the north. Some of the larger bedforms have further ripples superimposed. Boulder fields have been identified in areas where the surficial sediment grows thin, especially to the south of the route and in sandwave troughs in the north. Seabed scarring from anthropogenic sources have also been observed.

Three major subsurface units have been interpreted withing the array area. Unit A is comprised of recent surficial sediments that form mobile bedforms at the seabed. Unit B includes reworked sediments and fluvial channel fill sediments within channels that have been cut into Unit C, which is interpreted to be the bedrock. Unit B sediments are expected to be coarser than Unit A sediments and often correlate with boulder fields where completely exposed at the seabed. The bedrock of unit C is not exposed at the seabed at any point in the array area and the minimum depth below seabed it has been interpreted at is 3.7m. The deepest the bedrock has been observed is 82.4m below seabed. In general, the bedrock deepens to the west, with various channels incised into its surface. The bedrock in the array area is expected to be Cretaceous Chalk.

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# 10. Appendices (Not provided with this copy)

I - Erebus Operational Dates

II - Vessel Specification Sheets

III - Survey Equipment Specification Sheets

IVa - Project Erebus Offshore Floating Wind Farm Environmental Baseline Survey Stations

IVb - Project Erebus Offshore Floating Wind Farm Habitat Assessment Survey Stations

V - Summary of Particle Size Distribution (PSD) analysis methodologies

VI - PSD grab sample survey logs

VII - PSD grab sample photos

VIII - Raw PSD data

IX – Summarised PSD data

X - Overview of habitat/biotopes assigned during the Project Erebus HA survey

XI - Habitat Assessment DDV transect survey log

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XIII - Habitat Mapping Shapefiles

XIV - Description of seabed imagery analysis methodologies

XV - Geophysical Chart Pack