Morlais Demo Zone (MDZ) Hydrographic & Geophysical Survey

P1830

Volume 2 – Survey Report

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EXECUTIVE SUMMARY

Partrac were commissioned by Mentor Môn to undertake a detailed multi-beam echo sounder, side scan sonar, magnetometer and single channel seismic hydrographic and geophysical survey of the Morlais Demonstration Zone (MDZ). Located to the west of Holy Island, Anglesey, the survey site consists of a 10.3km x 7.4km area (including 1km buffer).

The aim of the survey campaign was ultimately to inform the planned Environmental Impact Assessment (EIA) process, specifically to inform further studies and assessments for receptors including; Physical Processes, Benthic Ecology and Marine Archaeology. This was achieved through a single pass survey campaign along a pre-agreed line plan, extending across the defined area and 1 km buffer zone up to the 10m CD contour. Where vessel safety allowed, the survey was extended up to the 5m CD contour, along the eastern coast, except for within the area known as "Abraham's Bosom". The shallow extents of the landing area within "Abraham's Bosom", was mapped to the 0m CD contour or as far inshore as possible without compromising vessel safety.

Chart Datum water depths across the site range from -1.7 metres at the landfall to 80 metres in the north west of the site, with an average depth across the main site of approximately 40 metres.

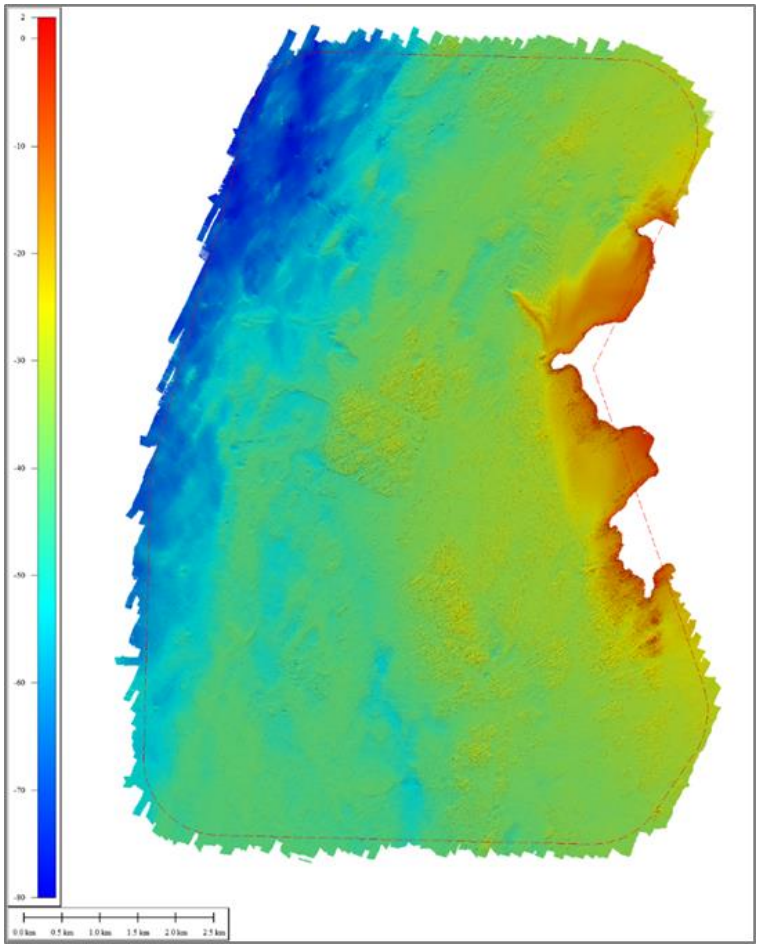

Figure 1 – Multibeam data results and site boundary, including buffer (red dash).

The seabed is dominated by outcropping Rock at surface and coarse sediment types such as Gravel, with consistent Boulders overlaying. This sorted Glacial Till overburden is a characteristic nature of seabed of high energy tidal environments. This coarse sediment is generally a shallow overburden, except in the west and southwest of the site where the Rockhead clearly dips away and sediment cover can increase to almost 30m below the surface, these deeper patches do not uniformly form a channel and highlight the complex, uneven geology that is seen where Rock is at surface (and mirrored on land). Throughout the site, megaripple features occur sporadically and can be seen to migrate slightly even during the survey period. However, as the site shallows to the east and reaches either the cliff face or the bays that make up the local coast line, clearly defined lines of sediment deposition are observed. 'Abraham's Bosom', understood to be the potential landing site, has an almost linear deposition of finer material across the entrance and this can be 7m deep in parts, within the bay itself the finest of the materials (Sands, potentially with Silt content) exist. Similarly, the bay north of 'South Stack' has clearly defined Sandy sediment deposits and, most notably, immediately north of 'South Stack' a large sand wave/ridge feature exists which is up to 10m above the surrounding seabed level.

The survey has identified several suspected anthropological features, potentially significant to the project. A total of five listed wrecks were expected prior to survey and these have all been positively identified, as far as they can be with this survey methodology (specialist analysis and video investigation may be required to be categorically confirmed). These have been confirmed with a mixture of side scan, multibeam and magnetometer datasets. In addition to these five targets a further eleven discrete magnetic targets were identified, which do not correlate with any further surface targets identifiable in the data. There were no additional, unidentified discrete surface targets picked during this survey. A series of extensive linear targets were clearly mapped across the breadth of the site, predominantly from the magnetometer dataset, but a single section of linear target could be correlated with the side scan and multibeam data. Although there is a small potential these linear targets could have a geological origin, the conclusion drawn with the information available, is that these are likely to be historical and redundant cables that do not feature on modern charts. Further desk-based study is suggested to confirm this theory.

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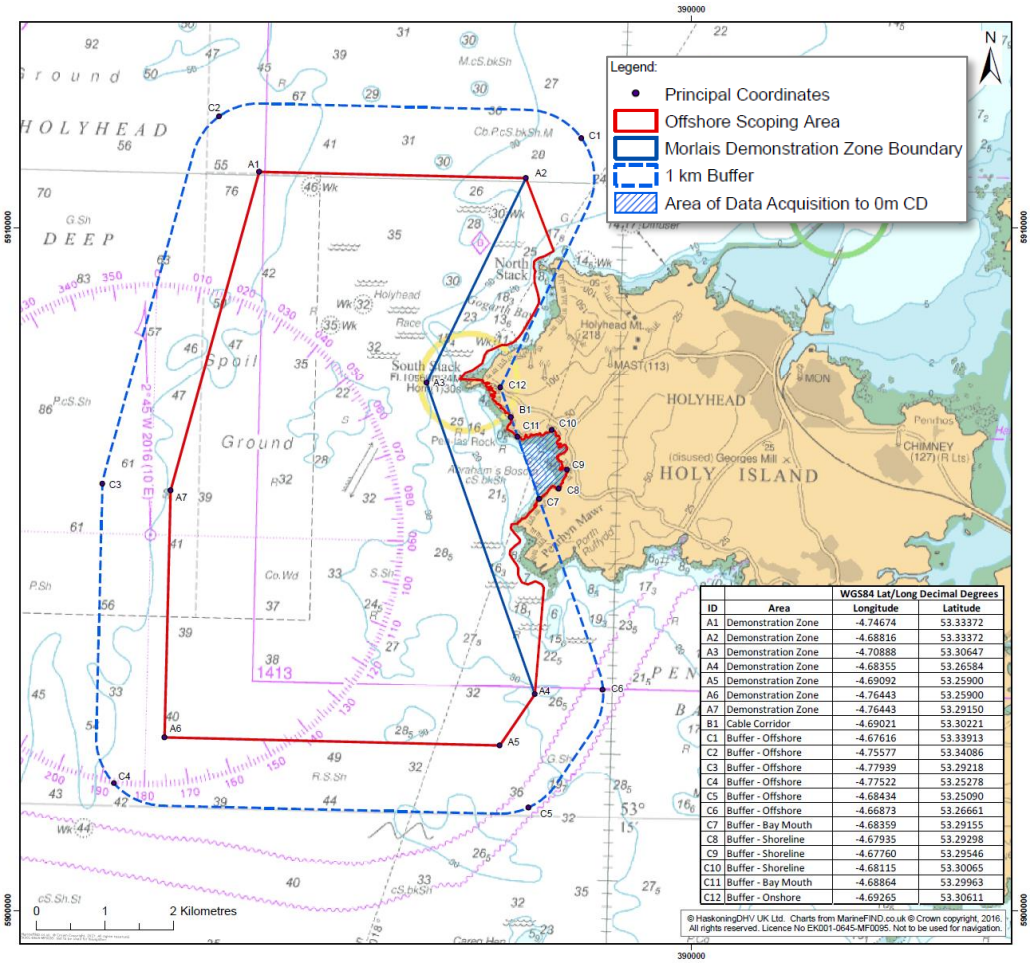
Abbreviations

AUV	Autonomous Underwater Vehicle
CD	Chart Datum
CPS	Cable Protection System
CTV	Crew Transfer Vessel
dGPS	Differential Global Positioning System
DTM	Digital Terrain Model
DVL	Doppler Velocity Log
ETRS	European Terrestrial Reference System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
IAC	Inter Array Cable
IHO	International Hydrographic Organisation
INS	Inertial Navigation System
IMU	Inertial Motion Unit
ITRF	International Terrestrial Reference Frame
LAT	Lowest Astronomical Tide
MBES	Multi-Beam Echo Sounder
MRU	Motion Reference Unit
MSL	Mean Sea Level
OD	Ordnance Datum
OSP	Offshore Substation
OWF	Offshore Wind Farm
QC	Quality Control
RAMS	Risk Assessed Method Statement
RTCM	Radio Technical Commission for Maritime Services
RTK	Real Time Kinematic
SBAS	Satellite-based augmentation systems
SD	Standard Deviation
THU	Total Horizontal Uncertainty
TVU	Total Vertical Uncertainty
USBL	Ultra-Short Baseline (underwater positioning)
UTM	Universal Transverse Mercator
VME	Vessel Mounted Echo sounder
VORF	Vertical Offshore Reference Frame
WGS	World Geodetic System
WTG	Wind Turbine Generator

1. INTRODUCTION

1.1 Operational Summary

Partrac were commissioned by Mentor Môn to undertake a detailed multi-beam echo sounder, side scan sonar, magnetometer and single channel seismic hydrographic and geophysical survey of the Morlais Demonstration Zone (MDZ). Located to the west of Holy Island, Anglesey, the survey site consists of a 10.3km x 7.4km area (including 1km buffer) (Figure 2).



		WGS84 Lat/Long Decimal Degrees	
ID	Area	Longitude	Latitude
A1	Demonstration Zone	-4.74674	53.33372
A2	Demonstration Zone	-4.68816	53.33372
A3	Demonstration Zone	-4.70888	53.30647
A4	Demonstration Zone	-4.68355	53.26584
A5	Demonstration Zone	-4.69092	53.25900
A6	Demonstration Zone	-4.76443	53.25900
A7	Demonstration Zone	-4.76443	53.29150
B1	Cable Corridor	-4.69021	53.30221
C1	Buffer - Offshore	-4.67616	53.33913
C2	Buffer - Offshore	-4.75577	53.34086
C3	Buffer - Offshore	-4.77939	53.29218
C4	Buffer - Offshore	-4.77522	53.25278
C5	Buffer - Offshore	-4.68434	53.25090
C6	Buffer - Offshore	-4.66873	53.26661
C7	Buffer - Bay Mouth	-4.68359	53.29155
C8	Buffer - Shoreline	-4.67935	53.29298
C9	Buffer - Shoreline	-4.67760	53.29546
C10	Buffer - Shoreline	-4.68115	53.30065
C11	Buffer - Bay Mouth	-4.68864	53.29963
C12	Buffer - Onshore	-4.69265	53.30611

Figure 2 – General location map (OffshoreSurveyArea_RH_20180404).

The site was accessed directly from the vessel's operational base at Holyhead Port within a one-hour transit time and all works were conducted during daylight hours.

The aim of the Morlais Demonstration Zone is for the development of tidal array projects. The zone will be used for test and demonstration centre and as a commercial development. Data collected will be used to characterise the site for the purposes of the Environmental Impact Assessment (EIA) process, and to inform further studies and assessments for receptors including:

- Physical Processes;
- Benthic Ecology; and
- Marine Archaeology.

To meet these objectives, a combined marine hydrographic and geophysical survey was conducted. The following techniques were employed during the survey:

- Multibeam echo sounding
- Side scan sonar
- Single channel marine seismic reflection profiling (boomer)
- Magnetometer

Survey operations were conducted between the 17th April and 19th May 2018 aboard the survey vessel *Norse*, operated from the port of Holyhead on a 12-hour basis. A full and detailed Operational Report forms Volume 1 of this report.

This volume (Volume 2) presents the survey results and charts, and details the processing completed together with a comprehension of the survey results.

2. RESULTS

2.1 Introduction

The following survey charts can be found in Appendix 1 to this report. All charts are provided at a scale of 1:10,000.

Chart No.	Chart Title
P1830/V2/001	Seabed Levels Chart
P1830/V2/002	Combined Seabed Features Chart
P1830/V2/003	Side Scan Sonar Mosaic
P1830/V2/004	Isopachyte to Horizon R1

Table 1 – Charts associated with this volume.

The following is a summary of the results presented on the charts and a general interpretation of the data for consideration in the Client's pending Environmental Impact Assessment report and further studies.

2.2 Bathymetric Results

The results of the bathymetry survey are presented on drawing P1803/V2/001 as a colour shaded relief image chart with contours overlaid. The shaded relief image has been generated from the 0.5m DTM resolution dataset, whereas the contours have been produced from a lower resolution DTM and are an indication of bed levels throughout the area.

Charted depths range from 0m Chart Datum (where safe vessel access was achievable) to 80m in the north west extremity of the site with mean average depths of 40m below Chart Datum. The seabed comprises large areas of outcropping bedrock with minimal relief above surrounding bed levels indicating horizontal bedding planes generally parallel to the seabed.

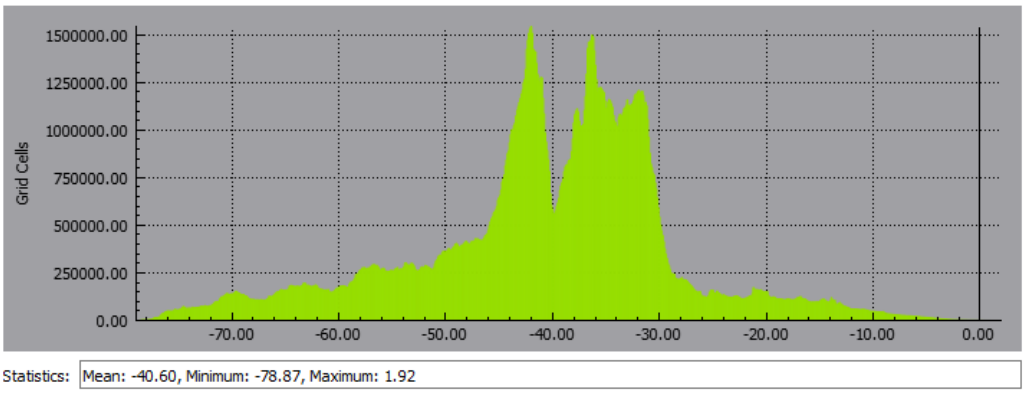


Figure 3 – Bathymetry Depth Histogram (0.5mBin).

Areas of outcropping rock are interspersed with pockets of coarse grained sediments which exhibit geomorphological features conducive to sediment mobility as expected in an area with high current velocities. The outcropping Rock contains many striations caused by an abundance of bedding planes (Figure 4).

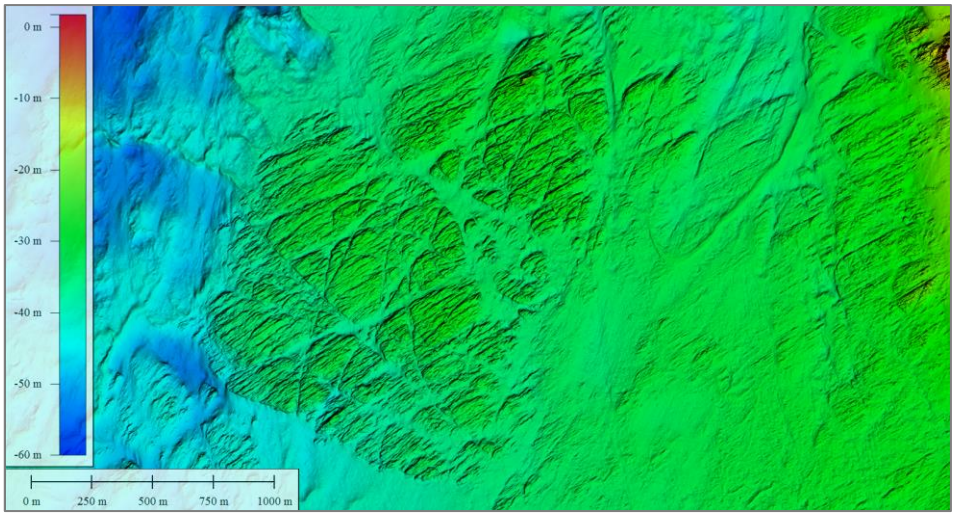


Figure 4 – Offshore rock outcrop data example.

Nearer to shore and away from the main tidal flow, several larger geomorphological features are evident, most notably a large sand wave feature near to 'South Stack' which extends to the northwest for approximately 1km. Bed levels either side of this feature are approximately 8 to 10m different in height either side of the ridge, with bed levels deeper on the southwest side. This ridge is generally symmetrical in profile. Several smaller ridge features run parallel to the main ridge, extending to the north-north-east. Immediately to the northeast of the primary ridge, there appears to be a large sediment deposition zone associated with 'Gogarth Bay'. These features are highlighted in Figure 5 below.

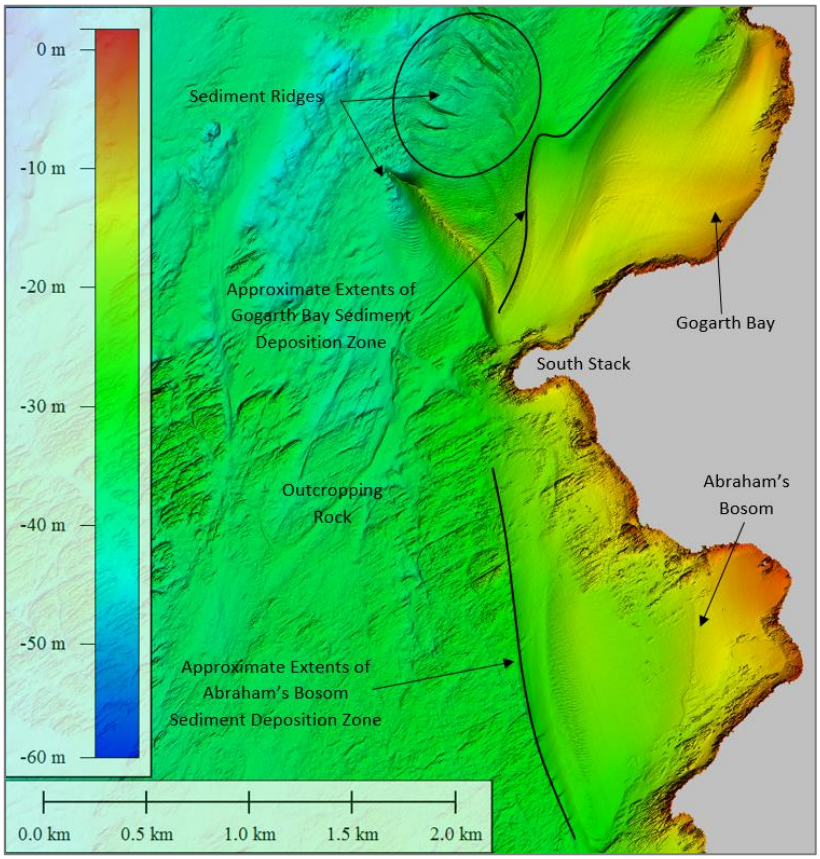


Figure 5 – Inshore geomorphological features.

Within the area known as 'Abraham's Bosom', data coverage was maximised as far inshore as safe navigation allowed, and it is understood that this area has been selected as a potential cable landfall. This area exhibits considerably lower tidal currents resulting in sediment deposition which appear from the data to be generally less coarse than the sediments located offshore and within higher current velocities. Rock outcrops remain visible to the north and south of the main bay.

Several potentially anthropogenic features are evident within the dataset consisting of both linear targets and evidence of previously charted wrecks and/or debris. These are shown in detail on chart P1830/V2/002, Combined Seabed Features, and examples are presented below.

Within the overall dataset several linear features are visible through the site, however only one can be seen on the bathymetric data, running north west to south east off the southern aspect of 'South Stack' towards a potential landing in somewhere north of 'Abraham's Bosom'. This feature does appear on the magnetic survey results, but does not correlate with a charted cable, where the nearest charted cable is the "BT-TE1 (Out of Service)" cable which passes to the south of the site and lands at Porth Dafarch.

	Easting	Northing	Length (m)
A	386510.8	5907618.6	159
B	386648.3	5907546.4	

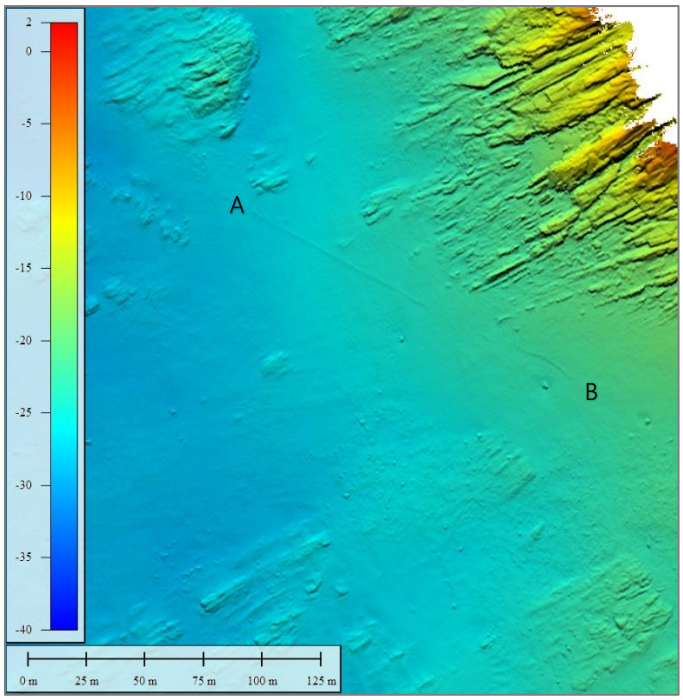


Figure 6 – Linear target (SW of South Stack)

From the publicly accessible information for the region there are up to 5 wrecks classified as 'live' that lie within the offshore site. Only two of these appear on general marine charts for the area. The details of this public information is as described in Table 2 and Figure 7, and the survey findings on an individual location basis are described in Figures 8-12.

ID	Name	Published Position	Published Depth	Published Dimensions (LxWxH)	Published 'Comment'
7144	Harold	53°18.720' N 004°41.512' W	14.5m max, 11.38m min	22.6m x 5.6m x 3.1m	Strong magnetic anomaly. Single boiler and small part of stern recognisable. Apparently salvaged (2013)
7228	Maarten Cornelius	53°19.002'N 04°43.394'W	41m max, 32m min	35.7m x 8.1m x 8.2m	NL fishing vessel sunk in 1971. Found intact with masts still standing up to 4m above main wreck. 5m scour hole (2014)
81389	Unknown	53°18.758'N 04°43.906'W	38m max, 35.4m min	24.4m x 6.3m x 3.4m	Bows partially collapsed and buried. Midships boiler highest point. (2014)
81387	Unknown	53°19,921'N 04°44,119'W	57m max, 46 min	23.6m x 12m x 10.5m	Possibly only keel and single boiler remaining (2014)
81388	Unknown	53°19,921'N 04°44,119'W	36m max, 30m min	63m x 22.8m x 5.93m	Two boilers evident. Fully collapsed and degraded (2014)

Table 2 – Offshore 'live' wrecks.

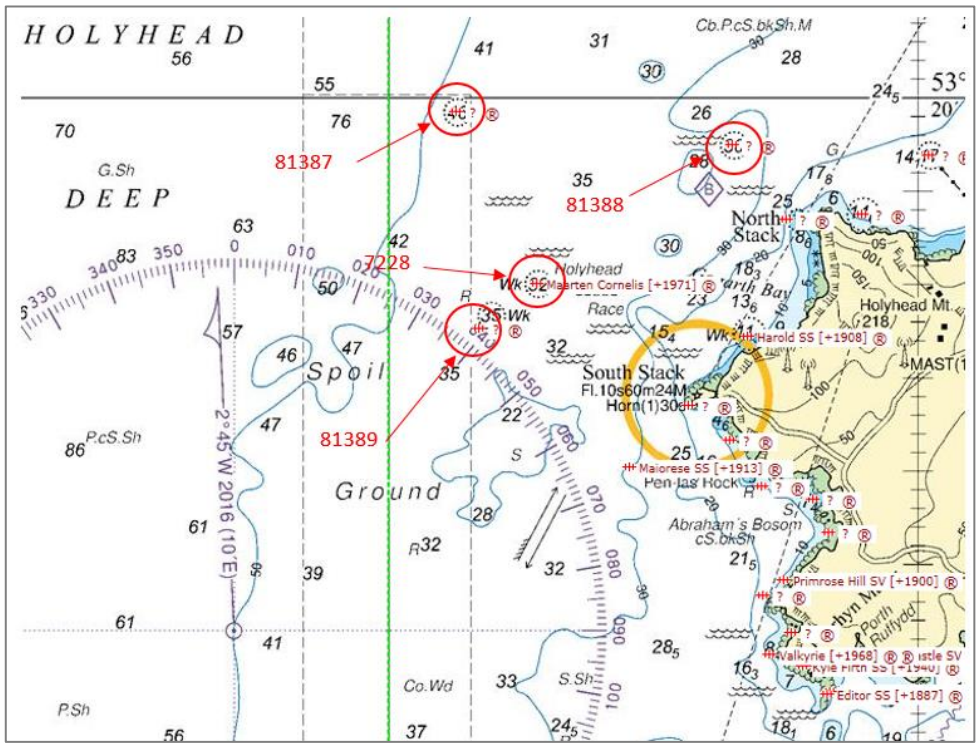


Figure 7 – Extract of 'Offshore' live wrecks within survey area (ref: https://www.wrecksite.eu/)

Of all the wrecks listed above, the most prominent in the data is the Maarten Cornelius:

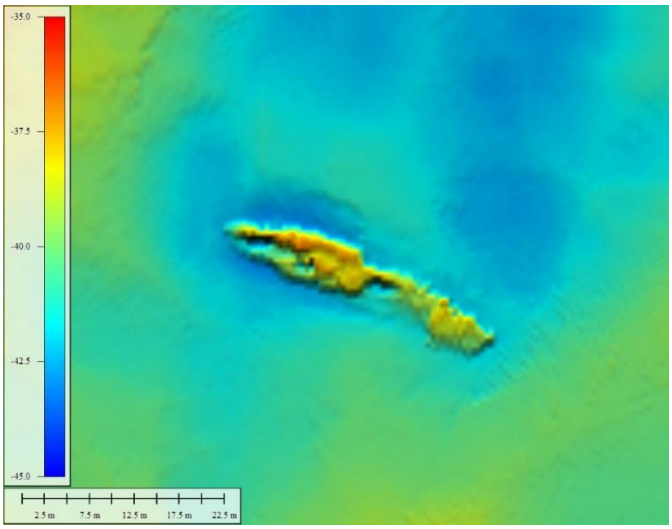
UKHO Wreck Number: 7228 Name: Maarten Cornelius As-found dimensions: 32.3mx5.4m As-found Height: 4.0m As-found orientation: 291° Position: 385205mE, 5908886mN Comment: Vessel shaped with clear scour pit. The target does provide a magnetic anomaly.	

Figure 8 – Data example of the Maarten Cornelius wreck.

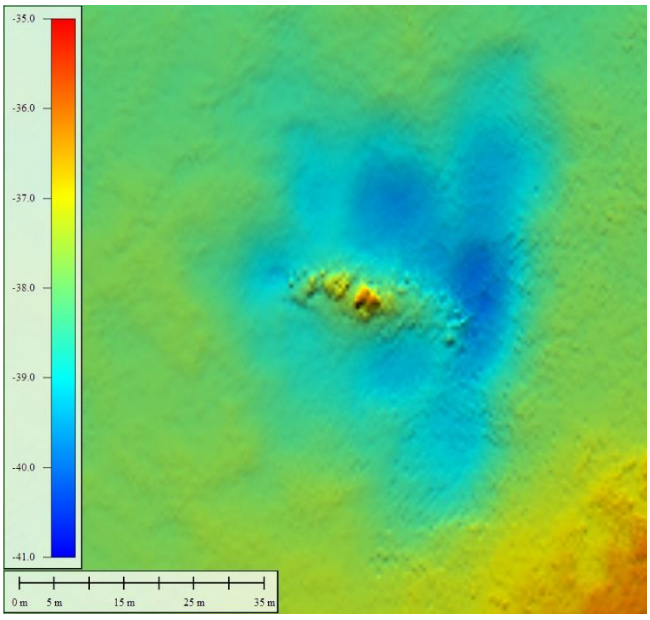
UKHO Wreck Number: 81389 Name: Unknown As-found dimensions: 27.5m x 7.1m As-found Height: 3.5m As-found orientation: 287° Position: 384626mE, 5908447mN Comment: No magnetometer reading over this target.	

Figure 9 – Data example of unknown wreck 81389.

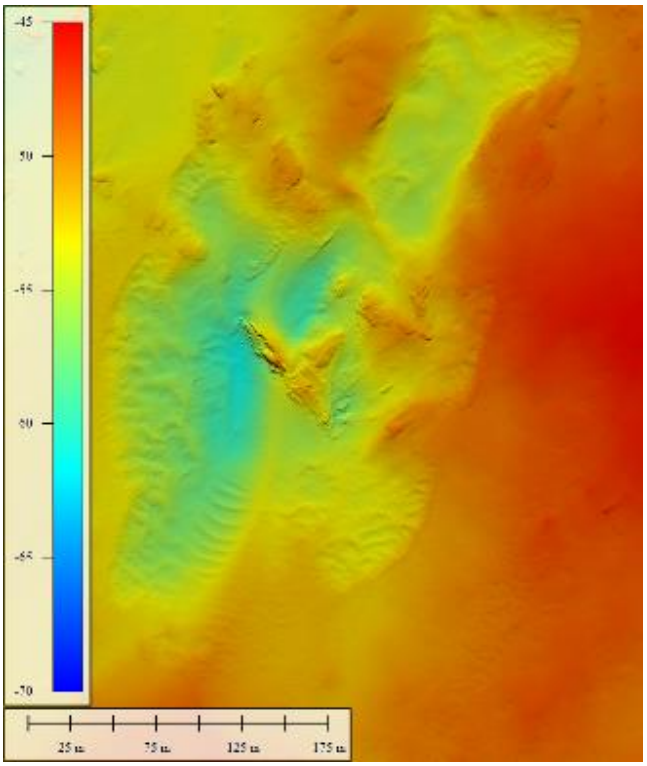
UKHO Wreck Number: 81387 Name: Unknown As-found dimensions: 89.5m x 14m As-found Height: 8m As-found orientation: 318° Position: 384442mE, 5910609mN Comment: Clearly a cause of scour, but no obvious wreck features in data. The target does provide a magnetic anomaly.	

Figure 10 – Data example of unknown wreck 81389.

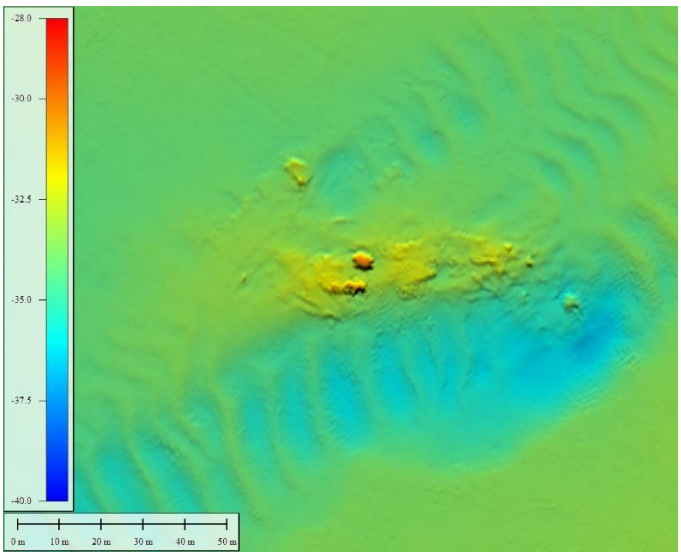
UKHO Wreck Number: 81388 Name: Unknown As-found dimensions: 65m x 14m As-found Height: 3.8m As-found orientation: 262° Position: 387178mE, 5910215mN Comment: Has the shape of a broken up wreck and what has been reported as 2 boilers can be seen clearly in data. A magnetic anomaly can be seen on this target.	

Figure 11 – Data example of unknown wreck 81388.

UKHO Wreck Number: 7144

Name: Harold

As-found dimensions: 25m x 12m

As-found Height: 1.7m

As-found orientation: ~149°

Position: 387283mE, 5908313mN

Comment:

A magnetometer anomaly can be seen on this target. What has been described as a boiler, on Admiralty database, is the most distinguishing feature in the bathymetry data.

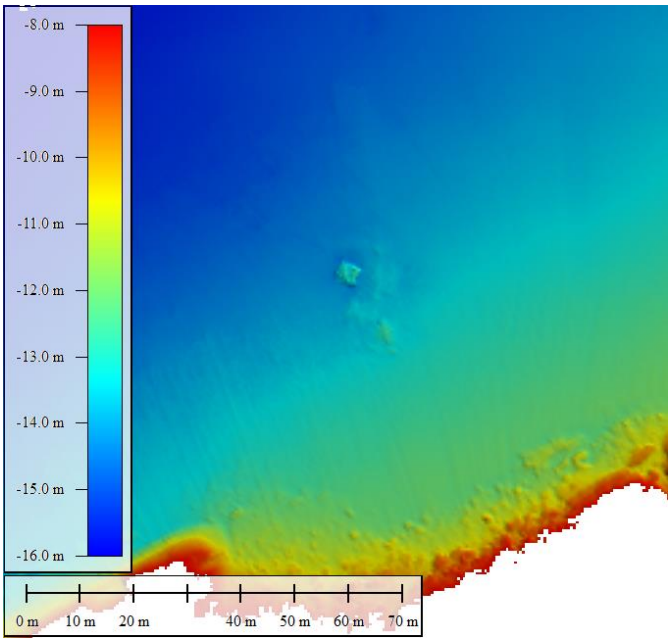


Figure 12 – Data example of the Harold wreck 7144.

2.3 Side Scan Sonar Results

Throughout most of the northern, central and eastern parts of the site the surface is dominated by the outcropping Rock and side scan sonar records correlate well with the obviously visible outcrops in the bathymetric data. Sandy Gravels generally make up the sediment patches that overlay the Rock that dominates the surface characteristic of the site. Throughout the deeper, western part of the site there is a relatively uniform Gravel or gravelly Sand surface material, with small areas of outcropping Rock to the north and localised megaripples to the south. Along the north western boundary of the site, small areas of Rock outcrops at the surface and there is an increase in grain size, meaning the Gravels that dominate the seabed may have coarser material contained within.

Away from the areas where Rock outcrops at the surface the material type appears to be uniformly coarse across the extent of the site, except for the bay areas. This consistent Gravel and Gravelly Sand is regularly interspersed with patches of clearly defined megaripples. As presented on the Combined Seabed Features chart (see also Figure 13 below), the megaripple orientation varies as the tidal flow moves along the coastline. The chart presents the general size, separation and orientation of the megaripples in each area. The mobility of these cannot be assessed as this is the initial survey data for the site, however, any mobility will be perpendicular to the megaripple crest orientation in normal conditions.

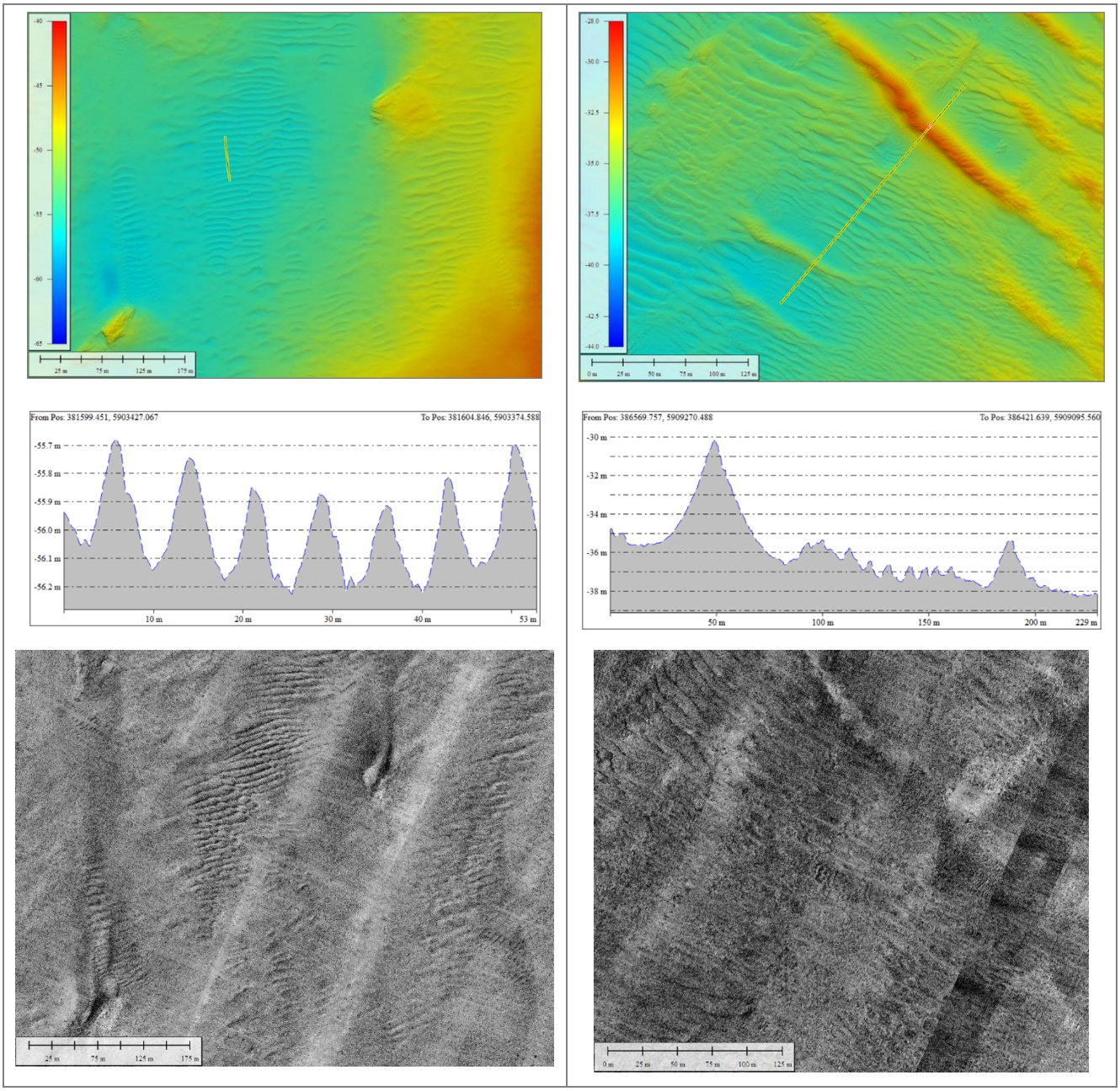


Figure 13 – Data example (MBES & SSS) of megaripples in both shallow and deeper water.

Within the shallower bay areas of the site, clear lines of lower tidal/current energy can be defined as finer sediments are deposited. The bays generally consist of Sandy Gravel or Coarse Sand and in the case of the shallow waters within 'Abraham's Bosom' the coarseness reduces further as the bay shallows up; this fine Sand (potentially Sandy Silt) area can be clearly defined on the side scan sonar records. As the survey boundary reaches the cliff face throughout the western extent, the Rock pinnacles and outcrops dominate the data. In localised gullies there are mixed seabed material and boulders clearly present. This material originating from the dynamic conditions of low current speeds allowing deposition of fine materials together with high energy wave impact breaking off boulders from the cliff face; the

nature of this material in these localised gullies would be representative of Glacial Till but further investigation in these shallow sites would be required to confirm the exact lithology.

Boulders are identified over almost the entire offshore area of the survey site, ranging in size from approximately 0.2m to 1.5m. With the exception of the wrecks and the single linear feature detailed within Section 2.2 above, there are no additional anthropological targets visible on the side scan sonar.

Five live wrecks are listed for the site, but these are generally undefinable in the side scan sonar records and have been defined using a combination of side scan, magnetometer and multibeam data. Full details presented in Section 2.2, above.

A Combined Seabed Features chart is presented in chart P1830/V2/002 and a Side Scan Sonar Mosaic in chart P1830/V2/03.

2.4 Magnetometer Results

Within the resultant residual magnetic field data, 16 no. discrete targets were identified (Table 3). In four cases these targets can be directly attributable to reported wrecks, as detailed above. However, 11 no. additional magnetic targets were found which could not be correlated with a visible surface target.

Id	Easting	Northing	Residual Magnetic Field Anomaly magnitude (nT)	Target
Mag_01	382624.4	5910243	66.1	Unknown
Mag_02	384474.8	5910609	314.1	Wreck - 81387
Mag_03	384328.1	5903675	48.8	Unknown
Mag_04	384730.4	5904803	74.9	Unknown
Mag_05	385047.5	5905742	41.3	Unknown
Mag_06	384979.0	5901264	85.0	Unknown, Located just outside of survey boundary
Mag_07	387277.8	5908454	-1598.9	Section of wreck 7144 Harold? 115m North of the Harold
Mag_08	387307.9	5908323	-207.9	Wreck – 7144 Harold
Mag_09	387196.4	5910198	-1090.9	Wreck - 81388
Mag_10	387927.1	5910030	445.3	Unknown
Mag_11	388279.1	5910496	-194.2	Unknown
Mag_12	385161.7	5908882	-54.7	Wreck - 7228 Maarten Cornelis
Mag_13	387262.7	5909502	42.6	Unknown
Mag_14	387177.7	5909588	22.6	Unknown
Mag_15	387682.9	5908744	51.3	Unknown
Mag_16	387823.5	5906694	-278.6	Unknown

Table 3 – Magnetic contacts list.

Further to these discrete objects the magnetometer dataset confirms suspected anthropological, linear targets are present at the site (Figure 14). A total of 4 significant linear targets cross the full extents of the site, including buffer area, from the shore in a north westerly orientation. Furthermore, three potential linear features are present, but these are less well defined, one running in parallel to the other targets and two potential linear features running north-south, although these are significantly less well defined.

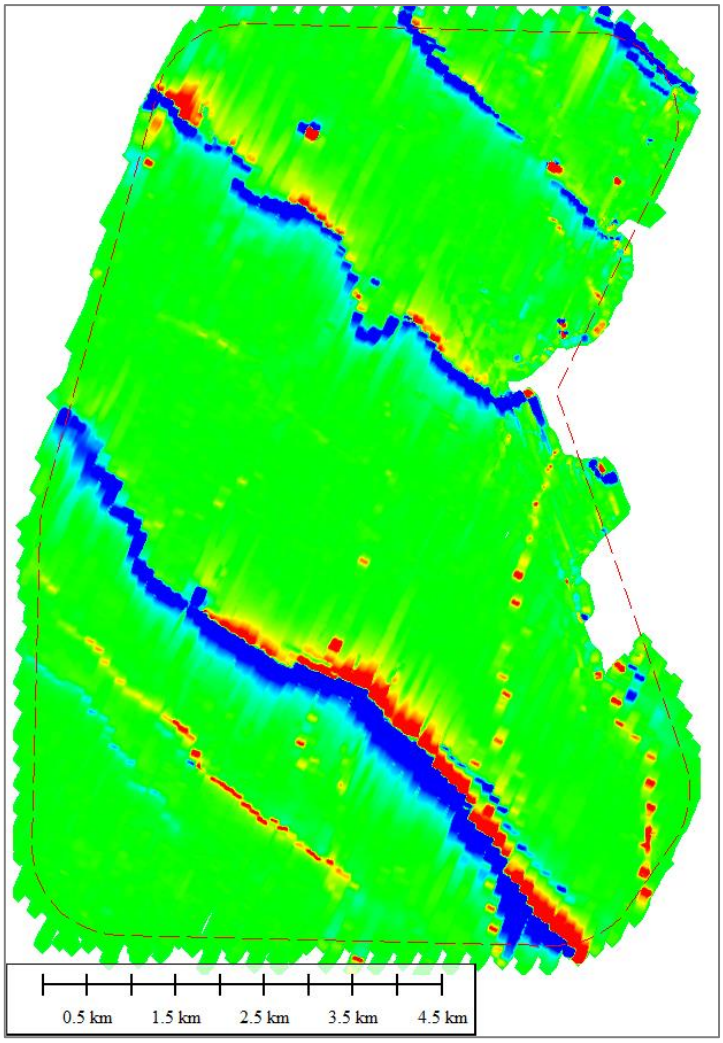


Figure 14 – Magnetic data overview with 9 linear targets clearly visible.

On an individual, line by line, basis these are tight, dipole type targets and do not appear to be geological; the exception to this is linear target 'Lin Mag 04' which has a signal more conducive to a geological feature. Furthermore, they do not correlate with any clear fault or other geological feature visible in the sub-bottom profiler, similarly there are no surface geomorphological features that would imply this geology is in place. Therefore, the targets are presumed to be anthropological in origin. These linear targets are certainly not fishing related, due to scale, and they are unlikely to be a small diameter pipe due to their irregular shape and lack of presence within the sub-bottom profiler data. Furthermore, 'Lin Mag 03' has a short section which correlates with the linear surface contact visible in both side scan

and multibeam data, as detailed in Section 2.2. Therefore, it is surmised these targets may be redundant/historical cables as they do not correlate with charted cable positions. Further desk-top research is suggested to correlate this theory.

Id	Start		End		Length
	Easting	Northing	Easting	Northing	
Lin Mag01	387690	5911983	388774	5911020	1.45km
Lin Mag02	385445	5911921	387941	5909363	3.61km
Lin Mag03	382666	5911099	383793	5910198	1.46km
Lin Mag04	383633	5910049	386871	5907640	4.5km
Lin Mag05	381650	5907448	387472	5901323	8.83km
Lin Mag06	381632	5905042	384952	5902065	4.57km
Lin Mag07	381259	5904661	382779	5903016	2.33km
Lin Mag08	386582	5901201	387203	5906961	5.86km
Lin Mag09	388199	5901911	387934	5904555	3.1km

Table 4 – Linear magnetic contacts list.

The locations of these targets are also shown on the combined seabed features chart P1830/V2/002.

2.5 Sub-Bottom Profiler Results

Throughout the survey area the geology is dominated by Rock at, or very close to, surface (Figure 15). The complex geology of Anglesey, and Holy Island specifically, extends through the site and it is clear the heavily folded pre-Quaternary Rock at surface mirrors the heavily glacially reworked Rock at the shoreline. The Rock at Holy Island forms part of the "Mona Complex" and the local coastline is dominated by relatively unique and localised "Monian Supergroup" of rocks, specifically the "South Stack Series". This sedimentary South Stack rock is the oldest in the immediate area and may be as old as Cambrian in age. Internally the Rock visible is generally featureless, massive in nature, within the penetration achieved, approximately 20-30m, but the features within the Rock have not been studied or presented. Although faulting is present across the geology of the region, no faults or significant unconformities are visible within the structure, similarly no associated seabed surface slumping is visible within the data.

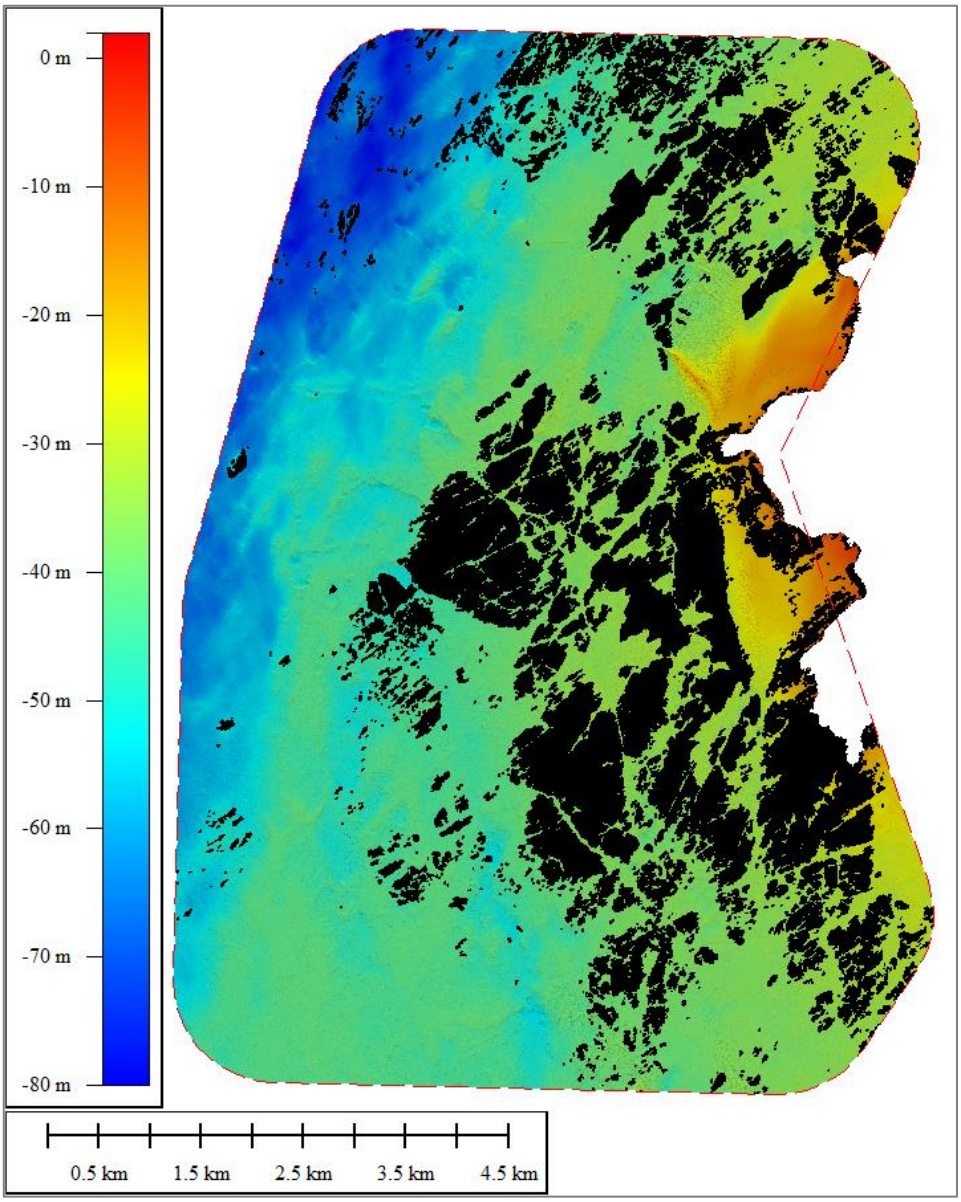


Figure 15 – Rock outcrop (only), black, overlaid on bathymetric results.

In all areas where Rock at surface is mapped within chart P1830/V2/004 striations within the rock have been filled with relatively coarse surface Quaternary deposits, where Glacial Till deposits have been sorted (finer materials removed) as would be expected at a site with strong tidal flows. Immediately adjacent to these outcrops, and within the gullies of the outcrops themselves, the cover is generally a veneer of Gravels both with and without Sand content. The larger geographical areas of cover that can be seen at the surface within these Rock outcrop areas do contain deeper localised sediment overburdens to a depth of approximately 10m. The largest example of such a deposition within the Rock outcrop area can be seen at 385,500mE 5,905,850mN, where a localised sediment cover of approximately 250m x 60m exists and Rock is >13m below the surface at its deepest point.

The deepest areas of cover can be found in the south west of the site, at its deepest rockhead can be seen 29m below the surface. These 'pockets' of deeper sediment cover do not form a

clear channel and are representative of the complex surface geology, where steep sided gullies and features exist.

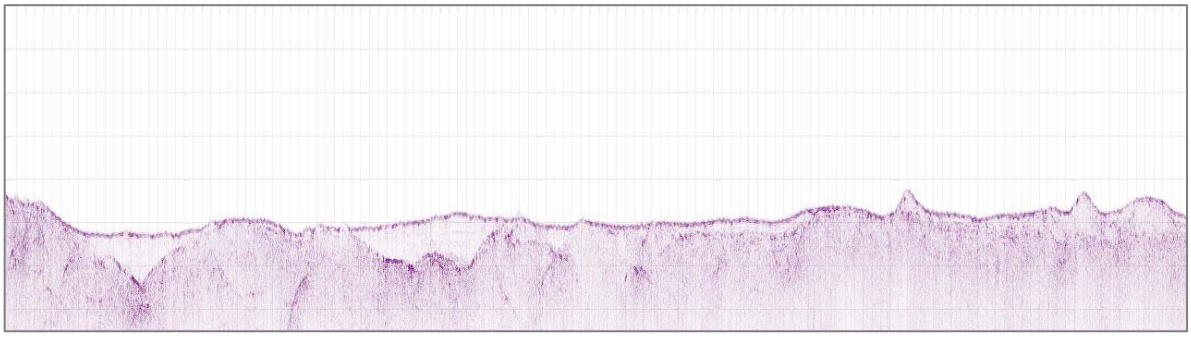


Figure 16 – Seismic Profile Line "M-125m-05", offshore within NW buffer zone. (data from Left-Right is acquired North-South).

Away from these deeper pockets of sediment cover to the south west and the Rock outcrops in the east and north of the site, the western part of the site generally experiences consistent sediment cover above rockhead. Depth to Rock is consistently between 2m and 14m below the surface and no definitive channel features can be mapped.

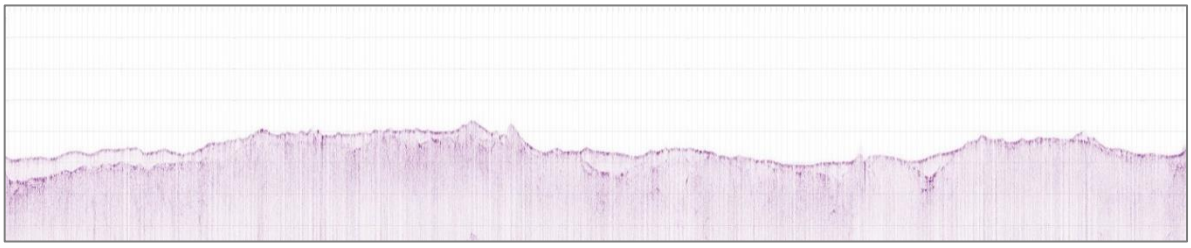


Figure 17 – Seismic Profile Line "M-125m-09", offshore approximately on-site boundary through the full site. (data from Left-Right is acquired South-North).

Within the shallower water areas of the site, sediment cover over Rock is less complex. At 'Gogarth Bay' to the north the approaches show extensive surface, geomorphological features overlaying a relatively flat rockhead. The approach to 'Abraham's Bosom' is dominated by a distinct area of finer sediment cover made up of Sand with potential Gravel content above Rockhead, to a depth of 7.3m below surface. Moving into the bay itself there is a second area of, finer, sediment deposition over a less uniform Rock surface, Rock is generally 2m to 4m below the seabed throughout the central part of the bay. The entire boundary of the bay shows Rock at surface and this is known to be steep sided rock gullies and pinnacles.

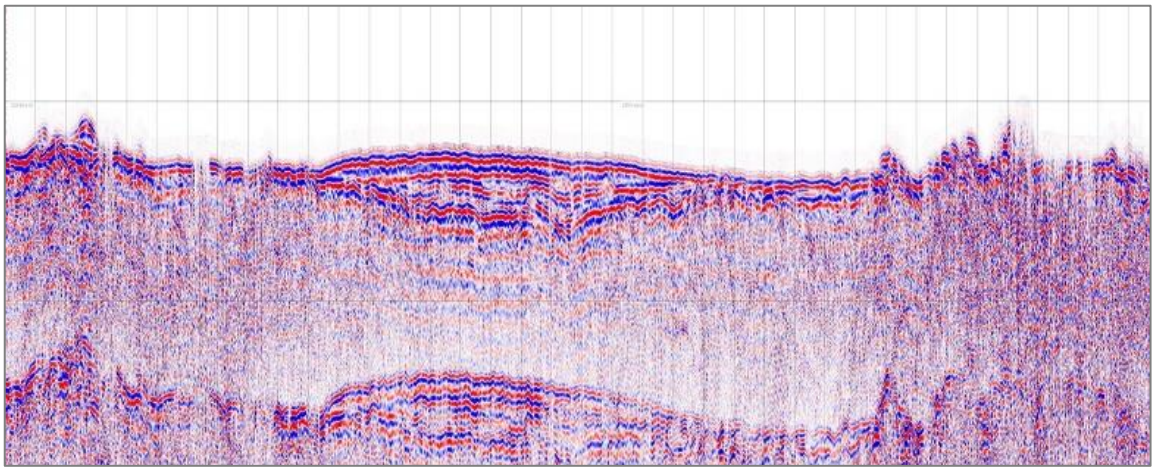


Figure 18 – Seismic Profile Line "M-50_S17", crossing the entrance of Abraham's Bosom(data from Left-Right is acquired South-North).

3. PROCESSING AND DATA QUALITY

3.1 Bathymetry

Data processing was carried out using BeamworX AutoClean software and deliverables created within AutoClean and Global Mapper. All data was reduced to Chart Datum online in QPS QINSy acquisition software using the UKHO Vertical Offshore Reference Frame (VORF) model.

The following bathymetry deliverables are supplied with the agreed version of this report:

Deliverables	Resolution	Format
Raw sounding data (including backscatter)	n/a	QINSy databases (*.db)
Processed XYZ (Interpolated and un-interpolated)	0.5m, 1.0m & 2.0m	Text file (*.txt)
Seabed shaded relief image	0.5m & 1.0m	GeoTiff (*.tiff)
Bathymetry chart	n/a	DWG & PDF
Track plot	n/a	Shapefile

Table 5 – Bathymetry deliverables.

3.1.1 Bathymetry Processing Methodology

The acquired bathymetric data was imported from QPS QINSy into BeamworX AutoClean and gridded to 0.5m. The gridded surface was initially checked for calibration values, quality and that all peripheral data had been applied correctly (e.g. motion sensor & sound velocity data). The data was then filtered for any shallow or deep outliers. Where obvious sound velocity deviations were visible, manual corrections where applied. Coarse spline filters were applied followed by a high-resolution spline filter where required. Any remaining spurious data was edited manually. The final surface was exported at a resolution of 0.5m for image creation and data delivery.

Online settings were controlled to achieve a 0.5m grid where possible, notably in depths shallower than 40m Chart Datum. However, in water depths deeper than 40m Chart Datum, a 0.5m grid was not fully achievable and several infill lines were required to increase data density as slant ranges were reduced to ensure high ping rate and increased along track resolution. Any minor data gaps were interpolated using BeamworX standard algorithms on completion of all processing. Resultant XYZ files have been produced, interpolated and un-interpolated (an example is provided in Figure 19).

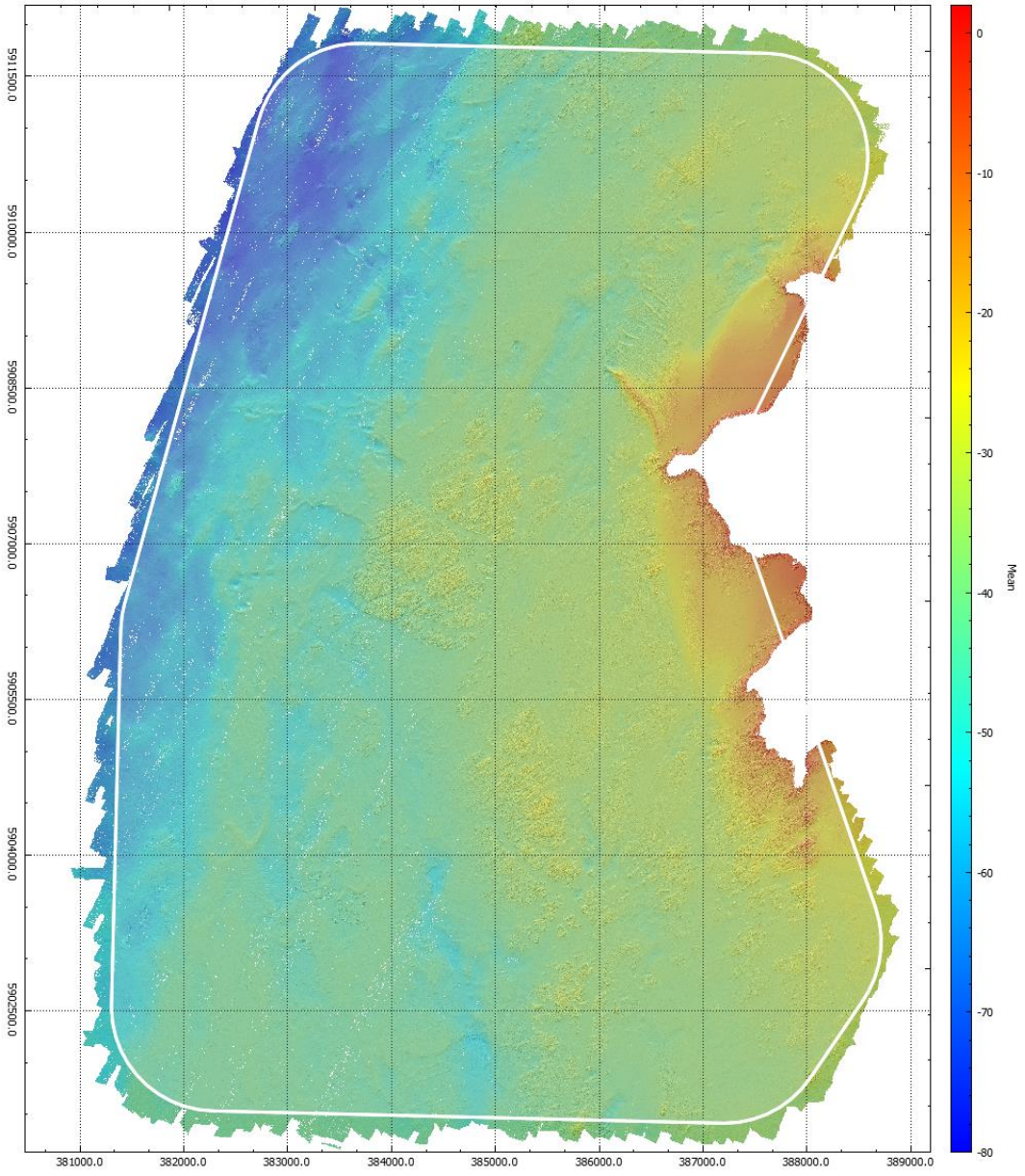


Figure 19 – Un-interpolated 0.5m Grid.

3.1.2 Processed Bathymetry Quality Checks

Throughout the processing workflow, further QC was carried out to ensure a quality dataset. These includes IHO test criteria, standard deviations and hit count per bin analysis.

IHO Order 1a has been met as BeamworX statistics show that 99.65% of the survey conforms to IHO order 1a (Table 6), with the requirement being 95%.

Survey Accuracy (Standard)	IHO Norm 1a, a = 0.500, b = 0.013
Footprints conform Survey Accuracy	1,809,249,588 (99.65%)

Table 6 – BeamworX survey accuracy statistics.

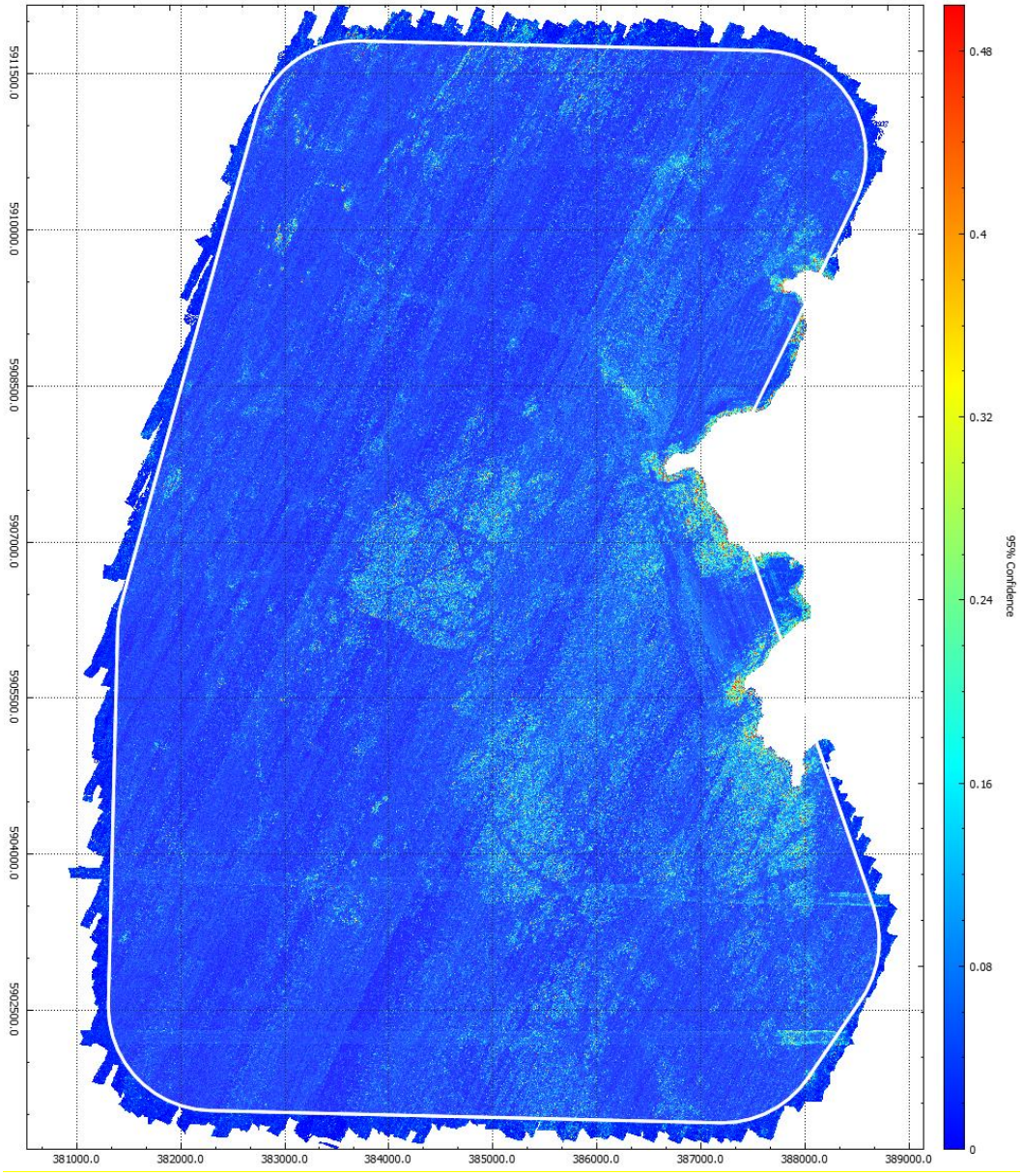


Figure 20 – Standard deviation plot at 95% confidence (data range: 0m to 0.5m).

The Standard Deviation analysis undertaken at 95% confidence supports these accuracies. All data within the site falls within the standard 0.5m deviation (Figure 20), except for localised extreme shallows, where rock pinnacles exist.

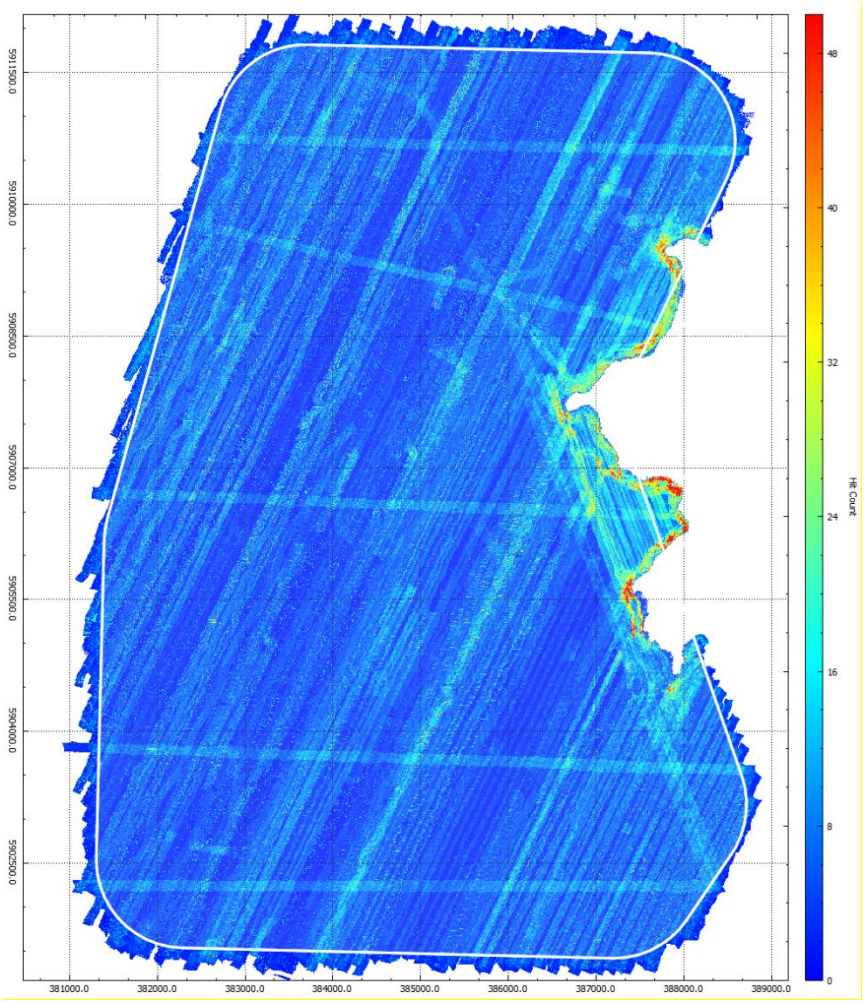


Figure 21 – Hit count per 0.5m bin.

Figure 21 shows a favourable and consistent hit count spread with the expected higher hit count in the shallower lines and along crosslines.

Lines run in opposite directions over megaripple features acquired on different days, highlight the minor geomorphological migration at the site. Figure 22 shows megaripples migrating or potentially oscillating, which is likely due to different current flow directions and weather events between acquisition periods. Some overlapping lines over megaripple areas therefore mismatch and these lines have been removed to improve the data.

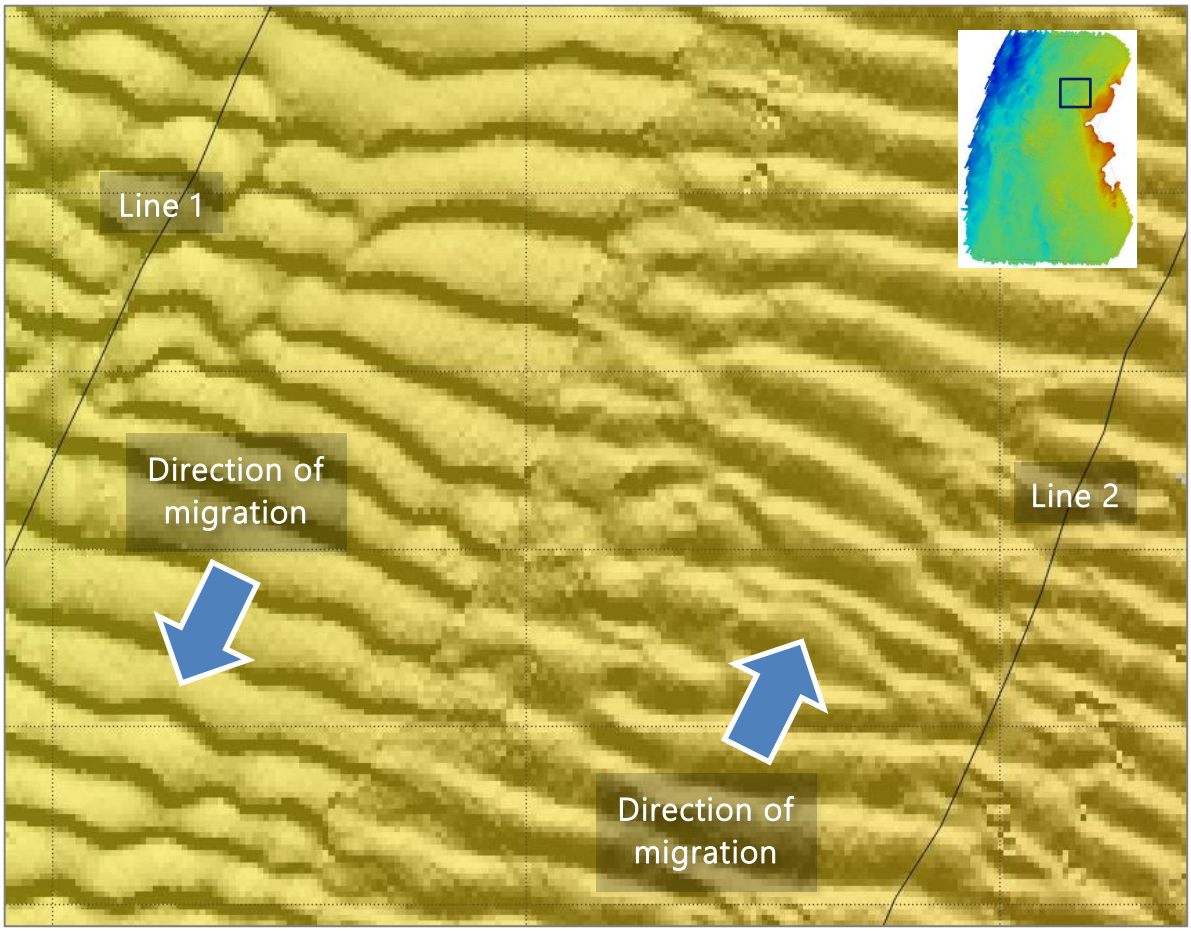


Figure 22 – Megaripple migration example.

3.2 Side Scan Sonar

All side scan sonar data was imported from the Edgetech Discover acquisition software into Chesapeake SonarWiz 7 for post processing. The software allows for all navigational/ultra-short base line corrections to be made, along with target and feature picking on a line by line basis as well as gain and colour pallet manipulations to improve aesthetics of the resultant mosaic.

During processing, minor localised manipulations of the side scan imagery positioning can be made as the data was overlaid on the multibeam results, allowing hard features to be cross correlated; ultimately improving the positional accuracy of the data beyond the accuracy successfully achieved by the acoustic positioning.

Throughout the post processing phase both the low and high frequency data was analysed. As reported in Volume 1, the high frequency dataset did suffer from the effects of the fast flowing currents in the area. However, these effects did not result in as significant a degradation of data as was expected prior to mobilisation at the site. Therefore, it has been possible to generate the mosaic from the high frequency data to provide an increased mosaic resolution. The mosaic in chart P1830/V2/003 is presented at 0.1m resolution.

As per the project specifications the low frequency range ensured 200% seabed insonification (nadir of adjacent lines completely covered) and the high frequency has been used for all target identification and key feature picking, in conjunction with the multibeam echo sounder results.

Both low and high frequency data accepted during the acquisition phase was at, or above, useable quality to meet the specifications and both frequencies form part of the digital deliverable to this report.

3.3 Magnetometer

All magnetometer data was corrected for acoustic positioning within the QINSy navigation software and processed within Geosoft's Oasis Montaj software. Within the software a line by line edit process is undertaken before the data is gridded.

Data were cleaned of dropouts and spikes and the signal quality reviewed to be of an acceptable level prior to completion of further processing. A non-linear filter of either 750 or 1500 readings was applied to calculate a background magnetic field dependent upon the line length to remove the ambient magnetic field and those long wavelength anomalies more commonly associated with geology. Where the non-linear filter was found to not produce a representative background field, manual edits were made to reduce the number of false 'positives'. From the resultant gridded dataset individual targets are interrogated, measured and cross correlated with both the magnetic profile data and surface (side scan sonar and multibeam echo sounder) and sub-bottom datasets.

During the survey operations no survey lines were rejected due to magnetometer data, however, the sensor was re-acquired along all planned side scan sonar re-runs to further increase data density.

3.4 Sub-Bottom Profiler

All data was acquired and processed within Coda Survey Engine Seismic+ software.

Throughout the post processing, survey lines are processed individually, and seabed surface and all visible geology is picked individually. The results are then cross referenced with the adjacent and cross lines, cross lines having been manipulated to attempt to cover the limited areas of sediment cover above rockhead, to ensure the consistency of depth below surface.

On loading of the data into the software, data quality was reviewed and acceptable files passed for further processing. Line failing this initial quality assessment were marked for a reacquisition during the field operations.

Following acceptance of the survey line, seabed tracking was completed. Positional data reviewed and adjusted for layback prior to series of gains and frequency filters being applied to enhance the geology of interest and the horizons being picked.

Due to the system sensitivity multiple lines were rejected during field operations and reacquired in improved current/weather/sea states. The resultant dataset provide a robust coverage of the entire site and exceeded the requirements of the specification.

APPENDIX 1 – CHARTS