GREENLINK
MARINE ENVIRONMENTAL STATEMENT- WALES

APPENDIX I

Cable Route Survey Report

P1975_R4484_RevF1
June 2019

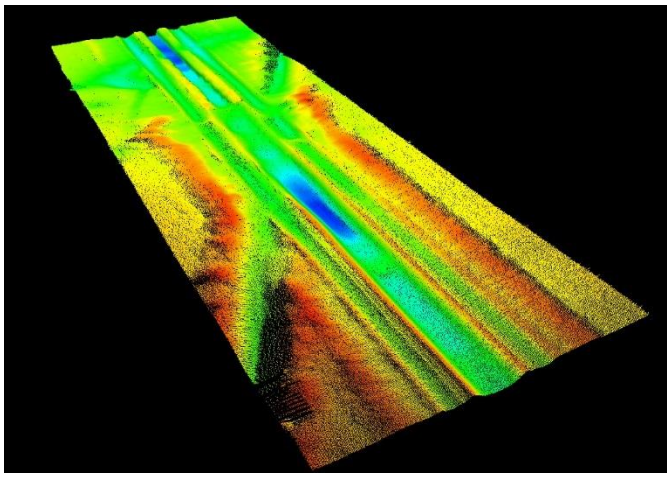
Greenlink Interconnector
- connecting the power markets
in Ireland and Great Britain

Greenlink
INTERCONNECTOR

Co-financed by the European Union
Connecting Europe Facility

GEOPHYSICAL SURVEY REPORT

102953-GRL-MMT-SUR-REP-GEOPHYRE
REVISION 03 | CLIENT REVIEW
APRIL 2019



Greenlink INTERCONNECTOR

GREENLINK INTERCONNECTOR
IRELAND – UNITED KINGDOM
OFFSHORE, NEARSHORE, ONSHORE

IRISH SEA
SEPTEMBER 2018 - APRIL 2019

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MMT

EXECUTIVE SUMMARY

GREENLINK SURVEY ROUTE AND CORRIDOR OVERVIEW

MMT were contracted by Greenlink Interconnector Ltd. to conduct a geophysical, geotechnical and benthic survey for a proposed high voltage direct current (HVDC) submarine power interconnector between Pembrokeshire, Wales, UK and County Wexford, Ireland. This report presents the results of the geophysical survey, encompassing seabed and sub-seabed conditions, obstructions and installation constraints. The results are divided by country into two sections: UK and Ireland. Results are presented for the Final Route, as well as surveyed route options A and E whenever they deviate from the Final Route. The survey corridor was 500 m wide and divided into 6 blocks covering nearshore and offshore areas.

PRINCIPAL ROUTE POINTS RPL_30112018_Rev0

Geodetic Datum & Projection: UTM Zone 30N (EPSG 16030)

Point	KP	Latitude (mm.mmm)	Longitude (mm.mmm)	Easting (m)	Northing (m)
Start: Block 06	0.000	51° 39.771' N	5° 03.870' W	357214	5725559
End: Block 01	159.267	52° 10.663' N	6° 49.797' W	238162	5787723

BATHYMETRY AND SEABED MORPHOLOGY

The route is generally characterised by flat or gradually changing seabed with very gentle to gentle slopes. The water depth is slowly increasing from the UK landfall towards a bathymetric trough, located approximately in the middle of the route. From there the water depth begins to decrease again, towards the Irish landfall. The maximum depth along the route is 127.8 m at KP 53.660 (UK offshore). Moderate gradients are generally associated with areas of mobile bedforms, comprising of megaripples and sandwaves, or over rocky outcrops. Mobile bedforms are frequently present throughout the corridor length. From the start of the route to KP 4.850 the route is leading through a valley between rocky outcrops. The maximum slope gradient encountered along the route is 12.26° over a rock located on the route at KP 2.400, in the UK offshore section.

SEABED SEDIMENTS AND FEATURES

The surficial sediments vary mainly between SAND and gravelly SAND/sandy GRAVEL with local areas of GRAVEL and SILT. BEDROCK is found outcropping and subcropping mainly in the UK and Ireland nearshore as well as the beginning of the route, for the first 43 km, approximately. Large areas of outcropping BEDROCK are present on route option A. Areas of occasional and numerous boulders are usually present in the vicinity of out- and subcropping BEDROCK. Large areas of BEDROCK and clayey TILL are covered by a veneer of mobile sediments, SAND to GRAVEL. Mobile bedforms of ripples, megaripples and occasionally sandwaves are present throughout the majority of the route. Some trawl marks were identified in the UK offshore section.

SHALLOW GEOLOGICAL FEATURES

The shallow geology along the route is characterized by a sequence of SAND, channel infills, TILL and BEDROCK (from top to bottom). A surficial SAND unit is present over almost all of the route, with varying depth of some decimetres, as veneers over BEDROCK or TILL, to more than 10 m in some infills or sandwave areas. The lower boundary of the SAND unit is usually characterized by a GRAVEL layer. On the Welsh platform, BEDROCK and TILL are present at shallower sediment depth, more frequently out-and subcropping, compared to the Irish platform. A thicker sediment cover is present in the basin extent of the St. George's Channel. Deep incisions in BEDROCK and TILL, filled by channel infill sediment (clay to gravel), are found throughout the route, although appear more extensively on the Irish platform.

Potential Installation Constraints

- BEDROCK outcrops are present from KP 2 to KP 42 and KP 158 to the end of the route.
- Boulder fields with occasional to numerous boulders are present mainly in UK offshore.
- Mobile sediments ranging from ripples to megaripples and occasional sandwaves, with associated local gradients, are present throughout the majority of the route.
- Six cables cross the route, one in UK and five in Irish waters. All are buried and were detected during the cable crossing campaign, see report 102953-GRL-MMT-SUR-REP-CABLECRE.
- A linear magnetometer anomaly trend at KP 6.325 might indicate a possible unknown cable.
- One known wreck, Saint Jacques, was confirmed at KP 4.717, 248.6 m south of the proposed route.

REVISION HISTORY

REVISION	DATE	STATUS	CHECK	APPROVAL
03	2019-04-24	Issue for Client Review	MB	MG
02	2019-01-30	Issue for Client Review	MB	MG
01	2019-01-25	Issue for Internal Review	MB	MG

REVISION LOG

DATE	SECTION	CHANGE
2019-04-24	Various	Updated according to Client comments and additional data from survey by Franklin 2019.

DOCUMENT CONTROL

RESPONSIBILITY	POSITION	NAME
Content	Sr. Geophysicist	Daniela Hanslik
Content	Data Processor	Emily Johnston
Content, Check	Project Geologist / Sr. Geophysicist	Hanna Milver
Content, Check	Project Report Coordinator	Maria Blom
Check	Reporting Quality Controller	Hampus Arvidsson
Approval	Project Manager	Martin Godfrey

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ABBREVIATIONS AND DEFINITIONS

BOB	Back of Beach
CHIRP	Compressed High Intensity Radar Pulse (SBP)
CPT	Cone Penetration Test
DDV	Drop Down Video Camera
DPR	Daily Progress Report
DTM	Digital Terrain Model
EPSG	European Petroleum Survey Group
GIS	Geographic Information System
GNSS	Global Navigation Satellite Systems
HDD	Horizontal Directional Drilling
HPVC	High Power Vibrocorer
HVDC	High Voltage Direct Current
ISO	International Organization for Standardization
kHz	kilohertz
KP	Kilometre Post
LAT	Lowest Astronomical Tide
MAC	Mobilisation and Calibration
MAG	Magnetometer
MASW	Multichannel Analyses of Surface Waves
MBES	Multibeam Echo Sounder
MDAC	Methane-Derived Authigenic Carbonates
MLW	Mean Low Water
MSL	Mean Sea Level
M/V	Motor Vessel
nT	nanotesla
OD	Ordnance Datum
ODMH	Ordnance Datum Malin Head
ODN	Ordnance Datum Newlyn
OSGM	Ordnance Survey Geoid Model
OSTN	Ordnance Survey Transformation Network
PCPT	Piezo Cone Penetration Testing
PPS	Pulse Per Second
ROV	Remotely Operated Vehicle
ROTV	Remotely Operated Towed Vehicle
RPL	Route Position List
SBET	Smoothed Best Estimated Trajectory
SBP	Sub-Bottom Profiler
SSS	Side Scan Sonar
Survey Corridor	The area specifically surveyed e.g. 500 m wide section

Survey Coverage	The area surveyed, this may be wider than 500 m in some instances
TVG	Transverse Gradiometer
UAV	Unmanned Aerial Vehicle
UK	United Kingdom
UTC	Coordinated Universal Time
UTM	Universal Transverse Mercator
UXO	Unexploded Ordnance
VC	Vibrocore
VORF	Vertical Offshore Reference Frame
WGS84	World Geodetic System 1984

1 | INTRODUCTION

1.1 | PROJECT INFORMATION

Greenlink Interconnector Limited, proposes to develop an interconnector, which will allow transfer of power between the high voltage grid systems of the UK and the Republic of Ireland. Greenlink will connect to the United Kingdom (UK) National Grid system at Pembroke substation in Pembrokeshire, United Kingdom and to the Irish network at Great Island substation in County Wexford, Ireland.

Figure 1 presents an overview of the survey area and final route.

Project details are presented in Table 1.

Table 1 Project details.

Client:	Greenlink Interconnector Limited
Project:	Greenlink Interconnector
MMT Sweden AB (MMT) Project Number:	102953
Survey Type:	Geophysical, Geotechnical, Environmental, Topographic, UXO, ROV infrastructure crossing, Land Seismic
Area:	Irish Sea
Survey period:	September 2018 – March 2019
Survey Vessels:	M/V Franklin, M/V Seabeam, M/V Olympic Challenger, M/V Sandpiper
MMT Project Manager:	Martin Godfrey
Client Project Manager:	Stephane Theurich

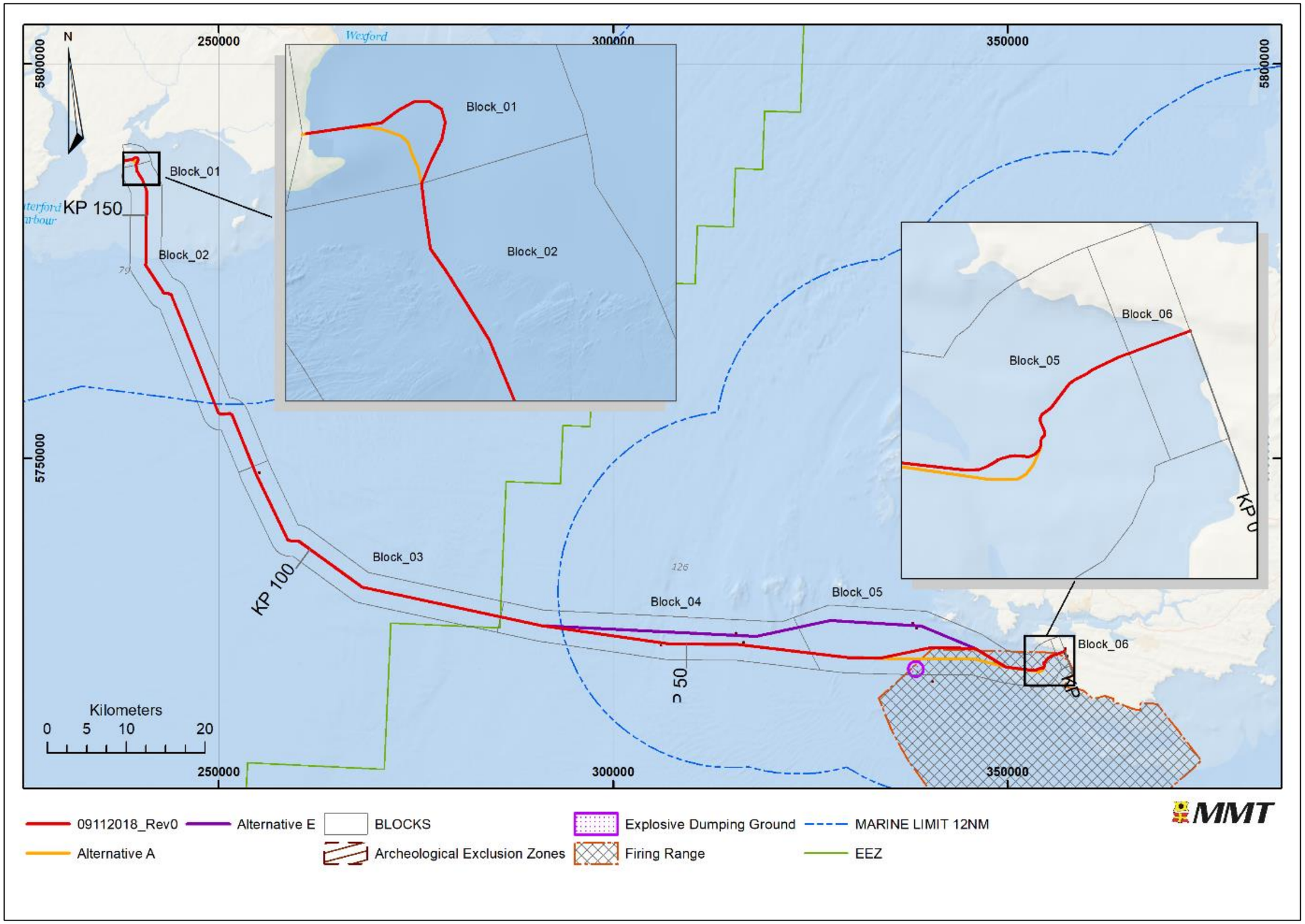


Figure 1 Overview of survey area.

1.2| SURVEY INFORMATION

The Greenlink marine survey scope of work comprises:

- Onshore/intertidal topographic survey
- Geophysical/hydrographic nearshore and offshore data acquisition
- Geotechnical investigations along the proposed route with vibrocoring (VC) and cone penetration testing (CPT)
- Environmental sampling and imagery
- Infrastructure crossing survey with remotely operated vehicle (ROV)
- Unexploded ordnance (UXO) survey
- Geotechnical boreholes to inform horizontal directional drilling
- Onshore reflection and refraction survey

These operations, in the nearshore and offshore, provide high resolution and accurate measurements of the bathymetry, seabed features and shallow geological conditions along the route(s). This was supplemented by localised UXO surveys, within the Castlemartin Firing Range area, environmental sampling and imagery as well as surveys of infrastructure crossings using an ROV.

1.3| SURVEY OBJECTIVES

1.3.1| DEVIATIONS TO SCOPE OF WORK

Due to fishing gear and extensive weather down time, in agreement with the client, the operations for M/V Franklin were suspended in December 2018, prior to completing the full geophysical scope of work. M/V Franklin returned to the project on 27th February 2019 for continuation of the agreed outstanding parts. Further information regarding this and other decisions made during the survey operations are further presented in the Operations Report (102953-GRL-MMT-SUR-REP-OPERATRE).

In addition to the above mentioned deviations the following changes were made:

- Due to strong currents and weather implications it was not possible to have both the vessel, Sparker and the Remotely Operated Towed Vehicle (ROTV) on the survey line at all times. In these instances, priority was given to the ROTV, which was accepted by the Client Representative on board.
- M/V Seabeam worked further offshore on the UK side than originally planned, covering parts of M/V Franklin's scope of work.
- The Nearshore survey on the Irish side was performed as a site survey due to the shape and location of the area, meaning the general route survey operation could not be surveyed as planned. Sub-bottom Profiler (SBP) and Magnetometer data was acquired over the centre lines.
- Boomer was not used during the nearshore survey on the UK landfall, it was only used during the landfall survey on the Irish side.
- Two additional survey lines were added perpendicular to Alternative A and Alternative E in order to get a broader knowledge about the surface conditions in-between the two alternative routes. The final survey route was routed between the original Alternative A and Alternative E.

1.3.2| GEOPHYSICAL SURVEY (OFFSHORE)

The offshore geophysical survey was performed with a hull mounted multibeam echo sounder (MBES) installed on M/V Franklin and a side scan sonar (SSS)/sub-bottom profiler (SBP) mounted on a remotely

operated towed vehicle (ROTV) with a tethered single magnetometer or transverse gradiometer (TVG). In addition to the Chirp system, a surface towed GeoSparker was used to achieve an enhanced penetration for the required >10 m depth.

It should be noted that the survey was carried out in two parts, where the first part was done as a reconnaissance survey focusing on block 5. The reason for the reconnaissance survey was to enable an environmental survey including video and still photos transects in order to send the data to Natural Resources Wales (NRW) for approval prior to deciding on a final route.

1.3.3| GEOPHYSICAL SURVEY (NEARSHORE)

The nearshore geophysical survey was performed by M/V Seabeam using a hull mounted MBES and a pole mounted SSS and SBP with a towed magnetometer. A boomer system was available on board, should the required penetration of 10 m not be fulfilled by the pole mounted SBP system. The boomer was only utilised on the Irish side.

Nearshore operations were carried out as a 12-hour operation including transport of survey personnel to the vessel, start-up of equipment and transport back to living quarters.

1.3.4| GEOPHYSICAL SURVEY (ONSHORE) - TOPOGRAPHIC

Topographical surveys were conducted by land based topography for UK and Ireland using drone-based photogrammetry techniques, i.e. unmanned aerial vehicle (UAV). The digital terrain model (DTM) has a resolution such that 0.25 m contours can be mapped. Infrastructure, obstacles and surficial sediments were mapped.

1.3.5| GEOPHYSICAL SURVEY (ONSHORE) – SEISMIC REFRACTION & REFLECTION

The scope was for a seismic refraction and reflection survey along a 350 m corridor in Freshwater West, UK, and a 300 m corridor in Baginbun, Ireland. The survey carried out P- and S-wave seismic refraction and multichannel analysis of surface waves (MASW) techniques

1.3.6| UXO SURVEY (NEARSHORE & OFFSHORE)

Since part of the route in UK waters is located within the Castlemartin firing range area, a focussed UXO survey, covering a 100 m wide corridor within the firing range, from KP 0.000 to KP 12.650, commenced on 27th February 2019. The UXO survey was performed using an ROTV with a tethered single magnetometer or transverse gradiometer (TVG)

Due to Castlemartin being an active defence training area with permission to fire live rounds into the sea, the performed UXO survey can only be considered valid for the time of the survey as future changes are highly likely.

1.4| PURPOSE OF DOCUMENT

This report presents the geophysical results from the onshore, nearshore and offshore geophysical surveys.

The document provides an overview of the bathymetry, topography, biotope, seabed features and shallow geology along the surveyed corridor, based on the interpretation of the geophysical data. Furthermore, the report summarises the conditions along the survey corridor with regards to other seabed features, e.g. infrastructure crossings, obstacles, potential sensitive habitat types, wrecks, and man-made objects, detected during the survey. Factors that may impose constraints on the cable laying operations have also been identified and considered.

Separate reports are issued for the geotechnical scope, UXO scope, environmental scope as well as infrastructure crossing scope. A full list of reports is given in Table 2. For a wider understanding of the conditions along the cable route, it is recommended to read this report in conjunction with the UXO report, Environmental report, Geotechnical Report, Cable Crossing Report as well as the Operations Report.

1.4.1| GEOPHYSICAL ALIGNMENT CHARTS

The geophysical alignment charts in this report illustrate and describe the results from the survey and are intended to assist in further planning and evaluation purposes of the cable route. The charts are presented at a horizontal scale of 1:10 000. A list of all produced charts are presented in Appendix C|.

The geophysical alignment charts contain the following data fields:

BATHYMETRY

The bathymetry is presented with labelled 0.5 m contour lines and colour-shaded relief, with the depth range set across the whole route.

The route with KP annotations, background cables/pipelines, a grid with north arrow and chart matchlines, which show the neighbouring chart limits with ID, is also present.

SURFICIAL GEOLOGY AND SEABED FEATURES

This panel presents the interpretation of the SSS results. The surficial geology is colour coded and the seabed features are presented as a hatch with patterns laid over the surficial geology interpretation. The surficial geology has a transparency applied as the SSS mosaic is also displayed behind the interpretation. SSS contacts, magnetometer anomalies and possible UXO's are also shown with symbols and ID along with both geotechnical and environmental sample locations.

The route with KP annotations, background cables/pipelines, a grid with north arrow and chart matchlines, which show the neighbouring chart limits with ID, is also present.

ISOPACH

The depth to base of sand is presented contoured at 1 m intervals, with labels.

The route with KP annotations, background cables/pipelines, a grid with north arrow and chart matchlines, which show the neighbouring chart limits with ID, is also present.

LONGITUDINAL PROFILE

This section illustrates the seabed profile along the surveyed route. Horizons have been mapped and annotated and geotechnical sample locations are also plotted.

The profile panel also contains a grid with depth and KP axis.

1.4.2| GEOPHYSICAL NORTH UP NEARSHORE CHARTS

The geophysical north up nearshore charts issued with this report illustrate and describe the results from the survey and are intended to assist in further planning and evaluation purposes of the cable route. The charts are presented at a horizontal scale of 1:5 000. A list of all produced charts are presented in Appendix C|.

The geophysical north up nearshore charts contain the information detailed below. In addition to this the route with KP annotations, background cables/pipelines and a grid with north arrow are also present.

BATHYMETRY

The bathymetry is presented with 0.5 m contour lines, with labels.

SURFICIAL GEOLOGY AND SEABED FEATURES

This panel presents the interpretation of the SSS results. The surficial geology is colour coded and the seabed features are presented as a hatch with patterns laid over the surficial geology interpretation. SSS contacts, magnetometer anomalies and possible UXO's are also shown with symbols and ID along with both geotechnical and environmental sample locations.

ISOPACH

The depth to base of sand is presented contoured at 1 m intervals, with labels.

1.5| REFERENCE DOCUMENTS

The documents used as references to this survey report are presented in Table 2.

Table 2 Reference documents.

DOCUMENT NUMBER	TITLE	AUTHOR
102953-GRL-MMT-QAC-PRO-PMQAPLAN	Project Manual and Quality Assurance Plan	MMT
102953-GRL-MMT-HSE-PRO-HIRA	Hazard Identification & Risk Assessment: Geophysical	MMT
102953-GRL-MMT-HSE-PRO-HSEFRANK	HSE Plan Franklin	MMT
102953-GRL-MMT-HSE-PRO-HSESEAON	HSE Plan Seabeam and Onshore	MMT
102953-GRL-MMT-QAC-PRO-CADGIS	CAD and GIS Specification	MMT
102953-GRL-MMT-SCH-PRO-SCHEDULE	Time schedule	MMT
102953-GRL-MMT-MAC-REP-FRANKLIN	Mobilisation and Calibration Report - Franklin	MMT
102953-GRL-MMT-MAC-REP-SEABEAM	Mobilisation and Calibration Report – Seabeam	MMT
102953-GRL-MMT-SUR-REP-OPERATRE	Operations Report	MMT
102953-GRL-MMT-SUR-REP-GEOPHYRE	**Geophysical Report**	**MMT**
102953-GRL-MMT-SUR-REP-UXOREP	UXO Report	MMT
102953-GRL-MMT-SUR-REP-GEOTECRE	Geotechnical Report	MMT
102953-GRL-MMT-SUR-REP-CABLECRE	Cable Crossing Report	MMT
102953-GRL-MMT-SUR-REP-ENVIRORE	Environmental Report	MMT
102953-GRL-MMT-SUR-REP-INTEGRRE	Integrated Report	MMT
P1975_ExhibitB_ScopeofWork	Scope of work	GRL
P1975_ExhibitC_TechnicalSpecifications	Technical Specifications	GRL
P1975_ExhibitG_Greenlink UXO DBS	UXO Desktop Study	GRL
P1975 Greenlink Clarification	Clarifications	GRL
P1975 Greenlink Addendum_Rev0	Clarifications	GRL

2| SURVEY PARAMETERS

2.1| GEODETIC DATUM AND GRID COORDINATE SYSTEM

Table 3 Geodetic parameters.

Geodetic Parameters	
Datum	World Geodetic System 1984 (6326)
Ellipsoid	World Geodetic System 1984 (7030)
Spheroid	WGS84
Semi Major Axis	6378137.000 m
Semi Minor Axis	6356752.31414035610 m
Inverse Flattening (1/f)	298.25722210100002
Unit	International metre

Table 4 Projection parameters.

Projection Parameters	
Projection	UTM Zone 30N (EPSG 16030)
Longitude at Central Meridian	003°00’00.0” W
Latitude of Origin	00°00’00.0” N
False Northing	0m
Scale Factor (Central Meridian)	0.9996
Units	Metres
Time Datum	UTC

The vertical reference parameters are presented in Table 5.

Table 5 Vertical reference parameters.

Vertical Reference Parameters	
Vertical reference (offshore)	DTU10 Lowest Astronomical Tide (LAT)
Height model (offshore)	Vertical Offshore Reference Frame (VORF)
Height model (nearshore)	Ordnance Survey Geoid Model 15 (OSGM15)
Vertical reference (nearshore UK)	Ordnance Datum Newlyn (ODN) Mean Sea Level (MSL)
Vertical reference (nearshore IRL)	Ordnance Datum Malin Head (ODMH) Mean Sea Level (MSL)

2.2| VERTICAL DATUM

Global navigation satellite system (GNSS) tide was used to reduce the bathymetry data to Lowest Astronomical Tide (LAT), the defined vertical reference level (Figure 2).

As vertical control for all depth and/or height measurements LAT via VORF LAT reduction from WGS84-based ellipsoid heights were used.

The nearshore geophysical data has also been provided to Ordnance Datum (OD), which is a local version of the Mean Sea Level (MSL). This was achieved using the OSTN15/OSGM15 model, which has been developed to incorporate UK and Irish OD in to one model.

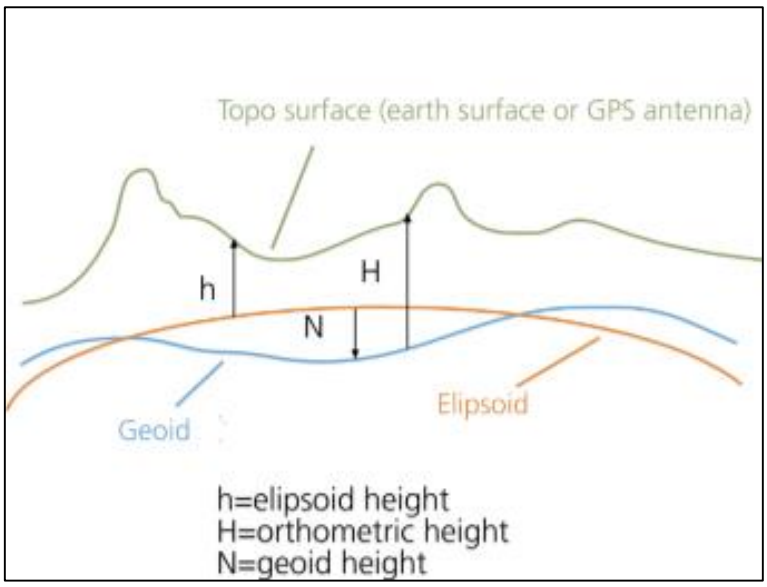


Figure 2 Overview of the relation between different vertical references.

This tidal reduction methodology encompasses all vertical movement of the vessel, including tidal effect and vessel movement due to waves and currents. The short variations in height are identified as heave and the long variations as tide.

This methodology is very robust since it is not limited by the filter settings defined online, and provides very good results in complicated mixed wave and swell patterns. The vessel navigation is exported into a post-processed format, SBET (Smoothed Best Estimated Trajectory) that is then applied onto the MBES data.

The methodology has proven to be very accurate as it accounts for any changes in height caused by changes in atmospheric pressure, storm surge, squat, loading or any other effect not accounted for in a tidal prediction.

2.3| TIME DATUM

Coordinated universal time (UTC) was used on all survey systems on board the vessel. The synchronisation of the vessel's onboard system was governed by the pulse per second (PPS) issued by the primary positioning system. All displays, overlays, and logbooks were annotated in UTC. The Daily Progress Report (DPR) refers to UTC.

2.4| KP AND SURVEY BLOCK PROTOCOL

Four routes were considered during the preparation and survey phase of the project, see Figure 3, namely Route A which was the base route starting with KP 0 at the landfall in Freshwater West, UK and with an increasing KP towards the landfall in Baginbun, Ireland.

In addition to Route A, Alternative E also starts at the landfall in Freshwater West, UK and increases in KP towards the landfall in Baginbun, Ireland. The difference between Route A and Alternative E is visible in Figure 3 where Alternative E runs north of Route A in blocks 4 and 5.

Option C deviates from Route A (as well as Alternative E) in block 3 where it turns south to an alternative landing point in Boyce's Bay, Ireland. Option C was never surveyed and no results are therefore present in this report.

Option D deviates from Route A (as well as Alternative E) in block 1 and runs further north of Route A before it joins Route A towards the landing point at Baginbun, Ireland.

The final route, RPL_09112018_Rev0, is presented in Figure 4, starting at Freshwater West, UK with KP 0 and increasing towards the landfall in Baginbun, Ireland. The final route is a mixture of Route A, Alternative E and Option D as well as re-routing conducted during the survey.

The parts surveyed which do not coincide with the final route are the following:

Table 6 Route deviations from Final Route.

Deviation	Start/End Route	KP	Comments
Route A deviation 1	Start KP (final route)	3.653	
	Start KP (Route A)	3.647	
	End KP (final route)	25.389	The Final Route and Route A run parallel (max 0.12 m distance between the two routes) to each other from this point until KP 29.622 (Final route KP). For reporting purposes this deviation is not presented after KP 25.389
	End KP (Route A)	24.909	
Alternative E deviation 1	Start KP (final route)	13.173	
	Start KP (Alternative E)	13.373	
	End KP (final route)	68.600	
	End KP (Alternative E)	69.229	
Route A deviation 2	Start KP (final route)	156.667	
	Start KP (Route A)	156.187	
	End KP (final route)	158.759	
	End KP (Route A)	157.413	

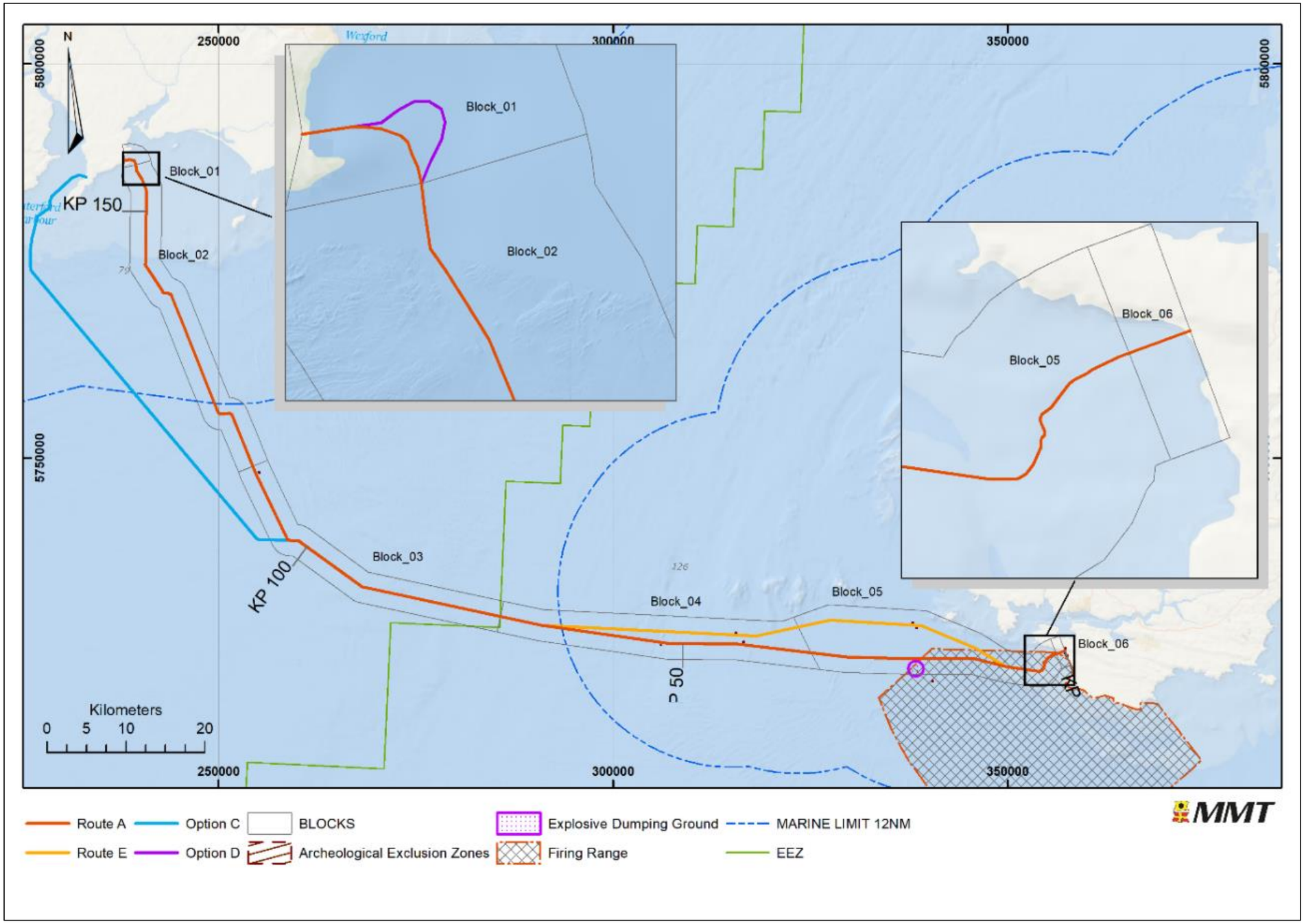


Figure 3 Initial route options.

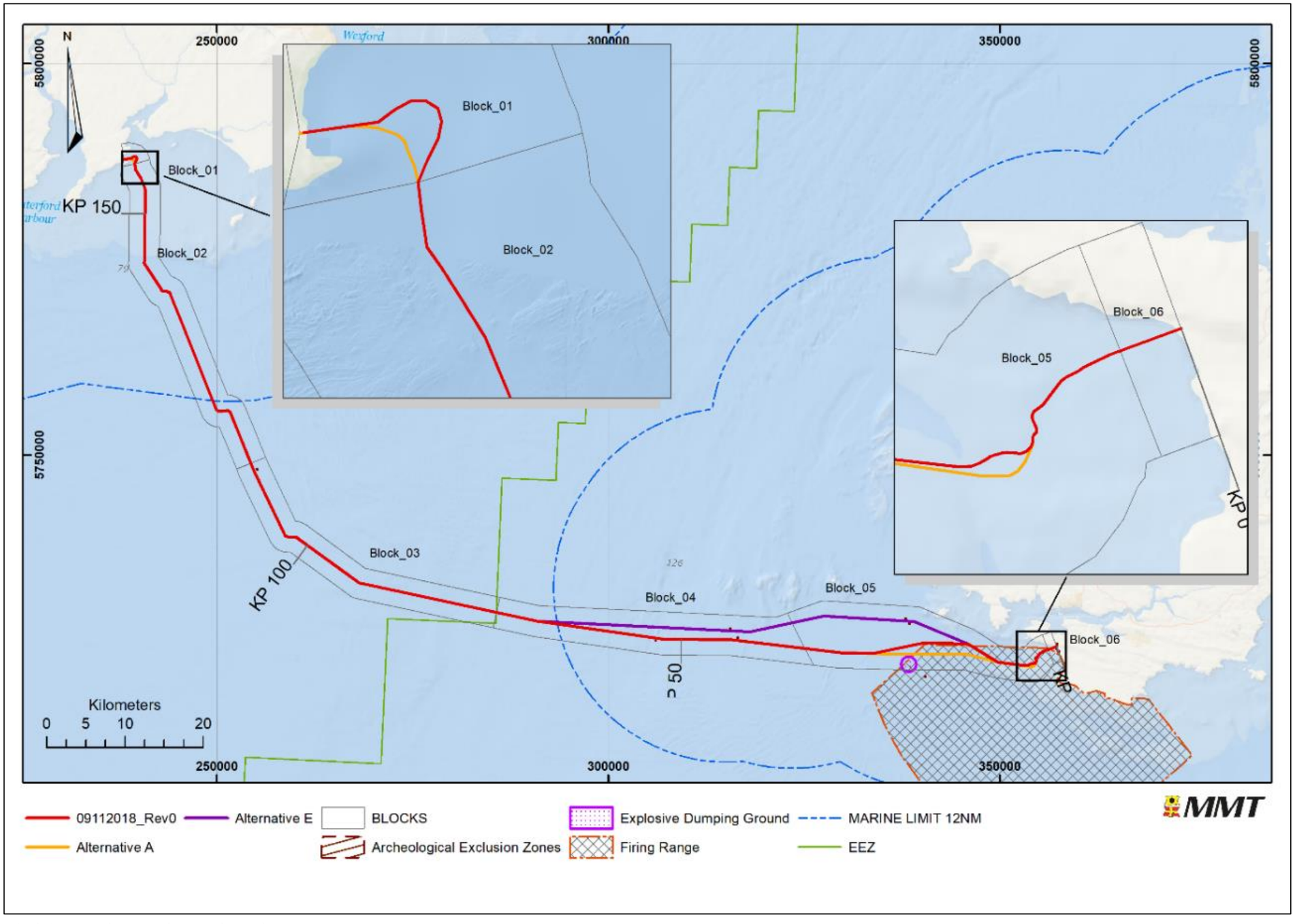


Figure 4 Final Route and reported route alternatives.

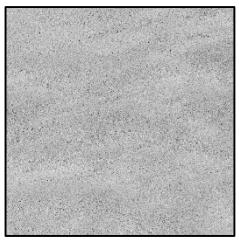
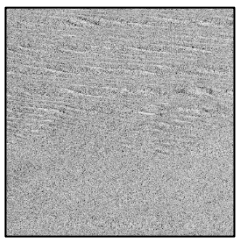
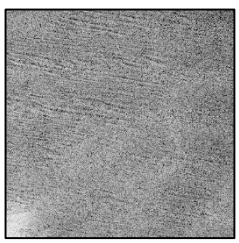
3| CLASSIFICATION AND TERMINOLOGY

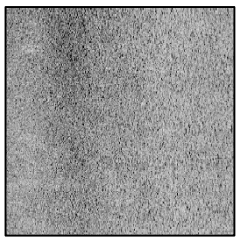
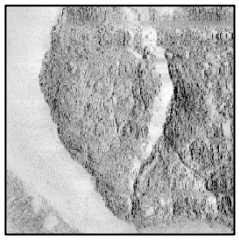
3.1| SEABED SEDIMENT CLASSIFICATION

The interpretation of surficial sediment types was derived from the acoustic character of the SSS data, and the interpretations were aided by MBES bathymetric 3D surfaces and SBP data. During the review of the SSS survey data, higher intensity sonar returns (darker grey to black colours) were interpreted as relatively coarser grained sediments, and lower intensity sonar returns (lighter grey colours) were interpreted as relatively finer grained sediments. Bathymetric data was used to correct the interpretation for the effects of seabed slope on sonar returns. The correlation with the geotechnical results was initially based on the field logs and further verified with the final geotechnical results.

The ID column in Table 7 defines the colour in the charts for the specific sediment type mapped along the survey corridor. All particle sizes refer to the soil classification in ISO 14688-1 (2002).

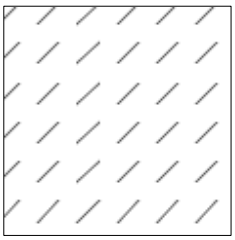
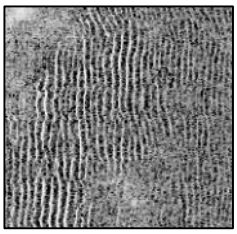
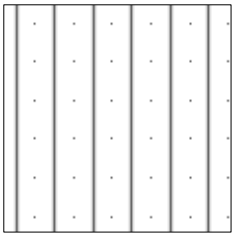
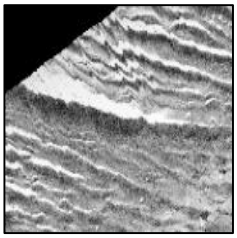
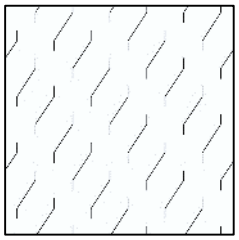
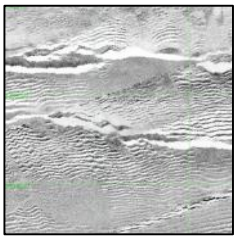
Table 7 Seabed sediment classification.

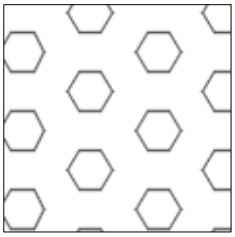
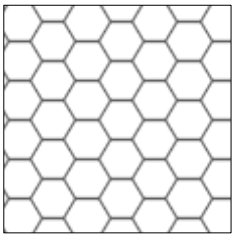
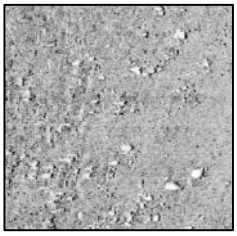
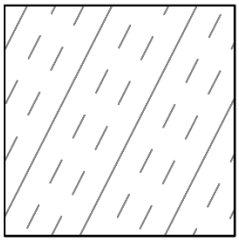
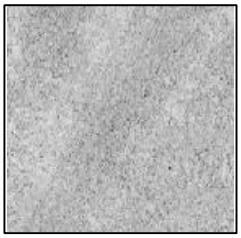
ID	SSS IMAGE	ACOUSTIC DESCRIPTION	LITHOLOGICAL INTERPRETATION
		Low to medium acoustic reflectivity. Slightly grainy to grainy texture.	**SILT** Predominantly silt, may have minor fractions of clay, sand and/or gravel.
		Low to medium acoustic reflectivity. Slightly grainy texture.	**SILT and SAND** The ratio between sand and silt can vary within this sediment type. The sediment often has a patchy appearance due to variation of the dominating sediment fraction.
		Medium acoustic reflectivity, slightly grainy texture. Often associated with ripples or sandwaves.	**SAND** Predominantly sand, may have minor fractions of clay, silt and/or gravel.
		Medium to high acoustic reflectivity. Slightly grainy to grainy texture, coarse texture in places. Often associated with ripples or megaripples.	**Gravelly SAND to sandy GRAVEL** The ratio between SAND and GRAVEL can vary within this sediment type but commonly it contains slightly gravelly sand to very gravelly sand.

ID	SSS IMAGE	ACOUSTIC DESCRIPTION	LITHOLOGICAL INTERPRETATION
		High acoustic reflectivity. Grainy to coarse texture. Often associated with ripples or megaripples.	**GRAVEL** Predominantly gravel. May contain minor fractions of sand, silt or clay. May also contain gravel sized shell fragments.
		Medium to high acoustic reflectivity. Exhibits relief and texture.	**BEDROCK** Comprises outcrops of crystalline bedrock

The ID column in Table 8 defines the pattern in the charts for the specific seabed feature type.

Table 8 Seabed features classification.

ID	SSS IMAGE	SEABED FEATURE	CRITERIA
		Ripples	Wave length < 5 m
		Megaripples	Wave length 5-25 m
		Sandwaves	Wave length > 25 m

ID	SSS IMAGE	SEABED FEATURE	CRITERIA
		Boulder Field Occasional boulders All > 0.5 m	Concentration of 10 to 20 boulders within a maximum area of 50 x 50 m
		Boulder Field Numerous boulders All > 0.5 m	Concentration of > 20 boulders within a maximum area of 50 x 50 m
		Current Lineation	Current lineation

3.2| CLASSIFICATION OF CONTACTS AND ANOMALIES

The SSS contacts were selected according to the following criteria:

- Wreck
- Boulder
- Debris
- Other

During seabed interpretation, boulder occurrence at surface has been grouped based on the frequency and content of boulders >0.5 m per 50 x 50 m. Contacts less than 0.5 m were not picked.

Magnetic anomalies have been identified during both the geophysical survey and the UXO survey, details regarding the UXO survey and the associated UXO listings are presented in the UXO report (102953-GRL-MMT-SUR-REP-UXOREP).

Magnetic anomalies, if identified, are classified according to the following criteria:

- Dipole, monopole or complex shape
- Single anomaly or anomalies creating a linear trend relating to possible or identified cable/pipeline crossings.

3.3| SHALLOW GEOLOGY CLASSIFICATION

The classifications of the shallow geology have been derived through a combination of analysis and interpretation of the acoustic character of the SBP data and was modified according to the geotechnical results. A comparison with available background information was made and broken down into major sediment types along the route (Table 9).

Table 9 Shallow geology soil types and lithology summary.

SEDIMENT TYPE	ACOUSTIC CHARACTERISTICS	LITHOLOGICAL VARIATION
Veneer	-	Veneer of mobile sediments not resolved in seismic data (generally <0.5 m). Gravelly SAND to GRAVEL. Occasionally SILT on Irish side. Veneer of reworked sediment by winnowing of fines often present of top of TILL and BEDROCK.
SAND	Acoustically homogeneous to layered, low to medium amplitude recent sediments present at seabed. Base often medium to high amplitude indicating presence of coarser sediment.	Fine to coarse SAND. May locally contain shells, pebbles, cobbles and pockets of SILT, CLAY and GRAVEL. Commonly forming mobile sediment.
Channel Infills	Acoustically homogeneous to layered, low to medium amplitude recent sediments lying underneath surface sand layer and filling palaeo-channels.	Sandy to clayey sediments with layers of coarser sediment. May locally contain pebbles, cobbles.
TILL	Either heterogeneous with acoustic character indicating the presence clay with sand layers and possible coarser sediments, and boulders or Limited or no acoustic penetration.	Possible glacial deposit / till or diamicton. Unsorted sediment, soft to stiff clay with interbeds of sand, and layers/lenses of coarse sand and gravel. May contain pebbles, cobbles, and boulders.
BEDROCK	High amplitude top with no acoustic penetration.	Devonian Shale and Sandstone, Cretaceous Chalk

3.4| SEABED GRADIENT CLASSIFICATION

The seabed gradient is classified according to Table 10.

Table 10 Seabed gradient classification.

CLASSIFICATION	GRADIENT
Very Gentle	<1°
Gentle	1° - 4.9°
Moderate	5° - 9.9°
Steep	10° - 14.9°
Very Steep	>15°

4| DATA QUALITY AND INTERPRETATION

4.1| DATA QUALITY

4.1.1| ONSHORE TOPOGRAPHY

The onshore topographic survey data met all project requirements.

4.1.2| NEARSHORE SURVEY

The MBES data were of a good quality throughout. In Block 6 at Freshwater West between KP 0.290 and KP 0.44 there was evidence of mobile sediments, see Figure 6 in section 5.1.2|. A section was surveyed a few weeks after M/V Seabeam had initially surveyed in this area and there was up to 70 cm difference between the data. Due to the location of the survey being in the surf zone and considering the large tidal range in the area, it is expected to find seabed movement here. At both nearshore intertidal zones there are some data gaps in the UAV data. These could be explained by the presence of a very flat and featureless seabed, where an image is unable to be resolved. Other explanations for these gaps include bad light or visibility during the survey, or movement in the water, such as seaweed.

The SSS data were of good quality throughout, achieving all requirements. A slight increase in noise was noted towards the shore.

SBP data proved to be fit for purpose. Penetration of up to 13.4 m with the Innomar system was achieved, meeting the project requirements.

The magnetometer data quality was good in general with noise increasing slightly towards the shore. There is a 40 m gap in the magnetometer data in Block 1. Infill was attempted but unsuccessful. The data gap was accepted by the client representative.

4.1.3| OFFSHORE SURVEY (BLOCKS 5 TO 2)

The MBES data are generally very good. In Block 4 there are occasional areas where the data quality was affected by the weather, so density is reduced due to cleaning out noisy data, meaning some parts of the corridor are unsurveyed. Throughout the offshore section, where the seabed is very flat, the overlap between survey lines is sometimes visible. This is to be expected in flat areas and the difference between overlapping lines is between 10 cm to 20 cm so is well within specification at these depths.

SSS data proved to be fit for purpose. The low frequency (300 kHz) SSS data was mainly interpreted. The high frequency data was used to aid in the interpretation.

The overall quality of the Sparker and Chirp data were good. Average penetration with the Sparker was 50 m. The penetration of the Chirp was usually between 1 m and 15 m. Greater signal attenuation was observed when thick layers of surficial sand were present.

The magnetometer data quality was generally of good quality.

4.2| DESCRIPTION OF DATA INTERPRETATION

SSS data has been used for interpretation of surficial geology, identification of seabed features, and to select contacts. Sediment classes distinguished from topographical features identified from SSS records have been correlated with MBES data, grab samples and geotechnical information. Shallow geology interpretations are based on SBP data and have been correlated with the final geotechnical laboratory results from the VC and PCPT. SSS and MBES data were also used to corroborate the SBP interpretation in the uppermost layers.

Magnetometer records collected during the survey were used to identify cables/pipelines and ferrous objects on the seafloor within the survey corridor. Note that due to line spacing this does not constitute an UXO survey.

4.2.1| ISOPACH

For the isopach the base of SAND unit was chosen. The base is either on the top of stiff or hard sediments, e.g. TILL or BEDROCK, or is characterized by a layer of coarse sediment, e.g. GRAVEL. Isopachs are presented in the charts.

The isopachs are based on the data from all SBP systems and are gridded using flex gridding with 5 m cell size. The contours were subsequently created in GIS. The gridding was made using 17-60 m limit distance from data depending on survey line distance. Since the gridding process occasionally creates false surfaces over known bedrock outcrops, the data was subsequently cropped to the bedrock polygons from the interpreted surface geology.

5| RESULTS UNITED KINGDOM

5.1| UNITED KINGDOM NEARSHORE

5.1.1| OVERVIEW ROUTE OPTION RPL_09112018_REV0

Reported KP for the UK nearshore section are KP 0.000 to KP 1.152. The bathymetry description includes intertidal zone and surf zone data acquired by UAV from KP 0.000. Surficial geology descriptions start from the limit of the nearshore vessel at KP 0.334 and for the shallow geology at KP 0.498.

BATHYMETRY

The bathymetry in this area begins at the top of the intertidal zone and gently slopes away down to the surf zone where there is an area of mobile sediments and small ripples. The seabed continues to gently slope offshore to a depth of 10.02 m and the beginning of a rocky outcrop appears at the south side of the corridor (Figure 5). Depths are increasing with KP.

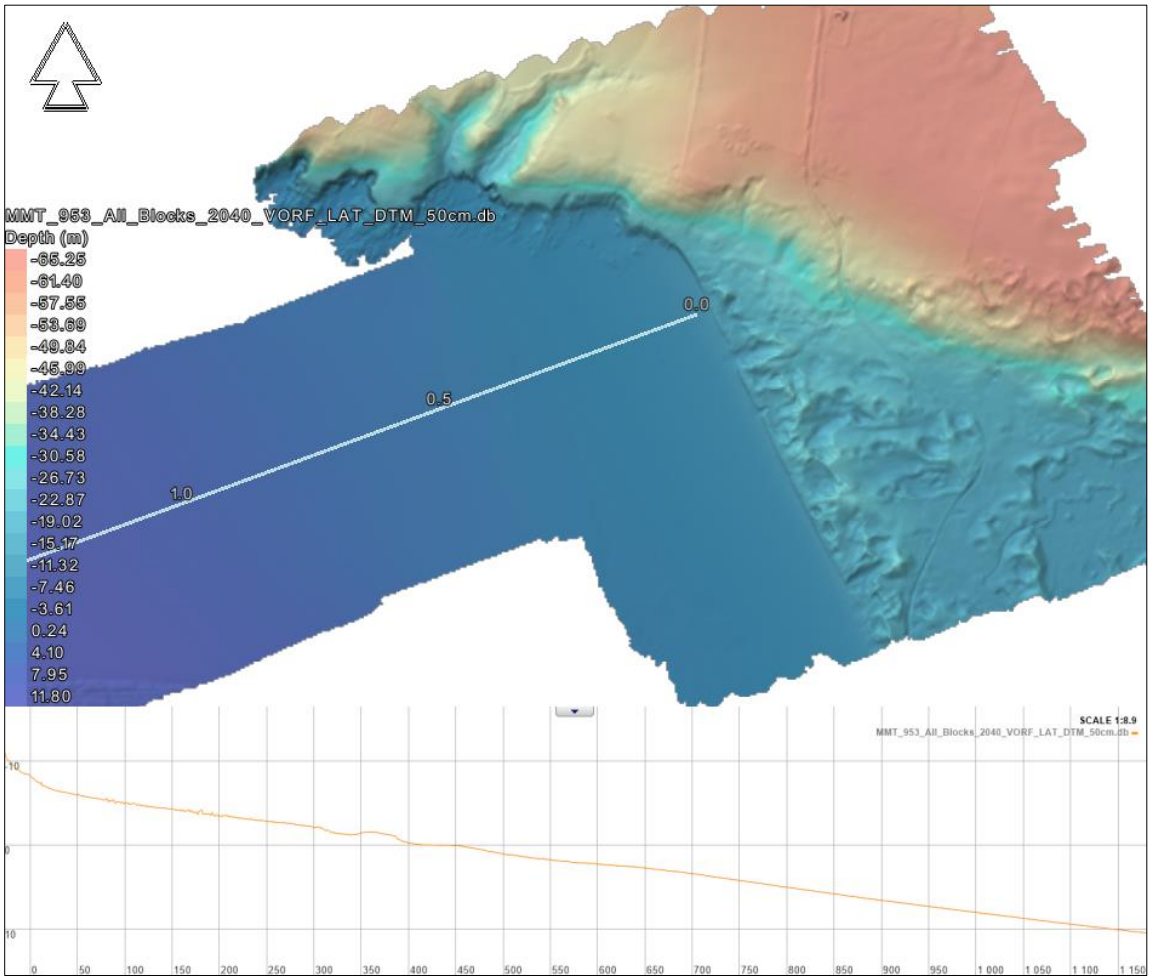


Figure 5 Shaded bathymetric relief and cross profile showing the shoreline at Freshwater West gently sloping out to KP 1.152.
Longitudinal profile (orange) depicts seabed along the route from KP 0.000 to KP 1.152. Negative values are above LAT (Profile vertical exaggeration: 1:8.9).

SURFICIAL GEOLOGY

The surficial geology in UK nearshore comprises of SAND. An area of megaripples is seen around KP 0.500.

SHALLOW GEOLOGY

The shallow geology in the UK nearshore area is typically characterised by a silty SAND unit over coarser SAND with some GRAVEL. These sediments overlie undulating BEDROCK, which can reach up to 2 m below the seabed surface.

5.1.2| DETAILED DESCRIPTION ROUTE OPTION RPL_09112018_REV0

A detailed presentation of the conditions and features in the UK nearshore corridor along the route are shown in Table 11.

Table 11 Seabed details route option RPL_09112018_REV0 KP 0.000 to KP 1.152.

KP	Associated Chart	Description	Remark
0.000- 1.152	102953-GRL-MMT-SUR-DWG-AL10KF01	**Bathymetry:** From KP 0.000 the seabed slopes gradually down through the intertidal zone to KP 0.340 where there is visible seabed movement at the surf zone of up to 0.7 m difference in depth. A sandbank has formed and migrated towards the beach over the course of three weeks between surveys, possibly due to a storm or the spring tide, see Figure 6. There are small ripples visible that run parallel to the shore in this area due to the oscillating movement of the waves. The ripples are no longer present from KP 0.620, where the seabed becomes smooth and flat and continues to gently slope deeper offshore down to 10 m. At KP 1.100 on the south side of the route there is the beginning of a rocky outcrop, see Figure 5.	Gentle gradient with a maximum value on the route of 5.5 degrees at KP 0.000. Depths range up to 10.02 m LAT on the route (Figure 7).
		Surficial geology: The surficial geology interpretation starts at KP 0.334 and consists of SAND. Megaripples are also present.	(Figure 8)
		Shallow Geology: The shallow geology interpretation starts at KP 0.498. A surface SAND unit of 1-2 m thickness is present over SAND with some GRAVEL. The underlying BEDROCK is generally >2 m below seabed.	(Figure 9)

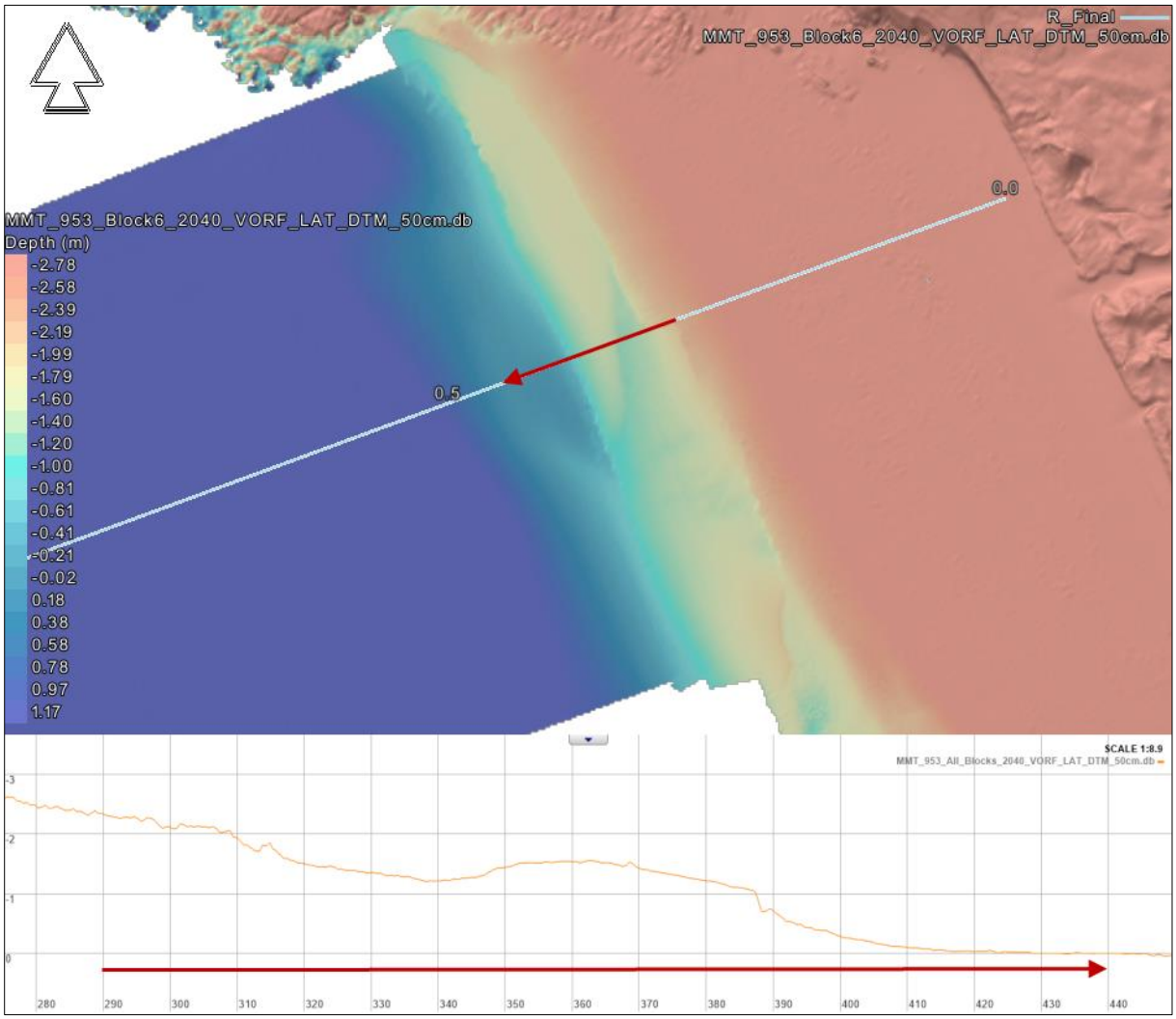


Figure 6 Shaded bathymetric relief showing mobile sediment in the surf zone.
The palette has been adjusted to highlight the area. Longitudinal profile (orange) depicts seabed along the route and the red arrows demonstrate the direction. Negative values are above LAT (Profile vertical exaggeration: 1:8.9).

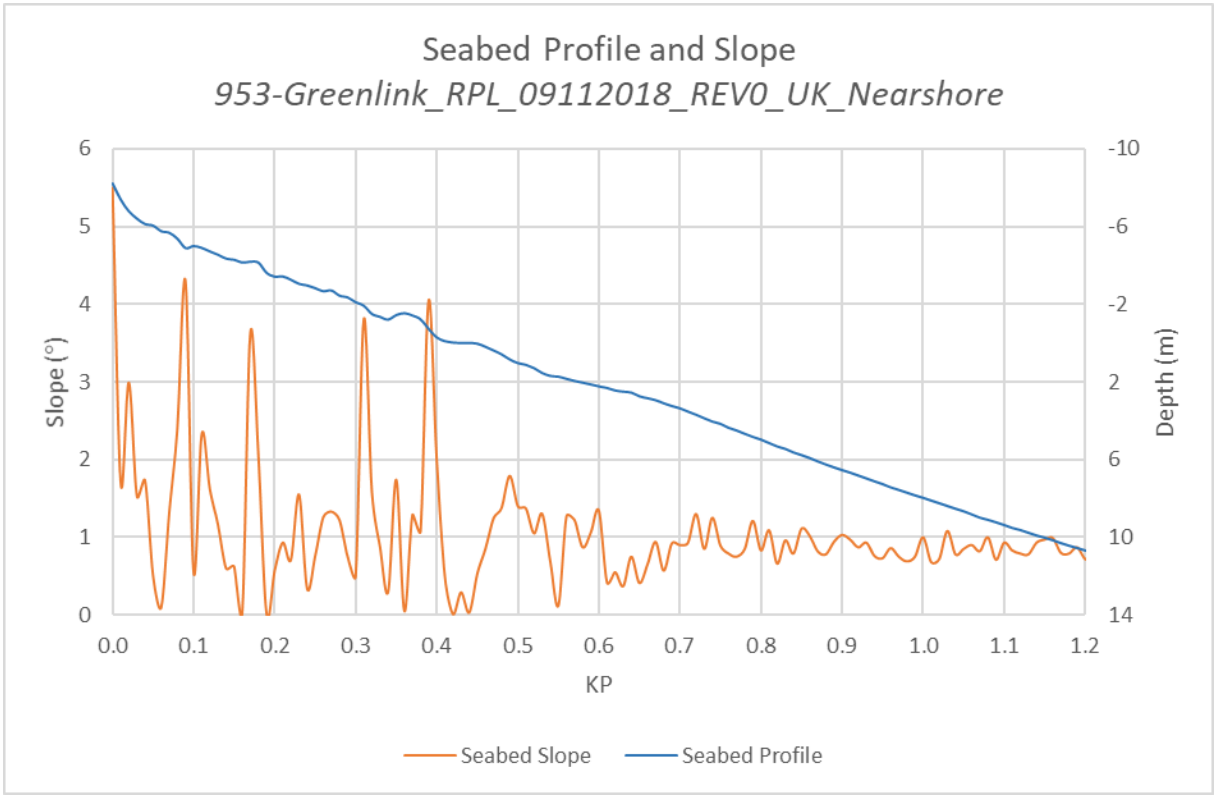


Figure 7 Seabed gradient and depth on the Final route between KP 0.000 – KP 1.152. Negative values are above LAT.

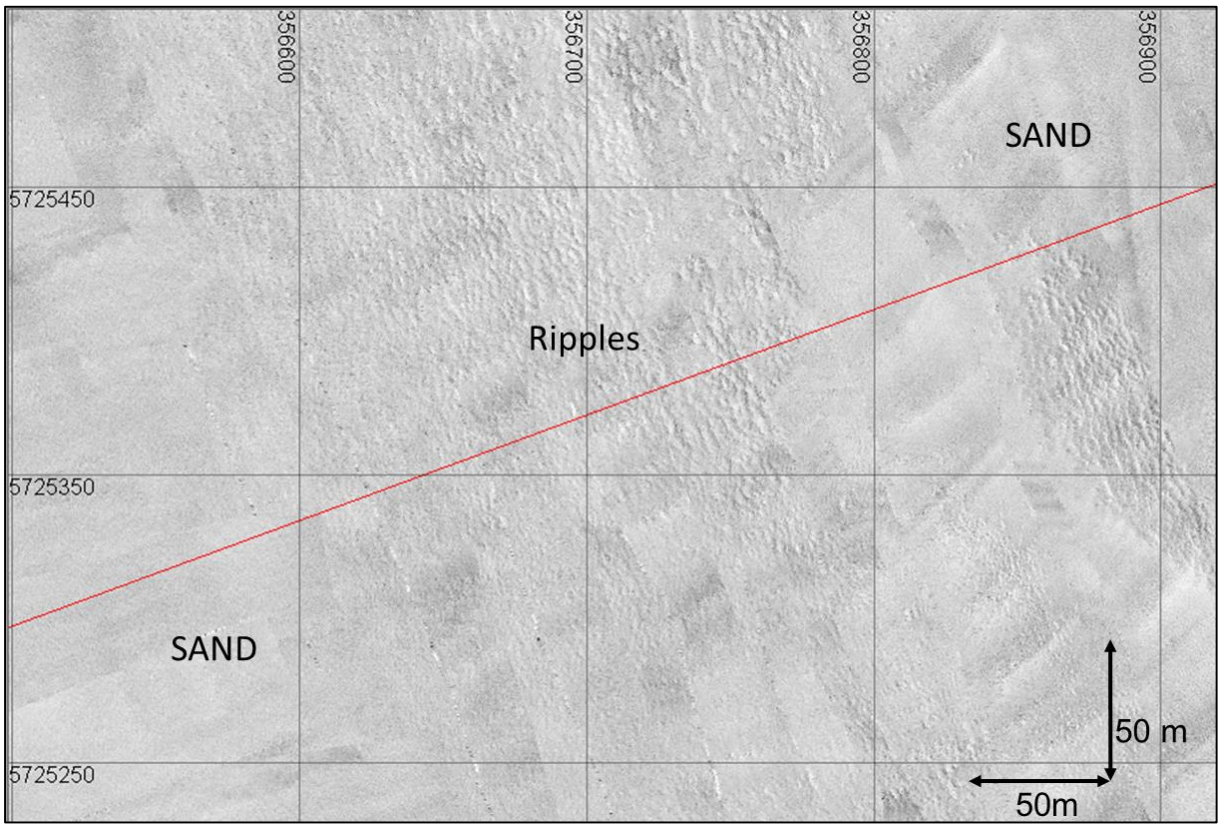


Figure 8 SSS plan view example from KP 0.315 to KP 0.762 showing SAND with Ripples. Image is north up.

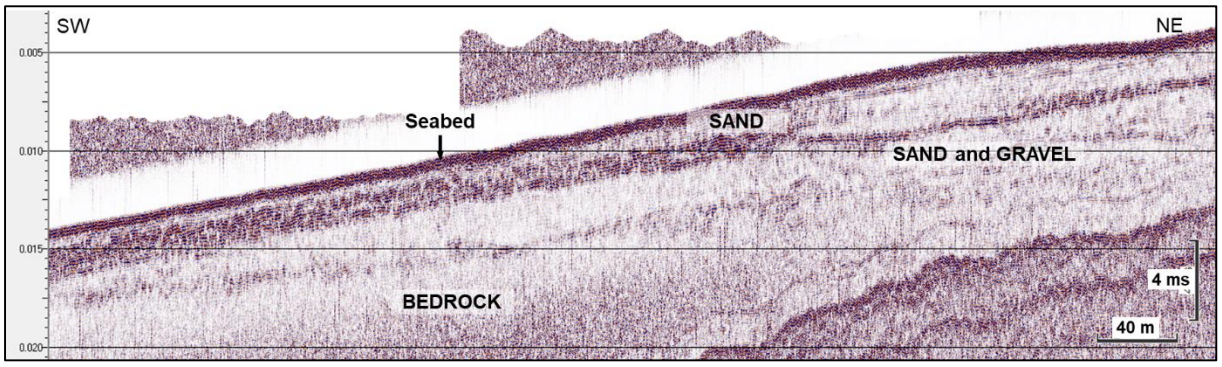


Figure 9 Innomar SBP data example from KP 0.537 to KP 1.063. Showing surface SAND layer overlying SAND and GRAVEL and BEDROCK.

5.1.3| CONTACTS AND ANOMALIES ROUTE OPTION RPL_09112018_REV0

No SSS contacts were identified from the data within the survey corridor in UK nearshore.

A total of 15 magnetic anomalies were detected in the UK nearshore corridor. Of these, 15 were unclassified (

Table 12)

A total of 0 SSS contact positions correlated with detected magnetic anomalies.

Table 12 Summary of UK nearshore magnetic anomalies.

CLASSIFICATION	NUMBER
Unclassified, possible objects	15
Cable	0
Total	**15**

5.2| UNITED KINGDOM OFFSHORE

5.2.1| OVERVIEW ROUTE OPTION RPL_09112018_REV0

Results are present for KP 1.152 to KP 73.906.

BATHYMETRY

Depths range from 10.02 m at KP 1.152, to 127.83 m on the route at KP 53.660. The depth reaches 130 m in the corridor to the north of the route at KP 53.693. Very gentle to gentle gradients in general with some moderate slopes in sandwave and ripple areas. Overall the depth is increasing with KP. The seabed has ripples, sandwaves, numerous boulder areas and occasional rocky outcrops.

SURFICIAL GEOLOGY

The surficial geology along the UK parts of the route is dominated by SAND or gravelly SAND/sandy GRAVEL, interrupted by areas of outcropping BEDROCK, the largest of which is seen between KP 2.000 and KP 5.000. In this area, the route is routed in a narrow channel like formation between areas of outcropping BEDROCK.

Mobile sediments are common along this part of the route. Most common are the megaripples, ranging in wavelength between 5 m and 25 m, however ripples <5 m wavelength are also seen. An area with sandwaves is present between KP 25.685 and KP 26.408.

Boulder fields are seen in several instances in this section. The density of boulders in the fields vary, from occasional to numerous. The largest boulder field area is present between KP 20.198 and KP 22.532. The boulders in the survey area range in height from very small up to 2.3 m.

SHALLOW GEOLOGY

The shallow geology is characterised by a gravelly to silty surface SAND unit overlying BEDROCK or/and TILL over large parts of the Welsh platform. The layer of SAND and TILL thickens as the southern extent of the St. George's Channel trough is reached.

The surface SAND unit is almost continuous and varies in thickness between 1 and 4 m. It reaches a thickness of >10 m in a sand accumulation between KP 5.120 and KP 9.520. The base of the SAND unit is not resolved in the seismic data from KP 42.853 to KP 45.746. The SAND unit can reach thicknesses of up to 6 m in the bathymetric trough beyond KP 44.620. The geotechnical sampling shows that the surface layer commonly comprises SAND, but local variations are seen where the amount of GRAVEL and CLAY might be significant.

BEDROCK is close to the seabed, often within 3 m, between KP 1.890 and KP 3.765 where the route leads through the trough of a channel, closely surrounded by BEDROCK to either side. The bedrock is also close to seabed surface between KP 9.520 to KP 24.900.

A distinction between BEDROCK and TILL based on the available seismic data is difficult between KP 25.700 and KP 44.500 as a lower boundary of TILL is not resolved. The geotechnical samples in this area terminate close to the upper boundary of the interpreted TILL and does not provide much more information regarding the boundary between the TILL and the BEDROCK below. TILL is present as a thick sediment unit within the trough beyond KP 44.620. Geotechnical results show that the TILL in the area typically comprises mainly high strength, stiff CLAY with varying fractions of sand, gravel and silt.

Incisions in the TILL or BEDROCK with channel infill sediments are present from KP 22.640.

5.2.2| DETAILED DESCRIPTION ROUTE OPTION RPL_09112018_REV0

A detailed presentation of the conditions and features in the UK offshore corridor along the route are presented in Table 13.

Table 13 Seabed details route option RPL_09112018_REV0 KP 1.152 to KP 73.906.

KP	Associated Chart	Description	Remark
1.152 - 4.997	102953-GRL-MMT-SUR-DWG-AL10KF01	**Bathymetry:** The seabed continues to slope gently and smoothly towards KP 2.260 where there is a drop of approximately 1 m, see Figure 10. From here the seabed has ripples until KP 2.850 where it becomes smooth again amongst the rocky outcrops that flank the route. Ripples can also be observed between KP 3.600 and KP 3.750, and between KP 4.500 and KP 4.660.	Gentle to moderate gradients with a maximum of 12.26 degrees on a large rock in the centre of the route at KP 2.400, otherwise slopes ranging up to 8.91 degrees. Depths range up to 35.05 m on the route (Figure 13).
		Surficial geology: The surficial geology consists of mainly SAND and gravelly SAND to sandy GRAVEL. Small areas of BEDROCK outcrops are seen on the route between KP 2.214 and KP 4.873 and KP 4.997. Large areas of BEDROCK are outcropping <50 m to either side of the route. Occasional ripples and megaripples are present throughout.	Backscatter data was used for interpretation between KP 4.028 and KP 4.583. Bedrock outcrop on the route between: • KP 2.214 and KP 2.788 • KP 4.873 and KP 4.997 (Figure 14)
		Shallow Geology: From KP 1.152 to KP 2.213 the surface silty SAND unit of 1-2 m is underlain by gravelly SAND or sandy GRAVEL and BEDROCK. BEDROCK is subcropping with a thin SAND cover between KP 2.213 and KP 2.862 and outcropping at KP 2.388. From KP 2.862 to 4.997 BEDROCK is overlain by a surface SAND unit of 2-4 m	Geotechnical results shows absence of cohesive material, apart from KP 1.374, where SILT is recovered below 1.33 m (VC -094).
4.997 - 9.520	102953-GRL-MMT-SUR-DWG-AL10KF01 102953-GRL-MMT-SUR-DWG-AL10KF02	**Bathymetry:** The rocky outcrop stops flanking the route at KP 5.000 giving way to ripples and sandwaves across the corridor. The depth decreases gently until KP 5.680 where it levels out until KP 8.500. From here the depth begins to increase again.	Very gently to occasional moderate gradients, with a maximum value of 5.26 degrees. Depths range up to 44.27 m on the route (Figure 13).

KP	Associated Chart	Description	Remark
		Surficial geology: The surficial geology consists mainly of SAND with occasional areas of gravelly SAND to sandy GRAVEL. Megaripples covers this entire route section.	(Figure 15) Possible unknown cable identified during the UXO survey at KP 6.325 (Figure 64)
		Shallow Geology: A thick SAND unit up to 10 m thick is overlying BEDROCK. The unit thins towards KP 9.520 where the depth to BEDROCK becomes ~1.5 m .	
9.520 - 22.662	102953-GRL-MMT-SUR-DWG-AL10KF02 102953-GRL-MMT-SUR-DWG-AL10KF03	**Bathymetry:** Depth increases gently throughout. At KP 10.099 the ripples grow smaller and boulders appear between KP 11.318 and KP 12.000. More boulders are present on the north side of the route corridor from KP 13.268. At KP 13.385 the seabed is smooth with fewer ripples and numerous boulders throughout.	Very gentle to gentle gradients, with a maximum value of 3.74 degrees. Depths range up to 58.83 m on the route (Figure 13).
		Surficial geology: The surficial geology comprises mainly gravelly SAND to sandy GRAVEL. One BEDROCK outcrop is present at route centre line between KP 11.041 and KP 11.136. Ripples and megaripples are present from the start of the section up until KP 13.420. Fields with occasional boulders are crossing the route at several locations in this section.	BEDROCK outcrop crossing the route between: • KP 11.040 and KP 11.136 Boulder fields crossing the route between: • KP 11.500 and KP 11.574 • KP 11.788 and KP 11.831 • KP 16.002 and KP 16.623 • KP 16.557 and KP 16.961 • KP 17.839 and KP 18.134 • KP 19.237 and KP 19.312 • KP 19.429 and KP 19.587 • KP 20.200 and KP 22.535 (Figure 16)

KP	Associated Chart	Description	Remark
		Shallow Geology: The surface SAND unit is generally 1.5 m thick. It overlies BEDROCK with some possible coarse sediment or TILL on its top. A distinct boundary between coarse sediment and BEDROCK is not resolved in the seismic data.	Geotechnical results show very weak to weak, thinly laminated carbonaceous MUDSTONE below 0.3 m at KP 11.758 (VC-004, CPT-004).
22.662 - 34.989	102953-GRL-MMT-SUR-DWG-AL10KF03 102953-GRL-MMT-SUR-DWG-AL10KF04 102953-GRL-MMT-SUR-DWG-AL10KF05	**Bathymetry:** A rocky outcrop is observed at KP 23.590. Large ripples and sandwaves are present between KP 25.685 and KP 26.390 (see Figure 11) and ripples and boulders continue to be present on the route up to KP 34.989.	Gentle to moderate gradients in general, with a maximum value of 11.72 degrees at the sandwave at KP 26.02. Depths range up to 61.97 m on the route (Figure 13).
		Surficial geology: The surficial geology consists of alternating gravelly SAND to sandy GRAVEL and SAND. Minor areas of BEDROCK outcropping are present. Large parts of this section are covered with seabed features such as ripples and megaripples. One area with sandwaves is also seen. Boulder fields of different densities are seen on several locations along the route.	BEDROCK crossing the route between: • KP 24.178 and KP 24.202 Boulder fields present at the route between: • KP 24.924 and KP 25.439 • KP 33.914 and KP 34.368 (Figure 17 and Figure 18)
		Shallow Geology: The surface SAND unit is generally 1-3 m thick, up to 10 m in sandwaves. It overlies BEDROCK up to KP 26.414 and TILL from thereon. No clear distinction between TILL and BEDROCK can be made from the available seismic data. Several Channel infill sediments, typically comprising CLAY are present from KP 22.662 to KP 24.769, KP 27.364 to KP 28.502, KP 31.331 to KP 31.931 and KP 33.694 to KP 34.142.	(Figure 21)
34.989 - 37.980	102953-GRL-MMT-SUR-DWG-AL10KF05	**Bathymetry:** Very gently deepening seafloor continuing from KP 34.989. Occasional boulders are observed on an otherwise smooth seabed.	Very gentle to gentle slopes overall with a maximum value of 1.23 degrees. Depths range up to 64.43 m on the route (Figure 13).

KP	Associated Chart	Description	Remark
		Surficial geology: The surficial geology consists of mainly gravelly SAND to sandy GRAVEL and of SAND.	
		Shallow Geology: The surface SAND unit is generally 2-4 m thick and overlies TILL. Two channel infills are present. A lower boundary for the TILL unit or BEDROCK is not resolved in the seismic data.	
37.980 - 40.914	102953-GRL-MMT-SUR-DWG-AL10KF05 102953-GRL-MMT-SUR-DWG-AL10KF06	**Bathymetry:** Gently deepening seafloor up to KP 40.174 where the depth increases more rapidly for a short time until KP 40.366 where the depth begins to decrease gently. From KP 40.504 the seabed depth changes little up to KP 40.914.	Very gentle to gentle gradient with a maximum value of 3.41 degrees. Depths range up to 68.29 m on the route (Figure 13).
		Surficial geology: The surficial geology consists of mainly gravelly SAND to sandy GRAVEL. One field with numerous boulders is present, crossing the route between KP 38.108 and KP 38.571.	
		Shallow Geology: A deep basin with surface SAND and channel infill sediments over TILL characterize this section. The channel infills reach up to 16 m below seabed. TILL is overlying BEDROCK which is generally >8 m below seabed, but reaches within 2 m of the surface at KP 38.144.	
40.914 - 45.756	102953-GRL-MMT-SUR-DWG-AL10KF06	**Bathymetry:** Depth changes little from KP 40.914 until KP 41.572 where it begins to increase gently until it decreases from KP 41.931. There is a rocky outcrop at KP 42.070 and the seabed has patches of ripples. The depth increases gently again from KP 42.366 and the seabed is smooth until KP 43.881 where the seabed becomes uneven. Occasional boulders are observed throughout and at KP 45.619 trawl marks are observed on the south side of the corridor.	Very gentle to gentle slopes overall with a maximum value of 5.18 degrees on a rocky outcrop at KP 42.07. Depths range up to 80.90 m on the route (Figure 13).

KP	Associated Chart	Description	Remark
		Surficial geology: The surficial geology consists of mainly gravelly SAND to sandy GRAVEL interrupted by minor areas of SAND and outcropping BEDROCK. Megaripples are present between KP 41.847 and KP 42.424.	BEDROCK outcropping on the route between: KP 42.065 and KP 42.104
		Shallow Geology: This section starts with a surface SAND unit basin of up to 5 m thickness until KP 42.065. From there the SAND is discontinuous and if present underlain by channel infill sediments. SAND and channel infills overlie TILL/BEDROCK. The boundary between TILL and BEDROCK is not resolved in the seismic data. BEDROCK is outcropping at the seabed at KP 42.065. Penetration is limited between KP 42.860 und KP 44.505 and the lower boundary of TILL is not resolved. TILL/BEDROCK are here overlain by a veneer of gravelly SAND and sandy GRAVEL. The top of BEDROCK becomes discernible again at KP 44.505 and is overlain by TILL with a veneer of mobile sediments.	
45.756 - 48.233	102953-GRL-MMT-SUR-DWG-AL10KF06	**Bathymetry:** The seabed continues to deepen gently. At KP 46.517 trawl marks are observed.	Very gentle to gentle gradients with a maximum value of 4.49 degrees. Depths range up to 86.41 m on the route (Figure 13).
		Surficial geology: The surficial geology consists of mainly gravelly SAND to sandy GRAVEL with no seabed features.	
		Shallow Geology: The surface SAND unit is varying between 0.5 and 5 m. The Underlying TILL/BEDROCK is dipping down and is generally 10 m below seabed surface.	(Figure 22) Organic material found in upper parts of geotechnical sample at KP 47.645 (VC-102)
48.233 - 59.641	102953-GRL-MMT-SUR-DWG-AL10KF06	**Bathymetry:** Gently to moderately deepening seafloor until KP 52.959 where the seabed undulates until KP 59.387. Occasional boulders and sporadic patches of ripples are present throughout.	Very gentle to moderate gradients with a maximum value of 8.22 degrees at KP 53.29. Depths range up to 127.83 m on the route (Figure 13).

KP	Associated Chart	Description	Remark
	102953-GRL-MMT-SUR-DWG-AL10KF07 102953-GRL-MMT-SUR-DWG-AL10KF08	**Surficial geology:** The surficial geology consists of alternating areas of SAND and gravelly SAND to sandy GRAVEL. Fields with occasional boulders are present at some locations. Ripples, megaripples and sandwaves are present throughout.	Boulder field crossing the route between: KP 53.137 and KP 53.467 (Figure 19)
		Shallow Geology: The surface SAND unit is generally around 1 m thick, up to 5 m between 46.412 and KP 48.754. TILL is present below the SAND with some channel infills between KP 57.609 and KP 58.616. BEDROCK is generally around 4-10 m below seabed. It reaches within 2-3 m of the seabed from KP 50.833 to KP 51.540.	
59.641 - 73.906	102953-GRL-MMT-SUR-DWG-AL10KF08 102953-GRL-MMT-SUR-DWG-AL10KF09	**Bathymetry:** Depths remain steady with some undulation. Occasional boulders and ripples are present throughout, with larger ripples and sandwaves between KP 63.275 and KP 73.906, see Figure 12	Very gentle to moderate gradients with a maximum value of 5.82 degrees. Depths range up to 116.18 m on the route (Figure 13).
		Surficial geology: The surficial geology consists mainly of SAND. Almost the entire section is covered by features indicating mobile sediment, such as ripples, megaripples and sandwaves. Trawl marks, indicating fishing activity are also present with different densities within the section.	Trawl marks are abundant. Cable crossing: Pan European Crossing 2 at KP 59.791 (Figure 20)
		Shallow Geology: The surface SAND unit it generally <2 m thick, slightly more in areas of sandwaves, up to 5 m from KP 59.641 to KP 61.706. The underlying TILL unit is thick and the boundary to BEDROCK is generally >10 m. Channel infill sediment is present between SAND and TILL from KP 66.947 to KP 70.198.	

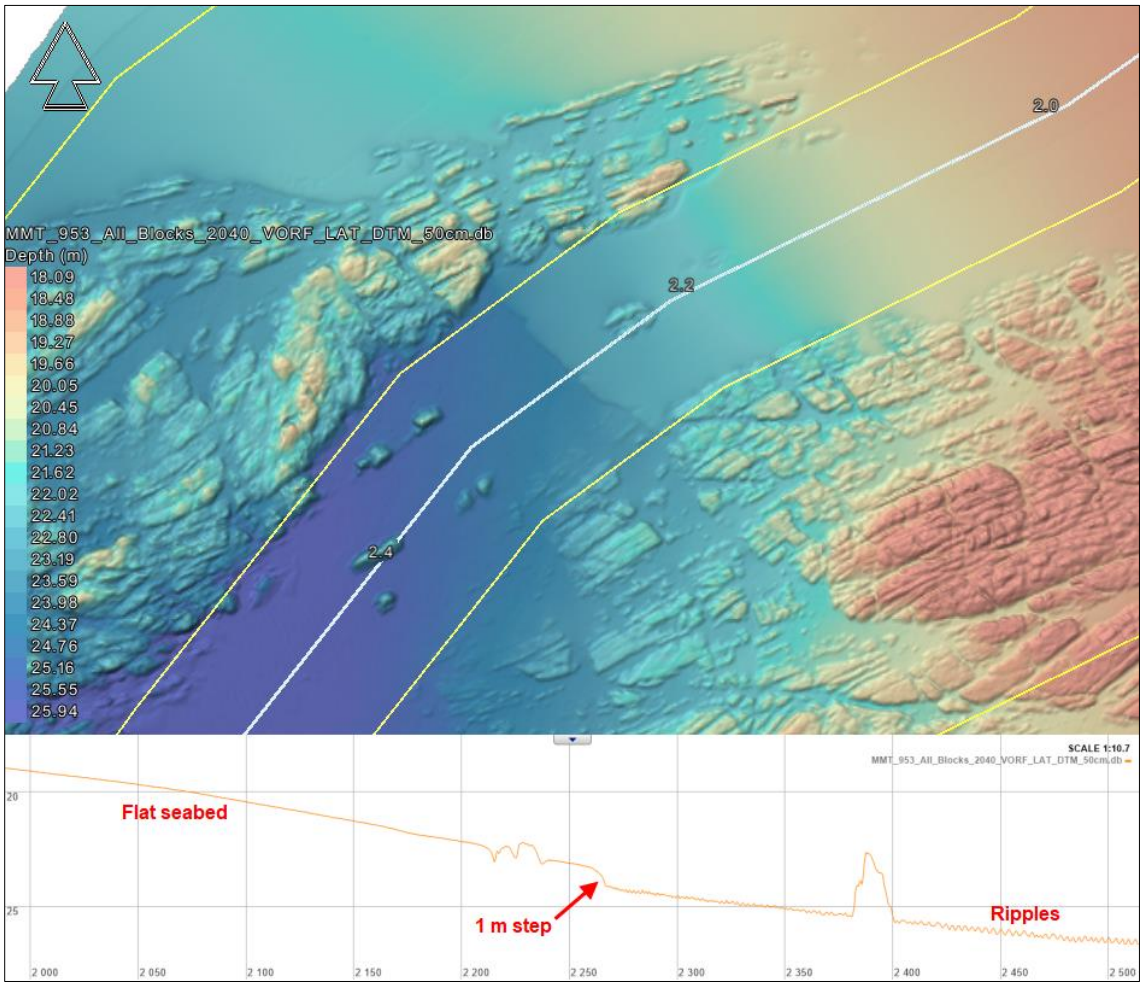


Figure 10 Shaded bathymetric relief showing the seabed gradually sloping deeper until a 1 m step at KP 2.26 where ripples begin to appear.
Longitudinal profile (orange) depicts seabed along the route from KP 2.000 to KP 2.500. (Profile exaggeration 1:10.7).

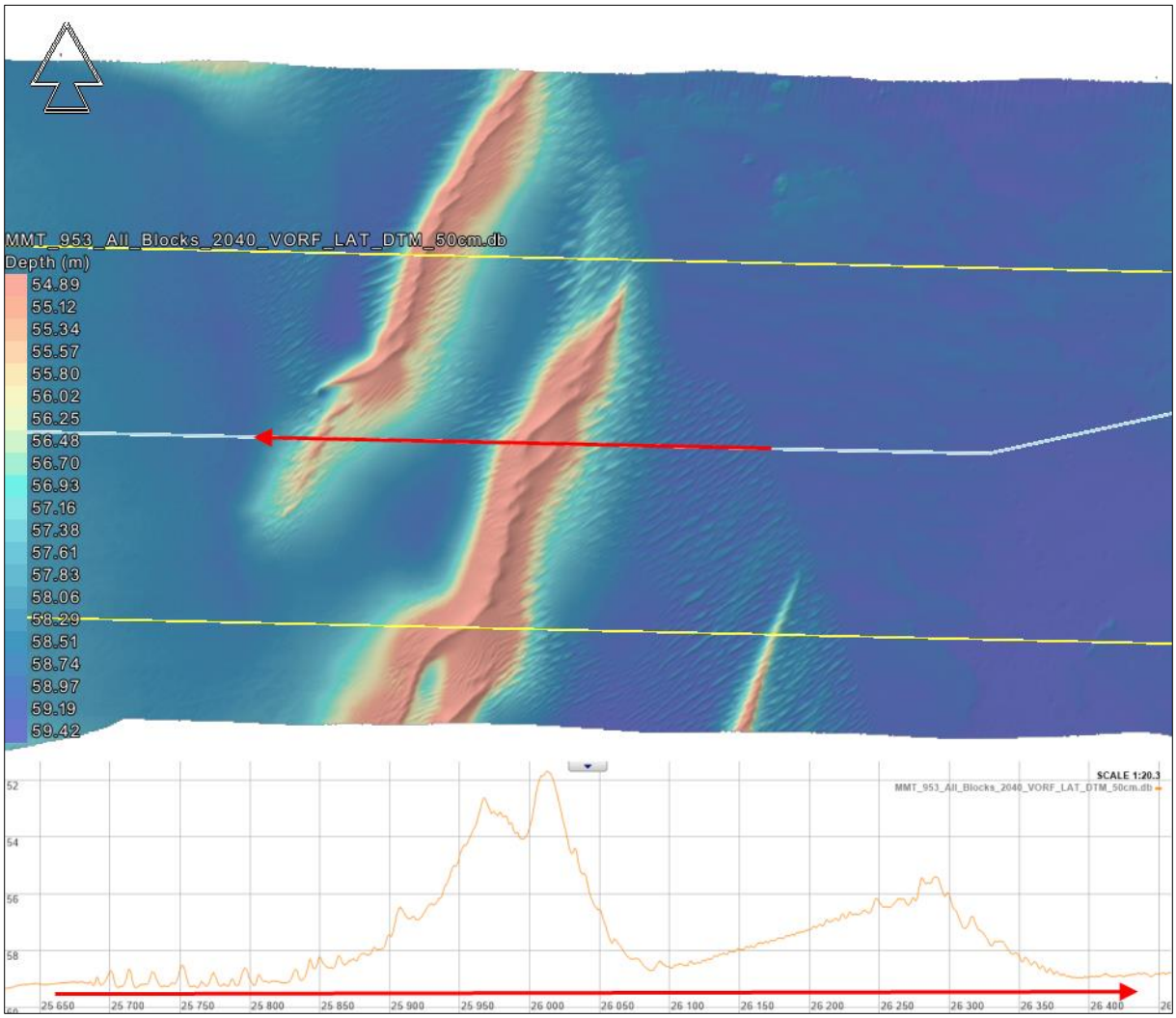


Figure 11 Shaded bathymetric relief showing ripples and sandwaves between KP 25.685 and KP 26.390.
Longitudinal profile (orange) depicts seabed along the route along the direction of the red arrow. (Profile exaggeration is 1:20.3). The palette has been adjusted to highlight the bathymetry.

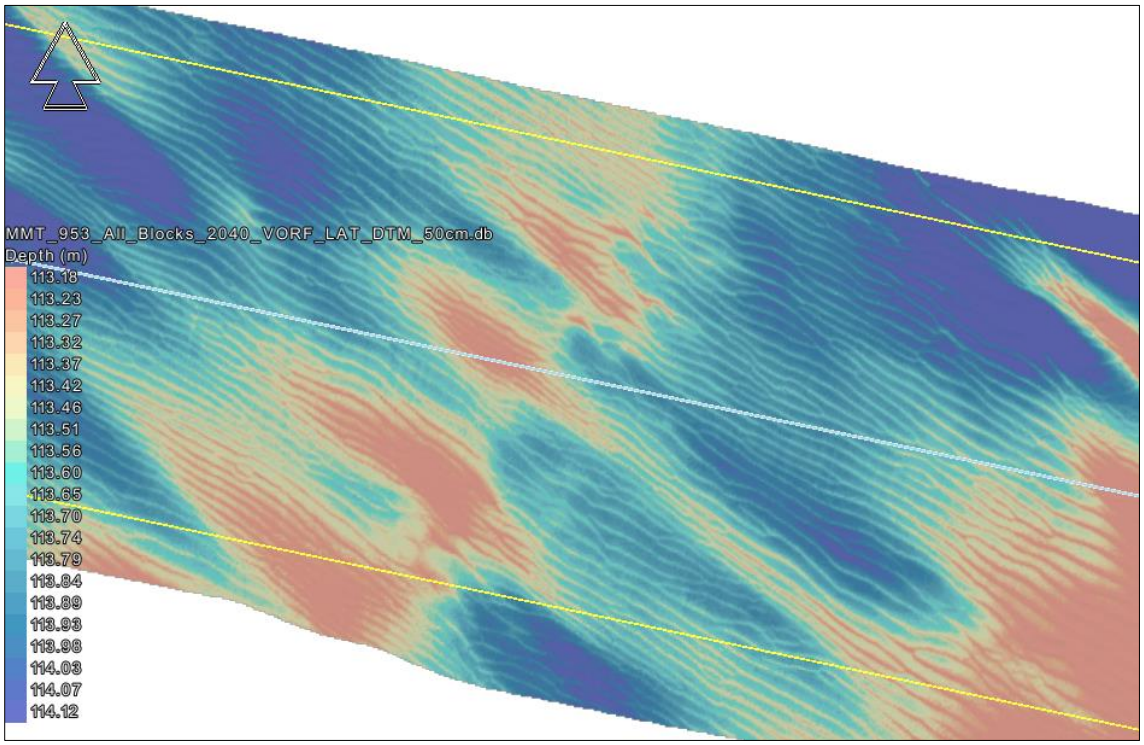


Figure 12 Shaded bathymetric relief showing ripples at KP 71.917.
The palette has been adjusted to highlight the bathymetry.

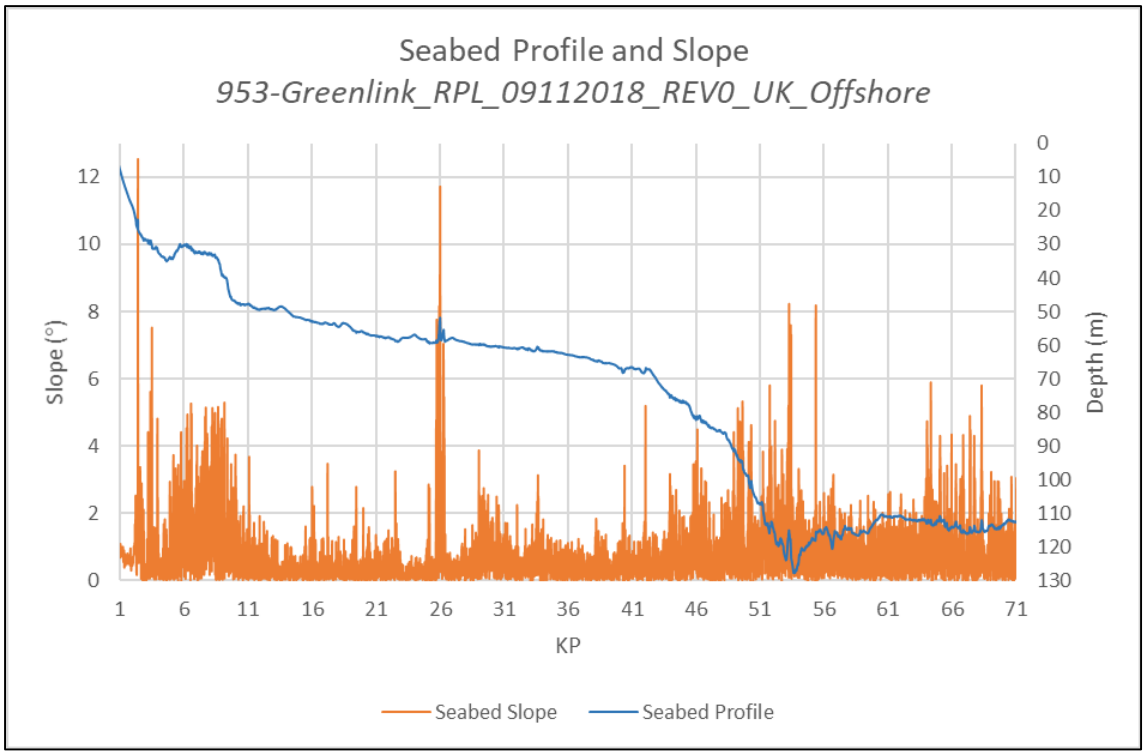


Figure 13 Graph presenting seabed gradient and depth on the Final route in the UK offshore section between KP 1.152 and KP 73.906.

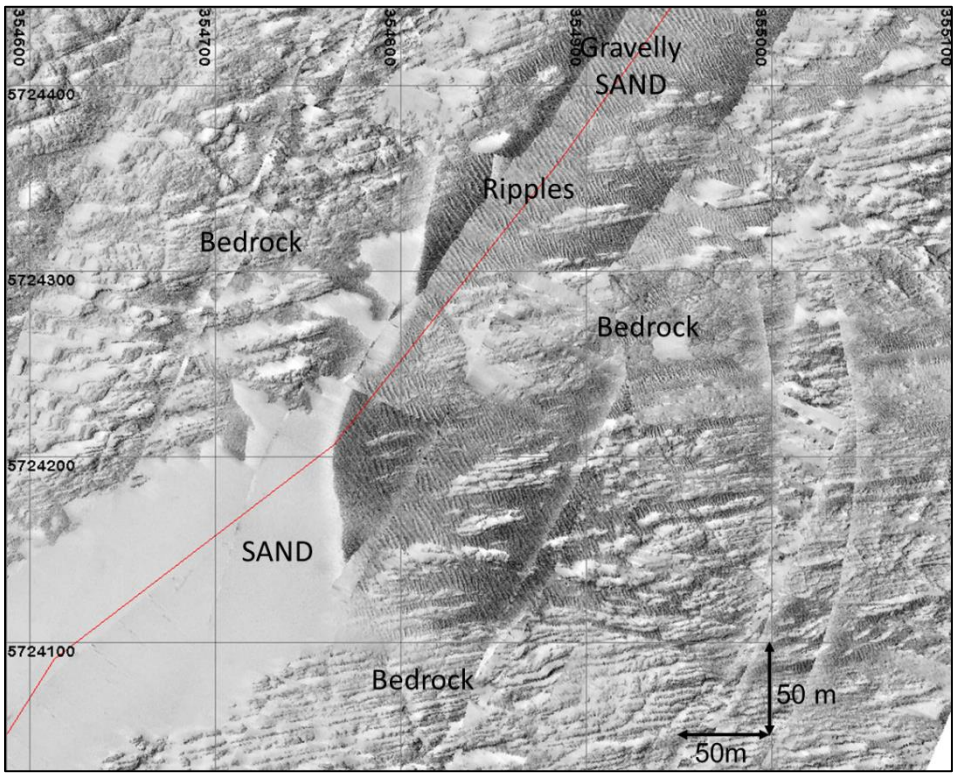


Figure 14 SSS plan view example from KP 2.565 to KP 3.099.
Showing a channel of rippled gravelly SAND and SAND between BEDROCK.
Image is north up.

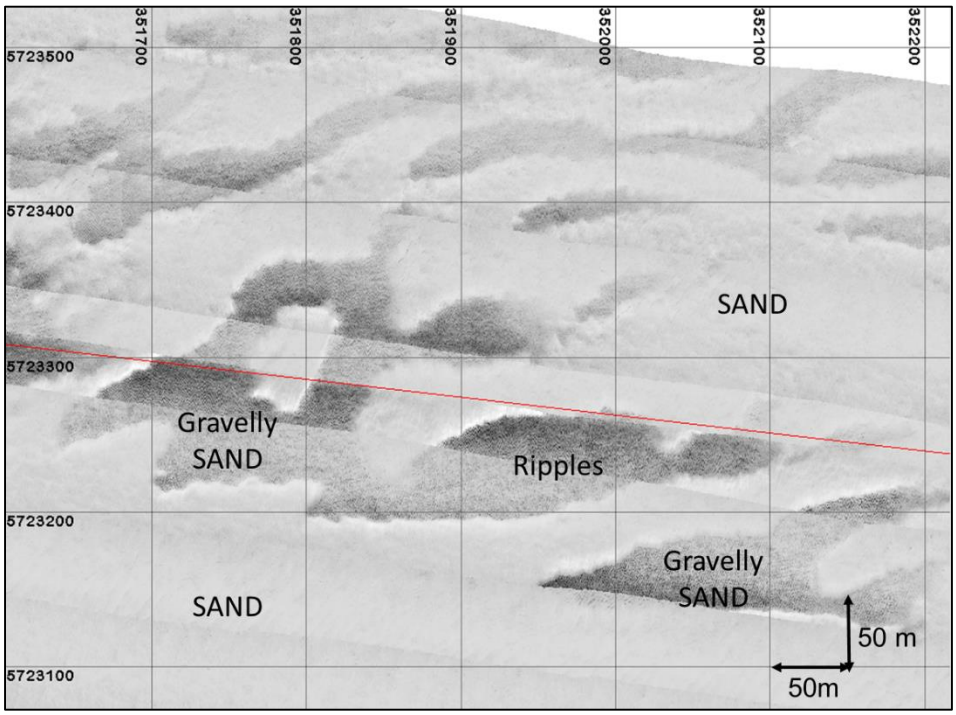


Figure 15 SSS plan view example from KP 6.174 to KP 6.787.
Showing patches of rippled gravelly SAND and SAND. Image is north up.

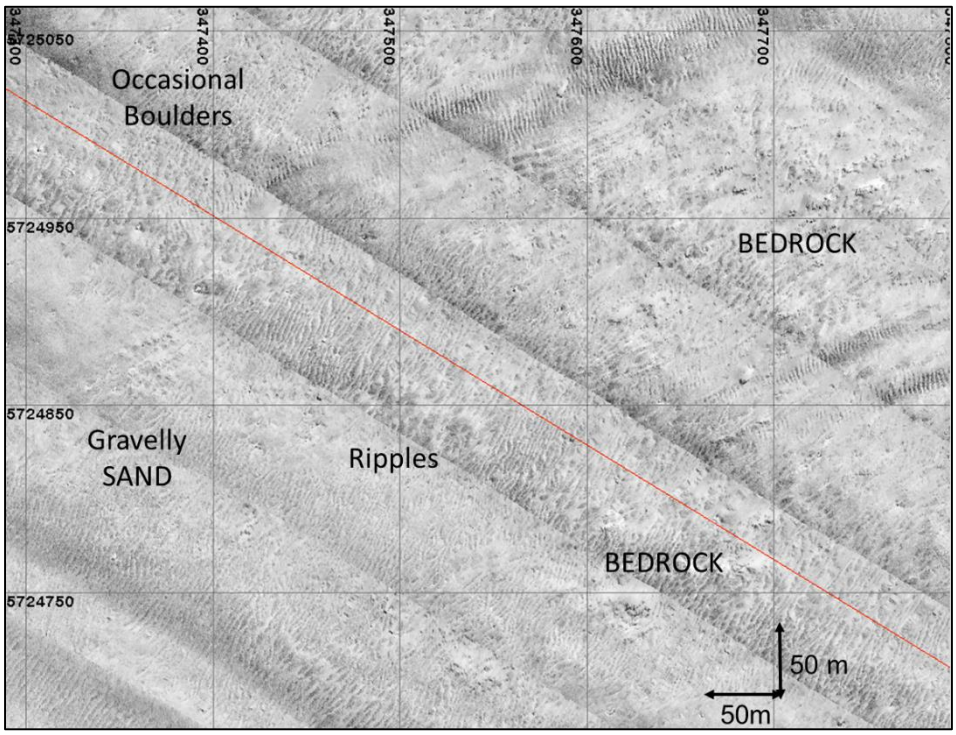


Figure 16 SSS plan view example from KP 10.951 to KP 11.476.
Showing rippled gravelly SAND with occasional boulders between outcropping BEDROCK. Image is north up.

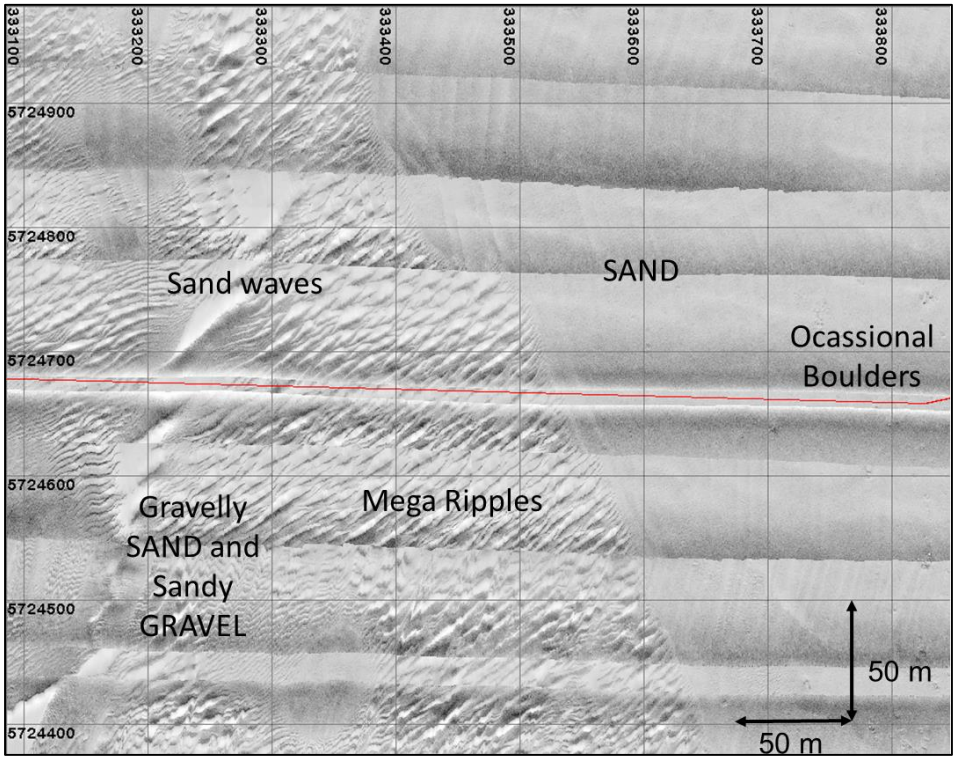


Figure 17 SSS plan view example from KP 25.369 to KP 26.129.
Showing SAND with occasional boulders and gravelly SAND and sandy GRAVEL with sandwaves and megaripples. Image is north up.

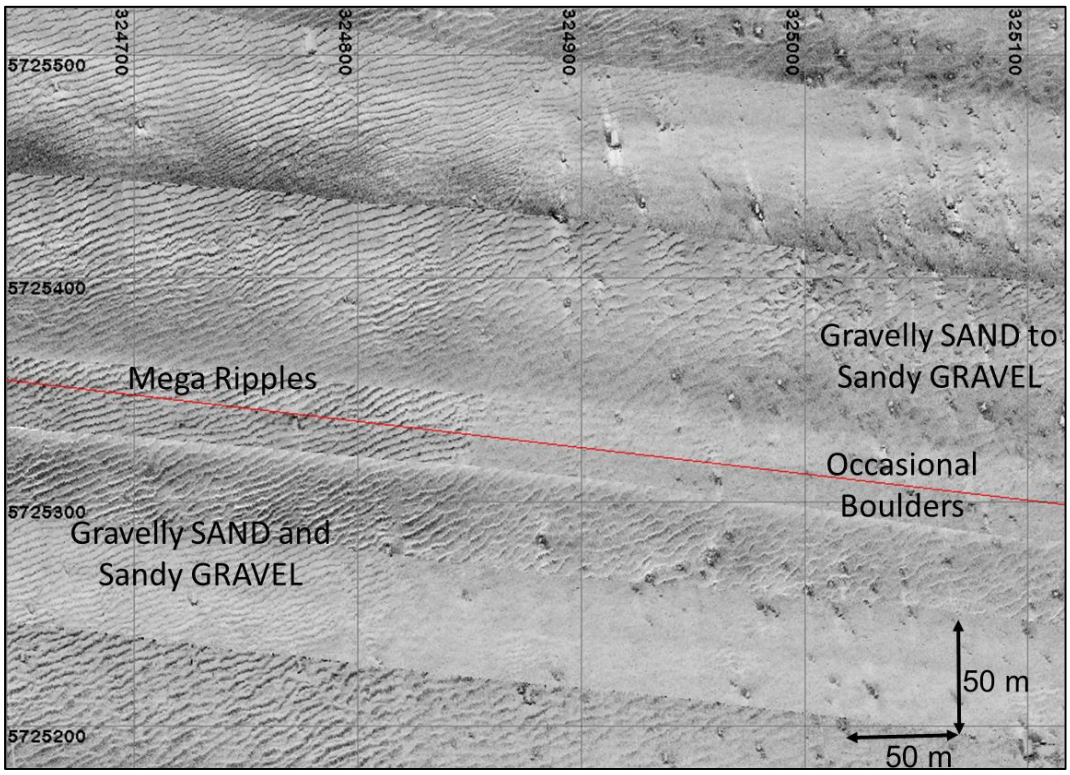


Figure 18 SSS plan view example from KP 34.118 to KP 34.609.
Showing gravelly SAND to sandy GRAVEL with occasional boulders. Image is north up.

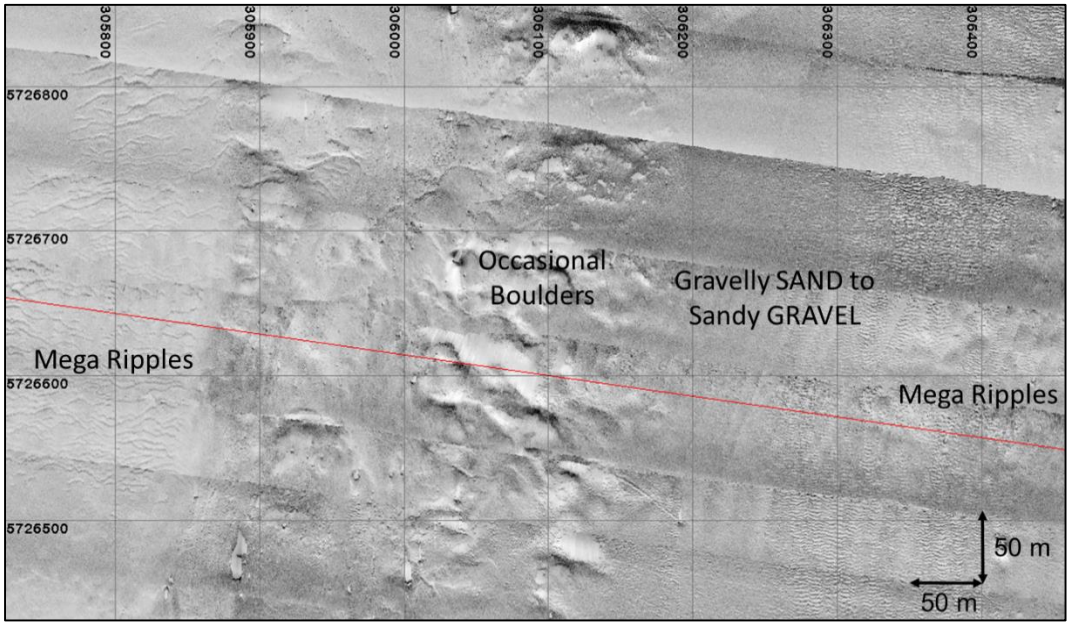


Figure 19 SSS plan view example from KP 52.858 to KP 53.602.
Showing gravelly SAND to sandy GRAVEL with areas of megaripples and occasional boulders. Image is north up.

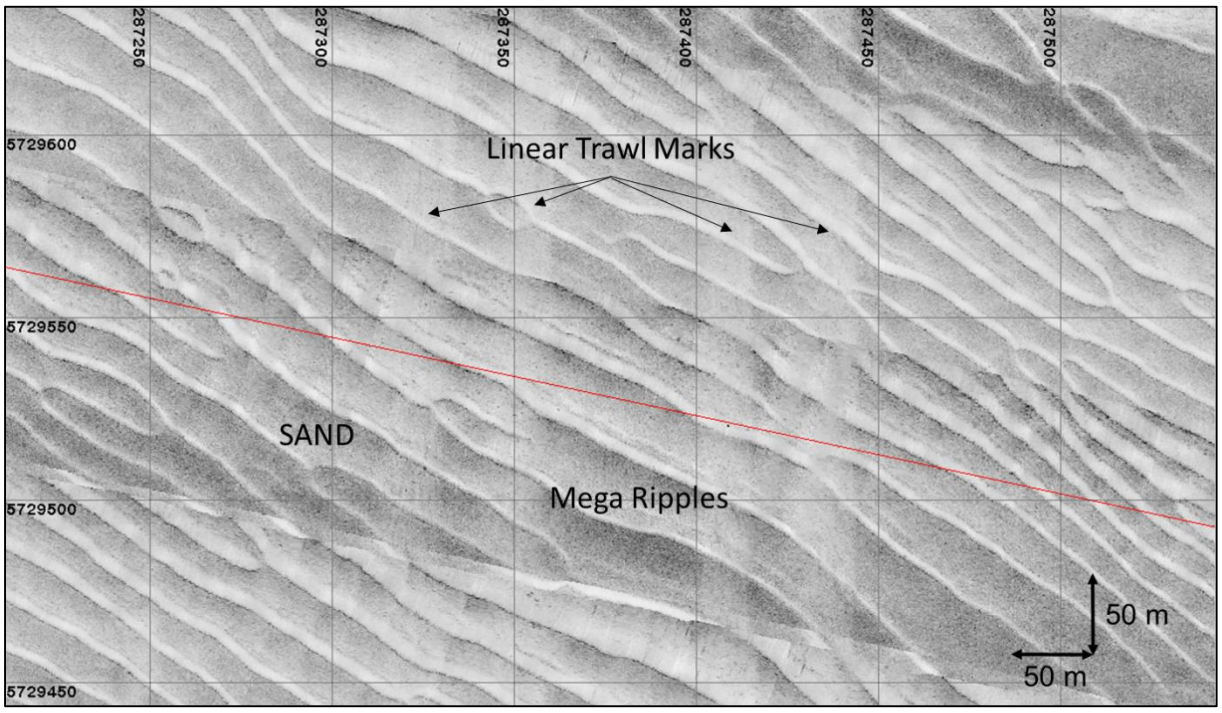


Figure 20 SSS plan view example from KP 72.011 to KP 72.349.
Showing SAND with megaripples and pairs of trawl marks. Image is north up.

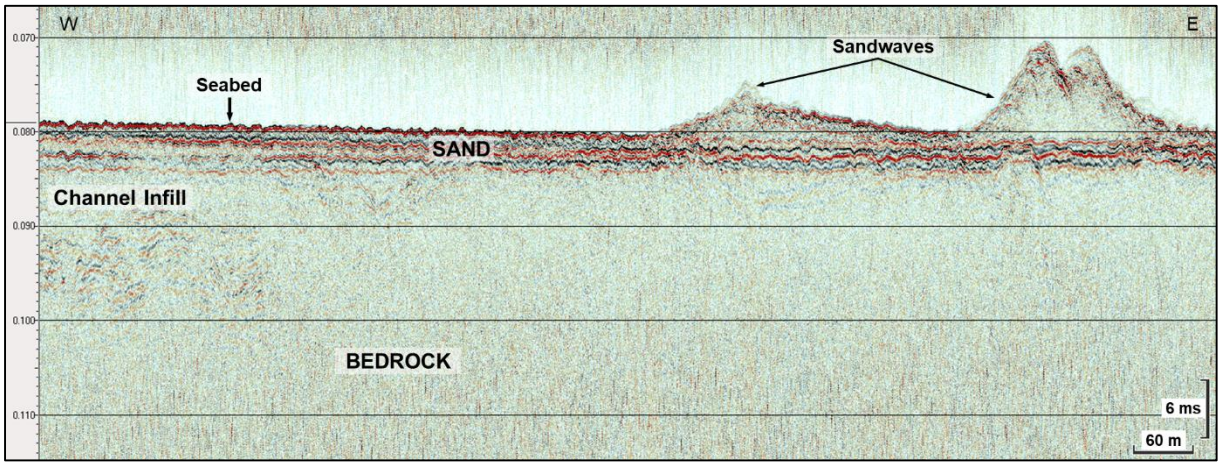


Figure 21 Sparker SBP data example from KP 25.835 to KP 26.950.
Showing surface SAND unit with sandwaves overlying a channel infill to the right and BEDROCK.

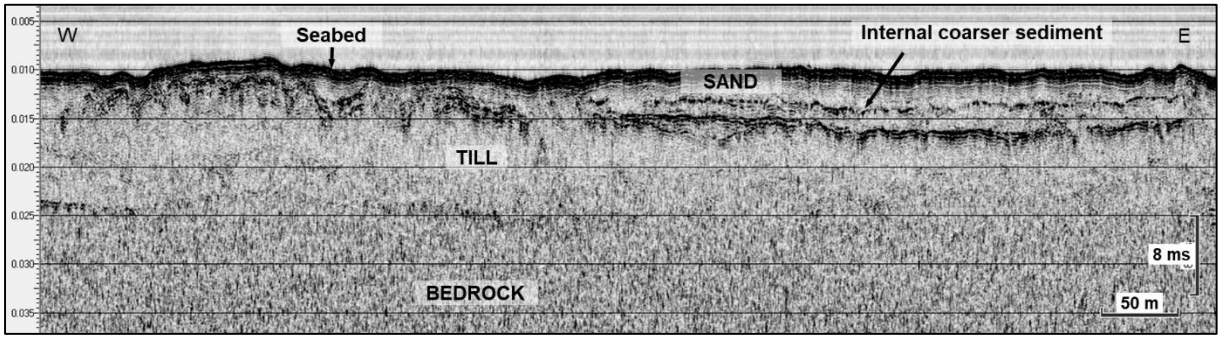


Figure 22 Chirp SBP data example from KP 46.540 to KP 47.320.
Showing surface SAND unit with coarse internal reflector overlying an erosional TILL surface and BEDROCK.

5.2.3| CONTACTS AND ANOMALIES ROUTE OPTION RPL_09112018_REV0

A total of 2690 SSS contacts were identified from the data within the survey corridor in UK offshore. The majority of the contacts were classified as either boulders or debris.

The SSS contacts are summarised in Table 14.

A total of 162 magnetic anomalies were detected in the UK offshore corridor. Of these, 161 were unclassified, 1 was a known wreck, a steel-hulled steamship, Saint Jacques (Table 15).

A total of 7 SSS contact positions correlated with detected magnetic anomalies from the geophysical survey and a total of 20 SSS contact positions correlated with detected magnetic anomalies from the UXO survey.

Table 14 Summary of UK offshore SSS contacts, route option RPL_09112018_REV0.

CLASSIFICATION	NUMBER
Boulder	2559
Other	5
Debris	125
Wreck	1
Total	**2690**

Table 15 Summary of UK offshore magnetic anomalies, route option RPL_09112018_REV0.

CLASSIFICATION	NUMBER
Unclassified, possible objects	161
Wreck	1
Cable	0
Total	**162**

5.2.4| OVERVIEW ROUTE OPTION A

Results are presented for KP 3.647 to KP 24.907 along route option A.

All KPs refer to route option A, RPL Route_A_WGS84_UTM30N_Rev1_20180521.

BATHYMETRY

Route A has a maximum depth of 59.66 m at KP 24.800 and is generally increasing in depth. The seabed is rocky to begin with, then ripples with sandwaves are observed before becoming rocky again. At the end of this section the seabed becomes smooth with occasional boulders. Gradients are very gentle to gentle with localised very steep slopes on the rocky areas.

SURFICIAL GEOLOGY

The surficial geology in Route Option A comprises outcropping BEDROCK in large parts. Between the BEDROCK outcrops, minor areas of gravelly SAND/sandy GRAVEL are seen. At the end of the section, the surficial geology comprises of mostly SAND.

Megaripples are common on the loose sediments in the section. Boulder fields are sparse, but some are seen in the survey corridor of Route Option A.

SHALLOW GEOLOGY

The shallow geology along route option A is characterised by outcropping BEDROCK and one large, thick SAND accumulation from KP 5.100 to KP 10.015. Deep incisions in the BEDROCK filled by channel infill sediments are present between KP 22.300 and KP 24.907.

5.2.5| DETAILED DESCRIPTION ROUTE OPTION A

A detailed presentation of the conditions and features in the UK offshore corridor along route option A are shown in Table 16.

Table 16 Seabed details route option A KP 3.647 to KP 24.909.

KP	Associated Chart	Description	Remark
3.647 - 5.094	102953-GRL-MMT-SUR-DWG-AL10KA01	**Bathymetry:** Rocky area with generally gentle depth changes and localised steeper slopes across the rocks, see Figure 23.	Very gentle to moderate gradient with locally very steep slopes of a maximum value of 20.37 degrees on the rocky areas. Depths range up to 34.56 m on the route (Figure 26).
		Surficial geology: The surficial geology consists of mainly BEDROCK and occasional areas consisting of gravelly SAND/ sandy GRAVEL. Megaripples are also present within the section.	Bedrock outcrops crossing the route between: • KP 3.803 and KP 3.829 • KP 3.846 and KP 3.920 • KP 4.008 and KP 5.094 (Figure 27)
		Shallow Geology: BEDROCK is outcropping.	(Figure 30)
5.094 - 8.879	102953-GRL-MMT-SUR-DWG-AL10KA01 102953-GRL-MMT-SUR-DWG-AL10KA02	**Bathymetry:** At KP 5.094 the rocky seabed becomes rippled and sandwaves are observed to KP 7.100, see Figure 24. Depth decreases gently to KP 5.970 where it begins to very gently increase again. Ripples are present throughout.	Very gentle to gentle gradients overall with localised moderate slopes of a maximum value of 5.41 degrees on the sandwaves. Depths range up to 34.68 m on the route (Figure 26).
		Surficial geology: The surficial geology consists of mainly SAND and occasional areas consisting of gravelly SAND/sandy GRAVEL. Minor areas with occasional boulders sparsely occurring. Megaripples are present throughout.	Boulder field crossing the route between: KP 7.799 and KP 7.870
		Shallow Geology: A thick SAND accumulation of up to 10 m thick is overlying BEDROCK.	(Figure 30)
8.879 - 10.865	102953-GRL-MMT-SUR-DWG-AL10KA02	**Bathymetry:** Between KP 8.879 and KP 10.400 the seabed depth increases gently by approximately 14 m then flattens until KP 10.865. Ripples are observed throughout.	Gently sloping seabed with a maximum value of 4.85 degrees on a ripple. Depths range up to 48.63 m on the route (Figure 26).

KP	Associated Chart	Description	Remark
		Surficial geology: The surficial geology consists of alternating areas of gravelly SAND/ sandy GRAVEL and SAND. Megaripples are present up to KP 10.337	
		Shallow Geology: The thick SAND layer continues to KP 10.015 where it pinches out to a thin layer of SAND over BEDROCK.	
10.865 - 22.310	102953-GRL-MMT-SUR-DWG-AL10KA02	**Bathymetry:** From KP 10.865 the seabed is rocky and gently becoming deeper throughout.	Very gentle to gentle gradient with localised very steep slopes on rocks, to a maximum value of 16.74 degrees. Depths range up to 59.1 m on the route (Figure 26).

KP	Associated Chart	Description	Remark
	102953-GRL-MMT-SUR-DWG-AL10KA03	**Surficial geology:** The surficial geology consists mainly of outcropping BEDROCK and occasional areas consisting of gravelly SAND to sandy GRAVEL. Occasional boulder fields are present within the interval, as well as megaripples and ripples.	Bedrock outcrops crossing the route between: KP 10.865 and KP 11.248 KP 11.478 and KP 14.657 KP 14.733 and KP 16.054 KP 16.536 and KP 16.609 KP 16.705 and KP 17.010 KP 17.157 and KP 17.756 KP 18.182 and KP 18.906 KP 18.929 and KP 19.995 KP 20.011 and KP 20.182 KP 20.284 and KP 20.504 KP 20.533 and KP 20.658 KP 20.763 and KP 20.827 KP 21.115 and KP 21.357 KP 21.395 and KP 21.798 KP 21.830 and KP 21.928 KP 21.986 and KP 22.311 Boulder fields crossing the route between: KP 16.147 and KP 16.345 KP 16.400 and KP 16.537 KP 16.610 and KP 16.706 (Figure 28)
		Shallow Geology: Mainly outcropping BEDROCK with some isolated small infills of SAND and GRAVEL.	
22.310 - 24.907	102953-GRL-MMT-SUR-DWG-AL10KA03	**Bathymetry:** The rocks give way to a smoother flatter seabed at KP 22.310 (see Figure 25) and depths gently become shallower until KP 23.200. From here the seabed gently deepens once more, remaining smooth with occasional boulders.	Very gentle to gentle slopes with a maximum value of 2.75 degrees at a boulder. Depths range up to 59.66 m on the route (Figure 26).

KP	Associated Chart	Description	Remark
		Surficial geology: The surficial geology consists of mainly SAND interrupted by a few areas comprising gravelly SAND/sandy GRAVEL. A field of occasional boulders is present at the end of the section. Ripple and megaripple areas are present at several locations in this section.	Boulder field area crossing the route from KP 24.527 to the end of the section. (Figure 29)
		Shallow Geology: The surface SAND unit is 1-3 m thick. Several deep incisions filled with mixed channel infill sediments are present in the underlying BEDROCK. The infills are up to 20 m deep.	(Figure 31)

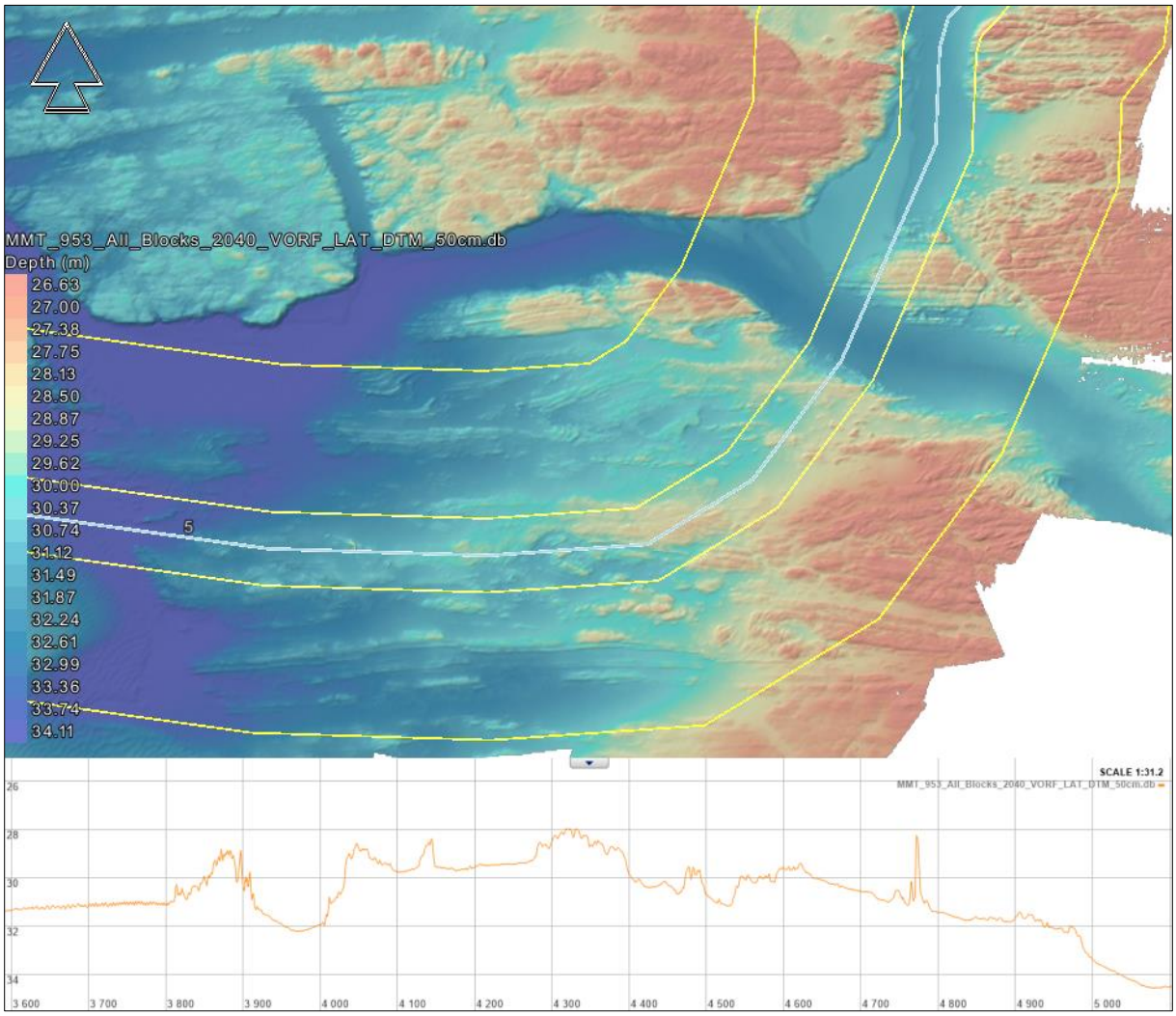


Figure 23 Shaded bathymetric relief showing rocky seabed on Route A. Longitudinal profile (orange) depicts seabed along the route from KP 3.647 to KP 5.094. (Profile vertical exaggeration: 1:31.2).

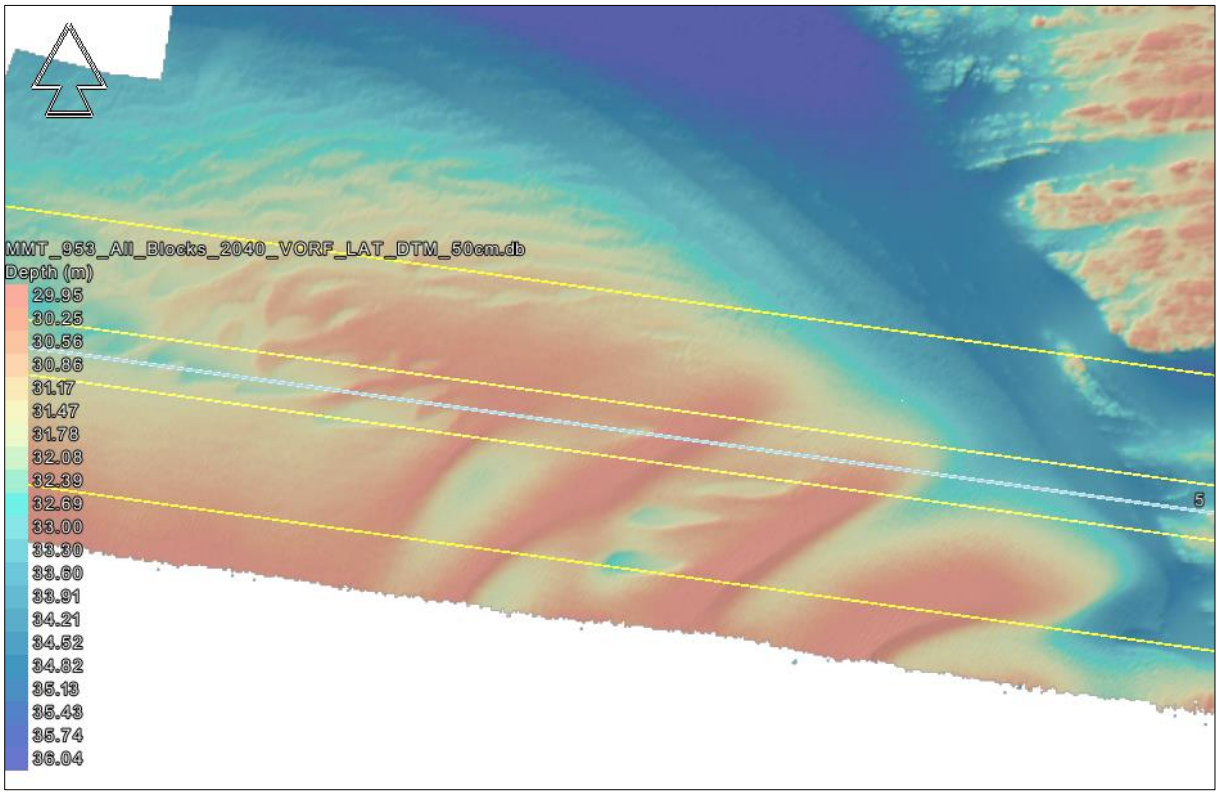


Figure 24 Shaded bathymetric relief showing the ripples and sandwaves on Route A between KP 5.094 and KP 7.100.

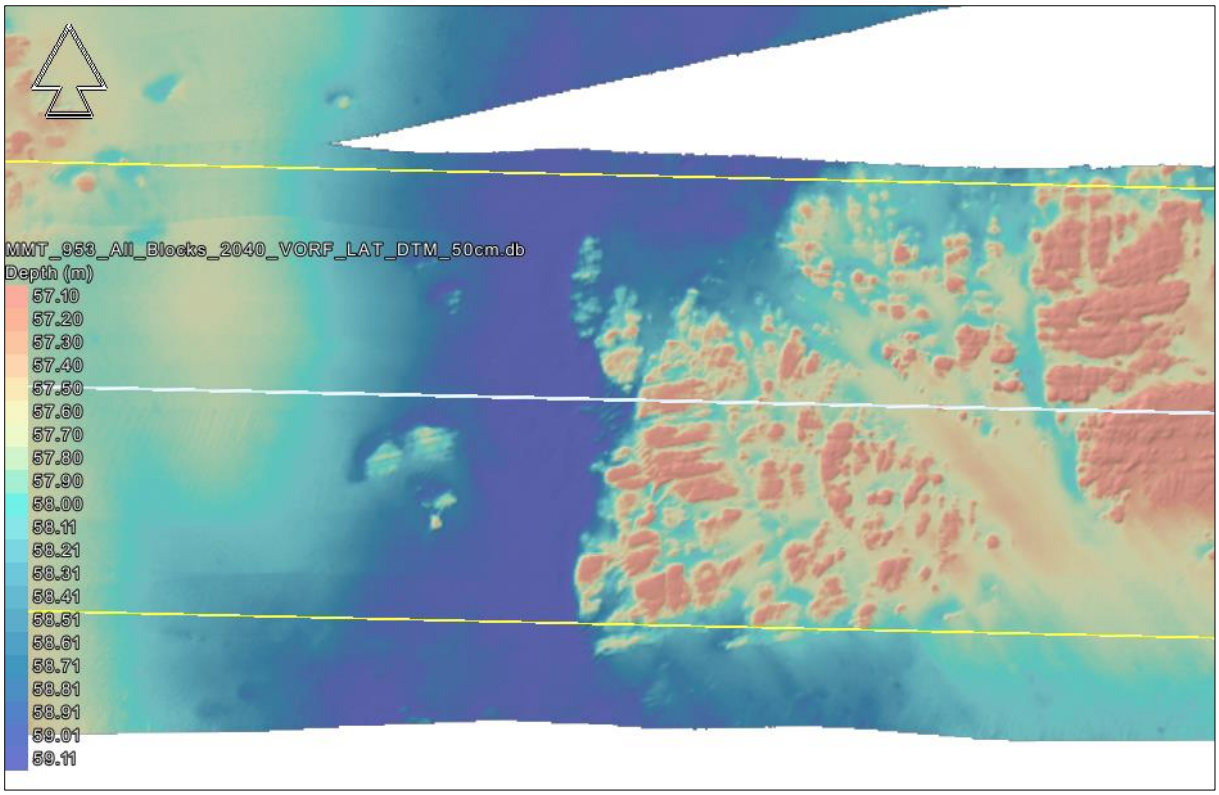


Figure 25 Shaded bathymetric relief showing the change in seabed from KP 22.310 on Route A.

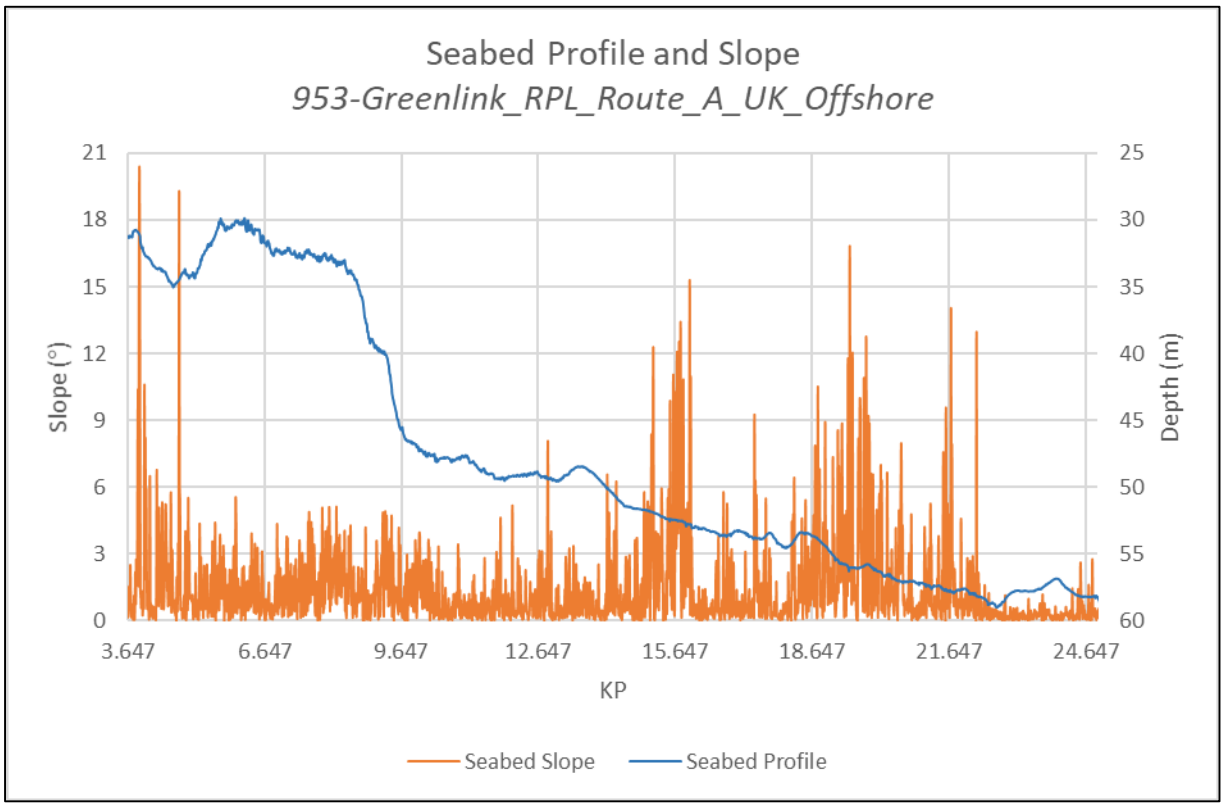


Figure 26 Seabed gradient and depth on route option A in the UK offshore section between KP 3.647 and KP 24.908.

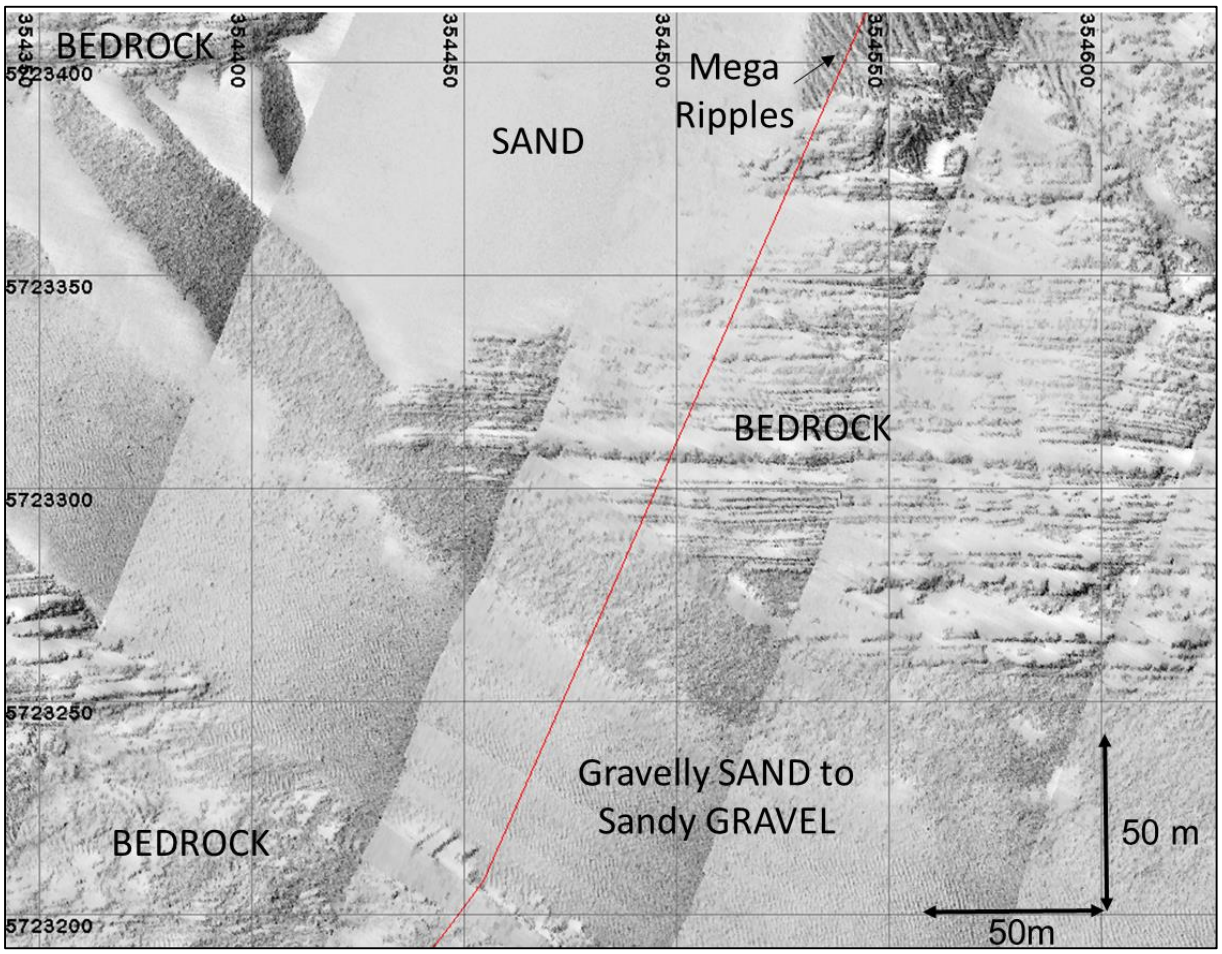


Figure 27 SSS plan view example from KP 3.785 to KP 4.053.
Showing gravelly SAND to sandy GRAVEL, SAND and megaripples with outcrops of BEDROCK.
Image is north up.

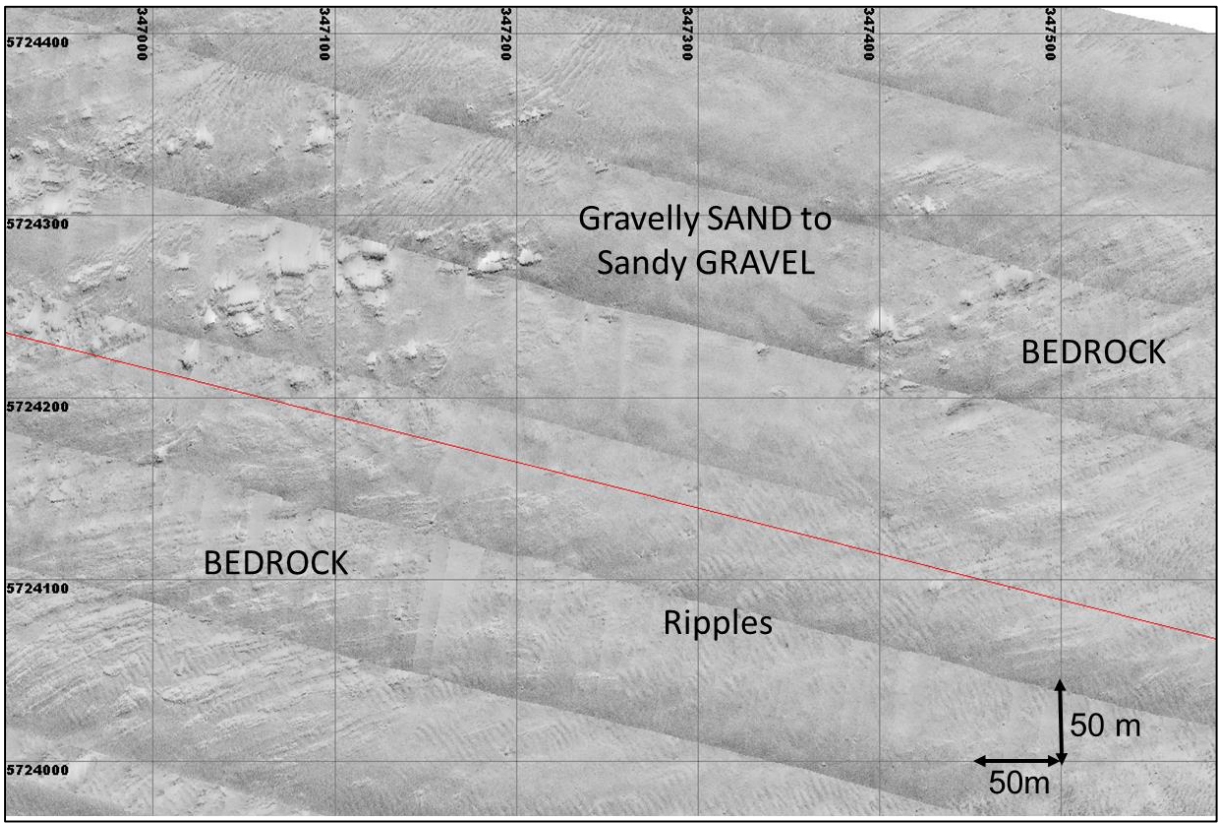


Figure 28 SSS plan view example from *KP 11.082 to KP 11.799.*
Showing gravelly SAND to sandy GRAVEL with ripples between outcropping BEDROCK. Image is north up.

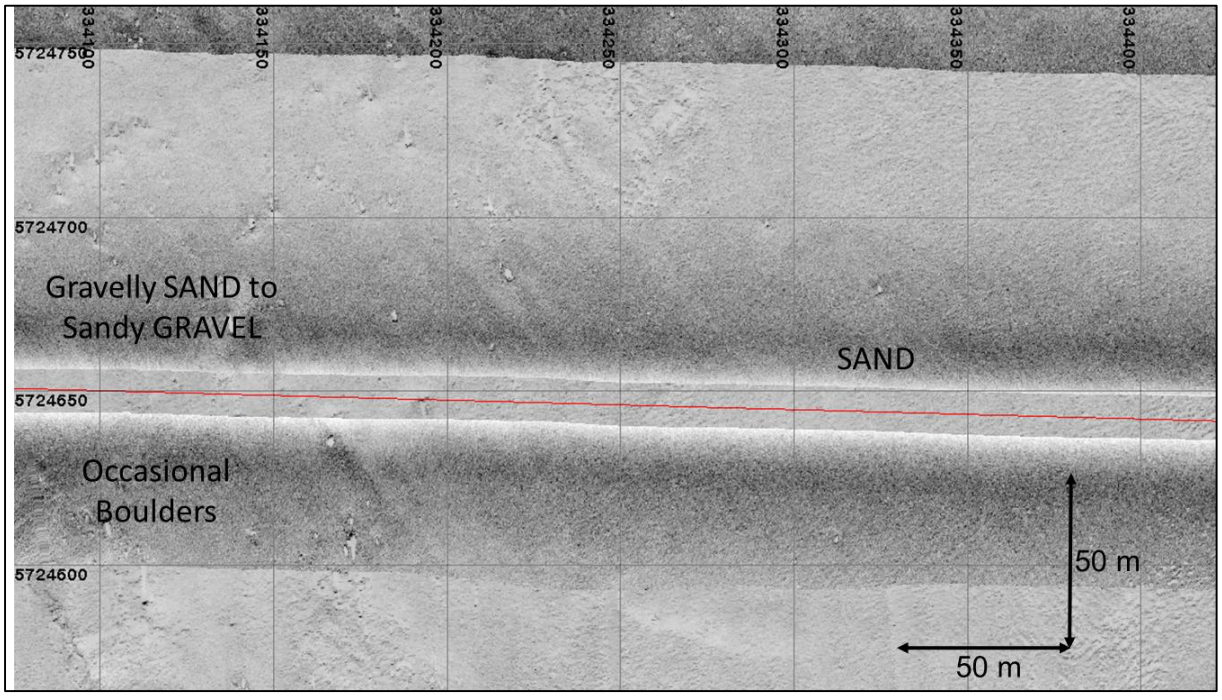


Figure 29 SSS plan view example from KP 24.356 to KP 24.656.
Showing SAND and gravelly SAND to sandy GRAVEL with occasional boulders. Image is north up.

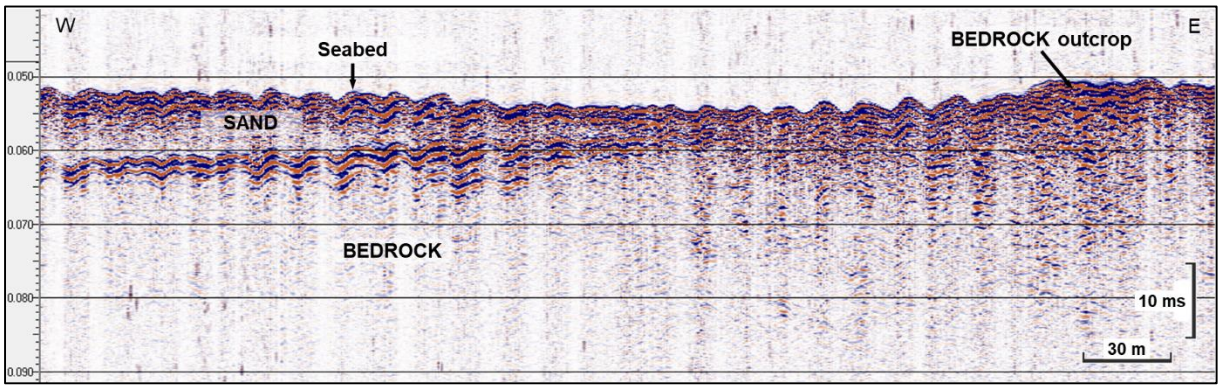


Figure 30 Sparker SBP data example from KP 4.926 to KP 5.350.
Showing BEDROCK (outcropping to the right) and the onset of a thick SAND accumulation.

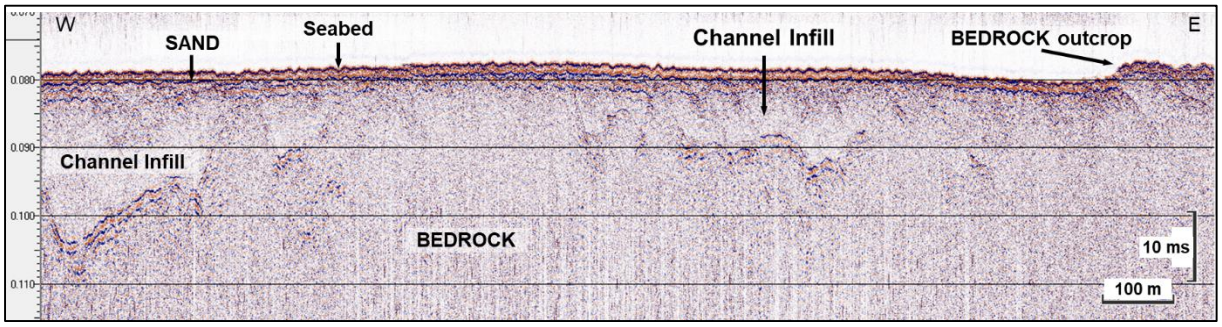


Figure 31 Sparker SBP data example from KP 22.107 to KP 23.965.
Showing undulating BEDROCK (outcropping to the right) covered by channel infills and surface SAND unit.

5.2.6| CONTACTS AND ANOMALIES ROUTE OPTION A

A total of 426 SSS contacts were identified from the data within the survey corridor in UK offshore. The majority of the contacts were classified as either boulders or debris.

The SSS contacts are summarised in Table 17.

A total of 72 magnetic anomalies were detected in the UK offshore corridor. Of these, 71 were unclassified, 1 was a known wreck, a steel-hulled steamship, Saint Jacques (Table 18).

One SSS contact position correlated with detected magnetic anomalies from the geophysical survey, the Saint Jacques wreck. No SSS contact positions correlated with detected magnetic anomalies from the UXO survey.

Table 17 Summary of UK offshore SSS contacts, Route A.

CLASSIFICATION	NUMBER
Boulder	419
Other	2
Debris	4
Wreck	1

CLASSIFICATION	NUMBER
Total	**426**

Table 18 Summary of UK offshore magnetic anomalies.

CLASSIFICATION	NUMBER
Unclassified, possible objects	71
Wreck	1
Cable	0
Total	**72**

5.2.7| OVERVIEW ROUTE OPTION E

Results are presented for KP 13.373 to KP 37.608 along route option E.

All KPs refer to route option E, RPL Route_E_WGS84_UTM30N_Rev1_20180521.

BATHYMETRY

Route E has a rocky seabed with areas of ripples and large sandwaves throughout, with occasional boulder areas. Depths range up to 63.05 m at KP 33.330 with very gentle to moderate gradients and some localised very steep slopes over the rocky areas. Depth is generally increasing along the profile and some undulation of the seabed is observed.

SURFICIAL GEOLOGY

The surficial geology along Route Option E comprises mainly of SAND to gravelly SAND/sandy GRAVEL. Smaller areas of outcropping BEDROCK is present at several locations along the route.

Large parts of the survey corridor in Route Option E is covered with seabed features indicating mobile sediment, such as ripples, megaripples and sandwaves. Several areas of boulder fields, both with numerous and occasional boulders, are also present in the survey corridor of Route Option E.

SHALLOW GEOLOGY

The shallow geology of route option E is characterised by an almost continuous surface SAND layer overlying BEDROCK. The SAND layer is present as a veneer on the BEDROCK, up to 1 m thick throughout the route, but can reach up to 4 m in sandwave areas. BEDROCK is outcropping and subcropping in several places. Several deep incisions are present in the BEDROCK. These are filled with mixed channel infill sediments.

5.2.8| DETAILED DESCRIPTION ROUTE OPTION E

A detailed presentation of the conditions and features in the UK offshore corridor along route option E are shown in Table 19.

Table 19 Seabed details route option E KP 13.373 to KP 37.608.

KP	Associated Chart	Description	Remark
13.373 - 37.608	102553-NEU-MMT-SUR-DWG-AL10KE01 102553-NEU-MMT-SUR-DWG-AL10KE02 102553-NEU-MMT-SUR-DWG-AL10KE03	**Bathymetry:** Boulders and ripples are present from KP 13.373, with larger ripples and sandwaves from KP 14.688 to KP 16.799. From here depth gently increases and numerous boulders are observed with occasional rocky outcrops. From KP 27 the seabed rises gently until KP 27.764 where it begins to slope gently down again. The seabed again rises at KP 29.732 to KP 29.912 where it gently increases in depth to KP 30.265. Here begins a rocky area until KP 33.432 where the seabed becomes smoother with further ripples and sandwaves.	Very gentle to moderate gradients to locally very steep slopes with a maximum value of 20.9 degrees on the sandwaves see Figure 33. Depths range up to 63.05 m.
		Surficial geology: The surficial geology consists of mainly gravelly SAND/sandy GRAVEL with occasional areas of SAND or GRAVEL. Small areas of BEDROCK outcrops are present. Boulder fields with occasional or numerous boulders occur throughout. Ripples, megaripples and sandwaves are common throughout.	BEDROCK outcrops crossing the route between: KP 24.330 and KP 24.351 KP 24.559 and KP 24.568 KP 26.475 and KP 26.646 KP 30.351 and KP 30.494 KP 30.893 and KP 30.939 KP 31.302 and KP 31.395 KP 31.496 and KP 31.571 KP 31.772 and KP 31.925 KP 33.216 and KP 33.231 KP 37.253 and KP 37.313 Boulder fields crossing the route between: KP 13.748 and KP 13.880 KP 17.803 and KP 17.138 KP 18.626 and KP 22.015 KP 24.669 and KP 24.909 KP 28.914 and KP 29.019 KP 29.258 and KP 29.277 KP 30.495 and KP 30.680 (Figure 34 to Figure 37)

KP	Associated Chart	Description	Remark
		Shallow Geology: A thin (~1 m) surface SAND unit is present over BEDROCK between KP 13.373 and KP 22.670. The SAND reaches up to 16 m in sandwave areas. Several deep channel incisions are present which are filled by sediment of SAND to GRAVEL. From KP 22.670 to KP 36.820 the surface SAND unit is mainly present as a veneer over BEDROCK. The SAND thickness increases in areas of sandwaves. The base of SAND is often poorly resolved. BEDROCK is outcropping or subcropping frequently (see Surficial Geology for KP intervals).	(Figure 38)

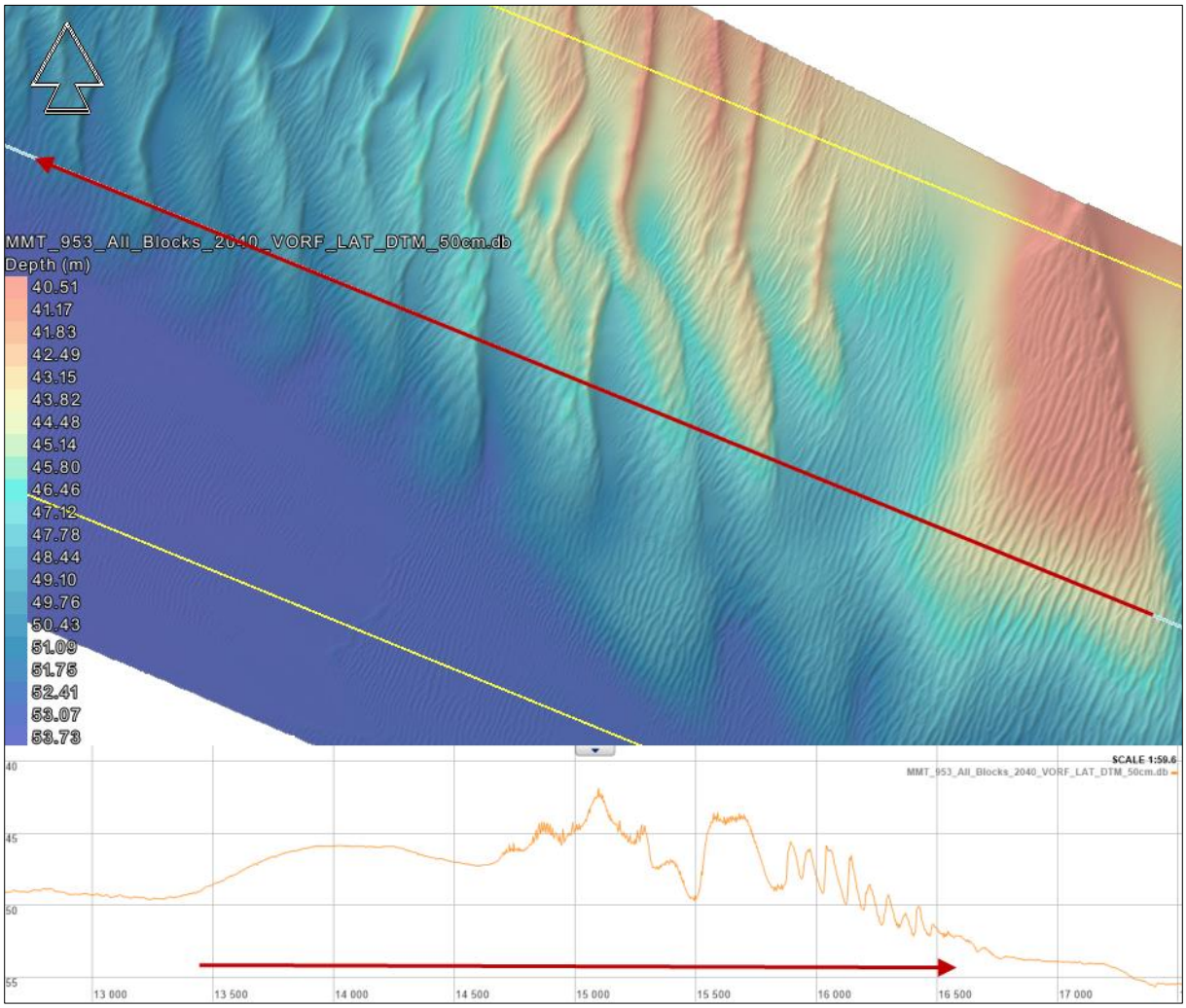


Figure 32 Shaded bathymetric relief showing the ripples and sandwaves on route option E centred on KP 16.040 where the steepest gradient is observed.
Longitudinal profile (orange) depicts seabed along the route along the direction of the red arrow (Profile vertical exaggeration: 1:59.6).

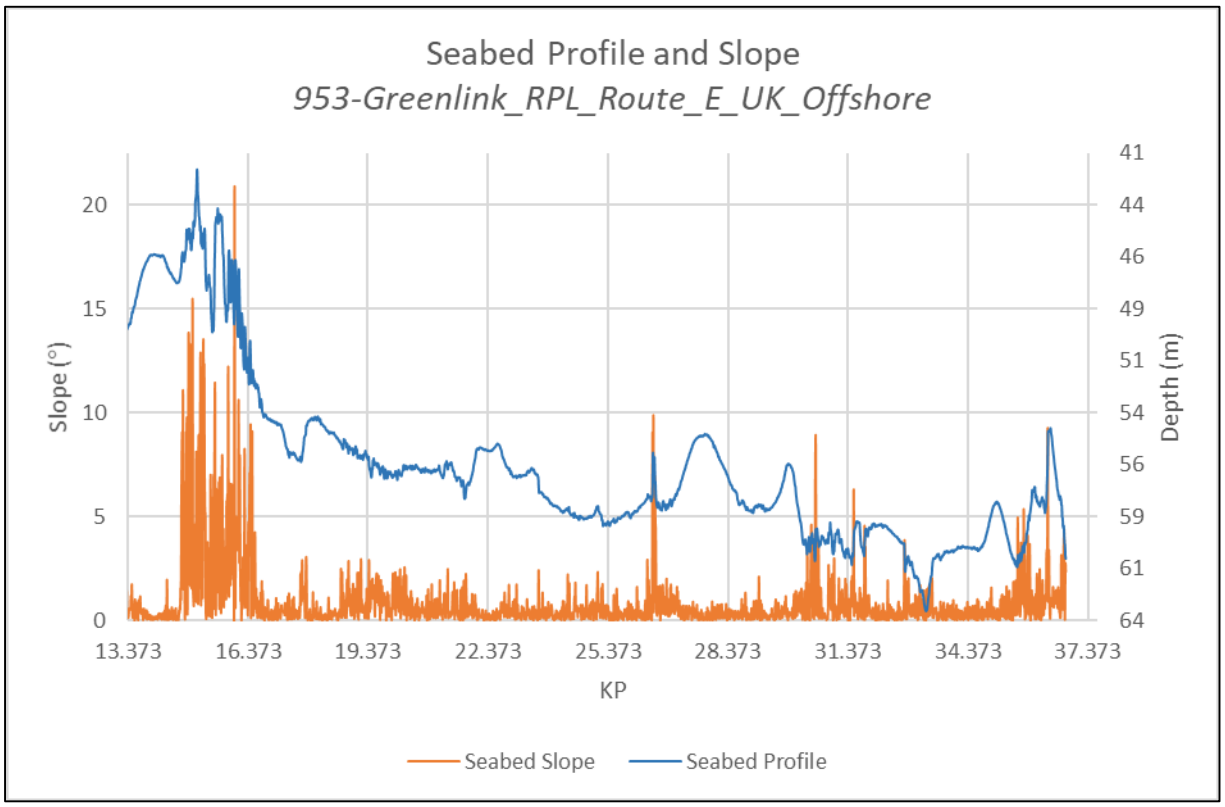


Figure 33 Seabed gradient and depth on route option E in the UK offshore section between KP 13.373 and KP 36.820.

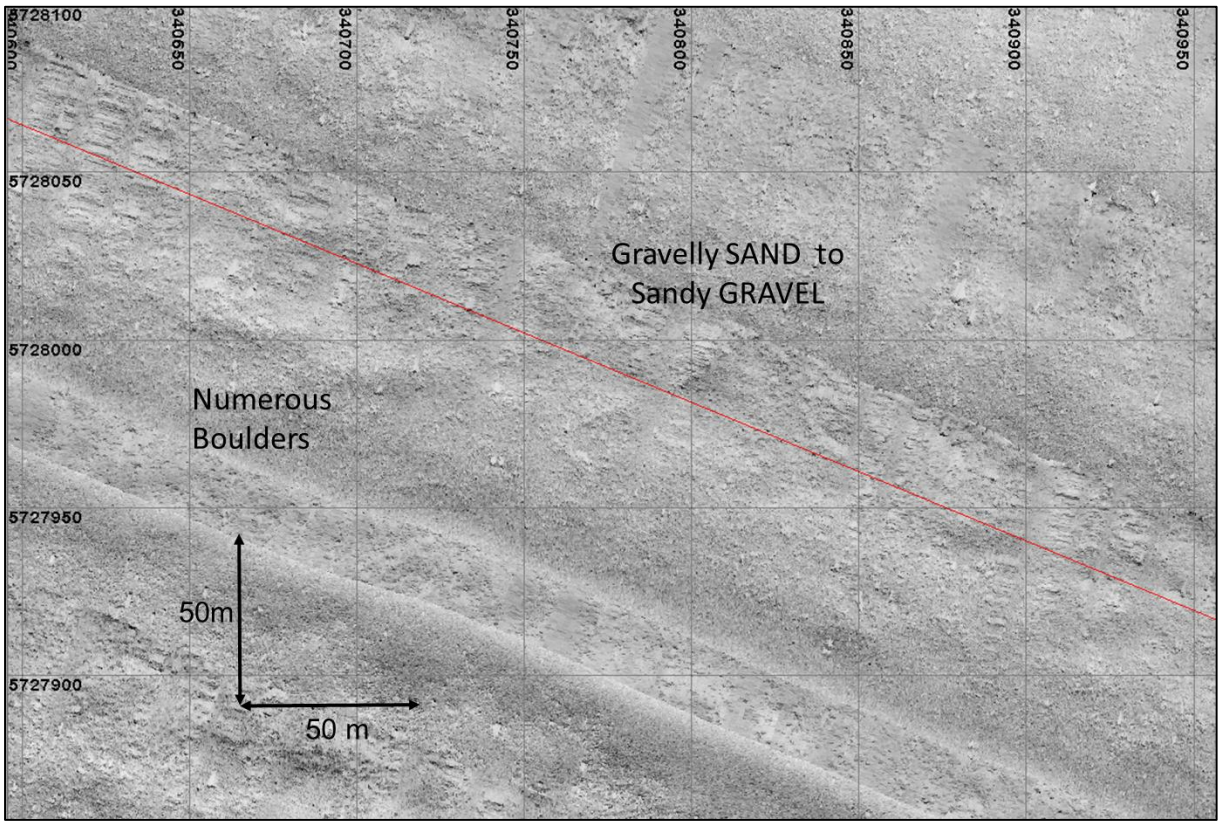


Figure 34 SSS plan view example from KP 18.725 to KP 19.105.
Showing gravelly SAND to sandy GRAVEL with numerous boulders. Image is north up.

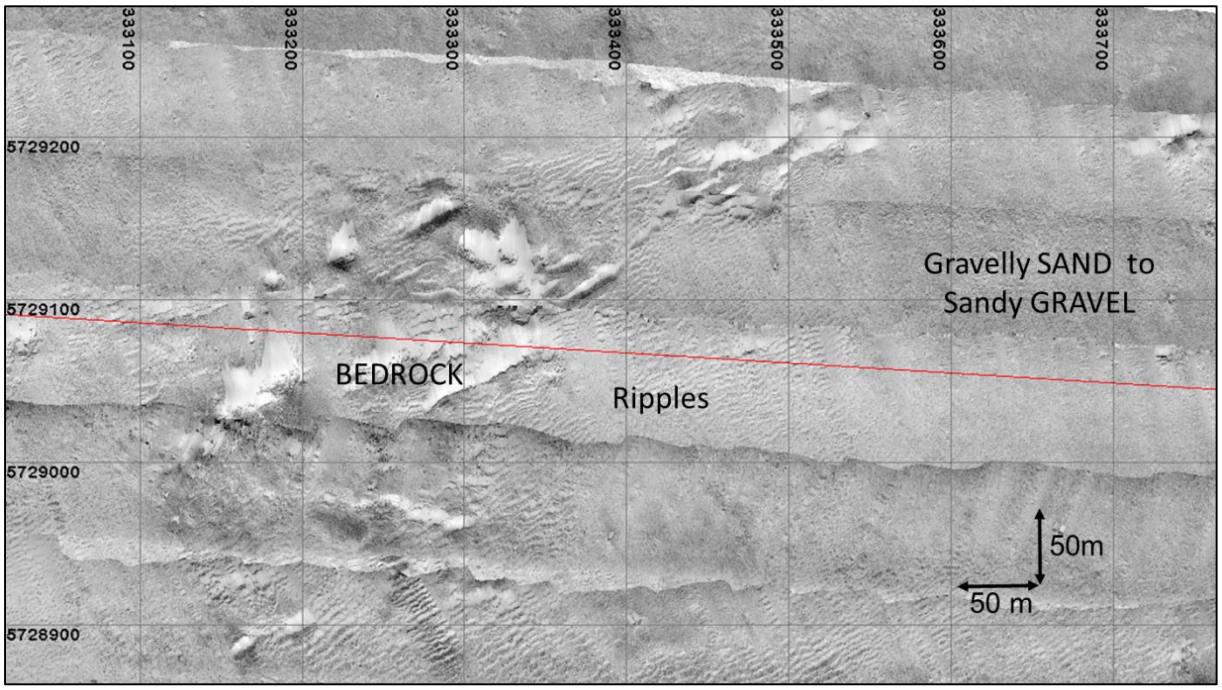


Figure 35 SSS plan view example from KP 26.081 to KP 26.826.
Showing gravelly SAND to sandy GRAVEL with ripples and outcrops of BEDROCK. Image is north up.

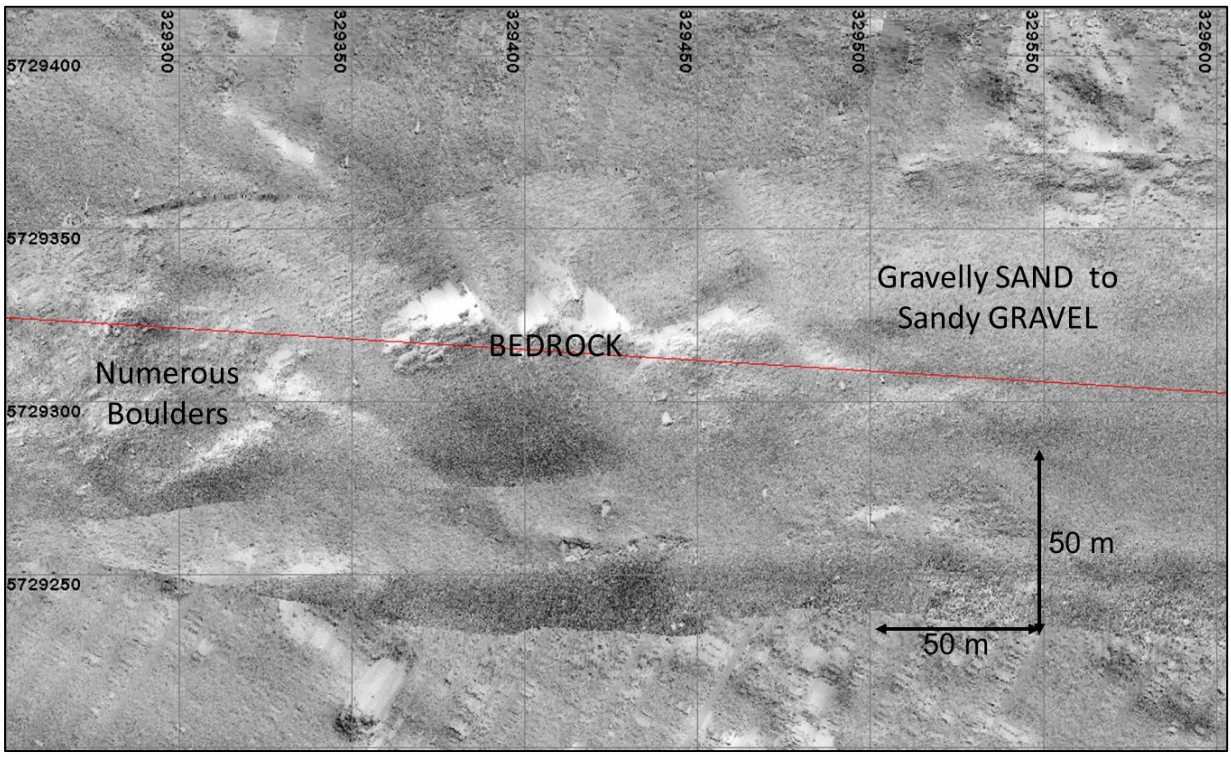


Figure 36 SSS plan view example from *KP 30.249 to KP 30.602*
Showing gravelly SAND to sandy GRAVEL with ripples and outcrops of BEDROCK. Image is north up.

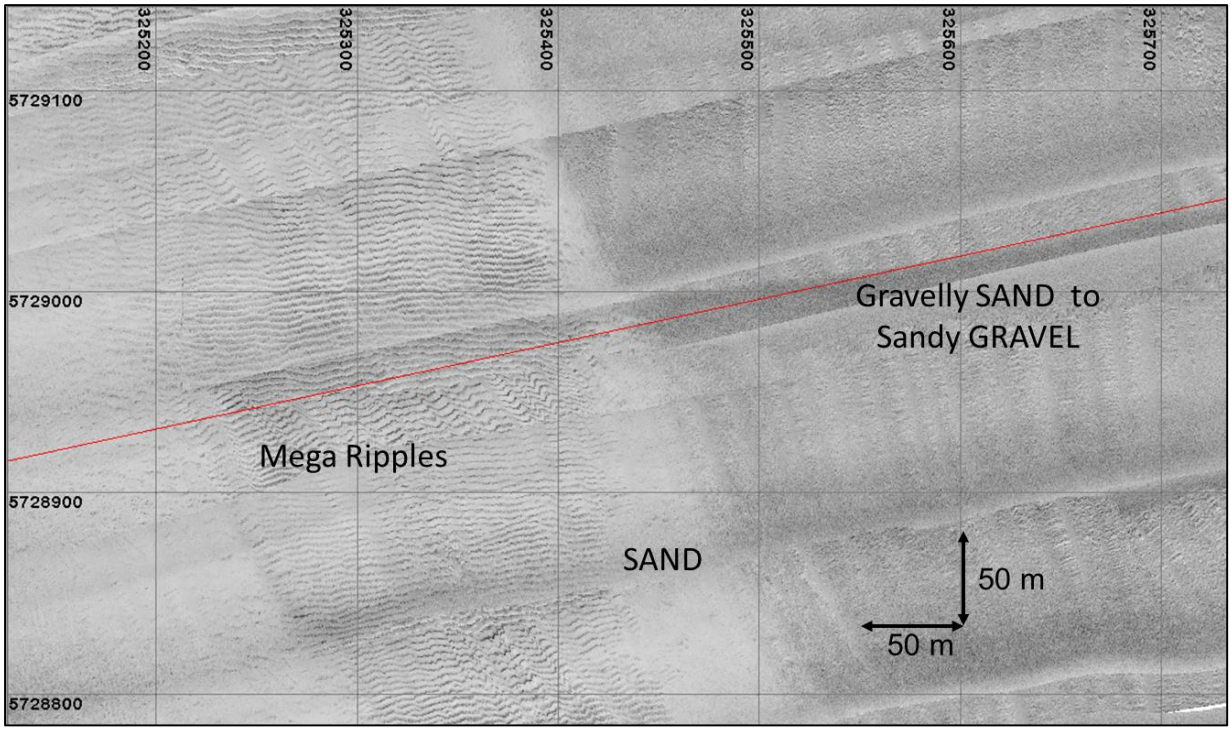


Figure 37 SSS plan view example from KP 34.167 to KP 34.784
Showing gravelly SAND to sandy GRAVEL and SAND with megaripples. Image is north up.

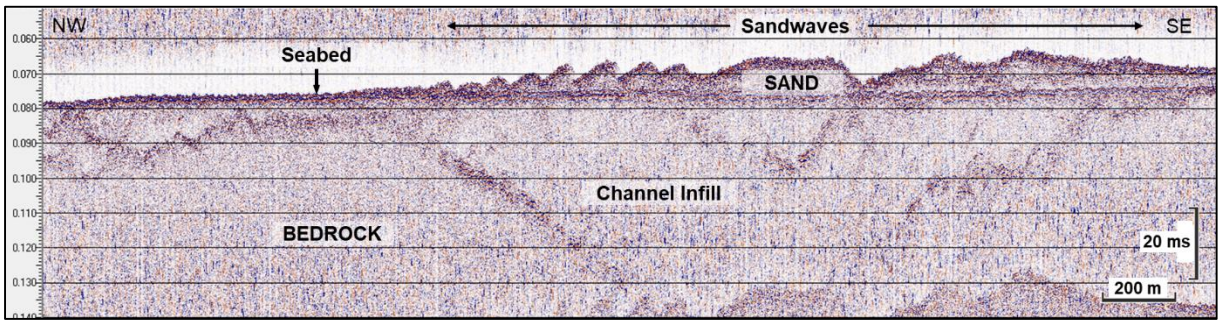


Figure 38 Sparker SBP data example from KP 14.640 to KP 17.440.
Showing surface SAND with sandwaves underlain by a deep channel infill on BEDROCK.

5.2.9| CONTACTS AND ANOMALIES ROUTE OPTION E

A total of 2139 SSS contacts were identified from the data within the survey corridor in UK offshore. The majority of the contacts were classified as either boulders or debris. Four contacts were classified as wrecks, two of which correlate with known wrecks from the background data.

The SSS contacts are summarised in Table 20.

A total of 88 magnetic anomalies were detected in the UK offshore corridor. Of these, 88 were unclassified (Table 21).

A total of 1 SSS contact position correlated with detected magnetic anomalies from the geophysical survey and no SSS contact positions correlated with detected magnetic anomalies from the UXO survey.

Table 20 Summary of UK offshore SSS contacts, Route E.

CLASSIFICATION	NUMBER
Boulder	2127
Other	0
Debris	9
Wreck	3
Total	**2139**

Table 21 Summary of UK offshore magnetic anomalies, Route E.

CLASSIFICATION	NUMBER
Unclassified, possible objects	88
Cable	0
Total	**88**

6| RESULTS IRELAND

6.1| IRELAND OFFSHORE

6.1.1| OVERVIEW ROUTE OPTION RPL_09112018_REV0

Results are present for KP 73.906 to KP 156.667.

BATHYMETRY

Depths in the corridor range from 13.50 m to 116.00 m and on the route the range is from 16.78 m to 115.95 m with depths generally decreasing with increasing KP. Very gentle to gentle gradients are predominant, with some moderate slopes in sandwave and ripple areas. The seabed has ripples, sandwaves, trawl marks, numerous boulder areas and rocky outcrops.

SURFICIAL GEOLOGY

The majority of the surficial geology in the Irish offshore section is characterised by SAND with megaripples and occasional sandwaves. The sand is occasionally interrupted by areas of gravelly SAND/sandy GRAVEL. The megaripples become less significant with increasing KP and are no longer present from KP 139.267.

From KP 148.300, the surficial geology becomes more varied, with areas of GRAVEL and abundant outcropping BEDROCK. In this area, boulder fields are also identified.

SHALLOW GEOLOGY

The shallow geology of the Ireland offshore section is characterised by a sequence of surface SAND unit, TILL and BEDROCK over large parts of the bathymetric trough, southern extent of St. George's Channel, and Nymphe Bank. The layer of SAND and TILL of the Nymphe Bank is thicker compared to the Welsh platform, up to KP 148.380 where these platform sediments pinch out.

The surface SAND unit is generally >2 m thick and is continuously present from KP 73.906 to KP 148.380. Within the trough it can reach thicknesses up to 15 m and more than 4 m in areas of aggregations of mobile seabed sediment.

The TILL comprise mainly low to high strength, soft to firm CLAY with varying sand, silt and gravel content. A thick sequence of TILL is present within the trough and from KP 102.510 to KP 130.520. The top of the TILL is highly undulating and the incisions are filled with mixes of channel infill sediments between KP 104.100 and KP 144.395.

For the majority of the Irish offshore section, BEDROCK is more than 5 m below the seabed surface. The top of BEDROCK is not resolved in the seismic data from KP 103.350 to KP 107.235 and KP 114.610 and KP 130.520. It reaches closer to the seabed between KP 148.380 and KP 155.480.

6.1.2| DETAILED DESCRIPTION ROUTE OPTION RPL_09112018_REV0

A detailed presentation of the conditions and features along the Ireland offshore route are shown in Table 22.

Table 22 Seabed details route option RPL_09112018_REV0 KP 73.906 to KP 156.667.

KP	Associated Chart	Description	Remark
73.906 – 77.134	102953-GRL-MMT-SUR-DWG-AL10KF09 102953-GRL-MMT-SUR-DWG-AL10KF10	**Bathymetry:** The seabed gently increases in depth until KP 75 where it begins to very gently decrease in depth. The seabed is rippled throughout.	Gentle to very gentle gradient with a maximum value of 3.45 degrees. Depths range up to 115.95 m on the route (Figure 41).
		Surficial geology: The surficial geology consists of mainly SAND. Megaripples are present throughout. Trawl marks indicating fishing activity are also seen.	Trawl scars abundant throughout the section.
		Shallow Geology: The surface SAND unit is generally <2 m and overlying TILL. The TILL shows a chaotic internal structure and overlies BEDROCK.	(Figure 47)
77.134 – 84.729	102953-GRL-MMT-SUR-DWG-AL10KF10 102953-GRL-MMT-SUR-DWG-AL10KF11	**Bathymetry:** Depth continues to decrease very gently. The seabed has ripples and occasional sandwaves.	Very gentle to gentle gradient and local moderate slopes with a maximum value of 6 degrees on the sandwave, see Figure 39. Depths range up to 112.14 m on the route (Figure 41).
		Surficial geology: The surficial geology consists mainly of SAND. Megaripples are present throughout as well as occasional sandwaves. Trawl marks indicating fishing activity are also common.	Trawl scars abundant throughout the section.
		Shallow Geology: The surface SAND unit reaches a thickness of 4 m or more (>10 m from KP 81.000 to KP 83.359 with a maximum of 15 m). An internal layer of possible coarser sediment is present approximately 1-2 m below the seabed. The SAND is overlying TILL and BEDROCK.	(Figure 48)
84.729 - 95.028	102953-GRL-MMT-SUR-DWG-AL10KF11	**Bathymetry:** The seabed continues to rise gently and is rippled with occasional sandwaves throughout.	Very gentle gradient with a maximum value of 2.9 degrees. Depths range up to 88.86 m on the route (Figure 41).

KP	Associated Chart	Description	Remark
	102953-GRL-MMT-SUR-DWG-AL10KF12	**Surficial geology:** The surficial geology consists of mainly SAND with occasional areas of GRAVEL. Megaripples are present throughout. Sandwaves are also seen in some locations along the route, often associated with areas of GRAVEL. Trawl scars indicating fishing activity are abundant in the initial parts of the section.	Trawl scars abundant up until approximately KP 88.000. Cable crossing- Hibernia Atlantic Seg D at KP 86.700. (Figure 42)
		Shallow Geology: The undulating seabed with several sandwaves results in varying SAND unit thickness from >0.5 m to 6 m. over TILL. The TILL overlies BEDROCK, which is generally >6 m below seabed but reaches ~4 m at KP 90.749.	
95.028 - 98.058	102953-GRL-MMT-SUR-DWG-AL10KF12	**Bathymetry:** The seabed continues to rise gently and has ripples and sandwaves throughout.	Gentle gradient with a maximum value of 2.91 degrees. Depths range up to 73.49 m on the route (Figure 41).
		Surficial geology: The surficial geology consists mainly of SAND. Megaripples are present throughout with occasional areas of sandwaves.	Cable crossing - Pan European Crossing 1 at KP 95.935.
		Shallow Geology: The surface SAND unit and underlying channel infill and TILL sediments are <4 m thick. The underlying BEDROCK reaches to within 1 m of seabed surface at KP 96.460.	
98.058 - 102.564	102953-GRL-MMT-SUR-DWG-AL10KF12 102953-GRL-MMT-SUR-DWG-AL10KF13	**Bathymetry:** The seabed rises shortly before gently deepening again from KP 99.439. There are ripples present throughout.	Gentle gradient with a maximum value of 3.25 degrees. Depths range up to 70.76 m on the route (Figure 41).
		Surficial geology: The surficial geology consists of SAND. Megaripples are present throughout.	Cable crossing - ESAT 1 at KP 102.513

KP	Associated Chart	Description	Remark
		Shallow Geology: The surface SAND unit together with underlying channel infill sediments reach a thickness of at least 4 m and up to 8 m over BEDROCK.	
102.564 - 108.662	102953-GRL-MMT-SUR-DWG-AL10KF13	**Bathymetry:** Seabed is rippled throughout with little variance in depth up to KP 106.922 where the seabed begins to rise once more and depths decrease gently. Trawl marks are also observed.	Very gentle to gentle gradient with a maximum value of 2.56 degrees. Depths range up to 68.61 m on the route (Figure 41).
		Surficial geology: The surficial geology consists of mainly SAND with only one instance of gravelly SAND/sandy GRAVEL. Megaripples are present throughout.	(Figure 43)
		Shallow Geology: The surface SAND unit of approximately 2-4 m thickness overlies deep channel infill sediments followed by a thick sequence of TILL. The channel infill reaches up to 16 m below seabed.	BEDROCK reflector is too deep and is not resolved in the seismic data.
108.662 - 114.625	102953-GRL-MMT-SUR-DWG-AL10KF13 102953-GRL-MMT-SUR-DWG-AL10KF14	**Bathymetry:** The seabed has ripples and sandwaves with occasional boulders and trawl marks.	Very gentle to gentle gradient with a maximum value of 3.41 degrees. Depths range up to 68.6 m on the route (Figure 41).
		Surficial geology: The surficial geology consists of SAND. Megaripples are present throughout. A few sandwave crests are present.	
		Shallow Geology: The SAND unit reflects sandwaves at the seabed and varies from 1 to 8 m in thickness. It is underlain by TILL and some channel infill sediments. The undulation BEDROCK reaches to 4 m below seabed surface at KP 110.893. It dips to beyond sparker resolution at KP 114.625	

KP	Associated Chart	Description	Remark
114.625 - 130.521	102953-GRL-MMT-SUR-DWG-AL10KF14 102953-GRL-MMT-SUR-DWG-AL10KF15 102953-GRL-MMT-SUR-DWG-AL10KF16	**Bathymetry:** Depths gently increase until KP 118.737 where they begin to gently decrease again. The seabed has ripples throughout and numerous trawl marks with occasional boulders see Figure 40.	Very gentle to gentle gradient with a maximum value of 3.8 degrees. Depths range up to 72.56 m on the route (Figure 41).
		Surficial geology: The surficial geology consists of mainly SAND with sparse areas consisting of gravelly SAND/ sandy GRAVEL. Megaripples are present throughout.	Cable crossing- SOLAS at KP 121.535
		Shallow Geology: This interval is characterised by frequent and sometimes deep channel infills on top of TILL. The surface SAND units varies from <1 to 6 m and channel infills in the deepest incision of up to 20 m. TILL is close to the seabed surface around KP 117.850.	BEDROCK reflector is too deep and is not resolved in the seismic data. (Figure 49)
130.521 - 138.639	102953-GRL-MMT-SUR-DWG-AL10KF16 102953-GRL-MMT-SUR-DWG-AL10KF17	**Bathymetry:** The seabed continues to rise with ripples and occasional boulders throughout.	Very gentle gradient with occasional gentle gradients up to a maximum value of 1.13 degrees. Depths range up to 57.32 m on the route (Figure 41).
		Surficial geology: The surficial geology consists of SAND. Megaripples are present throughout.	
		Shallow Geology: The surface SAND unit of 2-7 m is underlain by some channel infill sediments and TILL. BEDROCK is generally more than 6 m below seabed, but reaches to ~5 m at KP 137.223.	
138.639 - 148.402	102953-GRL-MMT-SUR-DWG-AL10KF17 102953-GRL-MMT-SUR-DWG-AL10KF18	**Bathymetry:** The seabed is mostly smooth with occasional boulders. Depths are gently decreasing.	Very gentle gradient with a maximum value of 0.91 degrees. Depths range up to 44.88 m on the route (Figure 41).
		Surficial geology: The surficial geology consists of SAND. Megaripples are present to approximately KP 139.	Cable crossing - CELTIC at KP 139.098

KP	Associated Chart	Description	Remark
		Shallow Geology: The thick surface SAND unit of 5-8 m pinches out towards KP 148.402. It is underlain by TILL with some channel infills. BEDROCK reaches close to the seabed from KP 148.290.	(Figure 50)
148.402 - 154.506	102953-GRL-MMT-SUR-DWG-AL10KF18 102953-GRL-MMT-SUR-DWG-AL10KF19	**Bathymetry:** Gently decreasing depths, with rocky outcrops, occasional boulders and ripples throughout.	Very gentle to gentle gradient with a maximum value of 3.61 degrees. Depths range up to 31.58 m on the route (Figure 41).
		Surficial geology: The surficial geology consists of alternating areas of GRAVEL, SAND and gravelly SAND/ sandy GRAVEL. Areas of outcropping BEDROCK are also present, none of which cross the route. Megaripple areas are present throughout, commonly associated with the more gravelly sediments.	(Figure 45)
		Shallow Geology: This section is characterised by TILL over BEDROCK with an unresolved veneer of mobile SAND and GRAVEL and some SAND infills between KP 149.045 and KP 151.961. BEDROCK reaches within 1-2 m from the seabed between KP 148.402 and KP 148.986 where the lower boundary of TILL is not resolved in the seismic data and around KP 151.240. The lower TILL boundary is also not resolved between KP 152.732 and KP 153.994.	
154.506 - 156.667	102953-GRL-MMT-SUR-DWG-AL10KF19	**Bathymetry:** The seabed continues to rise gently, small ripples are observed between rocky outcrops that flank the route.	Very gentle to gentle gradients with a maximum value of 2.25 degrees. Depths range up to 22.35 m on the route (Figure 41).

KP	Associated Chart	Description	Remark
		Surficial geology: The surficial geology alters between areas of gravelly SAND/ sandy GRAVEL, SAND, GRAVEL and BEDROCK outcrops. Ripples and megaripples are present throughout this section. A few boulder fields are also present. Neither the boulder fields, nor the BEDROCK outcrops cross the route. The BEDROCK outcropping is extensive both east and west of the route from KP 156.	(Figure 46)
		Shallow Geology: This section is characterised by TILL over BEDROCK with an unresolved veneer of mobile SAND and GRAVEL. BEDROCK reaches within 1-2 m from the seabed between KP 154.506 and KP 154.806 and again at KP 155.412.	

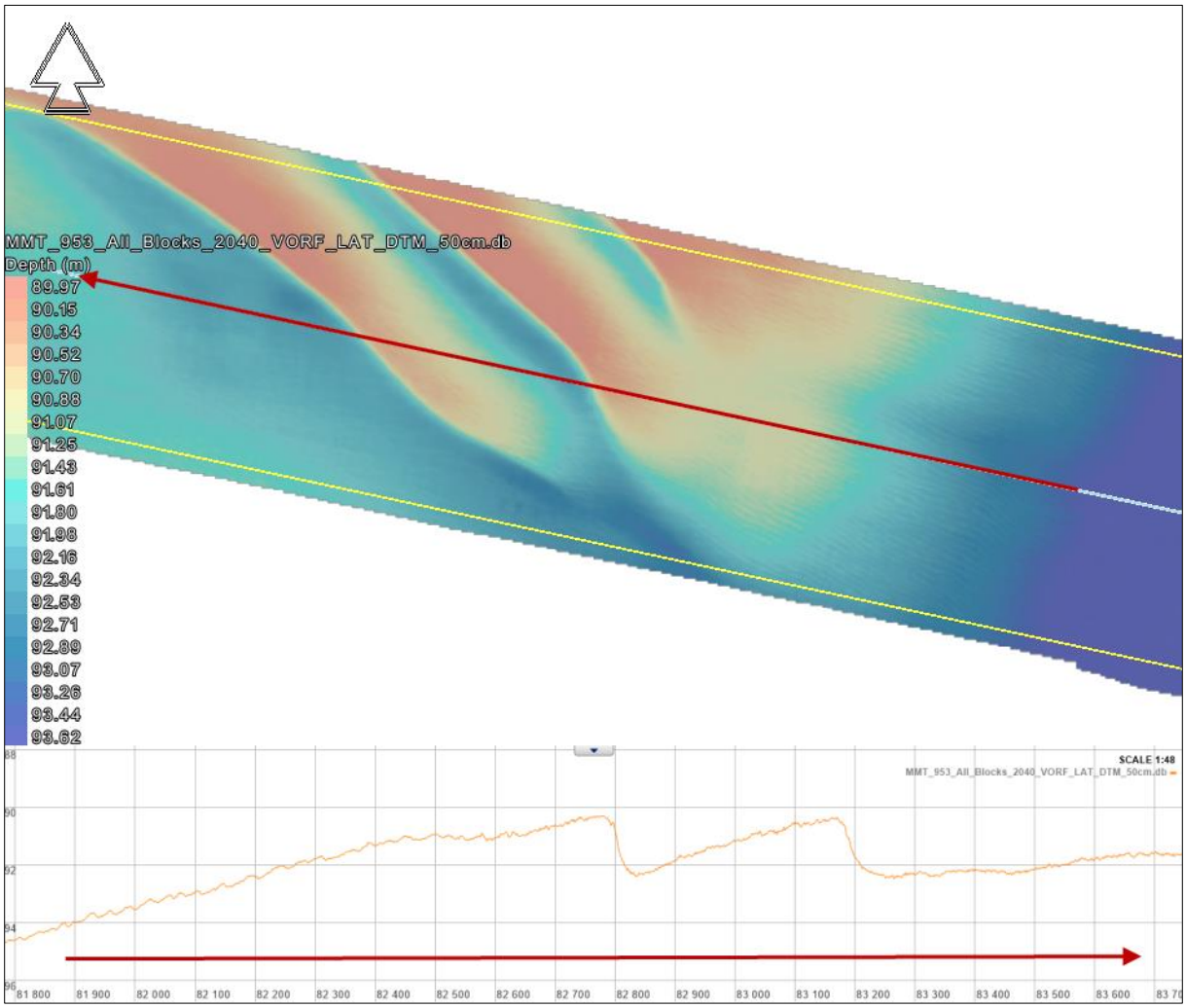


Figure 39 Shaded bathymetric relief showing the sandwaves centred on KP 82.800 where the steepest gradient is observed.
Longitudinal profile (orange) depicts seabed along the route in the direction of the red arrow (Profile vertical exaggeration: 1:48).

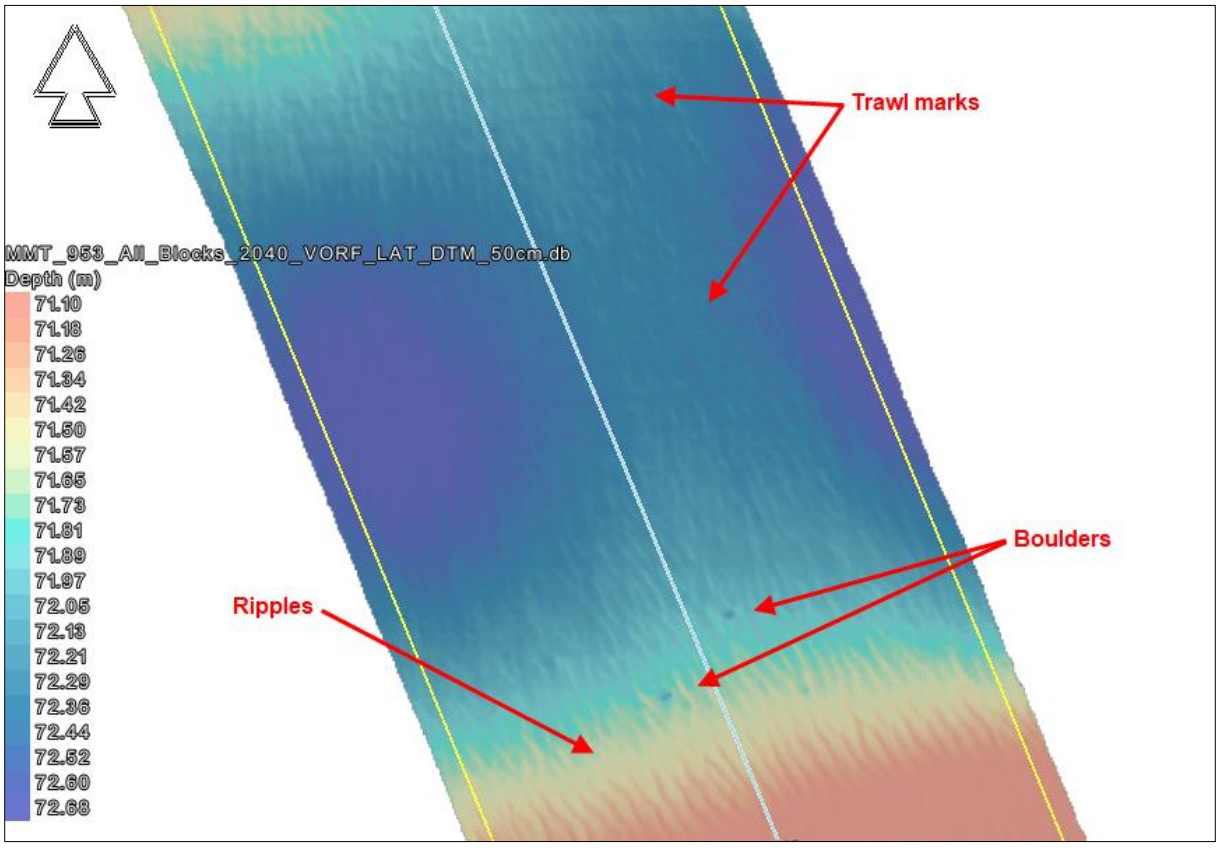


Figure 40 Shaded bathymetric relief showing the ripples, trawl marks and boulders around KP 118.400.
Palette has been adjusted to highlight features.

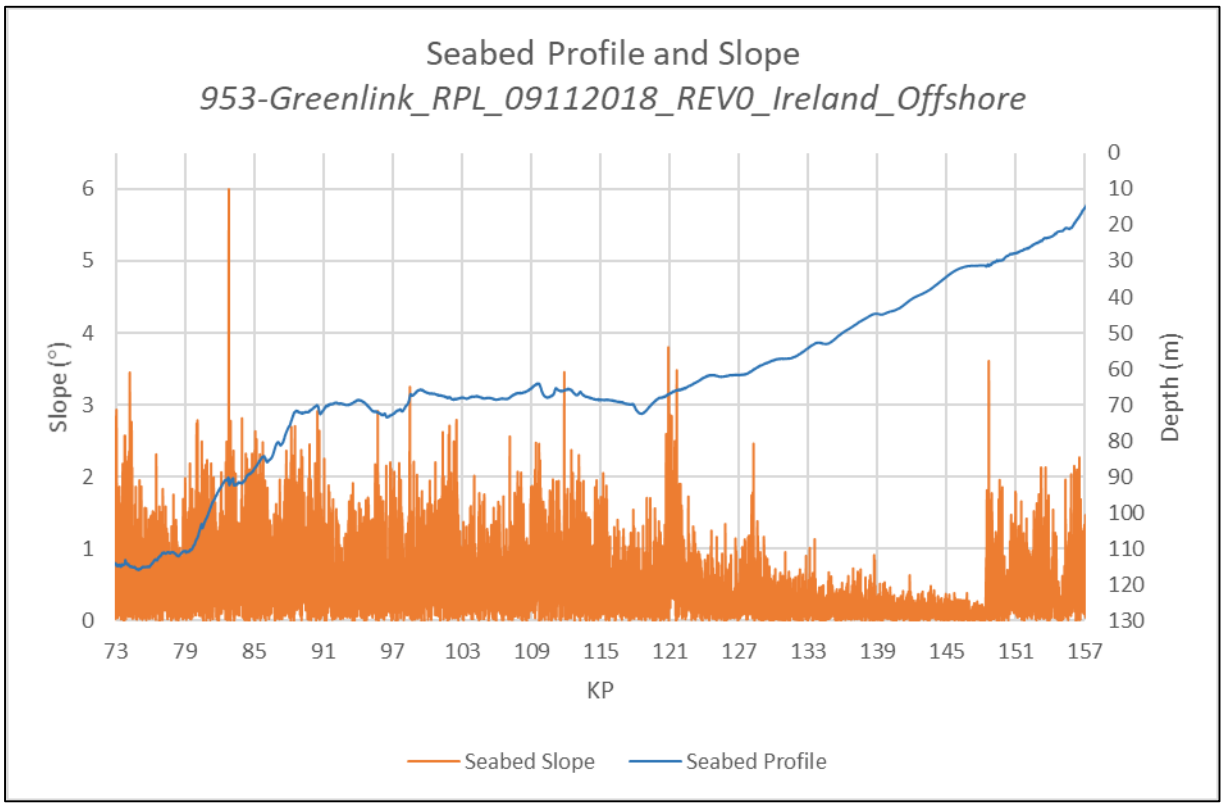


Figure 41 Seabed gradient and depth in the Irish offshore section from KP 73.906 to KP 156.667.

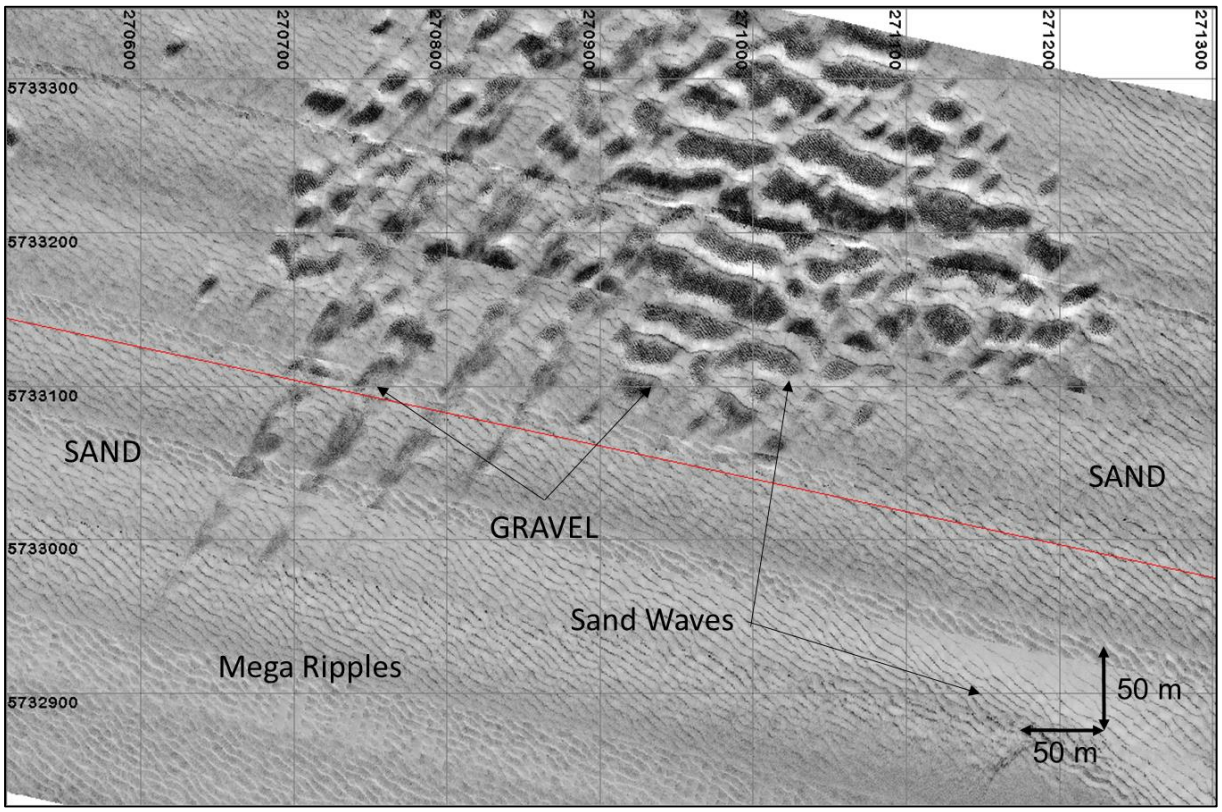


Figure 42 SSS plan view data example from KP 88.618 to KP 89.424.
Showing SAND and GRAVEL bed forms with megaripples and sandwaves. Image is north up.

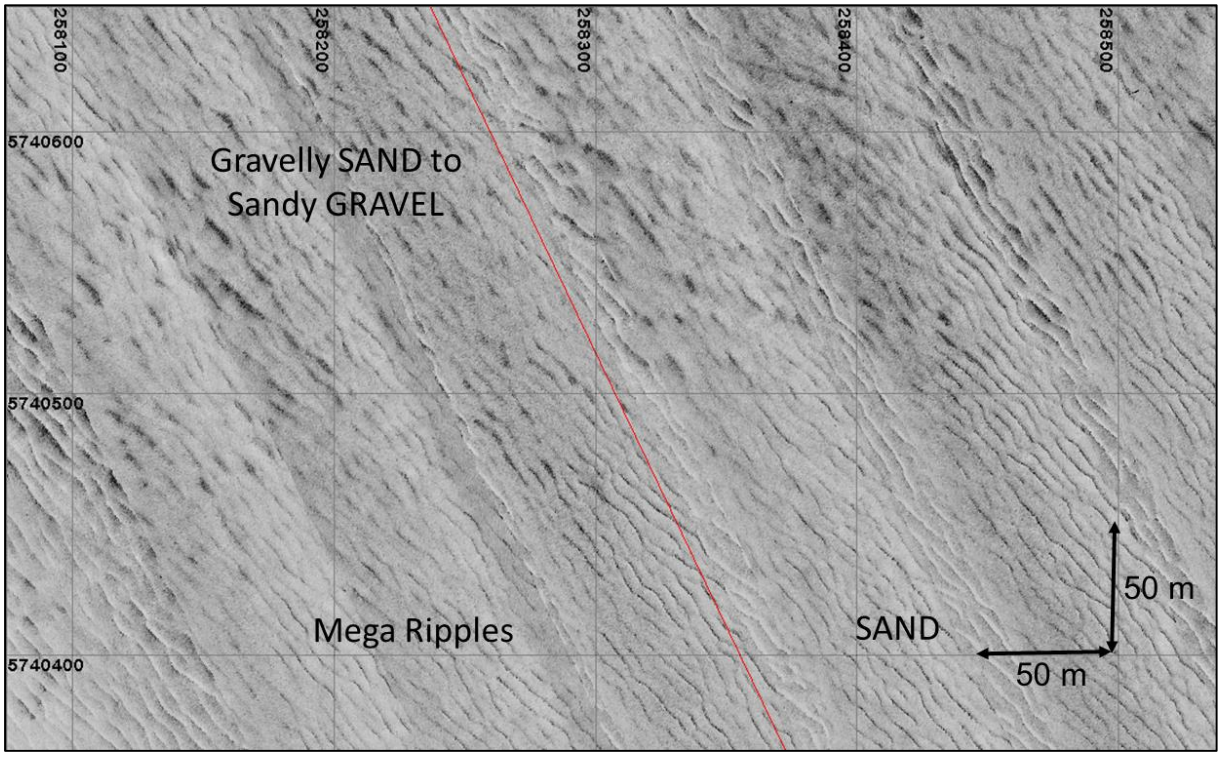


Figure 43 SSS plan view data example from KP 103.900 to KP 104.279.
showing SAND and gravelly SAND to sandy GRAVEL with megaripples. Image is north up.

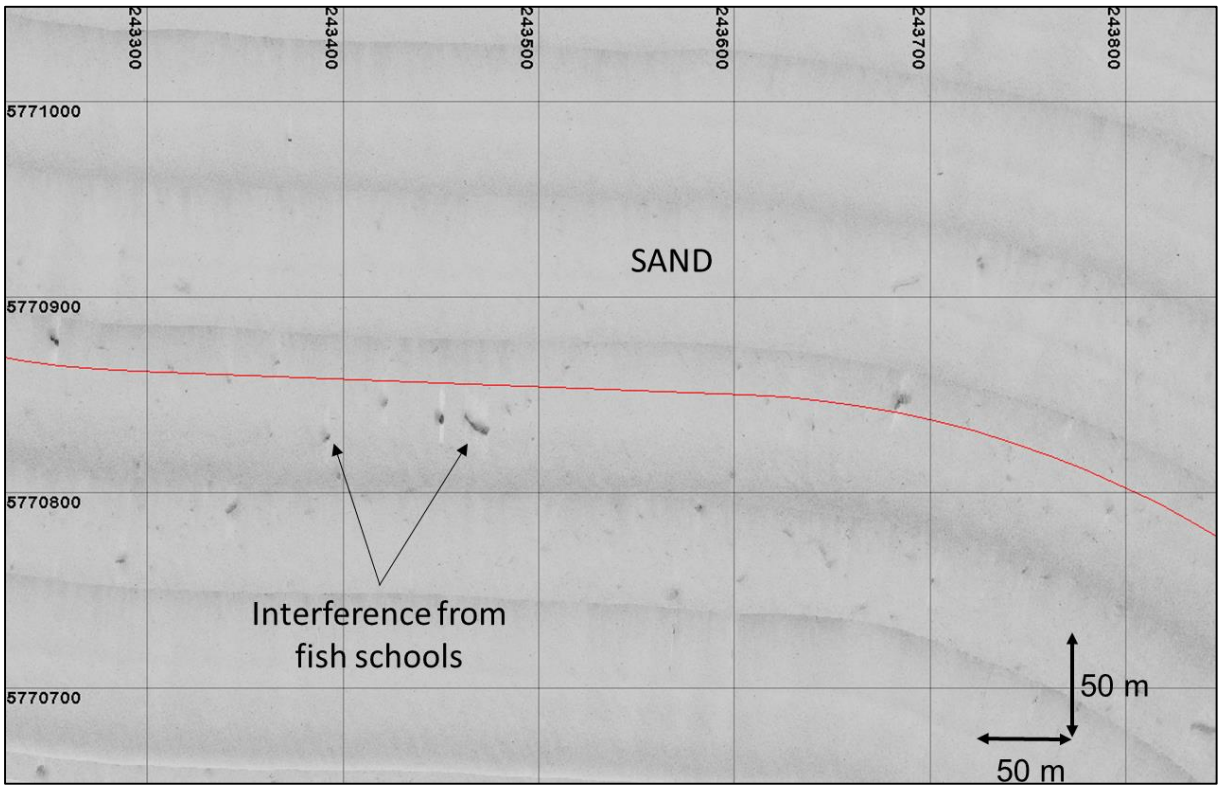


Figure 44 SSS plan view data example from KP 138.603 to KP 139.238.
Showing SAND with minor acoustic interference from fish schools. Image is north up.

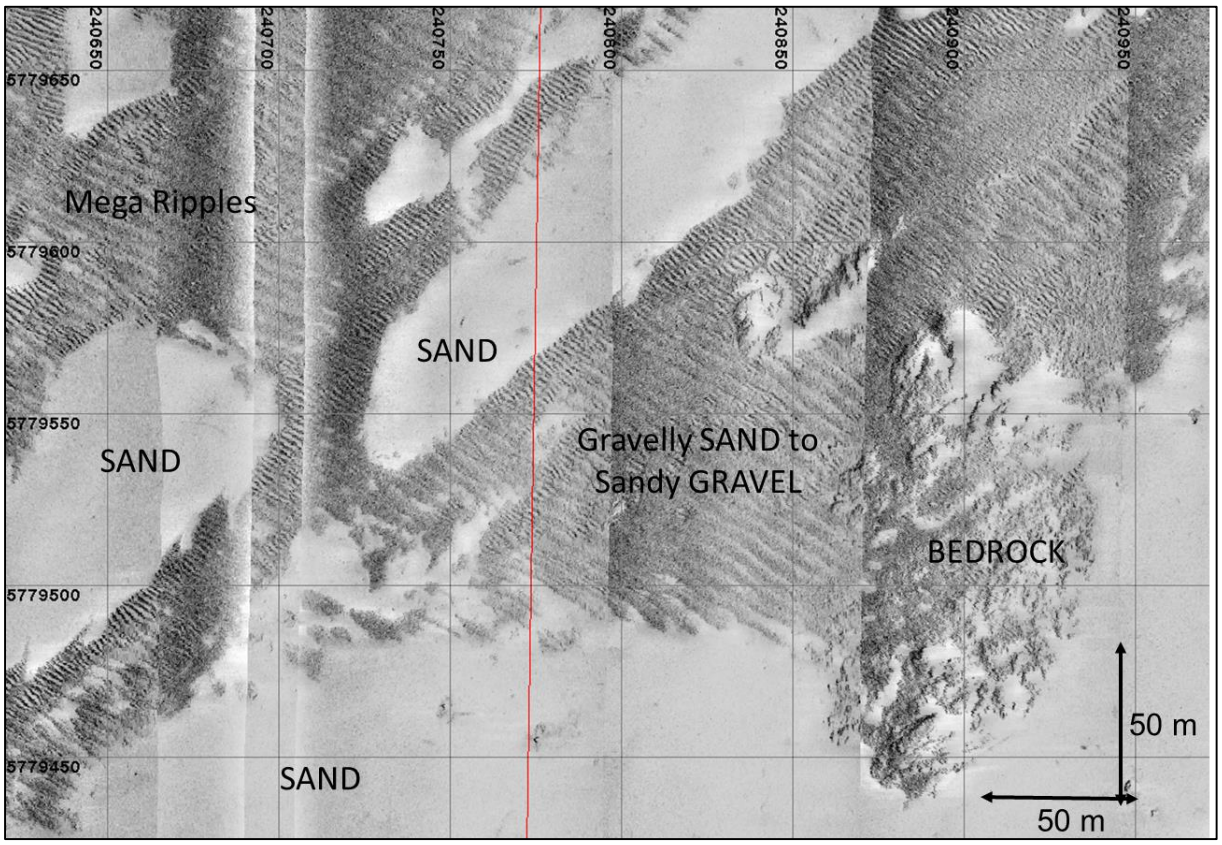


Figure 45 SSS plan view data example from KP 148.621 to KP 148.873.
Showing gravelly SAND to sandy GRAVEL with megaripples, SAND and an outcrop of BEDROCK.
Image is north up.

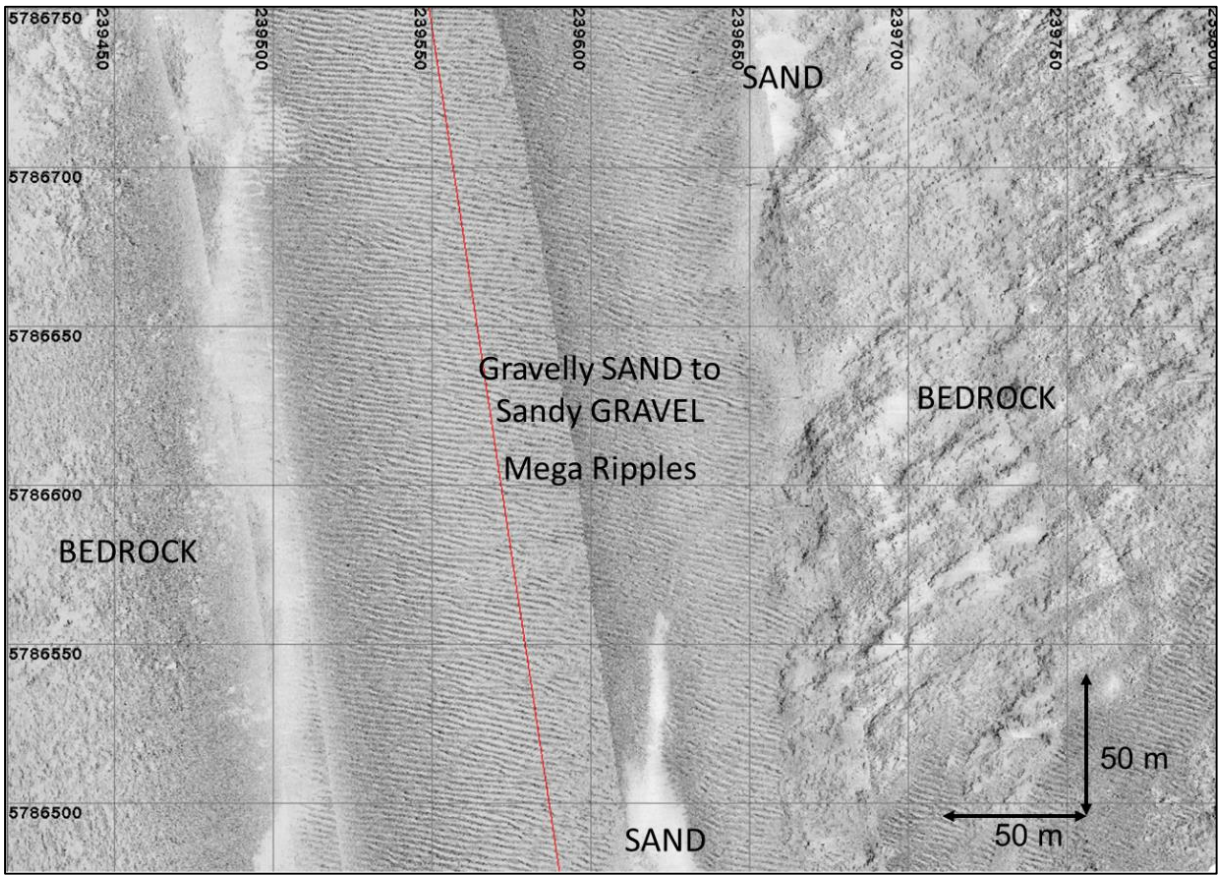


Figure 46 SSS plan view data example from KP 155.992 to KP 156.266.
Showing gravelly SAND to sandy GRAVEL with megaripples and outcrops of BEDROCK. Image is north up.

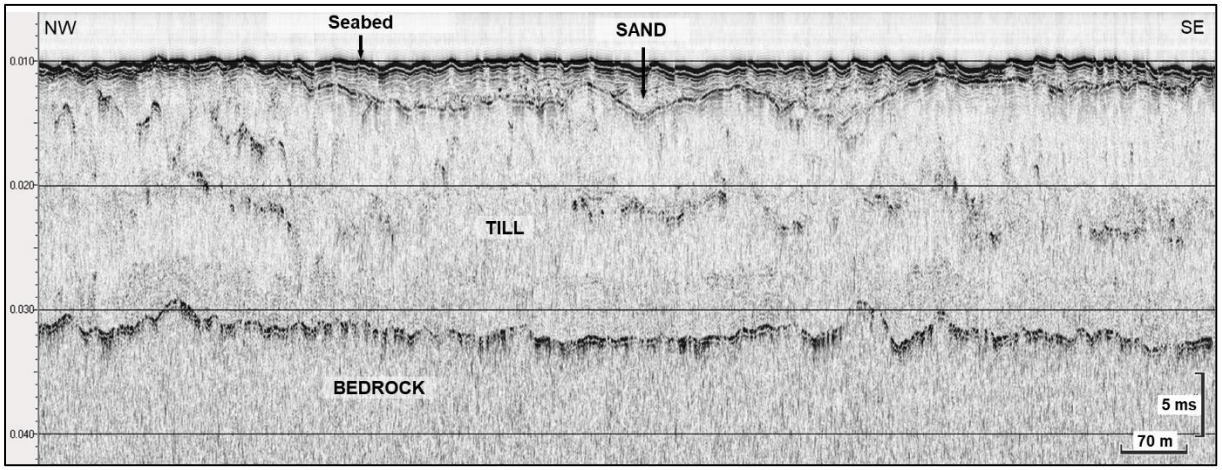


Figure 47 Chirp SBP data example from KP 73.950 to KP 75.250.
Showing surface SAND unit overlying a chaotic TILL sequence with multiple internal reflectors over BEDROCK.

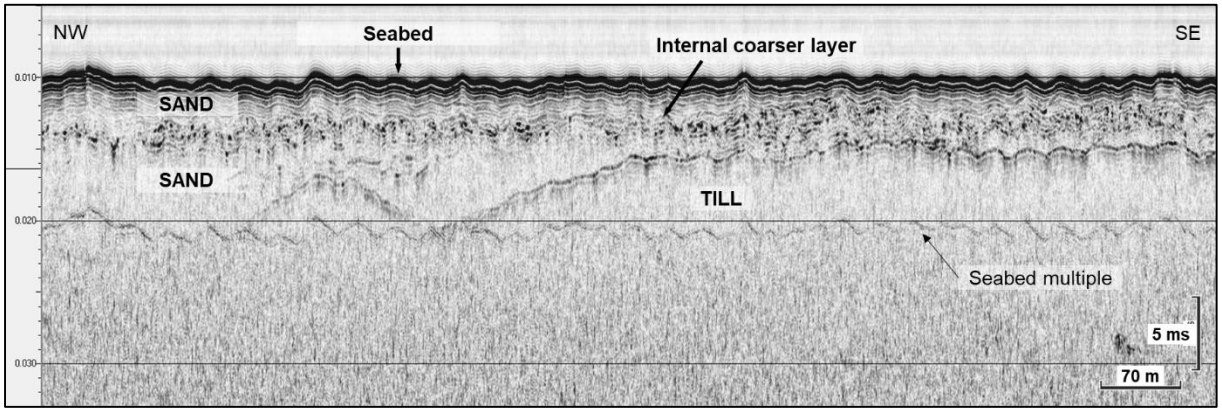


Figure 48 Chirp SBP data example from KP 78.990 to KP 80.040.
Showing surface SAND unit with an internal coarser sediment layer overlying TILL.

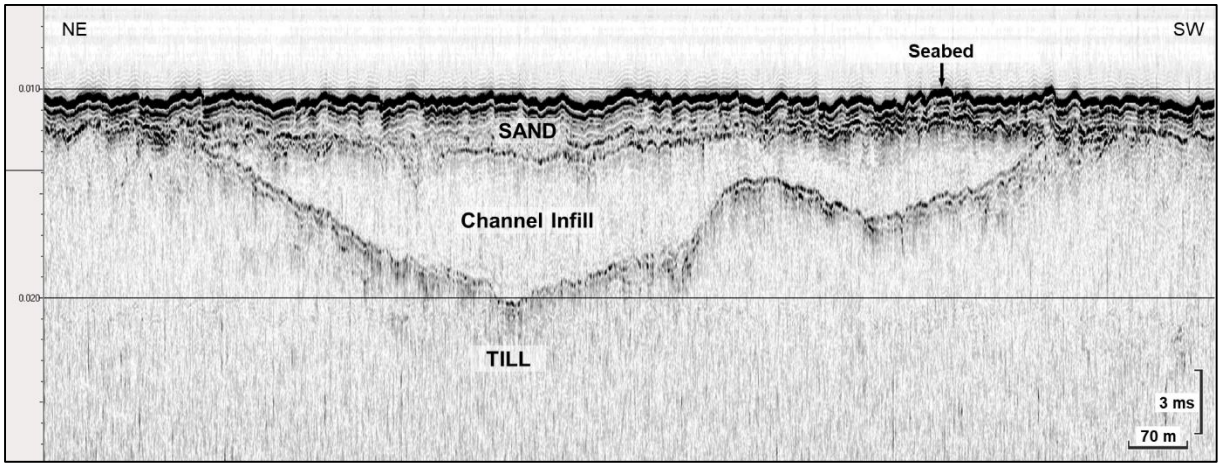


Figure 49 Chirp SBP data example from KP 115.500 to KP 116.500.
Showing an erosional TILL surface filled with channel infill sediments and covered by surface SAND unit.

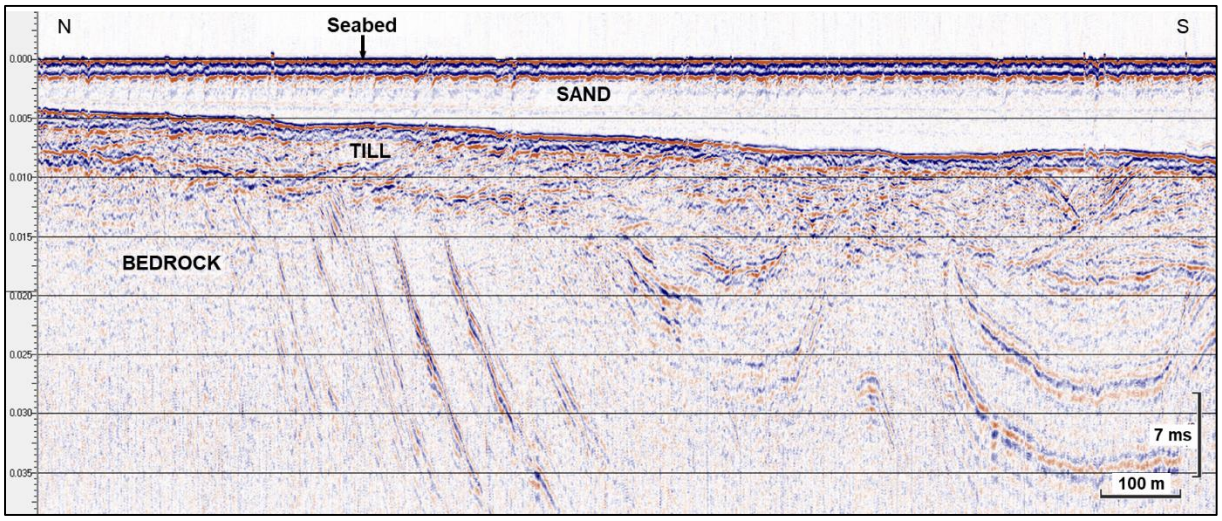


Figure 50 Sparker SBP data example from KP 145.350 to KP 146.860.
Showing the pinching out of a thick surface SAND layer over chaotic TILL and BEDROCK.

6.1.3| CONTACTS AND ANOMALIES ROUTE OPTION RPL_09112018_REV0

A total of 130 SSS contacts were identified from the data within the survey corridor in Ireland offshore. The majority of the contacts were classified as either boulders or debris.

The SSS contacts are summarised in Table 23.

A total of 42 magnetic anomalies were detected in the Ireland offshore corridor. Of these, 42 were unclassified (Table 24).

A total of 1 SSS contact positions correlated with detected magnetic anomalies.

Table 23 Summary of Ireland offshore SSS contacts route option RPL_09112018_REV0.

CLASSIFICATION	NUMBER
Boulder	102
Other	2
Debris	26
Wreck	0
Total	130

Table 24 Summary of Ireland offshore magnetic anomalies, route option RPL_09112018_REV0.

CLASSIFICATION	NUMBER
Unclassified, possible objects	42
Cable	0
Total	42

6.2| IRELAND NEARSHORE

6.2.1| OVERVIEW ROUTE OPTION RPL_09112018_REV0

Results are present for KP 156.667 to KP 159.172.

BATHYMETRY

The bathymetry in this area gently slopes up to the shore from a depth of 16.67 m. The seabed is rocky with occasional smooth flat areas that the route follows over, skirting around rocky outcrops. As the seabed gently rises up to the shore ripples are observed and from KP 159.071 the seabed is rocky until the end of the route, see Figure 51.

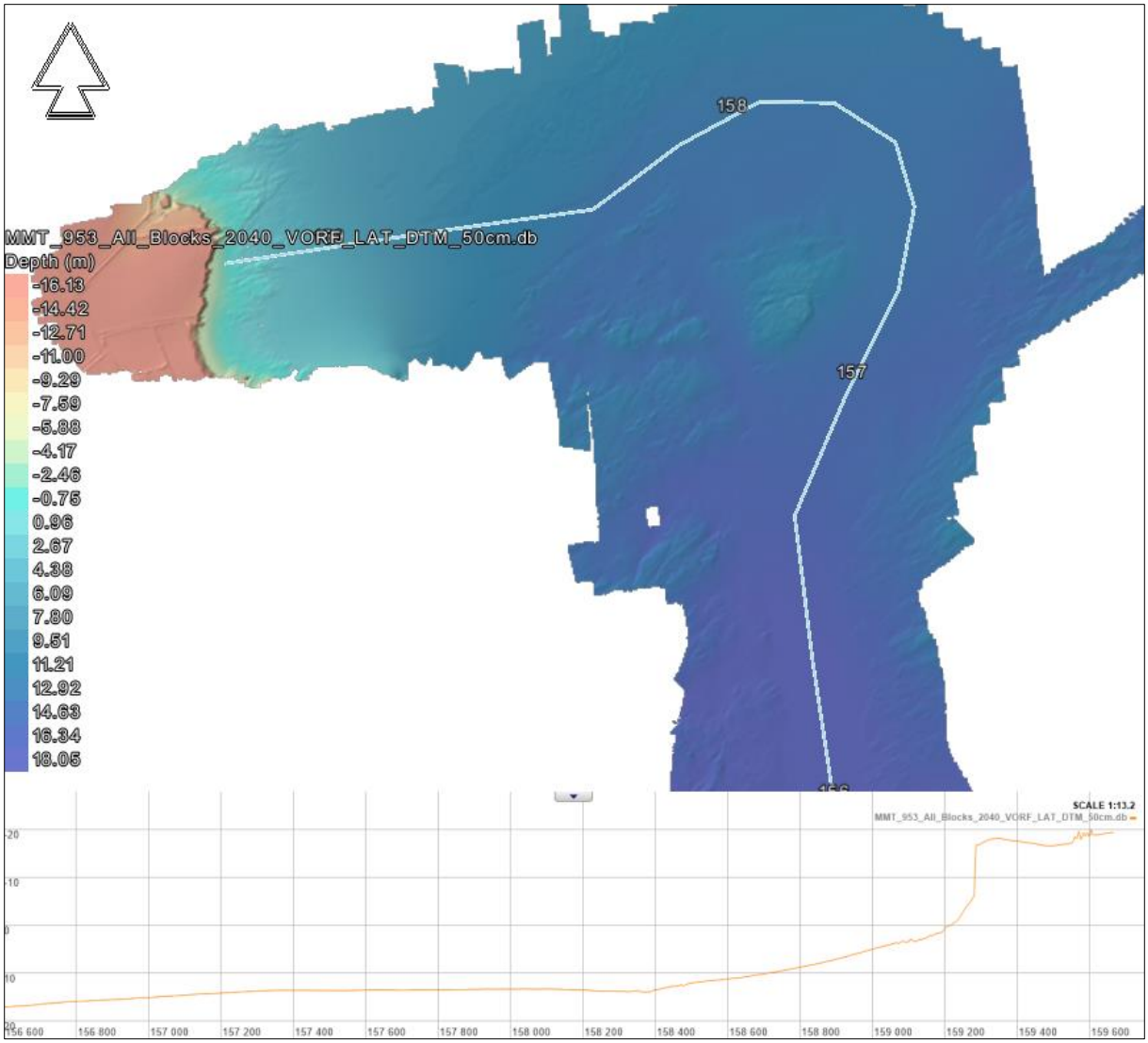


Figure 51 Shaded bathymetric relief and cross profile showing the shoreline at Baginbun gently sloping from KP 156.667.
Longitudinal profile (orange) depicts seabed along the route from KP 156.667 to the beach. Negative values are above LAT (Profile vertical exaggeration: 1:13.2).

SURFICIAL GEOLOGY

The surficial geology in the nearshore parts of the Irish route is varied. Large outcrops of BEDROCK are common, interrupted by areas of SAND, SILT or gravelly SAND/sandy GRAVEL. Large areas of megaripples and sandwaves are also present, most commonly in the eastern parts of the block.

SHALLOW GEOLOGY

The shallow geology in the Ireland Nearshore section is characterised by a basin infill and outcropping BEDROCK.

The TILL over BEDROCK present at the beginning of the nearshore section at KP 156.667 turns into a deep basin filled surface SAND layer and channel infills of mixed sediment up to 8 m thick. The basin is an incision in TILL or BEDROCK, a definite distinction with depth is not resolved. BEDROCK is outcropping from KP 158.365 to KP 158.847 and from KP 159.069 to the end of the available seismic data. In between the outcrops a thin layer of SAND is present.

6.2.2| DETAILED DESCRIPTION ROUTE OPTION RPL_09112018_REV0

A detailed presentation of the conditions and features along the Ireland nearshore route are shown in Table 25.

Table 25 Seabed details route option RPL_09112018_REV0 KP 156.667 to KP 159.172.

KP	Associated Chart	Description	Remark
156.667 - 157.710	102953-GRL-MMT-SUR-DWG-AL10KF19	**Bathymetry:** Depth decreases to KP 157.3 where it becomes generally flat. The seabed has ripples throughout the route with rocky areas in the outer corridor.	Very gentle to gentle gradients with a maximum value of 1.8 degrees. Depths range up to 16.67 m on the route (Figure 53).
		Surficial geology: The surficial geology consists of mainly gravelly SAND to sandy GRAVEL up to KP 157.721 where the dominating sediment becomes SILT. Megaripples are present along the route to KP 157.604.	(Figure 54)
		Shallow Geology: The start of this section to KP 157.060 is characterised by TILL over BEDROCK with an unresolved veneer of mobile SAND and GRAVEL. This is followed by a basin infill with the surface SAND unit of up to 4 m and some channel infill sediments over TILL and BEDROCK. The boundary between TILL and BEDROCK is not well resolved in the seismic data.	(Figure 56)
157.710 - 158.296	102953-GRL-MMT-SUR-DWG-AL10KF19	**Bathymetry:** There is little variation in depth until KP 158.106 where it increases very gently by 0.5 m. The seabed is rippled until the route turns at KP 157.611 on to smoother seafloor.	Very gentle gradient with a maximum value of 0.65 degrees. Depths range up to 13.77 m on the route (Figure 53).
		Surficial geology: The surficial geology consists of mainly SILT interrupted by areas comprising of SILT and SAND.	(Figure 55)
		Shallow Geology: Continued basin infill with the surface SAND unit of up to 4 m and some channel infill sediments, reaching a maximum of 8 m below seabed, over TILL and BEDROCK. The boundary between TILL and BEDROCK is not well resolved in the seismic data. TILL/BEDROCK reaches to within 1 m from the seabed from KP 158.230.	(Figure 56)

KP	Associated Chart	Description	Remark
158.296 - 159.172	102953-GRL-MMT-SUR-DWG-AL10KF19	**Bathymetry:** The route moves through a small rocky area at KP 158.365 (Figure 52), then at KP 158.5 continues to gently decrease in depth over smooth seabed until KP 159.070 where there is another rocky area leading on to the shore.	Very gentle to locally moderate gradients with a maximum value of 5.76 degrees over the rocks. Depths range up to 13.92 m on the route (Figure 53).
		Surficial geology: The surficial geology consists of mainly SAND interrupted by areas of SILT and SAND. In this section, the BEDROCK outcrops occasionally cross the route.	Bedrock outcrops crossing route between: • KP 158.426 and KP 158.490 • KP 159.073 to end of route
		Shallow Geology: BEDROCK or TILL/BEDROCK are close to seabed throughout this section. BEDROCK is outcropping (or with a veneer of SILT and SAND) between KP 158.365 and KP 158.847 and from KP 159.070 to the end of the route. SAND and some channel infill sediments of 1-2 m thickness are present between these BEDROCK outcrops, KP 158.847 to KP 159.069.	(Figure 57)

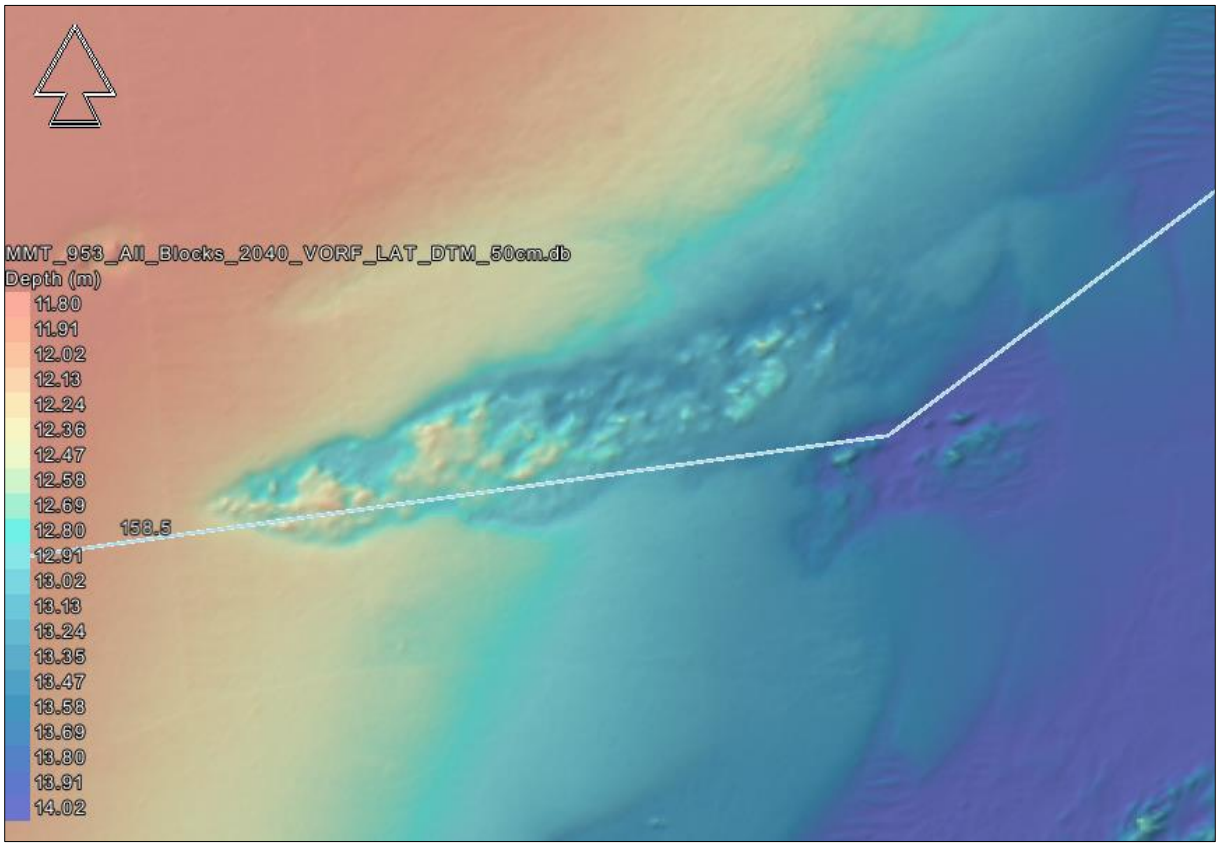


Figure 52 Shaded bathymetric relief showing the route passing over a rocky outcrop at KP 158.402. Palette is adjusted to highlight area.

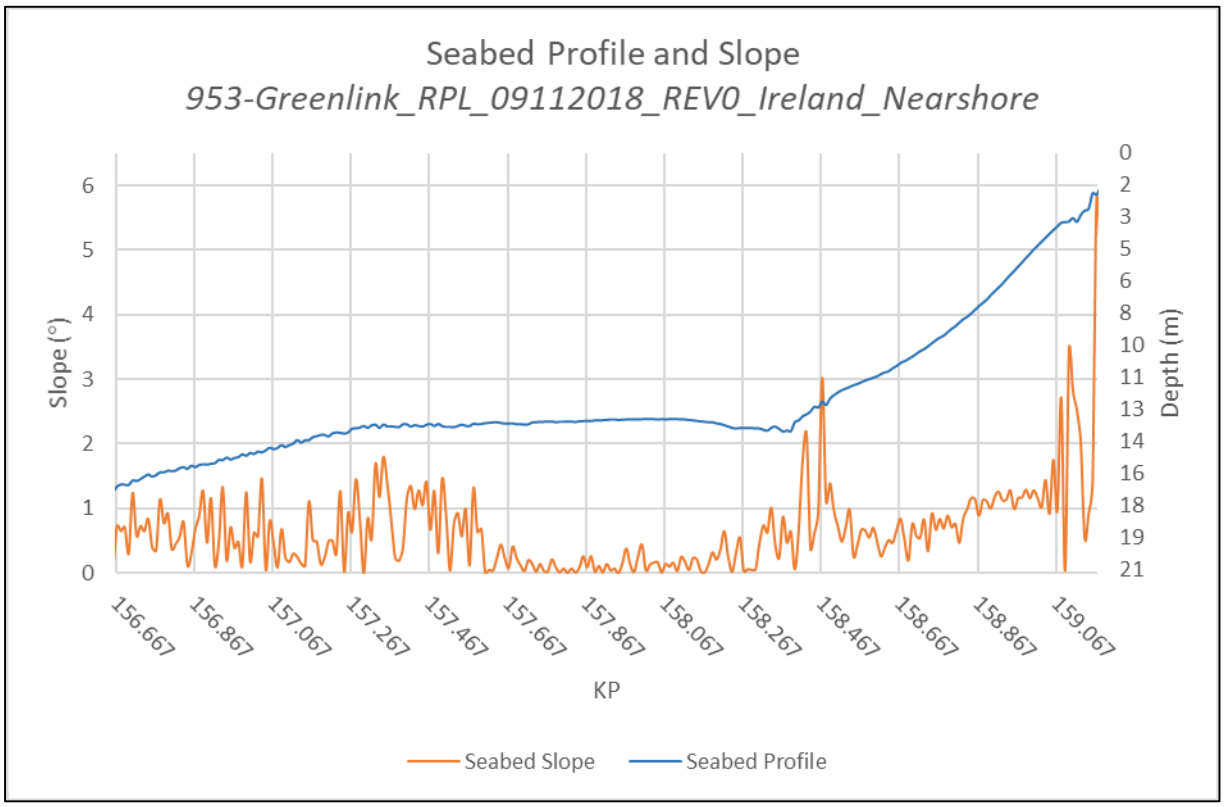


Figure 53 Seabed gradient and depth at the Irish nearshore section from KP 156.667 to KP 159.172.

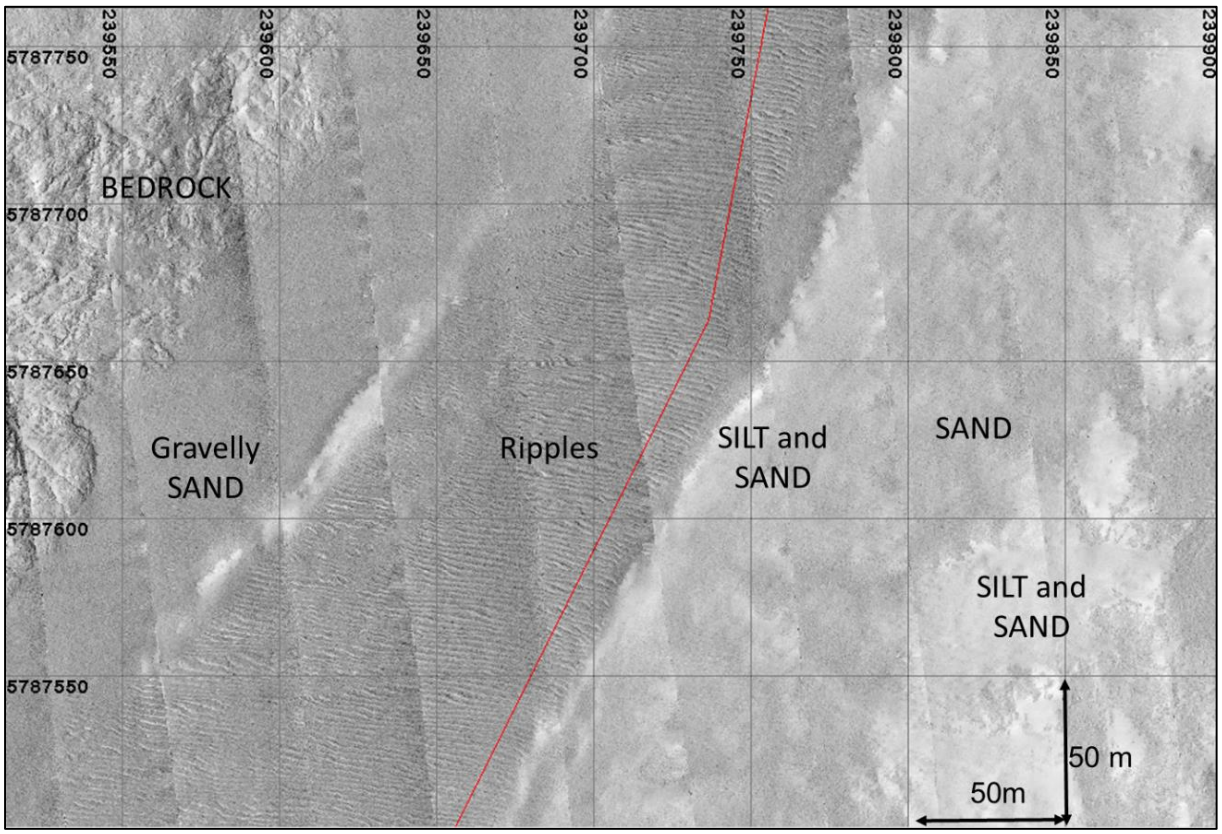


Figure 54 SSS plan view example from KP 157.145 to KP 157.335.
Showing gravelly SAND with ripples, patches of SILT and SAND between SAND and an outcrop of BEDROCK. Image is north up.

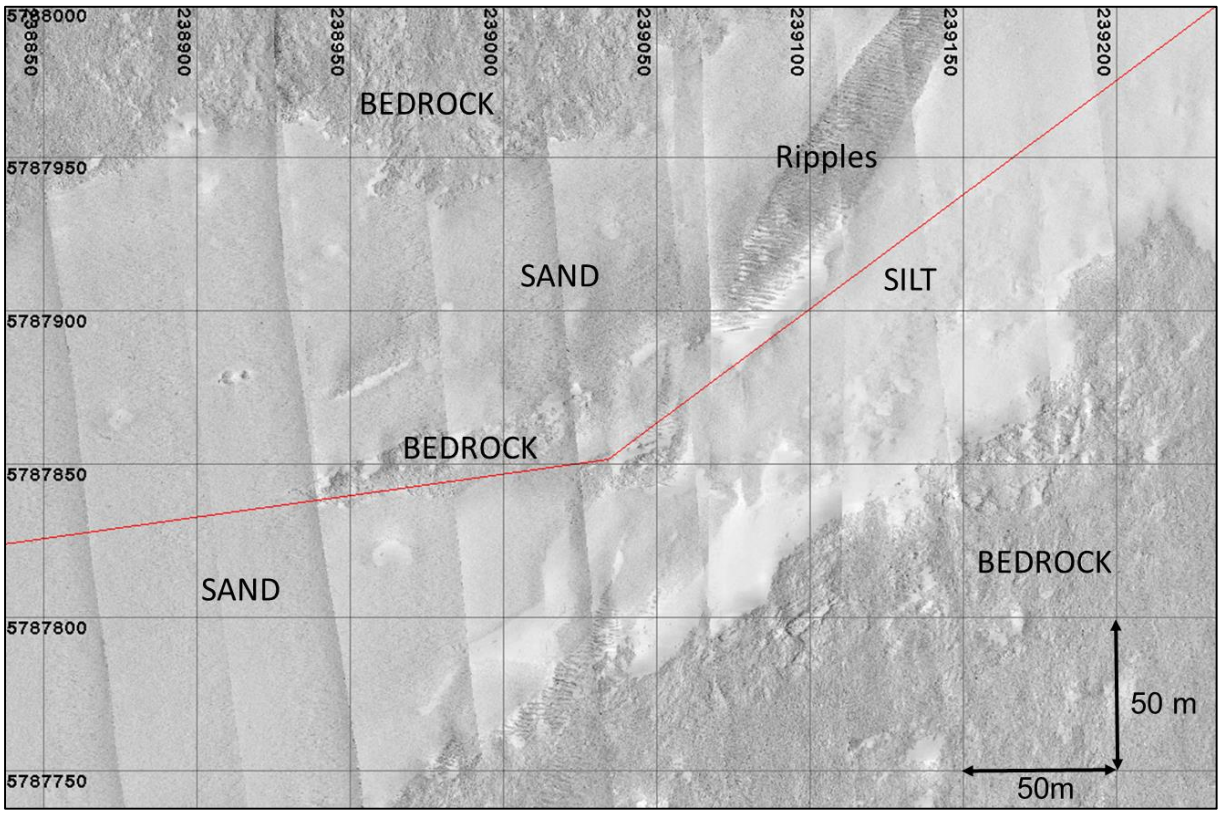


Figure 55 SSS plan view example from KP 157.925 to KP 158.584.
Showing SAND and SILT between BEDROCK. Image is north up.

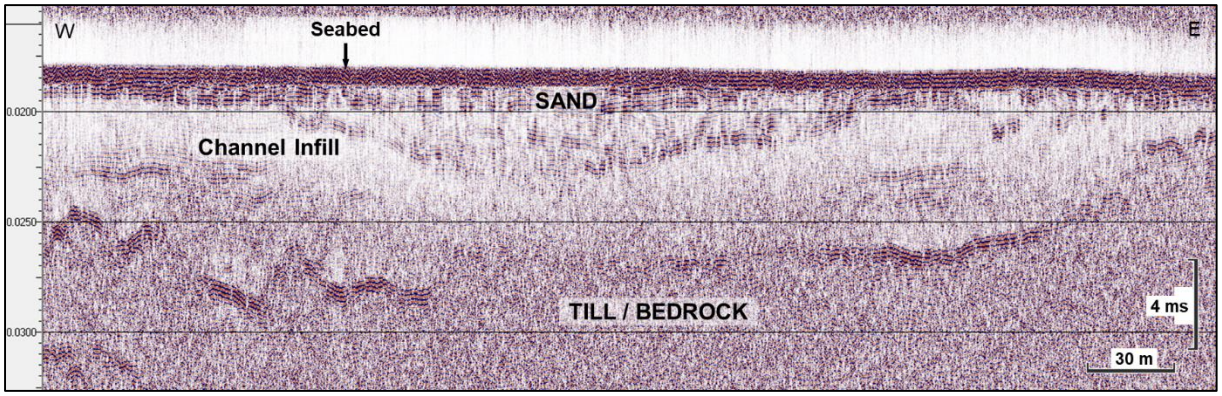


Figure 56 Innomar SBP data example from KP 157.570 to KP 158.020.
Showing a basin infilled by SAND and channel infill sediments over TILL/BEDROCK.

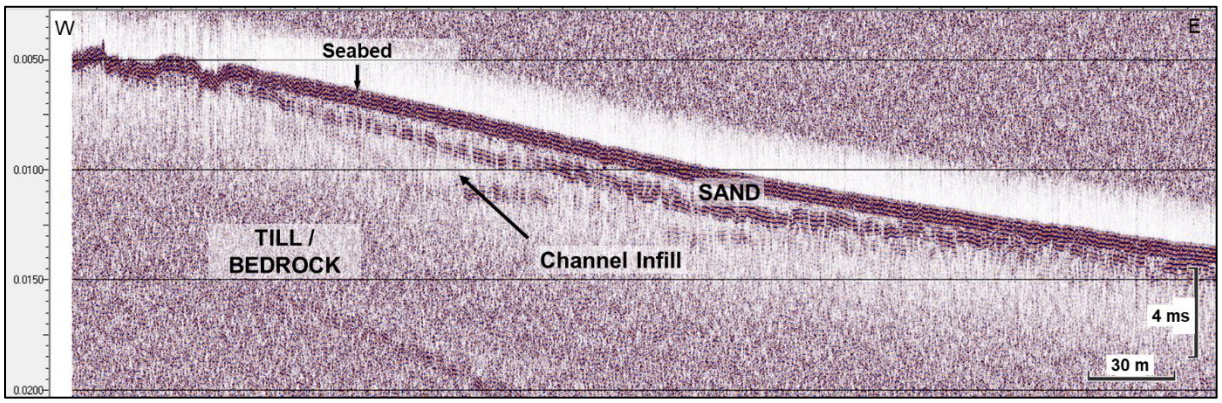


Figure 57 Innomar SBP data example from KP 158.420 to KP 159.110.
Showing a thin surface SAND layer and some channel infill sediments over TILL and BEDROCK towards the landfall on the left.

6.2.3| CONTACTS AND ANOMALIES ROUTE OPTION RPL_09112018_REV0

A total of 73 SSS contacts were identified from the data within the survey corridor in Ireland nearshore. The majority of the contacts were classified as either boulders or debris.

The SSS contacts are summarised in Table 26.

A total of 19 magnetic anomalies were detected in the Ireland nearshore corridor. Of these, 19 were unclassified (Table 27).

A total of 1 SSS contact positions correlated with detected magnetic anomalies.

Table 26 Summary of Ireland nearshore SSS contacts, route option RPL_09112018_REV0.

CLASSIFICATION	NUMBER
Boulder	57
Other	3
Debris	13
Wreck	0
Total	**73**

Table 27 Summary of Ireland nearshore magnetic anomalies, route option RPL_09112018_REV0.

CLASSIFICATION	NUMBER
Unclassified, possible objects	19
Cable	0
Total	**19**

6.2.4| OVERVIEW ROUTE OPTION A

Results are presented from KP 156.187 to KP 157.413.

All KPs refer to route option A, RPL Route_A_WGS84_UTM30N_Rev1_20180521.

BATHYMETRY

The seabed along the route is generally smooth with rocky areas on the outer corridor which eventually get closer, causing the entire corridor to become rocky. The depth generally decreases throughout with some undulation over the rocky area. Very gentle to gentle gradients throughout.

SURFICIAL GEOLOGY

The initial section of the Irish part of Route Option A is dominated by gravelly SAND/sandy GRAVEL, whereas the latter part is dominated by SAND. Large areas of BEDROCK outcrops are present throughout the alternative route.

Megaripples are present in areas along Route Option A.

SHALLOW GEOLOGY

An 8 m deep basin infilled by SAND and mixed channel infill sediments, outcropping BEDROCK or BEDROCK with a veneer of sediment are present along the route.

6.2.5| DETAILED DESCRIPTION ROUTE OPTION A

A detailed presentation of the conditions and features along the Ireland nearshore route option A are shown in Table 28.

Table 28 Seabed details route option A KP 156.187 to KP 157.413.

KP	Associated Chart	Description	Remark
156.187-157.413	102953-GRL-MMT-SUR-DWG-AL10KA04	**Bathymetry:** The route passes over smooth seabed in between rocky outcrops until KP 156.817. From here the seabed is rocky until KP 157.078 when it becomes smooth again, see Figure 58. Depth decreases gently along the route.	Very gentle to gentle gradient with a maximum value of 3.41 degrees. Depths range up to 16.79 m on the route (Figure 59).
		Surficial geology: The surficial geology consists of mainly gravelly SAND to sandy GRAVEL surrounded by some smaller sections of SILT and SAND. SAND becomes more common towards the end of the route and from KP 157.046 SAND is the main surficial sediment type. BEDROCK is outcropping in large areas of the route. Megaripples are present in several smaller areas.	Bedrock outcrops crossing the route between: KP 156.406 and KP 157.241. (Figure 60, Figure 61)
		Shallow Geology: The shallow geology in this section starts with a basin of SAND and channel infill that pinches out at KP 156.650. From there to KP 157.000 BEDROCK is outcropping at seabed or covered by a thin veneer of gravelly SAND to sandy GRAVEL. Between 157.000 and 157.413 a thin SAND layer of generally <2 m is present over TILL/BEDROCK.	(Figure 62)

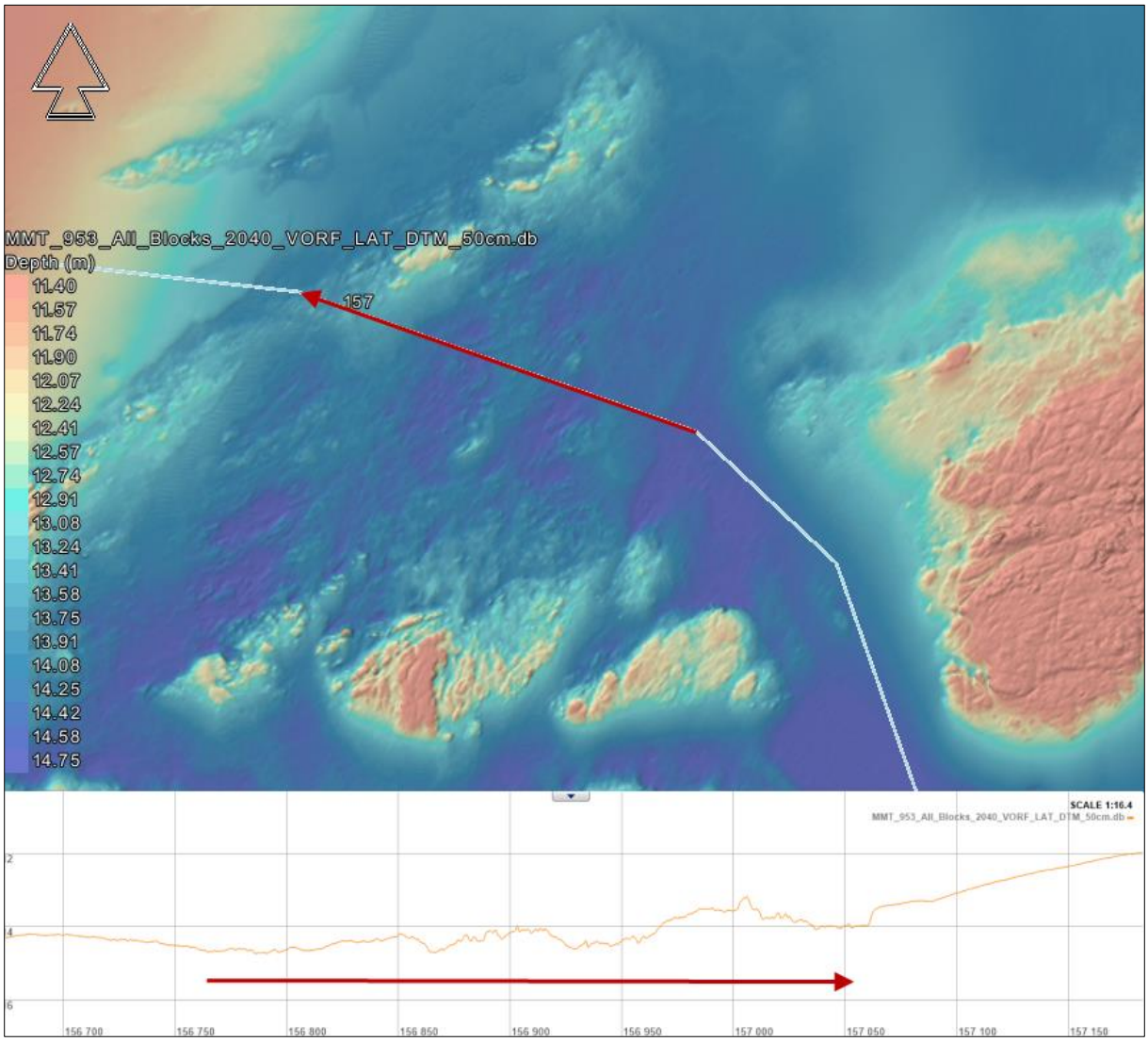


Figure 58 Shaded bathymetric relief showing the rocky seabed on Route A between KP 156.817 and KP 157.078.
Longitudinal profile (orange) depicts seabed along the route along the direction of the red arrow (Profile vertical exaggeration: 1:16.4).

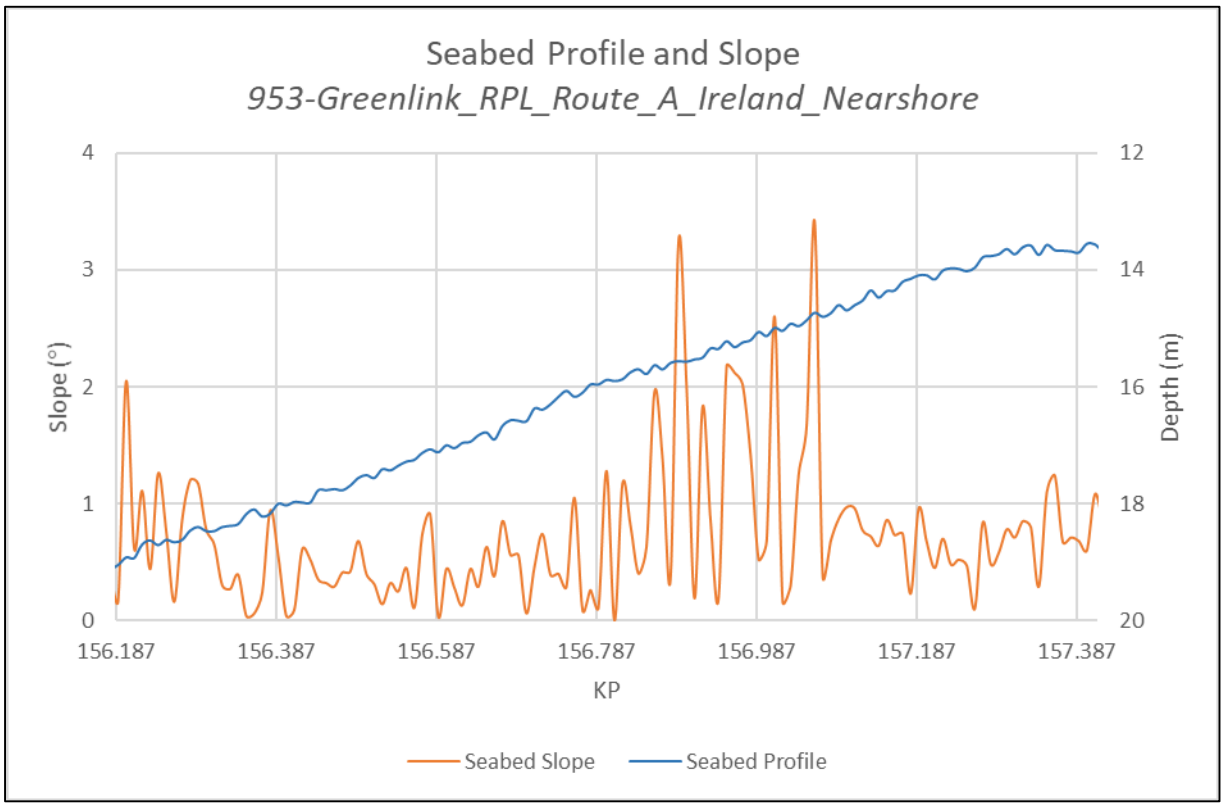


Figure 59 Seabed gradient and depth on route option A in the Irish nearshore section between KP 156.187 and KP 157.413.

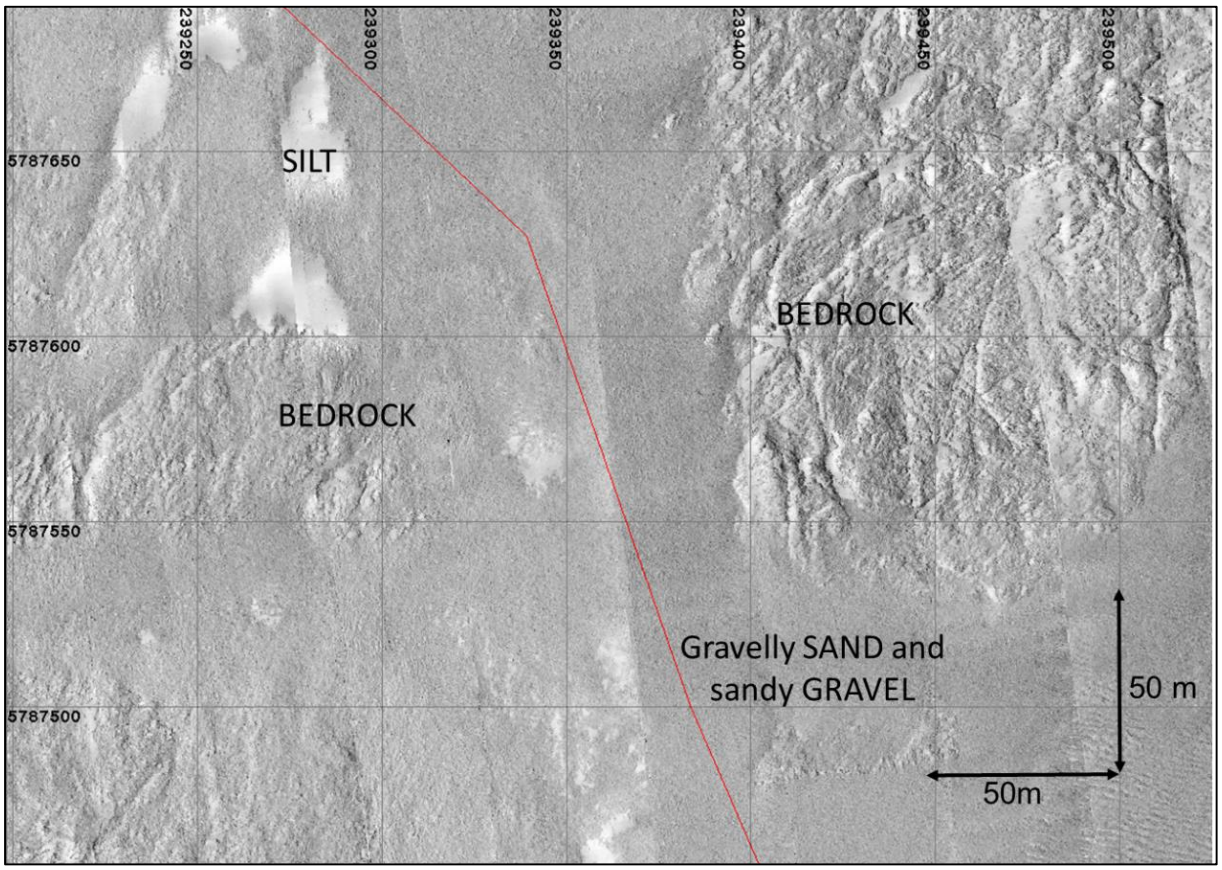


Figure 60 SSS plan view example from KP 156.782 to KP 157.241.
Showing a channel of gravelly SAND and sandy GRAVEL between BEDROCK. Image is north up.

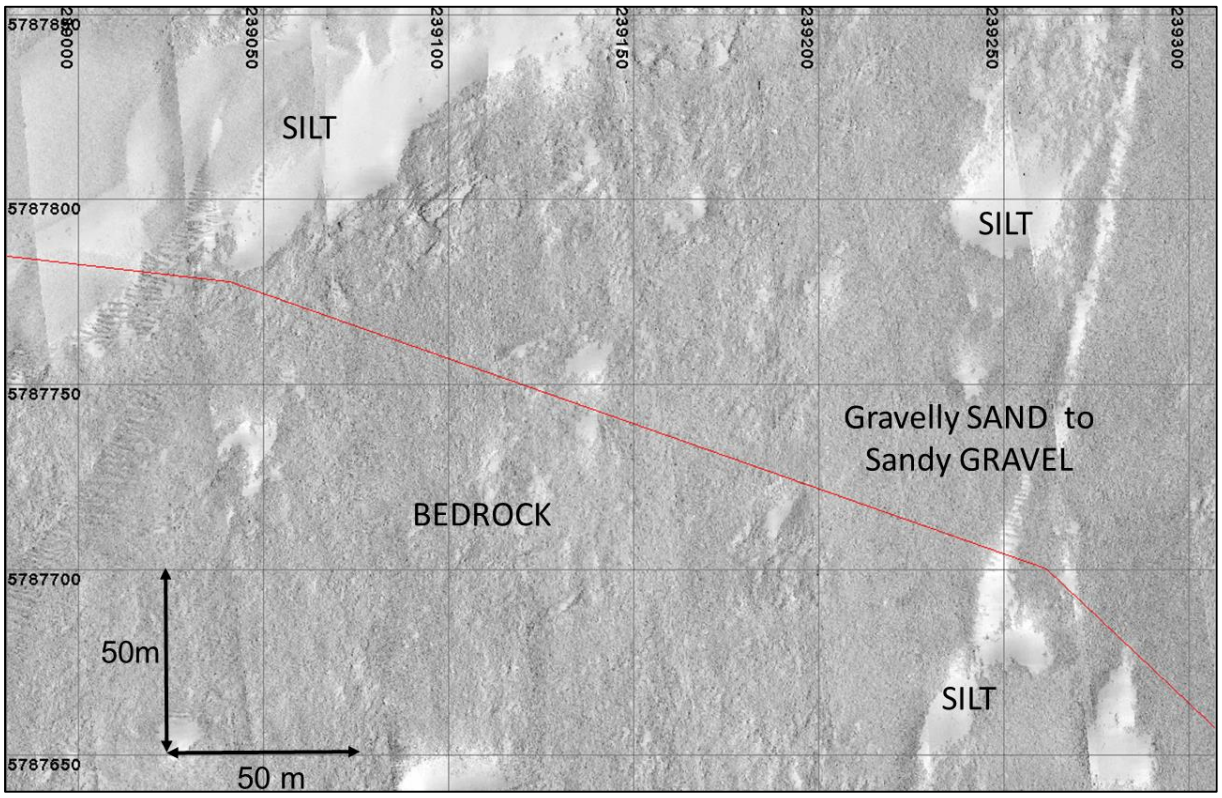


Figure 61 SSS plan view example from KP 157.095 to 156.739 095.
Showing BEDROCK with areas of gravelly SAND and sandy GRAVEL and patches of SILT. Image is north up.

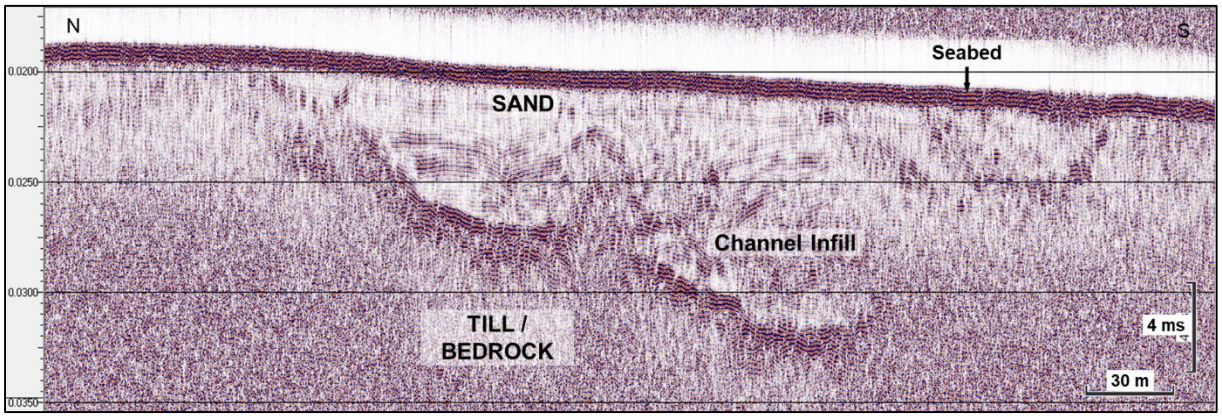


Figure 62 Innomar SBP data example from KP 156.330 to KP 156.720.
Showing a basin infilled by SAND and channel infill sediments over TILL/BEDROCK.

6.2.6| CONTACTS AND ANOMALIES ROUTE OPTION A

A total of 21 SSS contacts were identified from the data within the survey corridor in Ireland nearshore. The majority of the contacts were classified as either boulders or debris.

The SSS contacts are summarised in Table 29.

A total of 2 magnetic anomalies were detected in the Ireland nearshore corridor. Of these, 2 were unclassified (Table 30).

No SSS contact positions correlated with detected magnetic anomalies.

Table 29 Summary of Ireland nearshore SSS contacts, Route A.

CLASSIFICATION	NUMBER
Boulder	13
Other	2
Buoy	0
Debris	6
Wreck	0
Total	**21**

Table 30 Summary of Ireland nearshore magnetic anomalies, Route A.

CLASSIFICATION	NUMBER
Unclassified, possible objects	2
Cable	0
Total	**2**

7| INSTALLATION CONSTRAINTS

7.1| POSSIBLE CHALLENGES TO CABLE INSTALLATION AND PROTECTION

7.1.1| SEABED GRADIENTS

Steep ground is considered problematic when the seabed has a slope of a magnitude that affects the speed or effectiveness of the trenching operation. The critical slope angle depends on the trenching equipment. There may well be a difference in critical angle between along track slopes and across track slopes. Trenching and/or rock installation may also change slope stability and induce sediment slides.

Steep ground may affect cable installation. If the slope angle is great enough it can cause the cable to move out of position, which could also result in excess tension in the cable.

Steep slopes may cause problems for cable protection, e.g. rock and gravel berms, if the slope angle causes the protective material to slide downhill and eventually expose the cable.

7.1.2| BEDROCK AND HARD SEDIMENT

Bedrock and hard sediment are considered an issue when the seabed proves to have properties that affect and effectively inhibit the use of the trenching methods.

Bedrock and hard sediment may cause problems with reaching the required burial depth. In addition, topographical irregularities in bedrock or hard sediment may cause freespan, point load, and abrasion. Methods to avoid problems with bedrock or hard sediment include appropriate micro-routing, deployment of heavier trenching machines, or the installation of additional cable protection such as Pre lay rock installation/dredging to level the route to avoid free span.

7.1.3| BOULDER FIELDS

Fields with boulders may cause freespan and point load problems, and may also cause problems during the potential trenching of the cable. Methods of avoidance include, rerouting, boulder removal by using e.g. an ROV or a pulled plough pushing the boulders aside, and pre-lay rock placement.

Buried boulders can cause difficulties, especially if they are discovered during trenching of the cable. An effective method for pre-burial assessment of buried boulders is to perform a pre-lay trench.

7.1.4| MOBILE SEDIMENT

Mobile sediments may bury or expose the cable. Both scenarios are to be avoided, since excess burial depth may result in overheating, and exposure will leave cables vulnerable to damage.

Cable protection by trenching in sandwave areas is complicated, in particular where the trenching equipment will pass through a crest or trough, and the equipment is not properly supported on ground. In such situations, the burial depth is affected, complicating the procedure of reaching the designated depth and protection level.

In areas where there is evidence of mobile sediments, pre-dredging or pre-sweeping the cable route prior to laying and trenching is considered a good solution for mitigating future problems with cable exposure, or excessive burial depths.

Using rock placement on top of the laid cable is also a method to stabilise an area with mobile sediments. However, this solution may cause stones to sink and spread uncontrollably in sand if the erosional forces

are strong, and may therefore require ongoing maintenance. Rock placements can also lead to scouring which may need post-lay control.

An often economically viable method of ensuring the safety of the cables is to perform frequent burial depth measurements and burial remediation, for example on a yearly basis in critical areas.

It is often necessary to perform a sandwave analysis, identifying any high risk areas in advance, and propose mitigation procedures based on pre-lay investigations. Post-lay activities may be very expensive, and are not always effective.

To be able to measure the mobility of the sediment, a reliable method is to compare at least two sets of data, which has been retrieved with some time elapsed in between the different surveys. Based on the result, the speed and volume of sediment movement can be calculated.

7.1.5| UNSTABLE SEDIMENT

Unstable sediment is a problem during cable installation, if sediment slumps, this may unbalance the equipment. Unstable sediments can cause problems for cable protection as a result of movement or collapse after installation. Unstable sediments can also cause problems for the operation integrity of the cable as slumping post installation can result in direct damage to the cable as well as freespan and exposure.

Trenching and/or rock installation may also change slope stability and induce sediment slides.

Mitigation includes cable re-routing.

7.1.6| ACOUSTIC BLANKING AND GAS SEEPAGE FEATURES

Shallow gas and gas seepage features, pockmarks, and Methane-Derived Authigenic Carbonates (MDAC) may cause problems to the cable installation. Sediment movements within pockmarks, uncontrollable movements of the cable may expose the cable to unnecessary strain. The thermal properties can be affected, causing problems with discharge of heat in the sediment around pockmarks. If a cable is laid in a pockmark or in a developing pockmark there is a risk for vortex induced vibrations in the cable, if it would go into freespan. Gas seeps may accelerate corrosion to the cable amour if seeps are corrosive.

The presence of MDAC and/or pockmarks can cause difficulties, especially if they are discovered during cable installation. During installation potential problems are reduced sediment stability, difficulties in choosing burial equipment, trencher instability, and potential problems to protect the cable in an acceptable way. It should also be considered that the presence of shallow gas may indicate larger amounts of gas at deeper levels.

Shallow gas may also be caused by organic matters, especially in the channel filled areas on the North Sea Plateau. Organic matters normally have a reduced thermal conductivity compared to minerogenic sediments and may cause overheating.

Mitigation includes cable rerouting and additional protection measures.

7.1.7| CABLES AND PIPELINES

Cable crossings and pipeline crossings should ideally be made as perpendicular as possible. Thus simplifying the design of the crossing arrangement, and minimising the risk of future maintenance and repair operations on neighbouring installations affecting the cable.

7.1.8| WRECKS

A wreck presents an abrasive threat to a cable, and may hold the cable in suspension from the seabed. Wreck sites can often be extended, with debris scattered around the main object. Subsequent secondary entanglement with fishing gear is another risk to a cable laid over wreck sites. It is also possible that shipwrecks may be considered of archaeological importance.

7.1.9| UXO

If UXO or UXO related objects are present, they may be possible to avoid by appropriate micro-routing. If rerouting is impractical, UXO clearance operations will be necessary. Magnetometer records collected during the survey were used to identify cables/pipelines and ferrous objects on the seafloor within the survey corridor.

A focused UXO survey was performed in the region surrounding the Castlemartin firing range which is further discussed in the UXO report (102953-GRL-MMT-SUR-REP-UXOREP). The UXO results can only be seen as valid at the time of the survey, as part of the route is located within the designated artillery range zone where future deposition of UXOs is possible.

7.2| UNITED KINGDOM

7.2.1| SEABED GRADIENTS

Gradients are generally very gentle to gentle with some localised moderate to very steep slopes which appear on rocks or sandwaves (Figure 63).

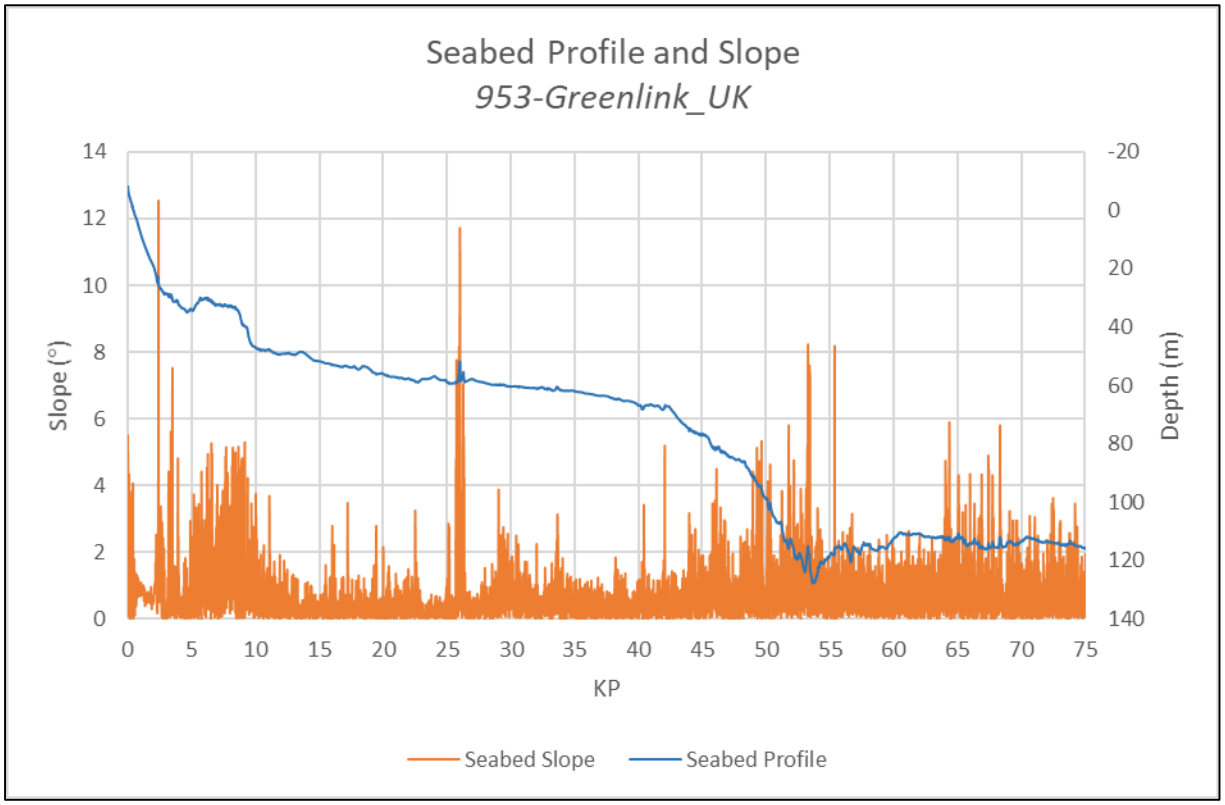


Figure 63 Seabed gradient and depth on the Final route in the UK, between KP 0.000 and KP 73.906.

7.2.2| BEDROCK AND HARD SEDIMENT

The proposed route crosses bedrock outcrops at several locations in UK waters. These are listed in Table 31.

Table 31 Outcropping bedrock along the proposed route.

Feature	KP start	KP stop
BEDROCK	2.216	2.222
BEDROCK	2.222	2.236
BEDROCK	2.380	2.403
BEDROCK	2.778	2.788
BEDROCK	4.874	4.997
BEDROCK	11.041	11.137
BEDROCK	24.178	24.202
BEDROCK	42.066	42.104

7.2.3| BOULDER FIELDS

The proposed route crosses boulder fields at several occasions in UK waters. These are listed in Table 32.

Table 32 Boulder fields along the proposed route.

Feature	KP start	KP stop
Occasional Boulders	11.497	11.574
Occasional Boulders	11.789	11.841
Occasional Boulders	16.003	16.123
Occasional Boulders	16.558	16.962
Occasional Boulders	17.839	18.135
Occasional Boulders	19.237	19.313
Occasional Boulders	19.430	19.588
Occasional Boulders	20.201	20.625
Numerous Boulders	20.625	20.949
Occasional Boulders	20.949	21.139
Numerous Boulders	21.139	21.309
Occasional Boulders	21.309	21.467
Numerous Boulders	21.467	21.512
Occasional Boulders	21.512	21.585

Feature	KP start	KP stop
Numerous Boulders	21.585	22.071
Occasional Boulders	22.071	22.532
Occasional Boulders	24.925	25.439
Occasional Boulders	33.915	34.368
Numerous Boulders	38.109	38.571
Occasional Boulders	53.137	53.468

7.2.4| MOBILE SEDIMENT

Mobile sediments are very common throughout the proposed corridor in UK waters. The mobile sediments are listed in Table 33.

Table 33 Mobile sediments along the proposed route, UK waters.

Feature	KP start	KP stop
Ripples	0.464	0.636
Ripples	2.267	2.380
Ripples	2.403	2.778
Ripples	2.788	2.863
Mega Ripples	3.188	3.195
Mega Ripples	3.330	3.367
Mega Ripples	3.596	3.747
Mega Ripples	4.502	4.660
Mega Ripples	4.997	8.841
Mega Ripples	8.841	9.404
Mega Ripples	9.404	11.041
Ripples	11.137	11.529
Ripples	11.841	11.937
Ripples	11.961	11.988
Ripples	12.103	13.421
Mega Ripples	22.373	22.402
Mega Ripples	22.532	22.900
Mega Ripples	23.533	23.821

Feature	KP start	KP stop
Mega Ripples	25.683	26.408
Sand waves	25.683	26.408
Ripples	26.482	26.802
Ripples	27.183	27.201
Ripples	27.213	27.260
Ripples	27.537	27.783
Ripples	27.855	29.061
Mega Ripples	29.061	29.136
Ripples	29.136	31.494
Ripples	32.684	33.429
Mega Ripples	33.429	33.915
Mega Ripples	34.368	34.988
Mega Ripples	35.060	35.094
Mega Ripples	41.848	41.900
Mega Ripples	41.933	42.066
Mega Ripples	42.299	42.424
Mega Ripples	48.233	48.722
Mega Ripples	48.873	49.068
Mega Ripples	49.136	49.822
Mega Ripples	49.822	50.022
Sand waves	50.051	50.212
Sand waves	50.279	50.390
Mega Ripples	50.390	53.070
Mega Ripples	53.468	53.634
Mega Ripples	53.734	54.254
Mega Ripples	55.248	55.301
Mega Ripples	55.471	55.906
Mega Ripples	56.461	57.985
Mega Ripples	58.113	58.395

Feature	KP start	KP stop
Mega Ripples	58.579	59.527
Mega Ripples	59.606	69.361
Sand waves	63.363	69.422
Mega Ripples	69.422	69.614
Sand waves	69.614	70.332
Mega Ripples	70.332	73.674
Sand waves	73.674	73.924

7.2.5| UNSTABLE SEDIMENT

No signs of unstable sediment were seen in the UK section of the proposed route.

7.2.6| ACOUSTIC BLANKING AND GAS SEEPAGE FEATURES

No acoustic blanking or signs of gas seepage was seen in the sediments along the UK parts of the proposed route.

7.2.7| CABLES AND PIPELINES

One cable crosses the proposed route in UK waters, the Pan European Crossing 2. It is buried at the crossing location. Details of the cable is given in Table 34. For detailed information, see the Cable Crossing Report (102953-GRL-MMT-SUR-REP-CABLECRE).

Table 34 Cables crossing the proposed route, UK waters.

Cable	Type of Cable	Owner	Depth of Burial BSB at Crossing Location	KP at Crossing Location
Pan European Crossing 2	In use cable	Century Link	0.2 m	59.791

Apart from this cable, a possible linear feature was detected during the UXO survey. It is seen at KP 6.325 (Figure 64). No correlation was seen, with either SSS or MBES contacts.

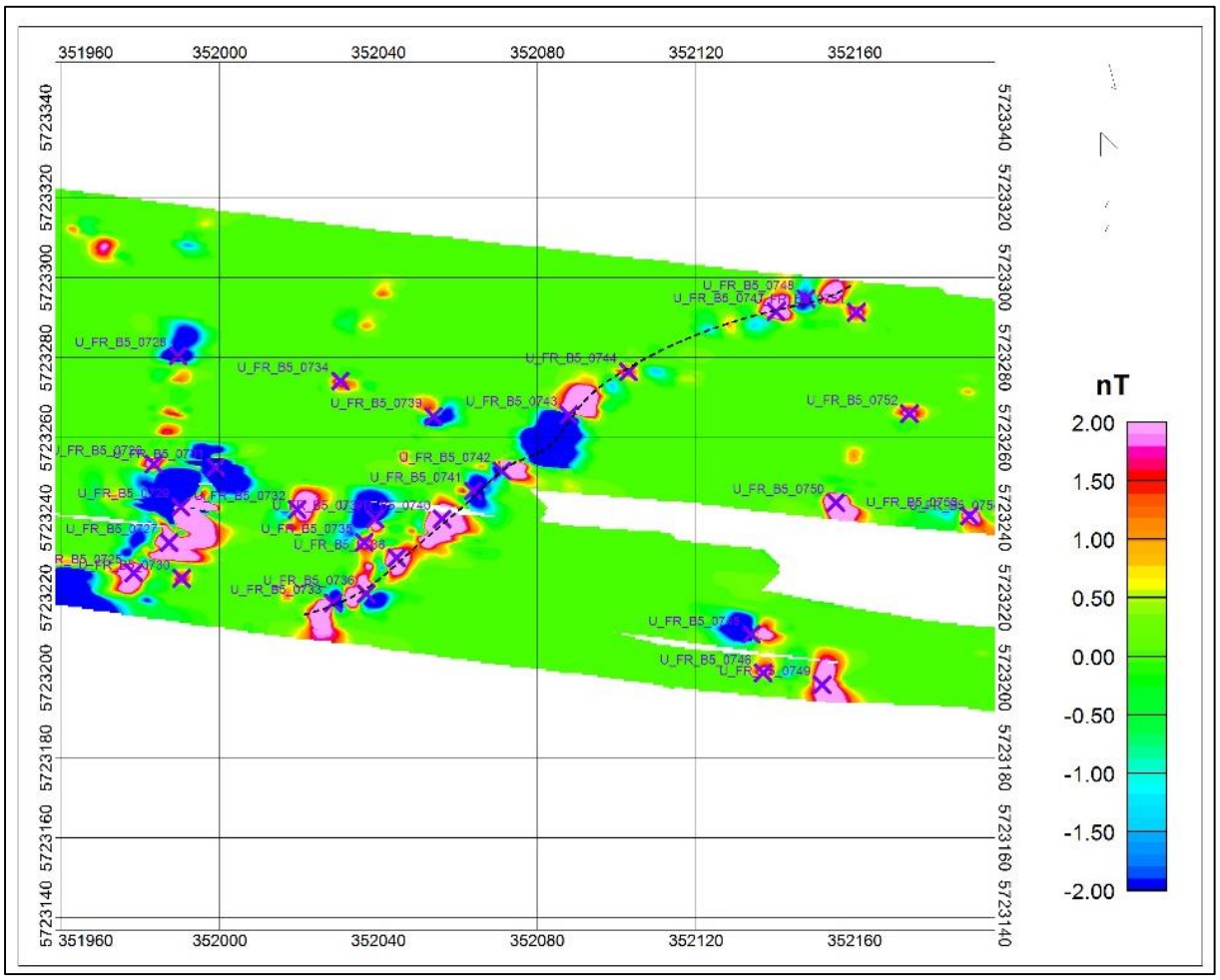


Figure 64 Linear magnetometer anomaly trend. Possible cable.

7.2.8| WRECKS

One SSS contact was confirmed as the previously known Saint Jacques wreck during the survey. This was located at KP 4.717, 248.6 m away from the proposed route, (Figure 65).

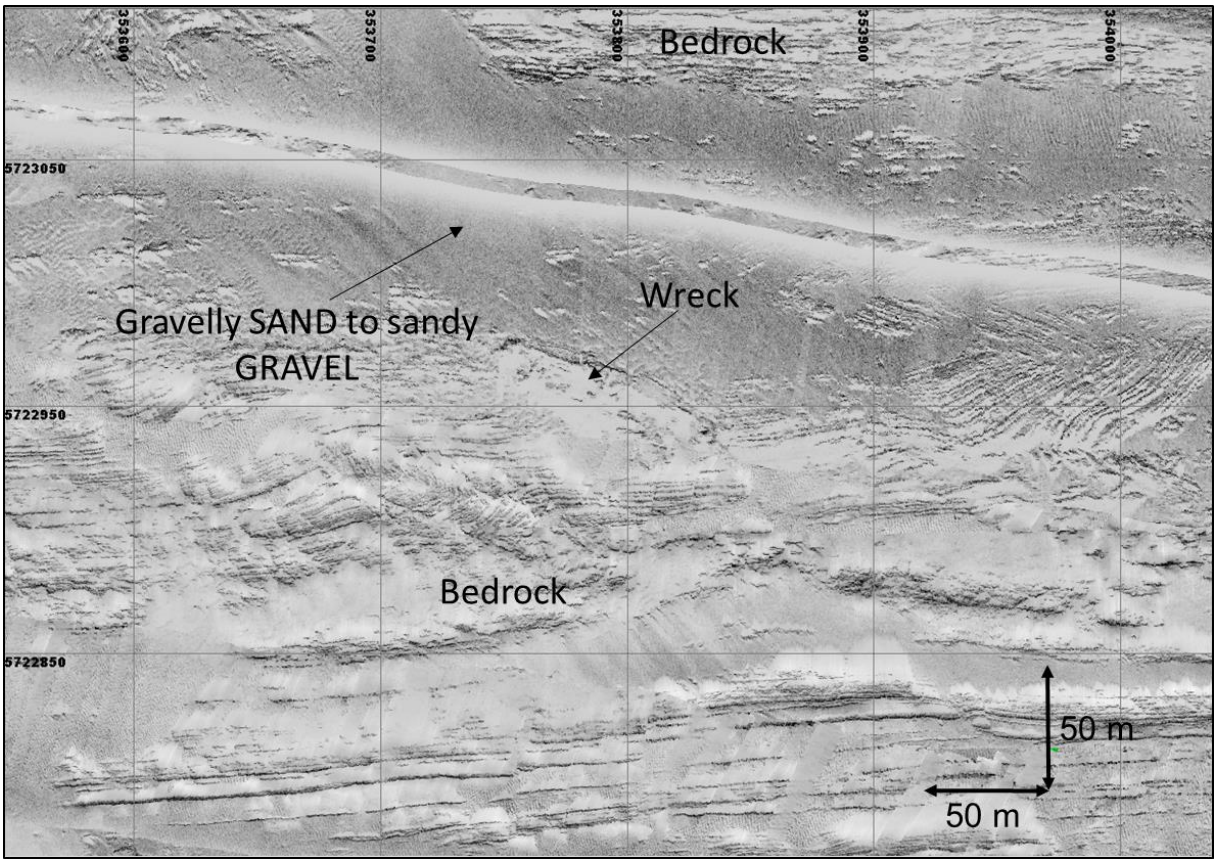


Figure 65 SSS plan view example from KP 4.717, south of proposed route.
Showing Saint Jacques wreck sitting on BEDROCK, near to areas of gravelly SAND and sandy GRAVEL. Image is north up

7.2.9| UXO

A total of 58 magnetic anomalies were detected in the UK nearshore UXO corridor. Of these, 17 were unclassified, 41 correlated with possible cables (Table 35).

No SSS contact positions correlated with detected magnetic anomalies.

Table 35 Summary of UK nearshore magnetic anomalies, route option RPL_09112018_Rev0..

CLASSIFICATION	NUMBER
Unclassified, possible objects	17
Possible cable correlation	41
Total	**58**

In the offshore UXO corridor, a total of 1051 magnetic anomalies were detected. Of these, 1041 were unclassified, 10 correlated with a possible cable (

Table 36).

A total of 23 SSS contact positions correlated with detected magnetic anomalies.

Table 36 Summary of UK offshore magnetic anomalies, route option RPL_09112018_Rev0.

CLASSIFICATION	NUMBER
Unclassified, possible objects	1041
Possible cable correlation	10
Total	**1051**

7.3| IRELAND

7.3.1| SEABED GRADIENTS

Gradients are generally very gentle or gentle but occasionally there are localised moderate slopes over rocky seabed (Figure 66).

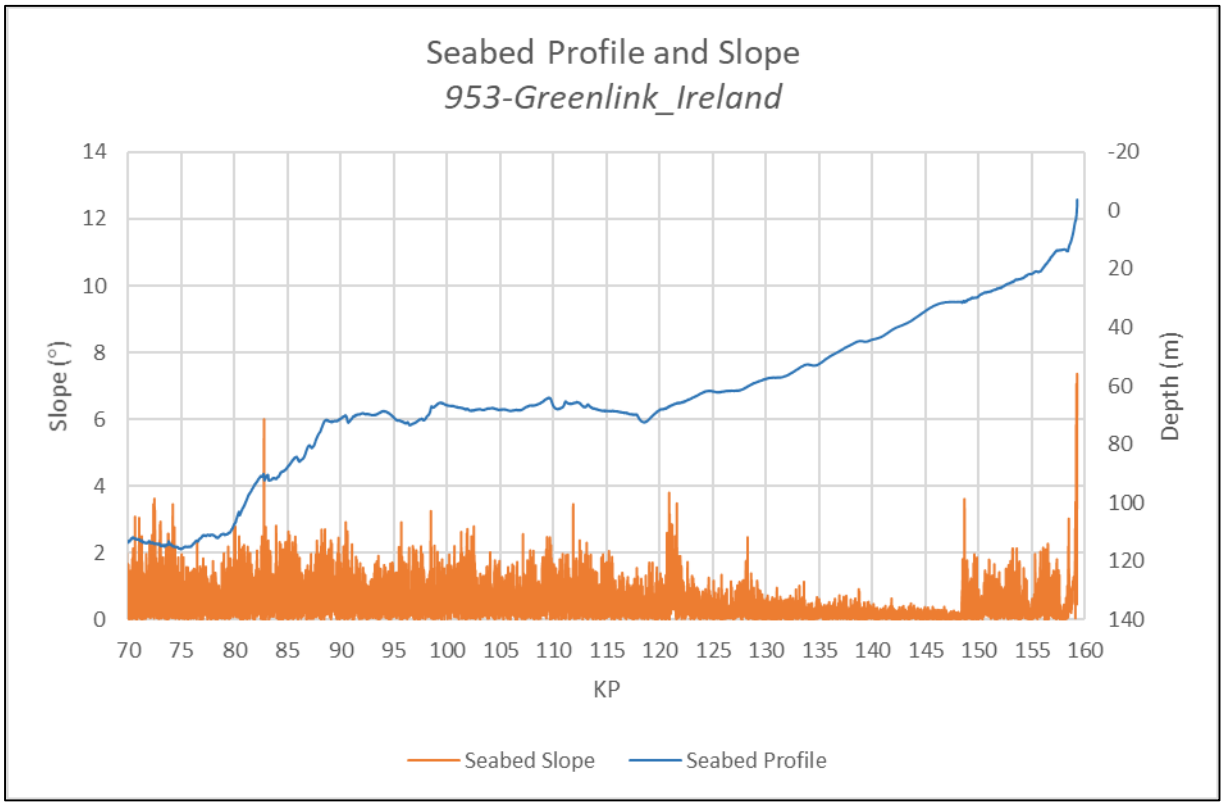


Figure 66 Seabed gradient and depth on the Final route in the UK, between KP 73.906 and KP 159.172.

7.3.2| BEDROCK AND HARD SEDIMENT

The proposed route crosses bedrock outcrops at several locations in Irish waters. These are listed in

Table 37.

Table 37 Outcropping bedrock along the proposed route.

Feature	KP start	KP stop
BEDROCK	158.387	158.395
BEDROCK	158.425	158.490
BEDROCK	159.071	159.078
BEDROCK	159.089	159.172

7.3.3| BOULDER FIELDS

No boulder fields are crossing the centre line in the Irish part of the proposed route.

7.3.4| MOBILE SEDIMENT

Mobile sediments are very common throughout the proposed corridor in Irish waters. The mobile sediments are listed in Table 38.

Table 38 Mobile sediments along the proposed route, Irish waters.

Feature	KP Start	KP Stop
Mega Ripples	73.924	79.241
Sand waves	79.241	79.305
Sand waves	79.392	80.158
Mega Ripples	80.310	80.485
Mega Ripples	80.582	89.082
Sand waves	82.607	83.267
Sand waves	89.082	89.098
Mega Ripples	89.098	89.125
Sand waves	89.125	89.146
Mega Ripples	89.146	89.167
Sand waves	89.167	89.200
Mega Ripples	89.200	89.213
Sand waves	89.213	89.245
Mega Ripples	89.245	91.171
Sand waves	90.484	90.592
Sand waves	91.171	91.483
Mega Ripples	91.483	92.289
Sand waves	92.289	92.342

Feature	KP Start	KP Stop
Mega Ripples	92.342	138.639
Sand waves	95.452	96.459
Sand waves	97.365	97.835
Sand waves	98.424	98.766
Sand waves	109.396	109.762
Mega Ripples	148.421	148.465
Mega Ripples	148.480	148.562
Mega Ripples	148.708	148.773
Mega Ripples	148.825	148.854
Mega Ripples	148.865	148.948
Mega Ripples	149.005	149.037
Mega Ripples	149.097	149.309
Mega Ripples	149.329	149.364
Mega Ripples	149.423	149.712
Mega Ripples	149.807	149.831
Mega Ripples	149.847	149.936
Mega Ripples	149.944	150.015
Mega Ripples	150.059	150.079
Mega Ripples	150.086	150.090
Mega Ripples	150.095	150.158
Mega Ripples	150.170	150.173
Mega Ripples	150.186	150.226
Mega Ripples	150.261	150.314
Mega Ripples	150.352	150.485
Mega Ripples	150.489	150.491
Mega Ripples	150.496	150.500
Mega Ripples	150.539	151.194
Mega Ripples	151.229	151.317
Mega Ripples	151.565	151.696

Feature	KP Start	KP Stop
Mega Ripples	151.721	151.734
Mega Ripples	151.739	151.749
Mega Ripples	151.763	151.769
Mega Ripples	151.786	152.126
Mega Ripples	152.333	153.287
Mega Ripples	153.333	153.796
Mega Ripples	154.003	154.037
Mega Ripples	154.066	154.352
Mega Ripples	154.360	154.364
Mega Ripples	154.380	155.166
Ripples	155.196	155.271
Mega Ripples	155.271	155.378
Mega Ripples	155.530	155.653
Mega Ripples	155.736	155.816
Mega Ripples	155.963	157.604

7.3.5| UNSTABLE SEDIMENT

No signs of unstable sediment were seen in the Irish parts of the proposed route.

7.3.6| ACOUSTIC BLANKING AND GAS SEEPAGE FEATURES

No acoustic blanking or signs of gas seepage was seen in the sediments along the Irish parts of the proposed route.

7.3.7| CABLES AND PIPELINES

Five cables cross the proposed route in Irish waters. All of them are buried at the crossing location. Details of the cables are given in Table 39. For detailed information, see the Cable Crossing Report (102953-GRL-MMT-SUR-REP-CABLECRE).

Table 39 Cables crossing the proposed route, Irish waters

Cable	Type of Cable	Owner	Depth of Burial BSB at Crossing Location	KP at Crossing Location
Hibernia Atlantic Seg D	In use cable	GTT Communications	0.3 m	86.700
Pan European Crossing 1	In use cable	Century Link	0.1 m	95.935

Cable	Type of Cable	Owner	Depth of Burial BSB at Crossing Location	KP at Crossing Location
ESAT 1	In use cable	BT Ireland Communications Ltd	0.7 m	102.513
SOLAS	In use cable	Eircom and Vodafone	0.4 m	121.535
CELTIC	Inactive HVDC cable	BT	0.2 m	139.098

7.3.8| WRECKS

No wrecks were found along the Irish part of the proposed route.

7.3.9| UXO

No UXO survey was performed in the Irish part of the proposed route.

8 | CONCLUSIONS

Greenlink Interconnector Limited, proposes to develop an interconnector, which will allow transfer of power between the high voltage grid systems of the UK and the Republic of Ireland. Greenlink will connect to the United Kingdom (UK) National Grid system at Pembroke substation in Pembrokeshire, United Kingdom and to the Irish network at Great Island substation in County Wexford, Ireland.

MMT conducted a topographic, geophysical, geotechnical, benthic, land seismic and, within the Castlemartin Firing Range, an Unexploded Ordnance (UXO) survey for the proposed routes. The following datasets were collected from hull mounted, pole mounted and towed platforms on different vessels: multibeam echo sounder (MBES), side scan sonar (SSS), sub-bottom profiler (SBP) and magnetometer. An unmanned aerial vehicle (UAV) was used for the topographic survey. The data sets were analysed and correlated to draw conclusions regarding seabed and sub-seabed conditions, obstructions and installation constraints. The survey corridor was 500 m wide and divided into 6 blocks covering nearshore and offshore areas. Geotechnical sampling was completed using Vibrocorer (VC) and Piezo Cone Penetration Testing (PCPT). Geotechnical locations were placed every 1.5 km and co-located. Benthic sampling sites were selected based on preliminary geophysical interpretations, corresponding to areas of potential sensitive habitats and reef formations. A total of 38 locations were visited, the survey consisting of an initial photograph using a drop down video camera (DDV) followed by three grab samples at each site.

The survey was conducted in a safe manner and good quality data was acquired throughout. The survey was conducted in three sections; the onshore topographic and land seismic surveys, the nearshore survey and the offshore survey.

Seabed gradient and slopes are generally gentle with the exception of some areas of mobile sediment with sandwaves and some bedrock outcrops crossed by the currently proposed route. The maximum water depth Lowest Astronomical Tide (LAT) along the route was 127.8 m and 130.0 m within the corridor, where a bathymetric trough was encountered approximately in the middle of the route. The unexploded ordnance (UXO) survey covered a 100 m wide corridor within the Castlemartin firing range.

The seabed sediments along the proposed route and within the survey corridor are interpreted to mainly comprise granular sediments such as SAND and GRAVEL, and mixtures in between. The surficial sediments form mobile sediments, ripples to sandwaves, along the majority of the route. BEDROCK is found outcropping and subcropping mainly in the UK and Ireland nearshore as well as the first 43 km of the route, approximately. Areas of occasional and numerous boulders are usually present in the vicinity of out- and subcropping BEDROCK. From the shallow geology interpretation, it can be concluded that the surface SAND is commonly gravelly to silty and is present as a generally 0.5 – 3.0 m thick unit throughout large parts of the route.

The TILL comprise mainly gravelly, sandy silty CLAY which generally is of higher strength closer to the UK landfall and of low to medium strength closer to the Irish landfall. Where TILL is present close to seabed, it is generally covered by a veneer of mobile sediments consisting of SAND to GRAVEL, where the finer sediment fraction is winnowed by current activity. The boundary between TILL and BEDROCK is not always resolved in the seismic data due to limited penetration or the presence of coarser sediment.

There are a number of factors based on geophysical results for cable protection within the survey corridor that should be considered during planning of the final cable route.

- Presence of shallow dense to very dense material along the route.
- Presence of COBBLES and coarse GRAVEL along the route.
- Seabed gradients and mobile sediments.
- Cables and pipeline crossings should be made as perpendicular as possible.

- Fishing needs to be considered as it is associated with high risks to the cable if not buried sufficiently. Trawl scars were observed mainly in UK waters. Fishing gear was also present during the survey in both UK and Ireland.
- Since part of the route in UK waters is within an artillery range zone, the performed UXO survey can only be considered valid for the time of the survey and future changes are highly likely. This is due to Castlemartin being an active defence training area with permission to fire live rounds into the sea.
- Fields of occasional or numerous boulders increase the risk of cable suspension and damage to trenching equipment.

The possible presence of sub-surface boulders should be considered.

9 | RESERVATIONS AND RECOMMENDATIONS

The information presented in this report is based on the interpretation of both geophysical and geotechnical data acquired during the course of the survey project. This interpretation and subsequent geophysical, geological and geotechnical findings described here are based on the requirements and scope of work contained within the Contract documentation. Whilst this report has been prepared with considerable due care and diligence, MMT AB of Sweden, or any other named party involved in the preparation of this report, cannot be held responsible, or be liable for any use of this report for purposes which do not form part of the specific Contract requirements.

The interpretation, discussion, and any geophysical or geological/geotechnical conclusions presented here are not exhaustive and reference should be made to the relevant survey records, together with the specific laboratory testing results provided. The selection of an installation methodology or construction technique, and the likely operational risks inherent in using a particular technique, are beyond the scope of this report. Any end-user of this report must satisfy themselves of the appropriateness of the results presented. This report considers the ground conditions along the proposed route at the time of survey. Inherent natural variation, or subsequent changes to the seabed or shallow sub-surface ground conditions can affect the reliability of data presented here. Decisions relating to future installation and construction methods must consider any changes in ground, site, regulatory, technological or economic conditions subsequent to the date of issue of this report. Distribution of this report, in whole or part, or the use of the data for a purpose not expressly stated within the contractual work scope or specified at the time of report issue is at the client's sole risk.

MMT's recommendations for further planning, within the survey corridor area of the Greenlink cable route, are:

- Route planning to avoid outcropping bedrock.
- The UXO results can only be seen as valid at the time of the survey, as part of the route are located with the Castlemartin designated artillery range zone where future deposition of UXOs is possible. This is further discussed in the UXO report (102953-GRL-MMT-SUR-REP-UXOREP).
- For future surveys and installation, the exposed location of the cable route to the North Atlantic with regard to wind and waves should be taken into consideration.

APPRENDICES

APPENDIX A | ROUTE POSITION LISTS

APPENDIX B | CONTACT AND ANOMALY LIST

APPENDIX C | LIST OF CHARTS

APPENDIX D | GEOTECH LOCATIONS

APPENDIX E | TERRADAT REPORTS

APPENDIX F | 4D OCEAN ORTHOPHOTOS