DOGGER BANK D WIND FARM

Preliminary Environmental Information Report

Volume 2

Appendix 8.2 Marine Geophysical Survey Report

Document Reference No: 2.8.2

Date: June 2025

Revision: V1

SSE Renewables

equinor

www.doggerbankd.com

DB3-SUR-10053

OFFSHORE SITE INVESTIGATION SERVICES, DOGGER BANK D HABITAT SURVEY 2022

FINAL REPORT (REV 1.0)

GUARD CELENA

ENVIROS Document No. ***ENV-22534-DFR-001***

EQ22465 DBD Array Survey 2022 Interpretation Report: -LF000016-SID-DOG-REP-0008

Rev	Date	Reason for Revision	Prepared	Approved	Approved
1.0	31 March 2023	Final Report	AT / RS	BO	MB
0.0	31 January 2023	Draft Final Report	AF	BO	MB

DOCUMENT AUTHORISATION AND DISTRIBUTION

Document Authorisation and Distribution		
Contractor	ENVIROS Survey & Consultancy Limited	
Client	SSE Renewables Services (UK) Limited	
FAO	Rob Cussons (Project Manager) Rob.Cussons@sse.com Roger Birchall (Project Geophysicist) roger.birchall@sse.com	
Document Ref	ENV-22534-DFR-001	
Title	FINAL REPORT	
Authors	Mohd Redzuwan b Sudin (Geophysicist) redzuwan.sudin@envirosgroup.com	Date: 31st March 2023
Checked	Bachir Ouzani (Project Manager) bachir.ouzani@envirosgroup.com Matthew Hudson (Operations Manager) matthew.hudson@envirosgroup.com	Date: 3rd April 2023
Approved	Mike Baker (Project Director) mike.baker@envirosgroup.com	Date: 3rd April 2023
	DOCUMENT	ISSUED TO
Authorised Copies	Original	Dogger Bank Windfarms
	Copy No.1	ENVIROS

CONTENTS

LIST OF FIGURES

LIST OF TABLES

APPENDICES

ABBREVIATIONS

The following abbreviations may be found in this document:

BGS	British Geological Survey
BSF	Below Seafloor
CD	Chart Datum
CM	Central Meridian
Contractor	Enviros Survey and Consultancy Ltd
CRP	Common Reference Point
CRS	Coordinate Reference System
CT	Coordinate Transformation
CTD	Conductivity, Temperature, and Density
DGNSS	Differential Global Navigation Satellite System
DGPS	Differential Global Positioning System
EOL	End of line
Geographical CRS	Geographical Coordinate Reference System
GNSS	Global Navigation Satellite System
HF	High Frequency
LAT	Lowest Astronomical Tide
LF	Low Frequency
km	kilometre
MBES	Multibeam echosounder
MSL	Mean Sea Level
MSS	Mean Sea Surface
nm	nautical mile
MV	Motor Vessel
SBP	Sub-bottom Profiler
SSS	Side Scan Sonar
SVP	Sound Velocity Profiler
USBL	Ultra-Short Baseline
WD	Water Depth
WGS84	World Geodetic System 1984

1 INTRODUCTION

1.1 Document Overview

This document has the purpose to present the findings of the DBD Habitat Survey 2022 campaign.

1.2 Project Overview

SSE Renewables awarded a contract to Enviros Survey & Consultancy to acquire an offshore site investigation survey within the DBD Offshore Windfarm site located at approximately 260 km west of Sunderland.

Enviros mobilized the dedicated survey vessel MV Guard Celena to perform the survey works between 10 August to 5 October 2022. The vessel was fitted with the following survey equipment:

- Veripos and Cnav Positioning
- QINSy 9.0 Navigation
- TSS Meridian Gyro Heading
- Teledyne T20R Multibeam Echo Sounder (bathymetry and backscatter)
- E20 Single Beam Echo Sounder
- INS20 Motion Sensor
- AML Plus X Sound Velocity Profiler
- EdgeTech 4200 Side Scan Sonar
- Sonardyne Scout Plus underwater positioning (USBL)
- Innomar SES-2000 Sub Bottom Profiler
- Geometrics G882 Magnetometer

A total of 275 mainlines and 10 crosslines with variable lengths were acquired during the survey campaign and the acquisition was carried out in a single pass mode.

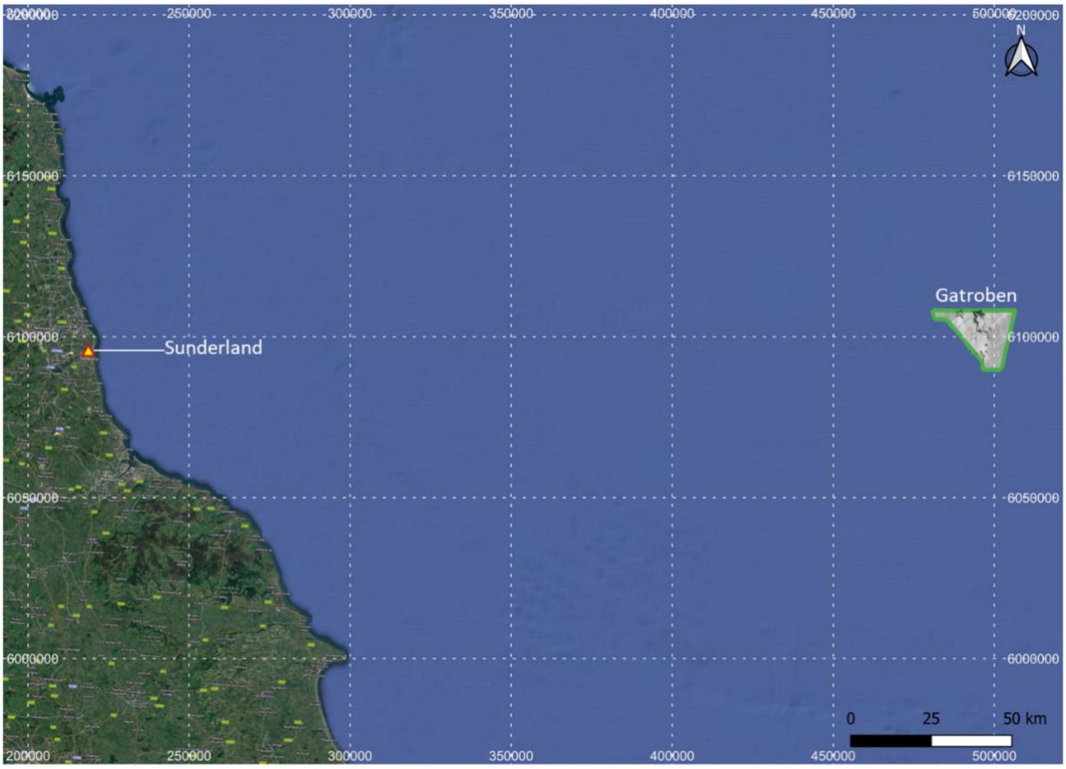


Figure 1: General Location Map

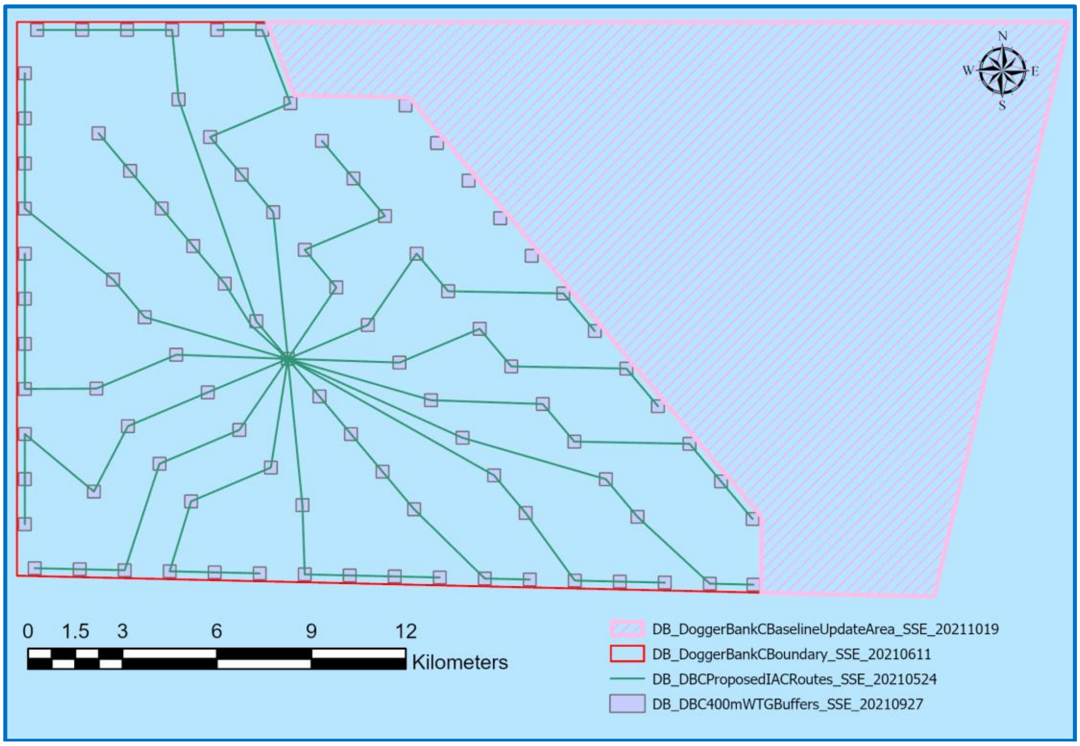


Figure 2: DBD Baseline Updated Work Area Details

1.3 Scope of Work

The scope of work required Enviros to carry out analogue survey within the DBD survey area to acquire MBES, SSS, SBP, MAG all run in single pass mode that will enable the following:

- Measure the water depth variations and slope changes.
- Investigate the morphology, nature of seabed and local geology.
- Locate and map natural or man-made, seabed or buried, obstructions i.e. rock outcrops, channels, depressions, gaseous fluid features, cables, etc.

The DBD survey area was divided into four sub-areas namely Area A, Area B, Area C AND Area D as shown below.

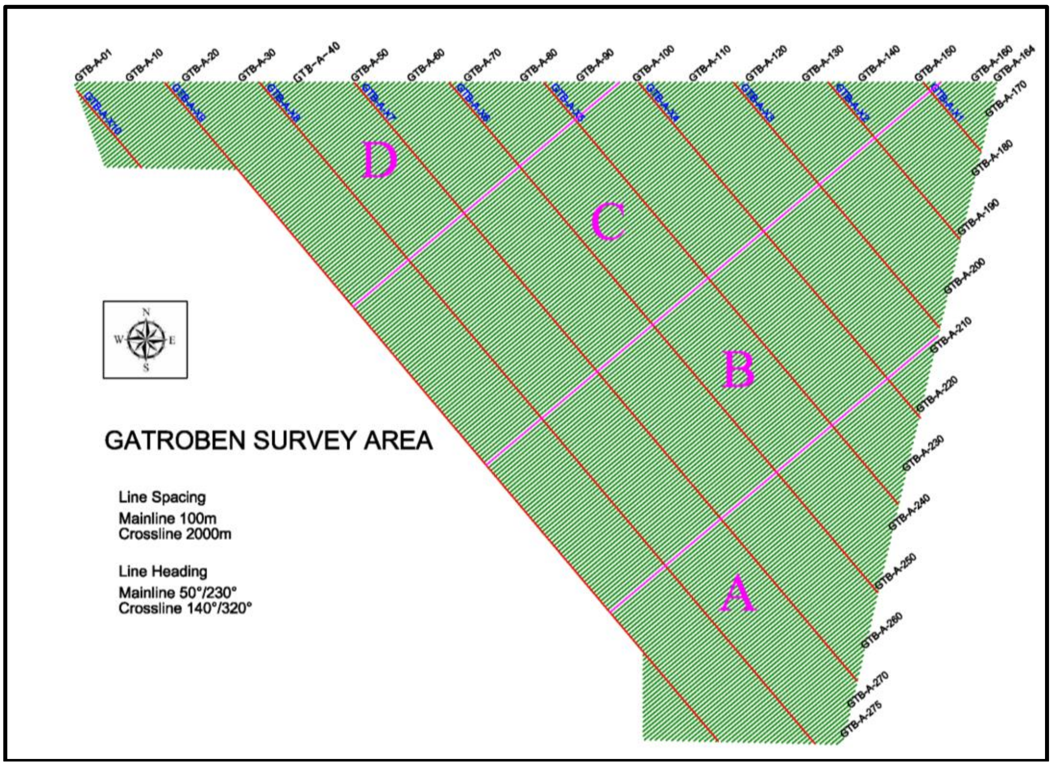


Figure 3: Specific location and division of the DBD survey area

The Final Grid Design for DBD Site is tabulated below.

DBD SITE		FINAL GRID DESIGN			
		Orientation	Line Spacing (m)	No. of Lines	Total KM
AREA A - D	Mainline	50°/230°	100	275	2494
	Crossline	140°/320°	2000	10	134

Table 1: Final Survey Grid Design

2 PROJECT CONTROL

2.1 Geodesy

The project geodetic and projection parameters are summarised in Table 2.1

Global Navigation Satellite System (GNSS) Geodetic Parameters	
Datum:	WGS84
EPSG Code:	6326
Semi major axis:	6 378 137.000 m
Semi minor axis	6 356 752.314 m
Reciprocal Flattening:	298.257 223 563
Project Projection Parameters	
Grid Projection:	Universal Transverse Mercator
UTM Zone:	31N
Central Meridian:	0°E
Latitude of Origin:	00° 00' 00.000" north
Longitude of Origin	003° 00' 00.000" east
False Easting:	500 000.000
False Northing:	0.000
Scale factor on Central Meridian:	0.9996
EPSG Code:	32631
Units:	Metres

Table 2.1: Project Geodetic and Projection Parameters

2.2 Vertical Control

The Vertical Datum for the entire scope is Lowest Astronomical Tide (LAT). The VORF (vertical offshore reference frame) supplied by the UKHO (United Kingdom Hydrographic Office) was used to reduce bathymetry data to LAT. The relations between the MSL and LAT is shown below:

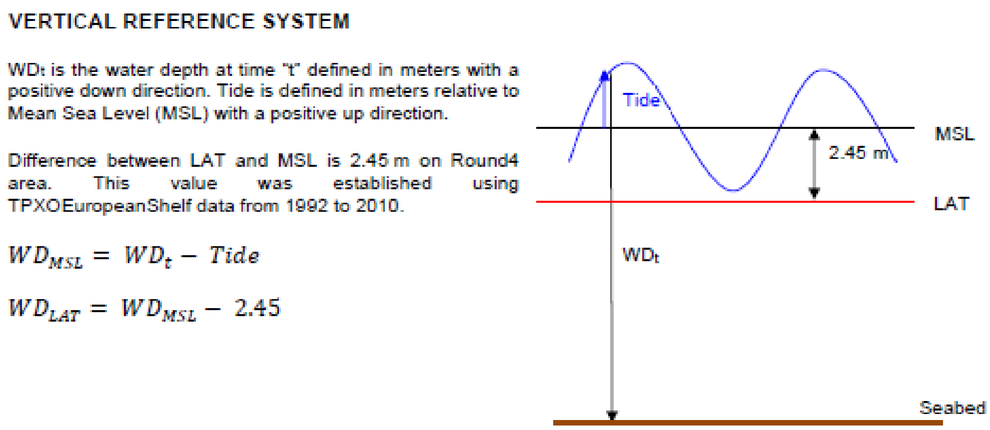


Figure 4: Vertical Reference System

2.3 Units

All units will be quoted using the SI metric system unless specified, to a representative accuracy as per the accurac of the survey sensors.

2.4 Vessel Details

The survey campaign was conducted onboard vessel; namely the MV Guard Celena. Vessel specifications are as follow.

2.4.1 MV Guard Celena

Figure 5: MV Guard Celena

DESCRIPTION	
Type	Offshore Support Vessel Polar Ship Certificate AMS, SPS, Unrestricted Services
Classification	ABS +A1(E)
Built/Re-built	2008
Flag	Marshall Islands
Call Sign	V7OY7
IMO	9500168
DIMENSIONS/PERFORMANCE	
Length Over All (LOA)	53.80m
Breadth	13.80m
Draught	4.10m
Gross Tonnage (GRT)	1,239 Tonnes
Nett Tonnage (NRT)	371 Tonnes
Speed Max	12 knots
ACCOMODATION	
Total	42 Berths in 15 Cabins
Messrooms	1 + 1
Survey	2 Offices
MACHNERY/PROPULSION	

Main Engines	2 x Cummins KTA 50-M2 1600 BHP
Generators	3 x Cummins QSM 11-D(M) 300KW
Bow Thrusters	1 x Cummins 6BTA5.9 M3 315 BHP
Emergency Generators	1 x Cummins 6BT5 40 KW

Table 2.2: MV Guard Celena – Vessel Specifications

2.5 Equipment List

The summary of equipment equipped onboard MV Guard Celena throughout the project period is as tabulated i sections below.

NAVIGATION & POSITIONING			
GNSS system 1	Veripos APEX 2x Veripos GA530 antenna 1x Veripos LD4 receiver	Navigation software	2x QPS QINSy v.9 2x spare
GNSS system 2	CNAV SF2 2x CNav 5000 antenna 1x CNAV 5000 receiver	Subsea Positioning	Sonardyne Scout Plus Side mounted pole c/w 3x Sonardyne 8271 omni directional transponder beacons
Gyrocompass	1x TSS Meridian (plus INS20 heading)	Secondary heading	1x LD4 GNSS system
GNSS system 1	Veripos APEX 2x Veripos GA530 antenna 1x Veripos LD4 receiver	Navigation software	2x QPS QINSy v.9 2x spare
BATHYMETRY – SBES, MBES & SVP			
MBES model	1x Dual head Reson T20R	MBES Frequency	190-400 kHz
Acquisition software	QINSy	Swath width	7x water depth
Bathymetry processing software	QPS Qimera	MBES mounting	Side mounted pole
Heave Compensator	1x INS20	Backscatter processing software	QPS Qimera
SVP probe	SVP70 MBES SV & 2x AML Plus-X	Max TVU & THU	0.26m TVU / 0.33m THU
SBES	E20 Echotrac (33/200 kHz) Side mounted pole		
SIDE SCAN SONAR SYSTEM			
SSS model	2x Edgetech 4200	SSS Frequency	300 & 600 kHz
SSS Acquisition software	Edgetech Discover	SSS processing software	SonarWiz
Deployed:	A frame	Winch:	Electrical winch
SUB BOTTOM PROFILER SYSTEM			
SBP model	Innomar SES-2000 side mounted pole	SBP Frequency	100kHz pri 4-15kHz sec
Acquisition software	Innomar	Interpretation software	Sonarwiz / IHS Kingdom Suite
MAGNETOMETER			
Model	2x Geometrics G882 (piggyback SSS)	Sensitivity	1nT

Acquisition software	Maglog lite	Processing software	Geosoft Montaj & Magpick
PMA/MMO			
PAM	1x Seiche 6 channel towed w/ powered winch		

Table 2.3: Summary of Equipment onboard MV Guard Celena

3 METHODS AND RESOLUTIONS LIMITATION

3.1 Bathymetry

Bathymetric data were acquired using single beam and multibeam echosounders. Water depths are quoted relative to Lowest Astronomical Tide (LAT) and are considered accurate to ± 1% of depth. The bathymetry data were reduced using observed Global Navigation Satellite System (GNSS) tides and corrected to LAT using Vertical Offshore Reference Frame (VORF).

Single beam and multibeam echosounder data were acquired along all lines. Single beam echosounder (SBES) data were recorded for each line and used for quality control only. Bathymetric features of smaller lateral extent than the line spacing may not have been detected by the SBES data; however, the multibeam echosounder (MBES) dataset provides coverage between single beam lines.

The MBES data were processed to a 1 m by 1 m grid cell size.

For bathymetric contours, the data were smoothed with a 1.0 m radius. Localised gradients or features of smaller lateral extent may be underestimated.

The difference between Mean Sea Level (MSL) and LAT within the survey area is 2.45 m.

3.2 Side Scan Sonar

Seabed features and obstructions have been interpreted from multibeam echosounder, side scan sonar and magnetometer data.

The horizontal resolution of the 600 kHz side scan sonar data is approximately 0.3 m; obstructions smaller than this may not have been detected. Heights of seabed obstructions estimated from the side scan sonar data are considered to have an accuracy of ± 20%.

The magnetometer system was cycled at 10 Hz. Given an average survey speed of 4 knots, the along-track resolution is estimated to be one sample per 0.2 m.

The positional accuracy of features interpreted from the side scan sonar data and magnetometer depends on a combination of the vessel positioning, acoustic positioning of the towfish relative to the vessel and interpretation of position relative to the towfish. For this dataset, the overall positional accuracy is estimated as ±2 m. Where seabed features show a bathymetric expression, the positions were refined using a combination of side scan sonar and echosounder datasets.

Isolated boulders and debris objects were manually picked in SonarWiz. Only boulders ≥ 0.3 m in any dimension were picked. Any boulders with dimensions of less than 0.3 m were not picked and may be underestimated.

3.3 Shallow Geology

Shallow soil conditions have been interpreted from the hull mounted Innomar sub bottom profiler data.

Sub-seabed depths have been calculated using an assumed seismic velocity of 1600 m/s. This velocity is reasonable for the interpreted sediments but has not been calibrated.

The vertical resolution of the sub-bottom profiler data is estimated to be 0.1 m for the hull-mounted innomar data. Sediment layers thinner than this may not have been separately detected. The seabed pulse was relatively strong, masking the uppermost 0.25 m of the shallow geology.

Lithological descriptions and stratigraphy of the geological sequence are derived from acoustic character and regional geological literature within the survey area.

4 SURVEY RESULTS

The interpretation is based on available data and is illustrated with charts (Appendix D) and data examples.

4.1 Bathymetry

The bathymetry within the DBD area is reduced to LAT using the Veripos GNSS tides and VORF (vertical offshore reference frame) supplied by the UKHO (United Kingdom Hydrographic Office). The DBD bathymetry is presented as Shaded Relief Bathymetry Charts (Appendix D).

The seafloor within the DBD survey area is ranging from smooth to undulating due to the presence of megaripples, areas of undulating seafloor, seabed depressions, seabed mound and seabed trough. Gradient descriptions used in the report are based on those shown in Table 4.1.

Description	Gradient
Very gentle	<1°
Gentle	1° - 4.9°
Moderate	5° - 9.9°
Steep	10° - 14.9°
Very steep	>15°

Table 4.1: Gradient Classification

Seafloor gradients within the DBD area are gentle. Localised gradients are greater, particularly across the slopes of the megaripples and seabed trough, where gradient can be very steep exceeding 15°. The bathymetry summary across the DBD survey area is shown in Table 4.2.

Bathymetry	Water Depth [m LAT]	Gradient [°]	Remarks
Minimum water depth	21.6	-	At southern edge of the survey area (E 501863, N 6089684)
Maximum water depth	34.6	-	At the base of seabed trough (E 494311, N 6106938)
Average (natural) seafloor gradient	-	1°	
Maximum seafloor gradient	-	> 15°	Along the slopes of the localised megaripples and seabed trough

Table 4.2: Summary of bathymetry across the DBD survey area.

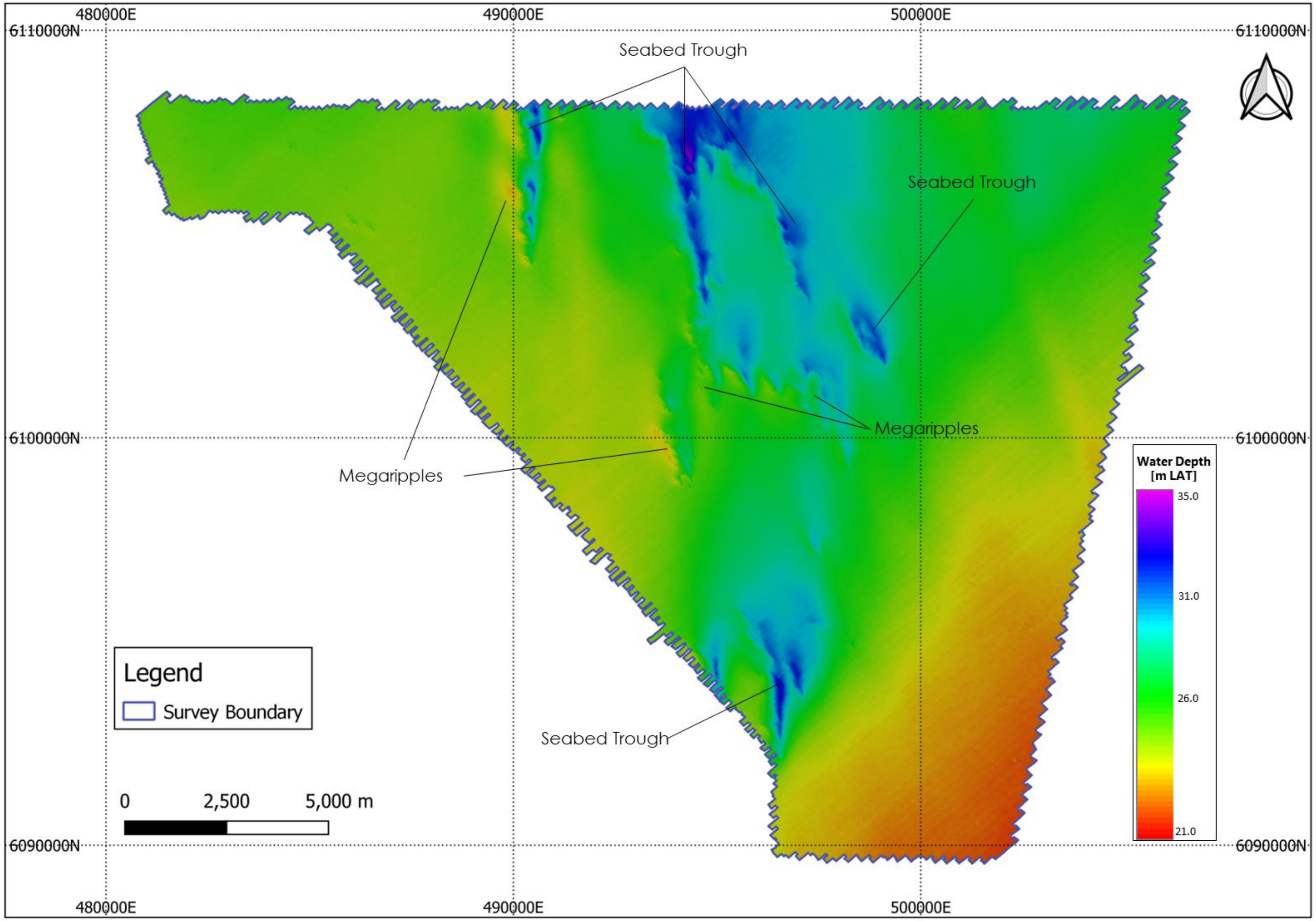


Figure 6: Overview of the Multibeam Bathymetry image within the DBD survey area.

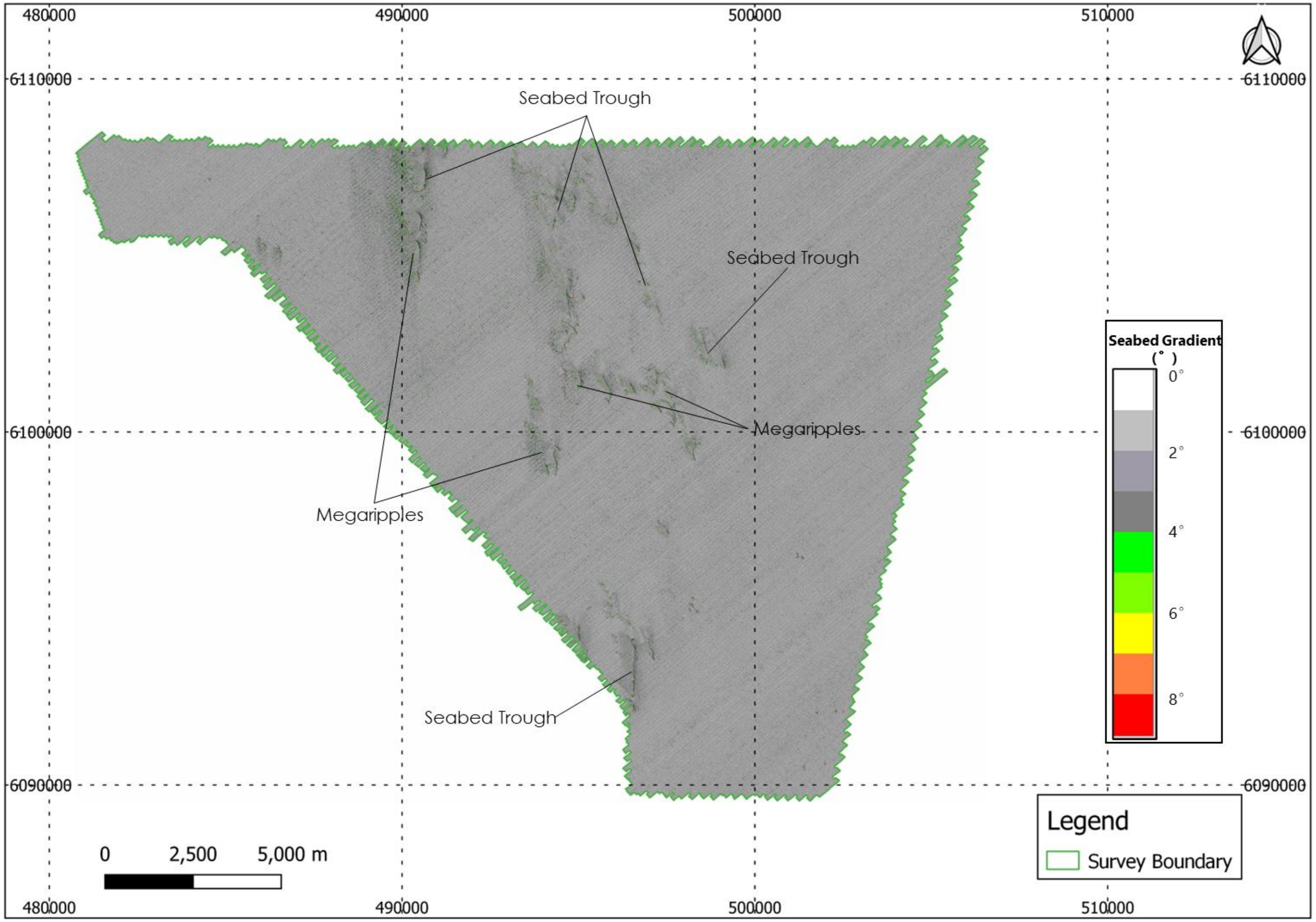


Figure 7: Overview of the Multibeam Bathymetry gradient image within the DBD survey area.

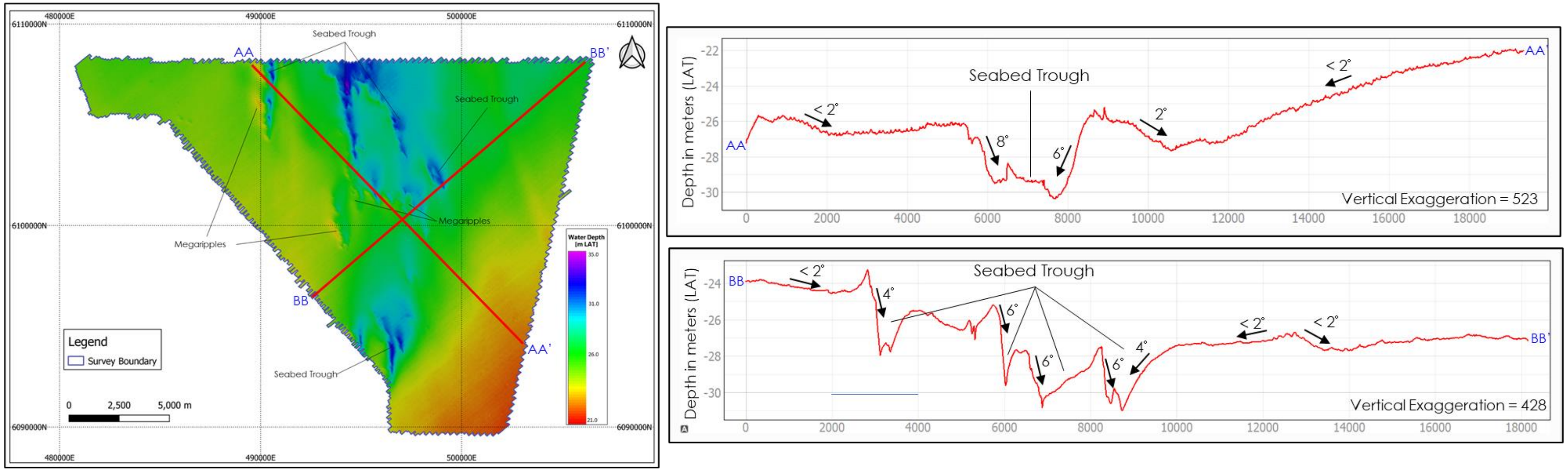


Figure 8: Overview of the Multibeam Bathymetry image and general seabed profiles across the DBD survey area

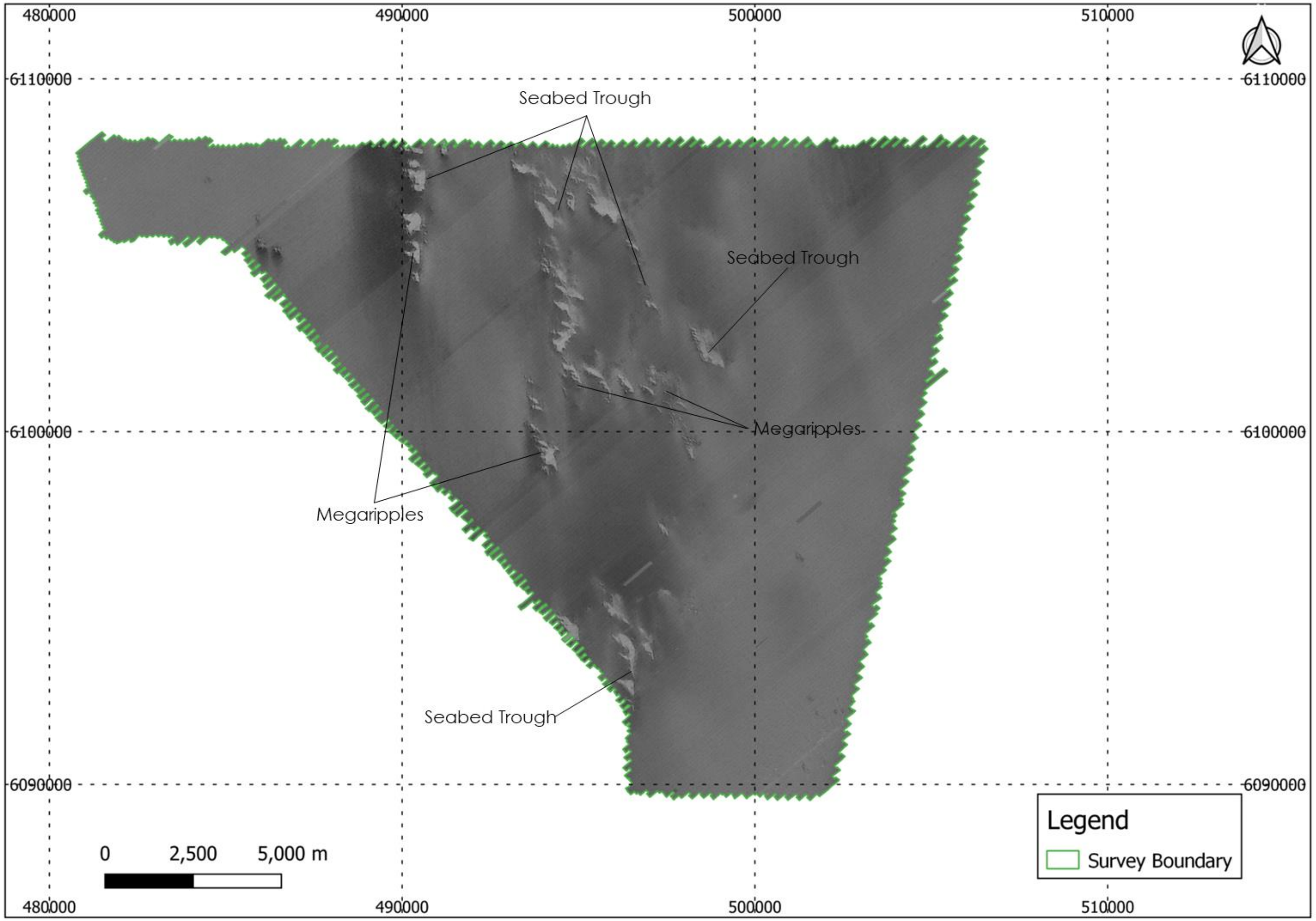


Figure 9: Overview of the Multibeam Backscatter image within the DBD survey area.

4.2 Seafloor Morphology

The DBD survey area is part of a dynamic landscape where Quaternary formations have been shaped by different geological processes and continue to be modelled by present day marine conditions. Holocene sediments form the surficial sediment across the area, these mainly derive from reworking of the glacial sediments that underly the Holocene.

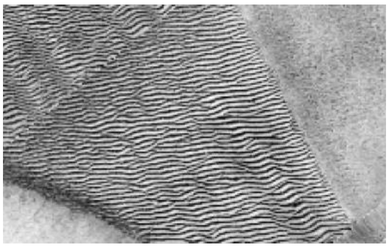
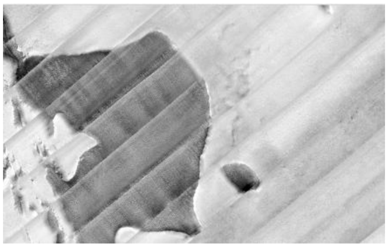
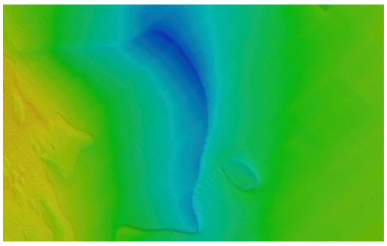
Marine currents have mobilised and redistributed surficial sediments, creating bedforms as well as erosional features.

Seafloor morphology interpretation was based on data from MBES, multibeam backscatter and SSS data. The data analysis was carried out using acoustic characteristics such as overall pattern, roughness and reflectivity.

The main morphological characteristics identified within the survey area are:

- Bedforms (megaripples)
- Seabed Trough
- Areas of Undulating Seafloor
- Areas of Coarse Sediments
- Seabed mound and depressions

The acoustic characteristics of the type of morphology identified are summarized in Table 4.3:

SSS Image	Acoustic Description	Morphological Interpretation
	Medium to high reflectivity	Megaripples
 	Low reflectivity	Seabed Trough

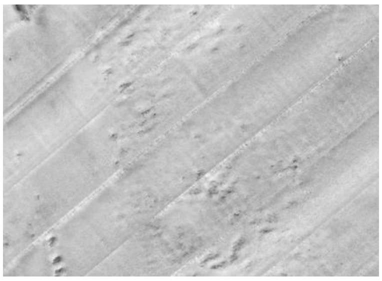
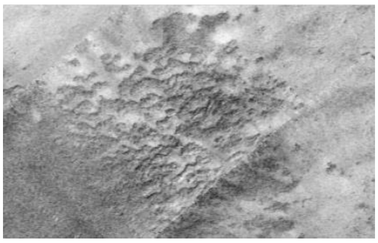
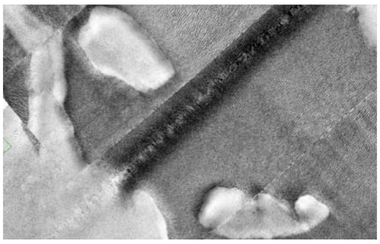
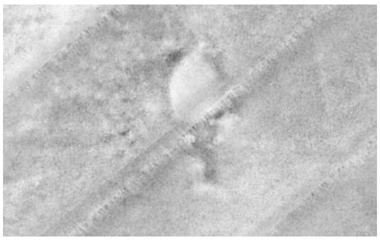
SSS Image	Acoustic Description	Morphological Interpretation
 	Medium to high reflectivity	Areas of Undulating Seafloor
	Medium to high reflectivity	Area of coarse sediments
 	Low reflectivity	Seabed mound and depressions

Table 4.3: Seafloor morphology interpretation.

The morphology is varied across the DBD survey area, and the different types are not restricted to certain areas. However, there is some trend to the morphology, these are:

- areas of featureless seabed are most prevalent in most part of the DBD survey area;
- areas of undulating seafloor are most frequent near the northern limit of the DBD survey area;

- areas of coarse sediments are observed often to be associated with megaripples in the northern half of the DBD survey area;
- Seabed trough were observed within the northern, central and southern part of the DBD survey area.

4.2.1 Mega-ripples

The only bedform identified within the DBD survey area is megaripples. These are produced by the flow of currents and tides over the seabed sediments.

The wave crests of the megaripples across the DBD survey area are aligned approximately in east-north-east to west-south-west, indicating a current direction of north-north-west / south-south-east. The megaripples are mainly symmetric and have heights that are generally between 0.15 m and 0.25 m with wavelengths of 3 m to 5 m.

4.2.2 Seabed Trough

Fifteen seabed troughs were observed within the survey area. These features are aligned in the north-northwest to south-southeast direction. The seabed troughs vary in dimensions with approximate length of up to 5 km, width of 4 km and depth of up to 4 m.

Within these topographic depressions, the sorting action of currents has created accumulations of coarser sediment in some part of the DBD survey area as the finer sediment has been winnowed away. Megaripples are often present within the seabed trough and are interpreted as sorted bedforms.

4.2.3 Seabed Mound and Depressions

Numerous seabed mound and depressions were observed throughout the DBD survey area. These features vary in dimensions with approximately length up to 208 m, width of 180 m and depth of up to 2 m. The seabed mound and seabed depressions appear to be concentrated within the southern half of the DBD survey area.

These features are interpreted to be the results of scouring within the DBD survey area forming localised gentle undulation throughout the DBD survey area.

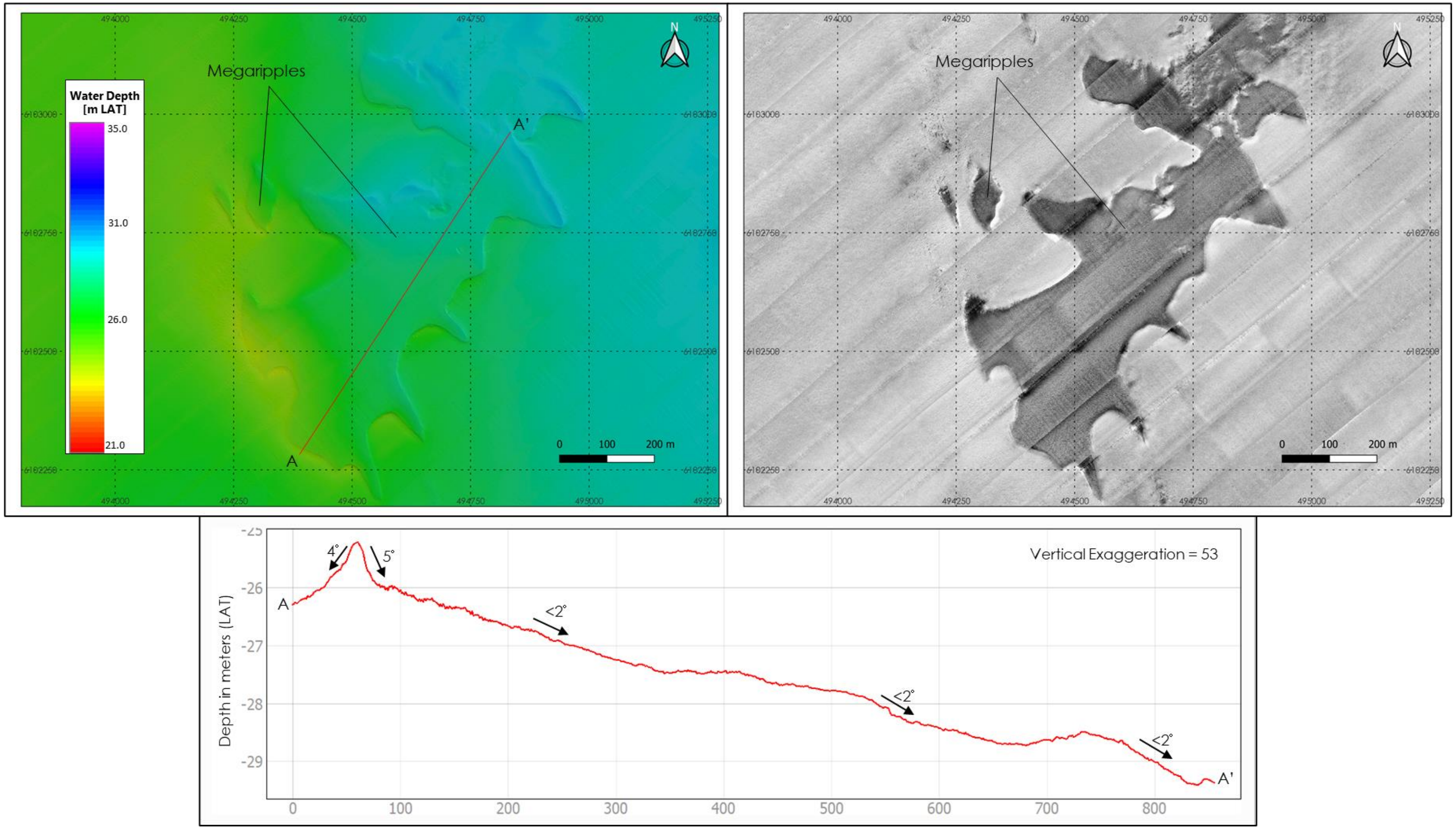


Figure 10: Multibeam bathymetric image, sidescan sonar image and seabed profiles across the megaripples within the DBD survey area.

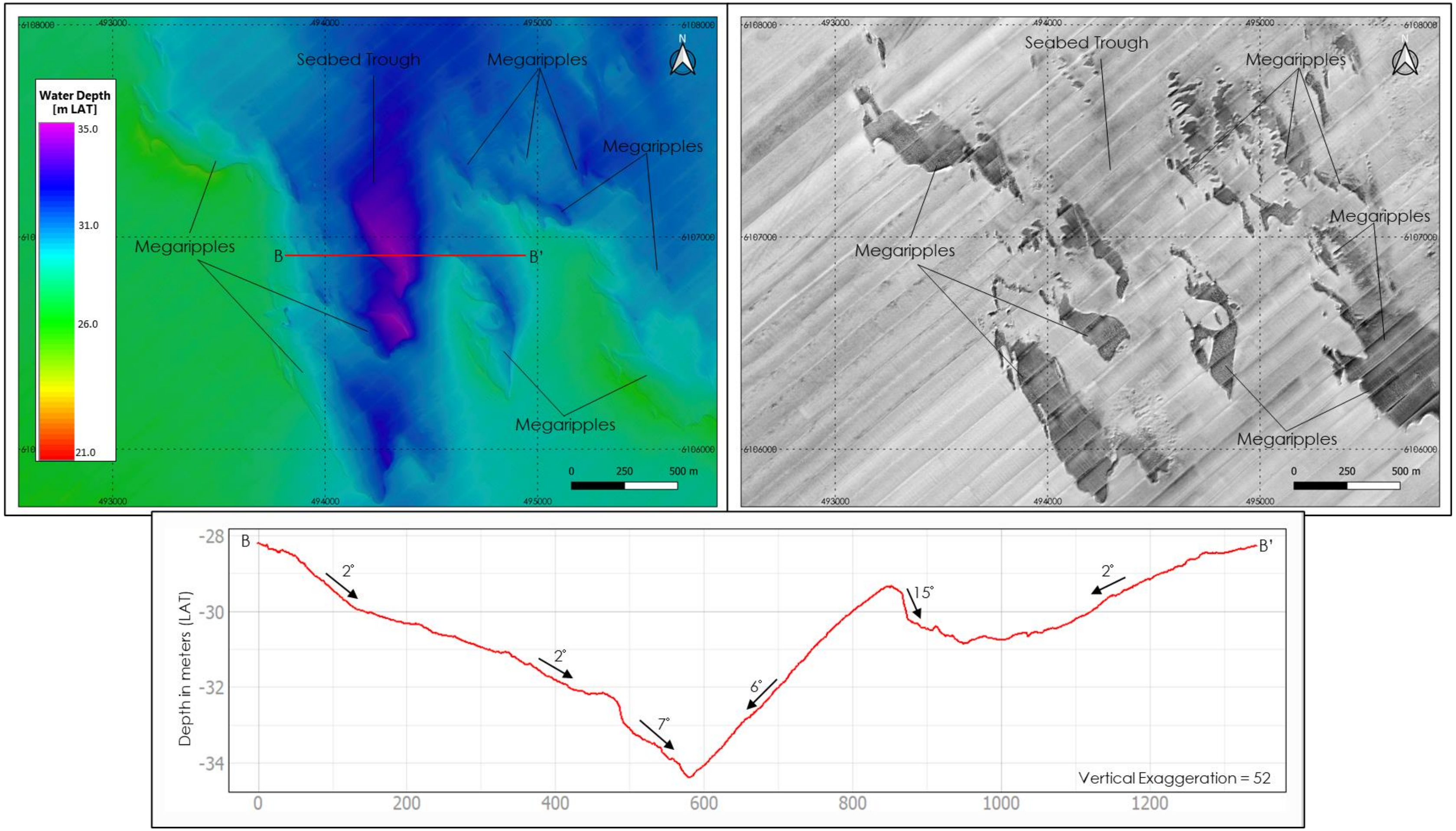


Figure 11: Multibeam bathymetric image, sidescan sonar image and seabed profiles across the seabed trough and megaripples within the DBD survey area

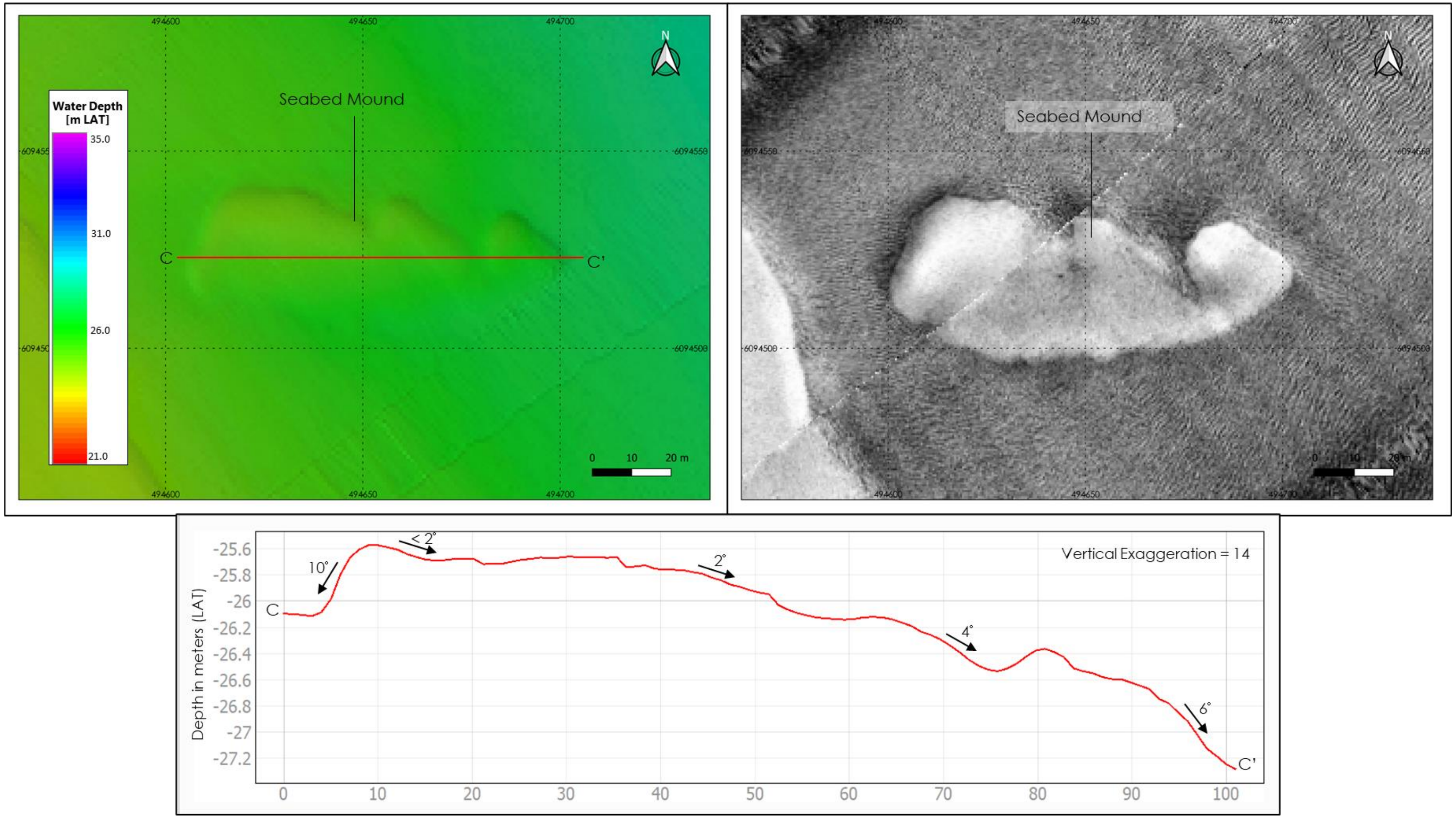
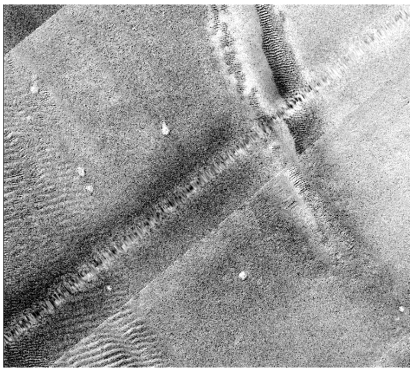
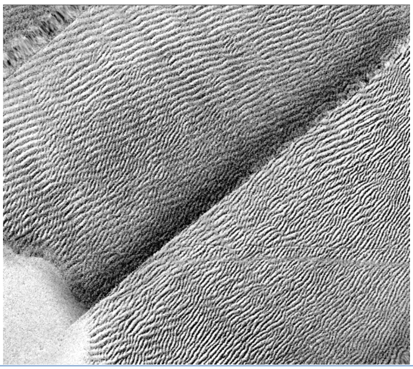


Figure 12: Multibeam bathymetric image, sidescan sonar image and seabed profiles across the seabed mound within the DBD survey area

4.3 Seafloor Sediment

An overview of the seafloor sediment interpretation and classification is presented on the charts in Appendix D.

Seafloor sediment interpretation and classification was based on a combination of data from MBES and SSS. The sediment classification was based on the British Standard code of practice (BSI, 2015). The data analysis was carried out using acoustic characteristics such as overall pattern, roughness and reflectivity. The acoustic characteristics of the seabed sediment types identified are summarised in Table 4.4.

SSS Image	Acoustic Description	Lithological Classification
 	High to medium reflectivity	Gravelly SAND
	Medium to low reflectivity	Slightly gravelly SAND

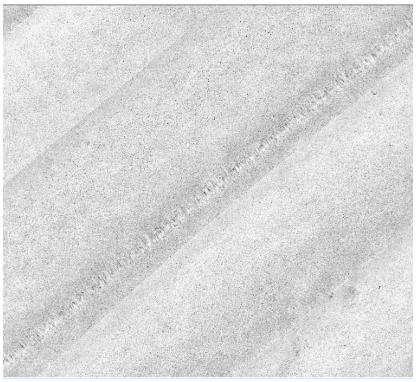
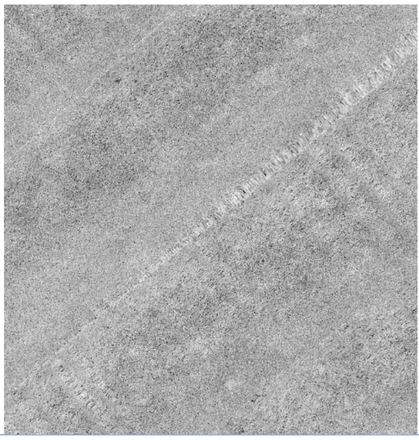
SSS Image	Acoustic Description	Lithological Classification
	Medium to low reflectivity	Slightly gravelly SAND
 	Low reflectivity	SAND

Table 4.4: Seabed sediment classification.

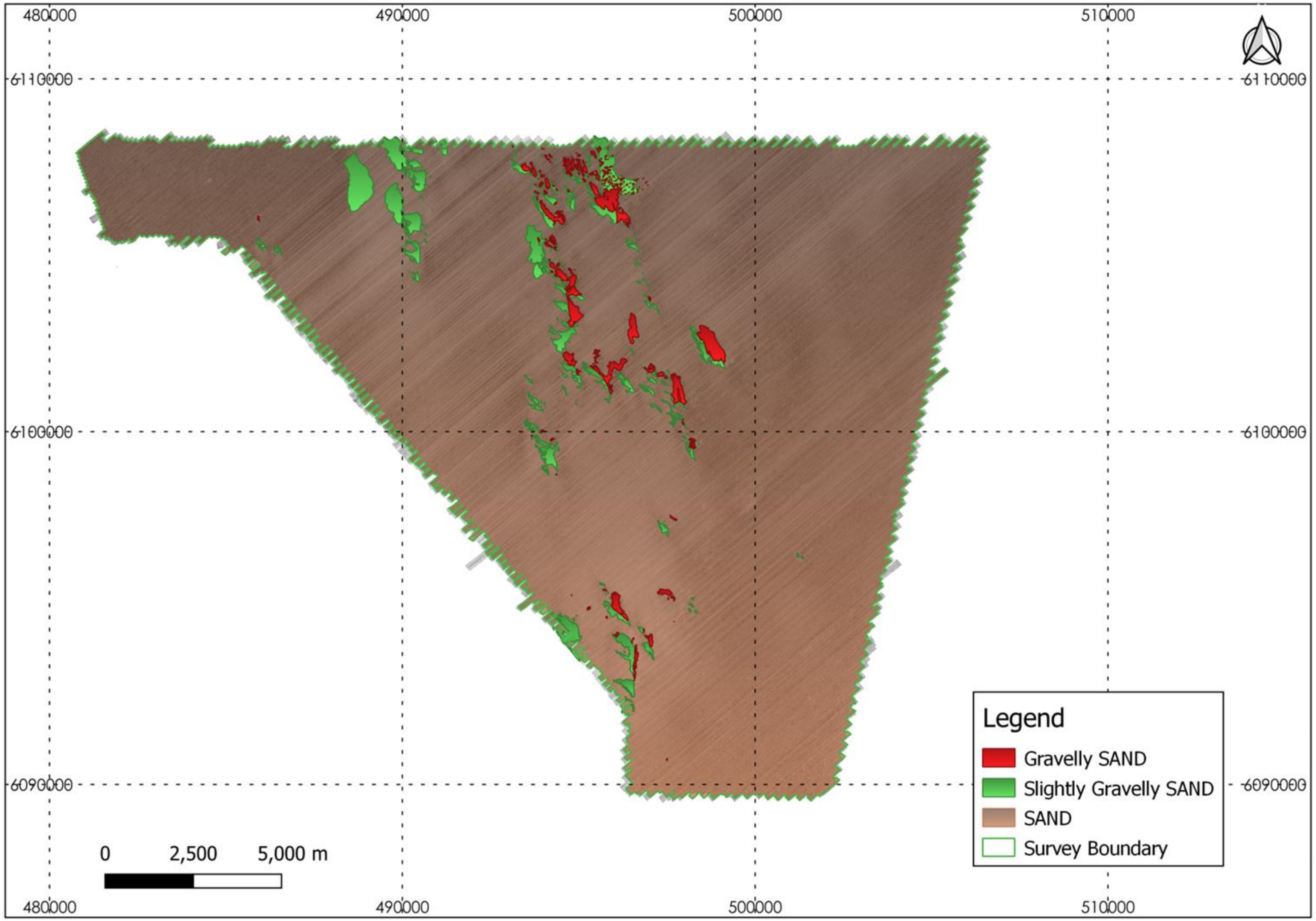


Figure 13: Seafloor classification map within the DBD survey area

4.4 Seafloor Contacts

Seafloor contacts were identified from one or more of the SSS, MBES and MAG sensors and cross-correlated where possible. The contacts present higher reflectivity than the surrounding general seabed.

The observed/mapped contacts within the DBD site are summarised in Table 4.5 below.

Sensor	Contact classification	Quantity
SSS/MBES	Boulder (manually picked)	1506
	Debris (object)	66
MAG	All contacts	8

Table 4.5: Summary of seafloor contacts within the DBD survey corridor.

4.4.1 Boulders

Boulders within the DBD survey area are most numerous in the central part and appear to be associated with megaripples and area of coarse sediments. The north-west and southern parts of the DBD survey area appear to consist of the fewest boulders. A total of 1506 boulders were identified within the DBD survey corridor.

The distribution of the identified boulders within the survey area is shown in Figure 14. Further details are presented in Appendix C.

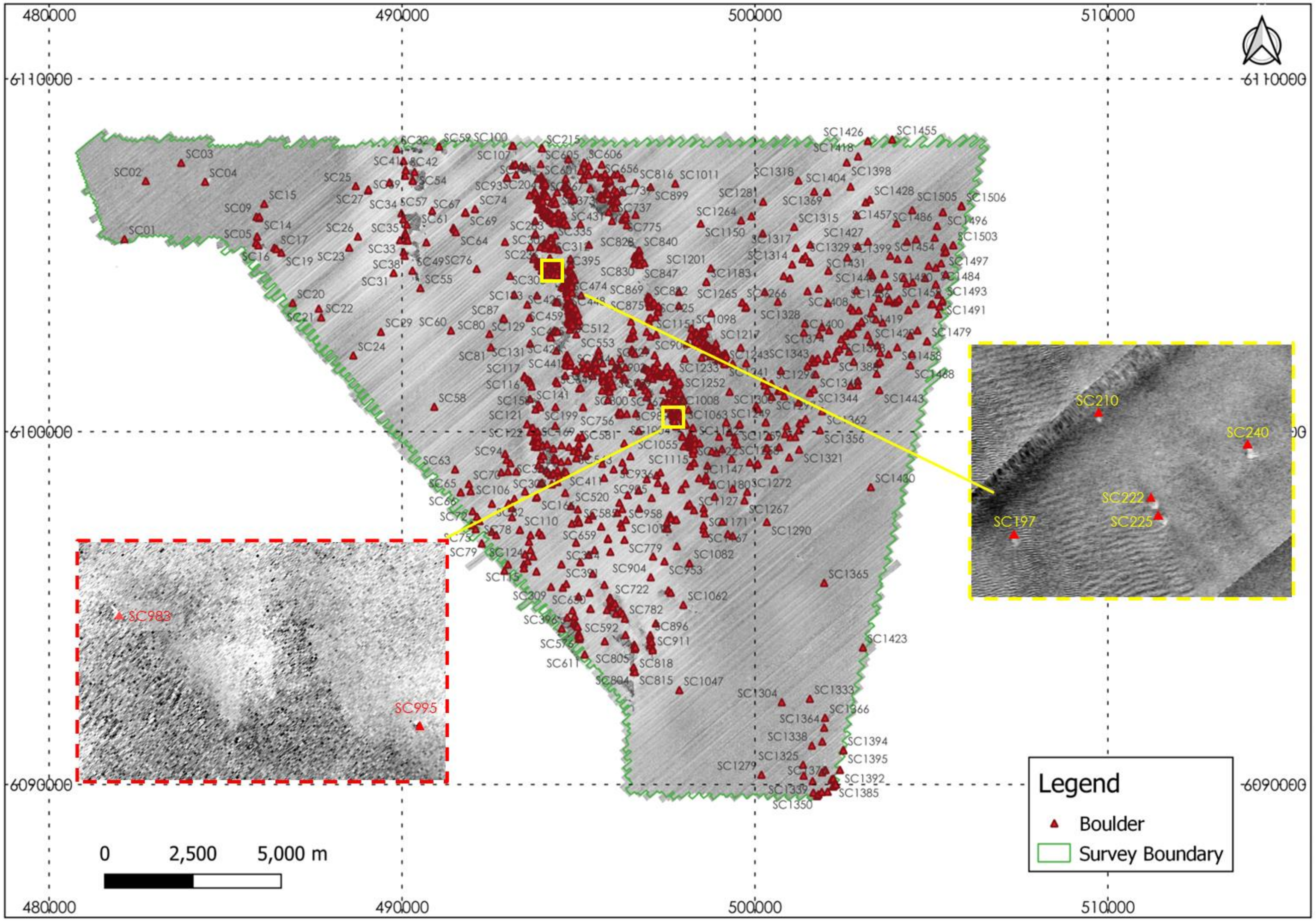


Figure 14: Sidescan Sonar Mosaic image showing the boulders distribution within the DBD survey area

4.4.2 Debris

A total of 66 debris were identified scattered throughout the DBD survey corridors. Details dimensions and coordinates of the debris are summarised in Table 4.6 below:

Debris	Easting	Northing	Dimensions			Remarks
			Length (m)	Width (m)	Height (m)	
ID01	482138	6105487	1.9	0.7	0.3	-
ID02	484534	6107141	25.1	5.8	0.7	Shipwreck
ID03	489709	6104506	3.5	1.6	0.3	-
ID04	491392	6101085	1.8	0.8	0.3	-
ID05	491430	6101146	2.3	1.1	0.3	-
ID06	491445	6104663	1.8	0.6	0.3	-
ID07	491847	6106897	2.1	0.7	0.7	-
ID08	492644	6097039	2.0	0.9	0.3	-
ID09	492990	6098870	1.9	0.7	0.3	-
ID10	493628	6098658	1.0	0.3	0.3	-
ID11	493785	6098624	2.6	0.4	0.3	-
ID12	493799	6097737	1.2	0.7	0.3	-
ID13	493858	6096456	1.6	1.3	0.3	-
ID14	493897	6101640	2.7	0.5	0.3	-
ID15	494466	6095527	2.6	1.3	0.3	-
ID16	494624	6101610	5.3	0.4	0.3	-
ID17	495009	6099901	0.7	0.5	0.6	-
ID18	495281	6102487	1.4	0.9	0.3	-
ID19	495513	6101710	3.1	0.4	0.3	-
ID20	495568	6094871	1.9	0.7	0.3	-
ID21	495695	6102270	1.5	0.6	0.3	-
ID22	496011	6107706	1.4	0.7	0.8	-
ID23	496195	6095541	1.1	1.1	0.3	-
ID24	496198	6097891	1.7	0.7	0.3	-
ID25	496273	6096921	1.8	0.9	0.3	-
ID26	496282	6106458	2.7	1.9	0.3	-
ID27	496491	6103298	1.0	0.3	0.3	-
ID28	496756	6102007	1.4	0.7	0.3	-
ID29	497079	6107091	1.4	0.5	0.4	-
ID30	497196	6100704	3.9	1.4	0.3	-
ID31	497313	6103377	1.7	0.4	0.3	-
ID32	497412	6096868	1.2	1.3	0.3	-
ID33	497689	6097073	1.0	0.5	0.3	-
ID34	497748	6097590	1.4	0.8	0.3	-
ID35	497831	6098080	3.7	0.8	0.3	-
ID36	498328	6099531	4.0	0.4	0.3	-
ID37	498417	6105857	1.0	0.5	0.3	-
ID38	498445	6097126	2.0	0.9	0.5	-
ID39	498547	6097936	2.7	2.3	0.7	-
ID40	498652	6097570	2.3	0.8	0.3	-
ID41	499182	6100684	3.0	1.1	0.3	-
ID42	499623	6103538	2.0	1.1	0.3	-
ID43	499724	6107260	1.7	0.4	0.3	-
ID44	499793	6107062	1.5	0.5	0.3	-
ID45	499885	6103669	2.1	0.5	0.3	-
ID46	499901	6107120	1.4	1.0	0.4	-
ID47	500031	6099040	1.4	1.3	0.3	-
ID48	500114	6098885	1.2	1.5	0.3	-
ID49	500123	6098693	1.3	1.0	0.3	-
ID50	500503	6099222	2.3	0.9	0.3	-
ID51	500787	6104770	1.1	0.4	0.5	-
ID52	501261	6104859	1.8	1.1	0.3	-
ID53	502621	6106995	1.1	0.7	0.3	-
ID54	502867	6104032	1.2	1.0	0.3	-

Debris	Easting	Northing	Dimensions			Remarks
			Length (m)	Width (m)	Height (m)	
ID55	502881	6104015	1.2	0.5	0.3	-
ID56	503221	6107729	4.2	1.3	0.3	-
ID57	503550	6101998	1.9	1.0	0.3	-
ID58	503723	6102150	1.5	0.8	0.3	-
ID59	503795	6103365	1.1	1.0	0.3	-
ID60	505154	6104508	2.4	0.9	0.3	-
ID61	505218	6104970	1.9	0.8	0.3	-
ID62	505259	6103231	2.0	1.2	0.3	-
ID63	505599	6105274	1.4	0.7	0.3	-
ID64	505603	6105281	2.1	1.5	0.3	-
ID65	505605	6105274	1.5	0.8	0.3	-
ID66	505613	6105282	1.8	0.7	0.3	-

Table 4.6: Summary of debris items within the DBD survey corridor.

Out of 66 items of debris, only debris items ID02 was observed to be associated with magnetic anomaly namely MC-01 and MC-02. Debris items ID02 appears to be well-preserved shipwreck lying on the seafloor in the northwestern half of the DBD survey area with dimensions of 25.1m x 5.8 m x 0.7 m (length x width x height).

4.4.3 Wrecks

One shipwreck was observed within the north-western half of the DBD survey area (Refer Figure 15 and Figure 18). The shipwreck appears to be well-preserved lying on the seafloor. Details of the as-found shipwreck are summarised in Table 4.7.

Debris	Easting	Northing	Dimensions			Remarks
			Length (m)	Width (m)	Height (m)	
ID02	484534	6107141	25.1	5.8	0.7	Shipwreck

Table 4.7: Summary of as-found shipwreck within the DBD survey corridor.

4.4.4 Cables and Pipelines

No cables or pipelines were identified within the DBD survey area.

4.4.5 Magnetometer Anomalies

A total of 8 magnetometer anomalies (contacts) were identified in the DBD survey corridors (Refer Figure 16). The magnetic contacts range from 17.6 nT/m to 734.2 nT/m.

Out of 8 magnetometer anomalies, only 2 magnetometer anomalies namely MC-01 and MC-02 were correlated to the as-found shipwreck within the north-western half of the DBD survey area. The remaining magnetic anomalies were interpreted as possible buried ferrous metal objects within the survey area. The details of the magnetometer anomalies are summarised in Table 4.8 below:

Magnetometer Anomalies	Easting	Northing	Magnetic Amplitude, nT/m	Remarks
MC-01	484492.85	6107170.33	28.0	Corresponded to the as-found shipwreck, ID02
MC-02	484582.62	6107117.49	17.6	Corresponded to the as-found shipwreck, ID02
MC-03	485403.25	6105324.73	111.5	Possible Buried Debris
MC-04	489437.82	6102300.74	18.9	Possible Buried Debris
MC-05	496551.99	6099675.55	32.1	Possible Buried Debris
MC-06	501855.53	6099012.79	734.2	Possible Buried Debris
MC-07	503851.88	6106963.91	150.0	Possible Buried Debris
MC-08	504249.14	6107705.94	75.6	Possible Buried Debris

Table 4.8: Summary of magnetometer anomalies within the DBD survey corridor.

4.4.6 Seabed Scars

Numerous seabed scars were observed throughout the DBD survey area (Refer Figure 17). These seabed scars are divided into anchor scars and trawl scars characterised based on the width and length of the seabed scars.

Trawl scars appear to be concentrated within the southern half and along the south-eastern and north-eastern survey limit of the DBD survey area whilst several anchor scars was observed near the south-south-western survey limit. These features are interpreted to be related to the active trawling activities and previous engineering activities within the DBD survey area.

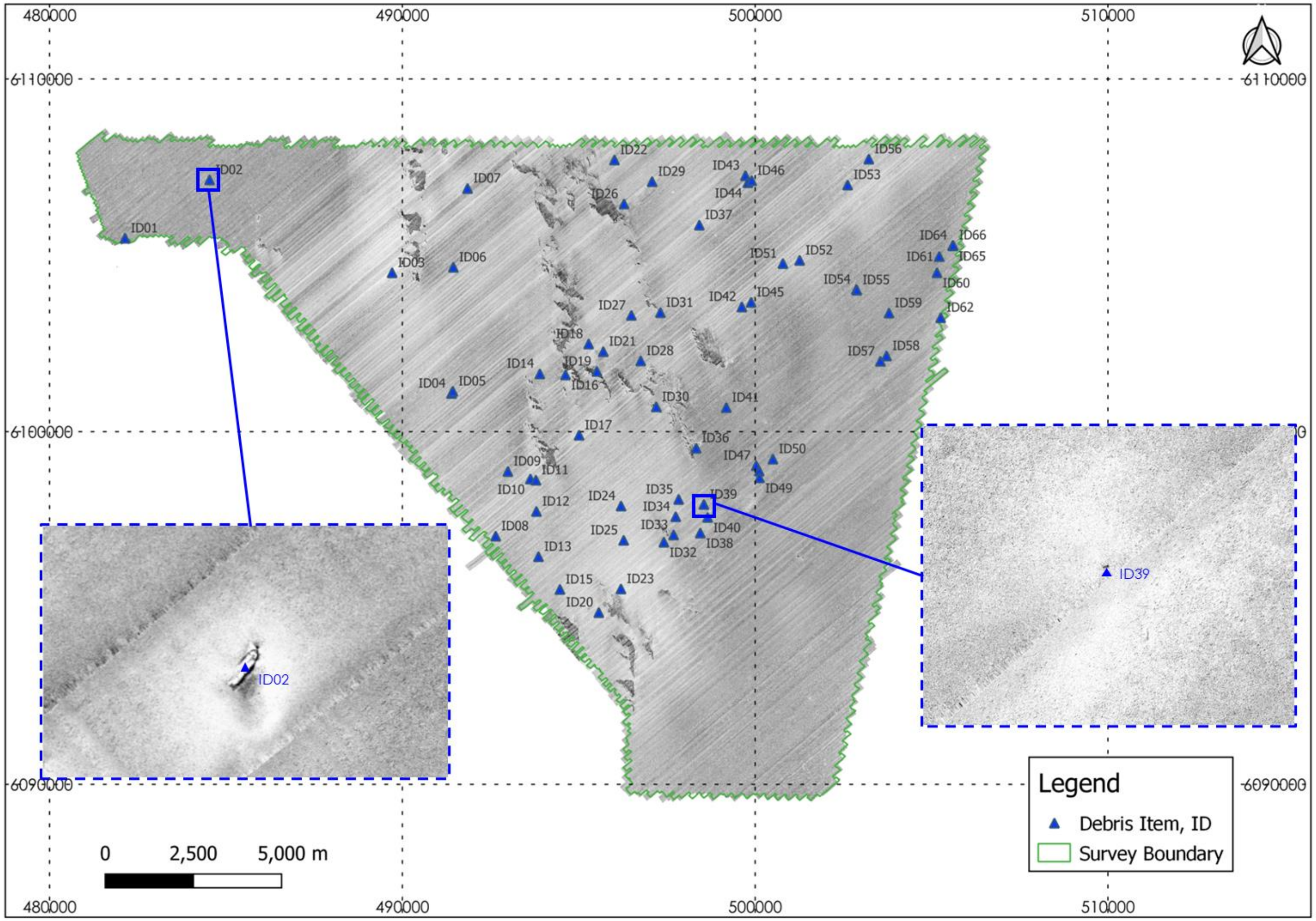


Figure 15: Sidescan Sonar Mosaic image showing the debris distribution within the DBD survey area.

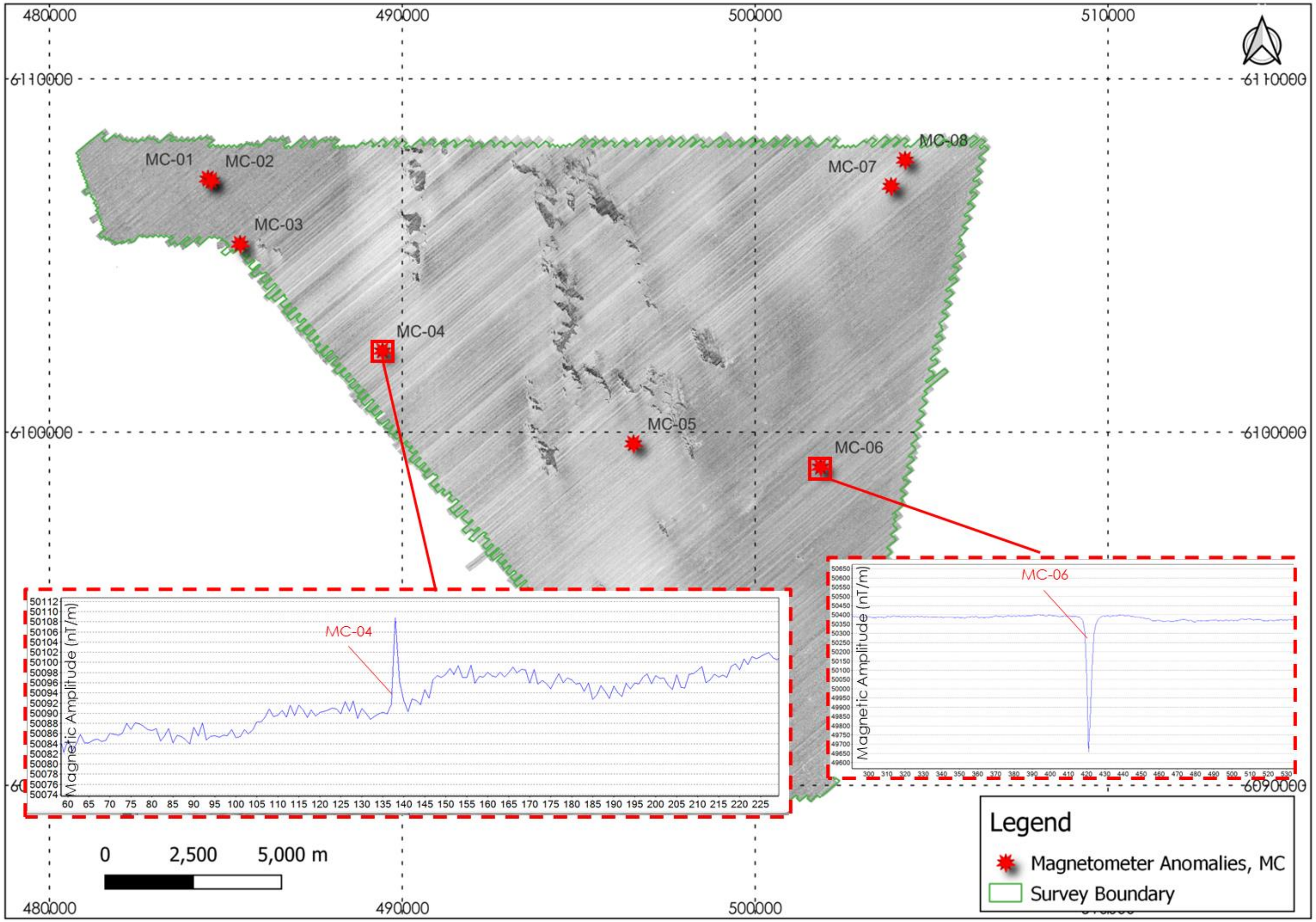


Figure 16: Sidescan Sonar Mosaic image showing the magnetometer anomalies distribution within the DBD survey area.

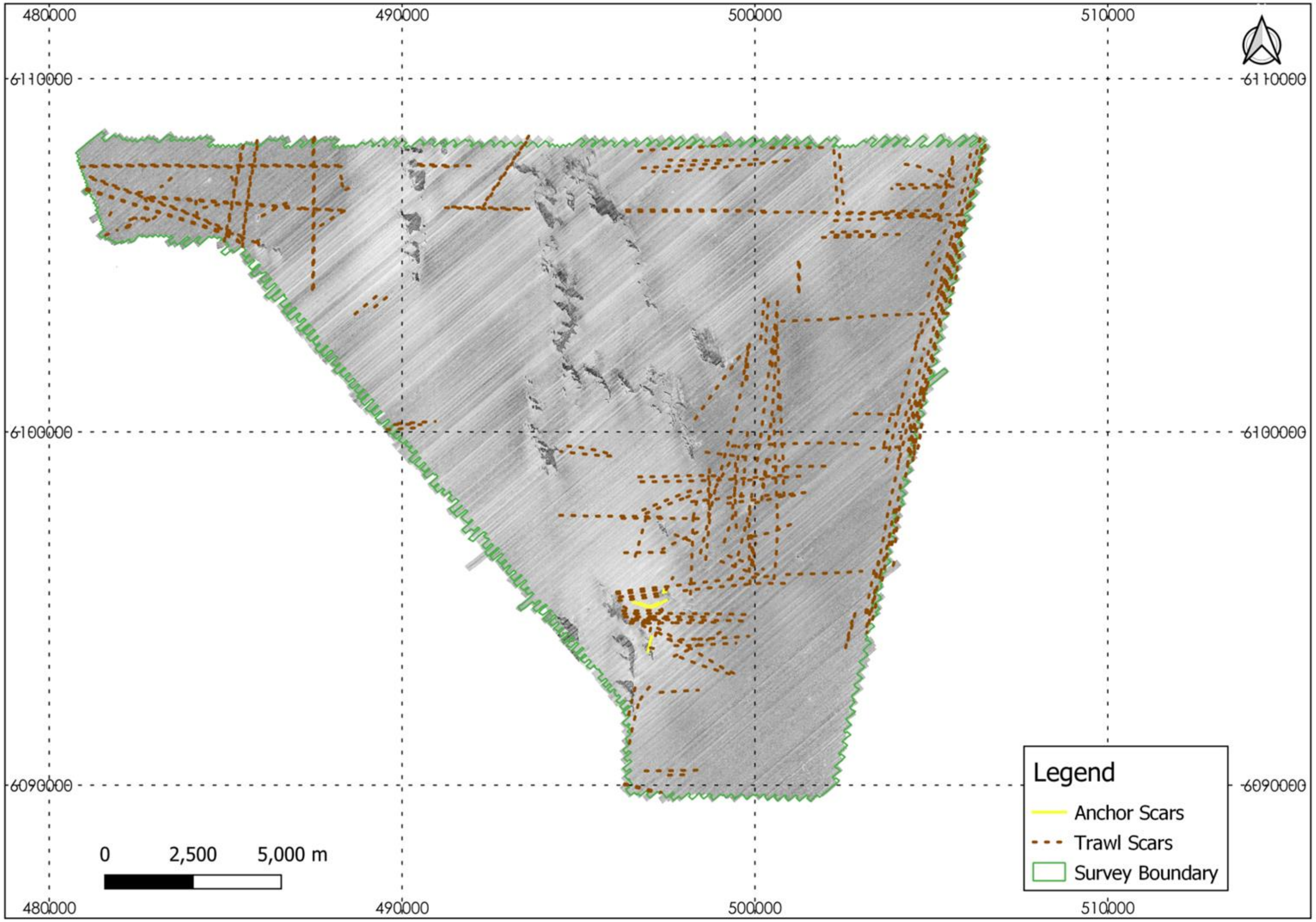


Figure 17: Sidescan Sonar Mosaic image showing the seabed scars distribution within the DBD survey area.

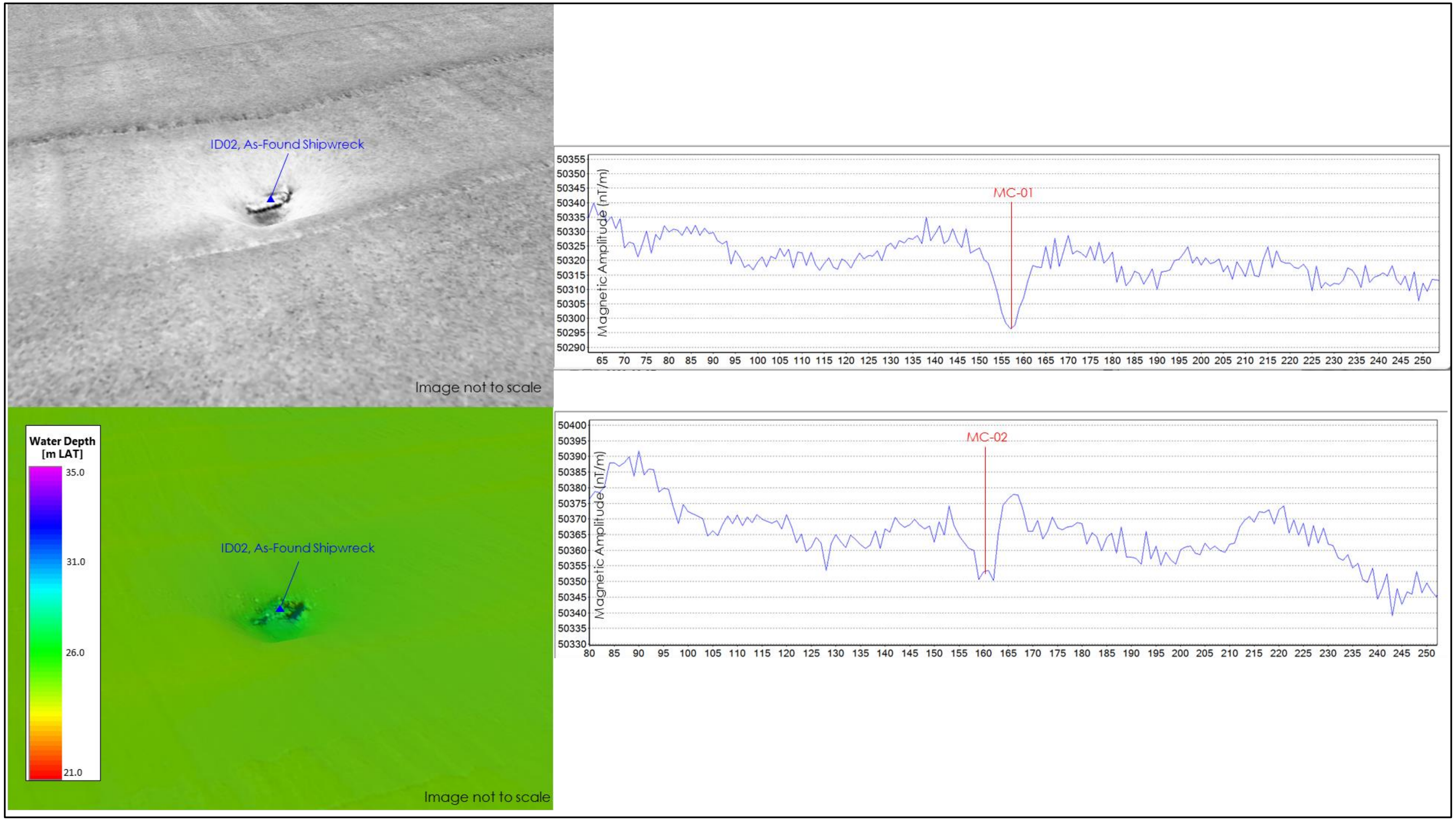


Figure 18: 3D view image and magnetometer anomalies showing the as-found shipwreck within the DBD survey area.

4.5 GEOLOGICAL SETTING

The DBD survey area falls is in the central part of the Dogger Bank in the UK sector of the North Sea. The Dogger Bank forms a topographic high within the southern North Sea and is thought to represent a thrust-moraine complex formed during the Weichselian glaciation.

The geological conditions within the DBD survey area have been affected by repeated advances and retreats of ice sheets during the Quaternary, leading to the deposition of a thick sequence of glacial, deltaic and marine sediments.

The variability of soil conditions in the Quaternary deposits is expected to result in glacial deformation of the Quaternary deposits and presence of buried ridges. The DBD area is believed to be flooded by Holocene sediments overlying the older glacier deposits during the Holocene period. These Holocene sediments are the results of reworked sediment by the recent marine processes within the DBD survey area.

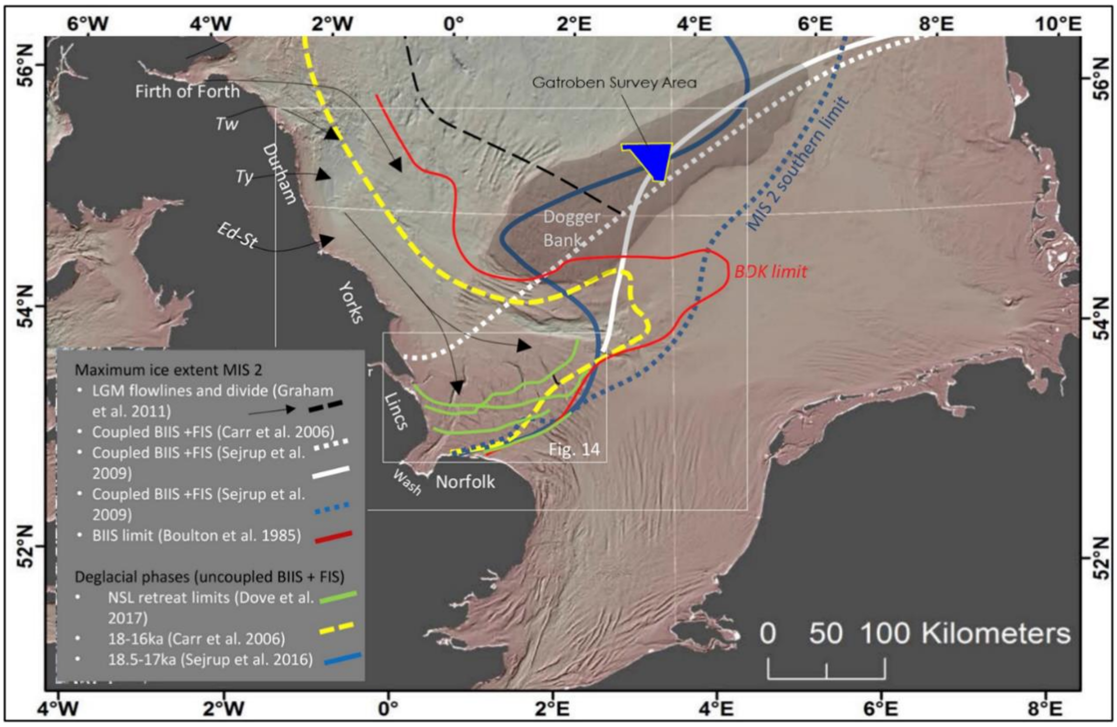


Figure 19: The physiographic setting of the southern North Sea with mapped ice limits for the Last Glacial Maximum (LGM)

4.5.1. Stratigraphy

An overview of the seismic horizons and corresponding seismic units as interpreted in the SBP data, is presented in Table 4.9and Figure 20. All depths are quoted in metres below seafloor (m BSF). Lithological descriptions and stratigraphy of the geological sequence are derived from acoustic character, regional geological literature within the survey area.

The shallow sediments within DBD survey area can be divided into six main units, namely Units A through G, separated accordingly by reflectors R1 to R6. Unit A is interpreted as Holocene marine sediments. This unit overlies the late Weichselian to early Holocene Formations which are Botney Cut and Dogger Bank Formation.

Fugro Unit	Formation	Basal Horizon	Depth (m BSF)	Anticipated Sediments	Remarks
A	Holocene Sand	R1	< 2	Loose to medium dense silty SAND	Acoustically semi-transparent to chaotic reflectors and appear to blanket the entire survey area.
B	Botney Cut	R2	< 1 to 4	Medium dense to very dense SAND overlying firm CLAY with silt and sand layers	Low to medium amplitude parallel reflectors, steeply inclined in the northern half of the survey area, appear dipping towards the south and locally incised by seabed trough in the central part of the survey area.
C		R3	< 1 to 5	Firm to stiff CLAY with silt and sand layers	
D		R4	< 1 to 7	Stiff CLAY with silt and sand layers	
E		R5	< 1 to 10	Very stiff CLAY with silt and sand layers	
F	Dogger Bank	R6	2 to 15	Very dense SAND overlying very stiff sandy CLAY	Acoustically semi-transparent to chaotic, undulating to irregular medium to high amplitude reflectors. Appear as buried channel infill sediments within the survey area
G		N/A	N/A	Very stiff CLAY	Chaotic, acoustically semi-transparent to transparent reflectos.

Notes:
N/A = Not Available

Table 4.9: Summary of shallow geology within the DBD survey area.

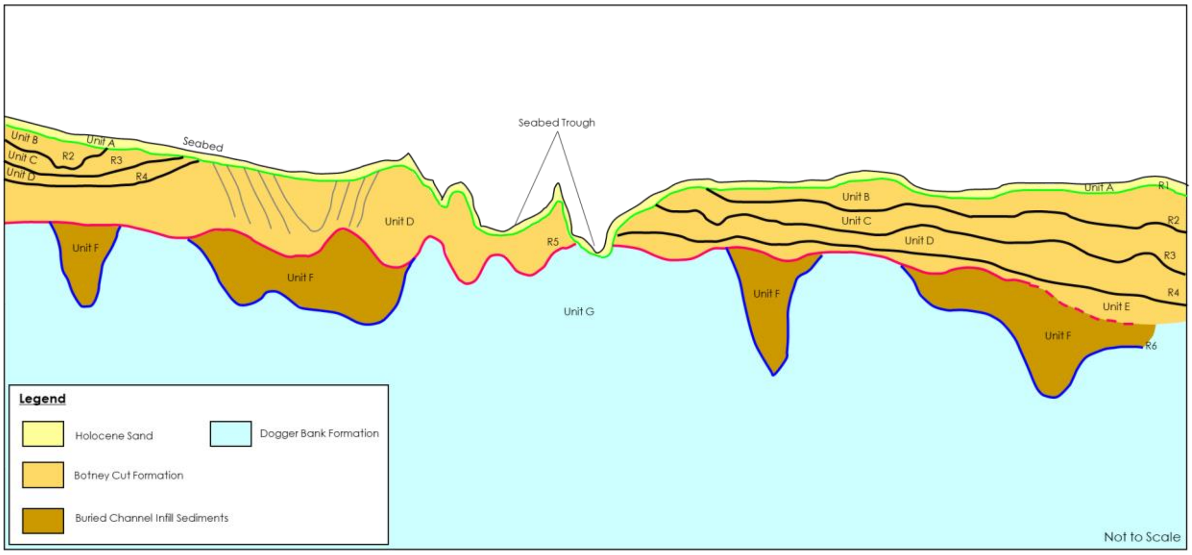


Figure 20: Geological schematic showing the interpreted units within the DBD survey area

4.5.1.1. Unit A

Unit A appear to blanket the entire DBD survey area as thin surficial sediments with thickness of less than 1.0 m below seafloor throughout the survey area (Refer Figure 23). Unit A is interpreted as Holocene SAND.

The internal seismic character of unit A is typically semi-transparent to chaotic reflections (Refer Figure 27 and Figure 28). The base of unit A is defined by reflector R1. However, due to the nature of thick seabed ringing on the sub-bottom profiler, reflector R1 was not able to be mapped accurately throughout the survey area.

4.5.1.2. Unit B to Unit E

Unit B to Unit E were observed mainly within the southern half and locally in the north-western limit of the DBD survey area. The bases of this units are defined by reflector R2 to R5 and is interpreted to represent the Botney Cut Formation within the DBD survey area.

Unit B to Unit E displayed low to medium amplitude parallel reflectors, steeply inclined in the northern half of the survey area, dipping towards the south and locally incised by seabed trough in the central part of the survey area (Refer Figure 27 to Figure 29). The thickness of these units ranges from less than 1.0 m and up to 10.0 m below seafloor throughout the survey area.

Due to the limitation of the sub-bottom profiler data penetration, the bases of these units was not able to be identified within the southern half of the survey area.

4.5.1.3. Unit F and Unit G

Unit F was interpreted as buried palaeochannel within Unit G mainly in the central part and northern part of the DBD survey area. Unit F appear to consist semi-transparent to chaotic, undulating to irregular medium to high amplitude internal reflectors with thickness ranges from 2.0 m to 15.0 m below seafloor throughout the survey area. The channel infill sediments within Unit F are expected to consist variable geotechnical properties and further analysis should be carried out in order to avoid any potential constraint to the engineering activities within the DBD survey area.

Unit G are the deepest sedimentary units observed within the DBD survey area and the bases of Unit G could not be identified as it is beyond the sub-bottom profiler data penetration. Unit G appear to consist chaotic, acoustically semi-transparent to transparent internal reflectos. Both Unit F and Unit G is interpreted as the upper part of Dogger Bank Formation within the DBD survey area (Refer Figure 27 to Figure 29).

4.5.2. Shallow Geology

4.5.2.1. Mobile Sediments

Unit A appear as the mobile sediments forming the present-day megaripples feature within the DBD survey area. Unit A interpreted as the most recent sediment deposition and highly influenced by active marine processes within the DBD survey area.

4.5.2.2. Palaeochannel system

Palaeochannel system within the DBD survey area can be divided into two systems. One buried palaeochannel systems was observed incising the Botney Cut Formation (Unit B to Unit E) near the north-western limit of the survey area with the base of this buried palaeochannel reach up to 7.0 m below seafloor (Refer Figure 21).

Another buried palaeochannel system was defined by Unit F, randomly incising the Dogger Bank Formation (Unit G) throughout the DBD survey area with the bases of this buried palaeochannel system may reach up to 15.0 m within the survey area (Refer Figure 22). However, due to the limitation of the sub-bottom profiler data penetration, the distribution and the bases of this palaeochannel system could not be mapped accurately throughout the DBD survey area. Caution is advised as the palaeochannel infill sediments are expected to consist variable geotechnical properties and may pose constraint to the engineering activities within the DBD survey area.

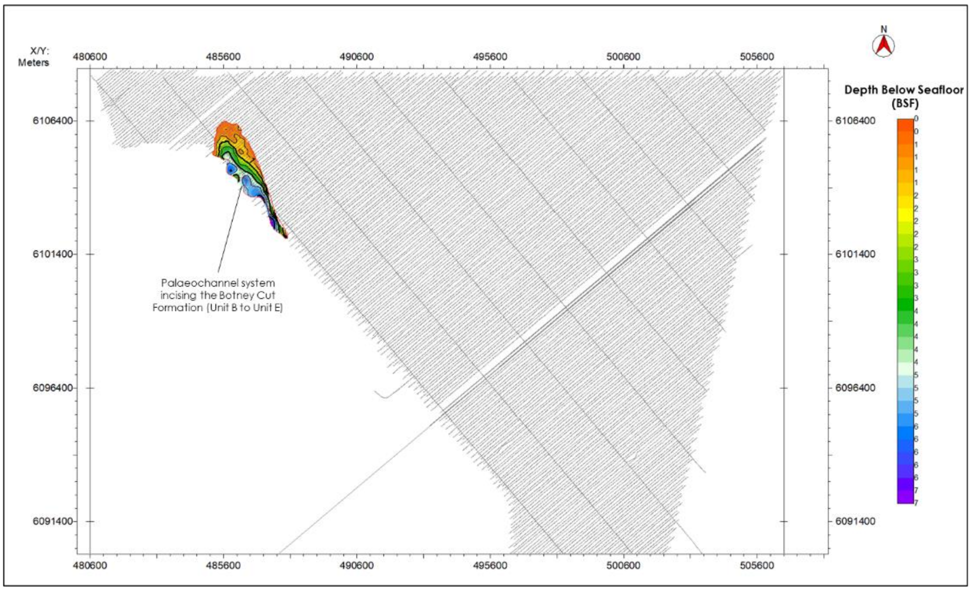


Figure 21: Overview of the palaeochannel system incising the Botney Cut Formation (Unit B to Unit E) near the north-western limit of DBD survey area.

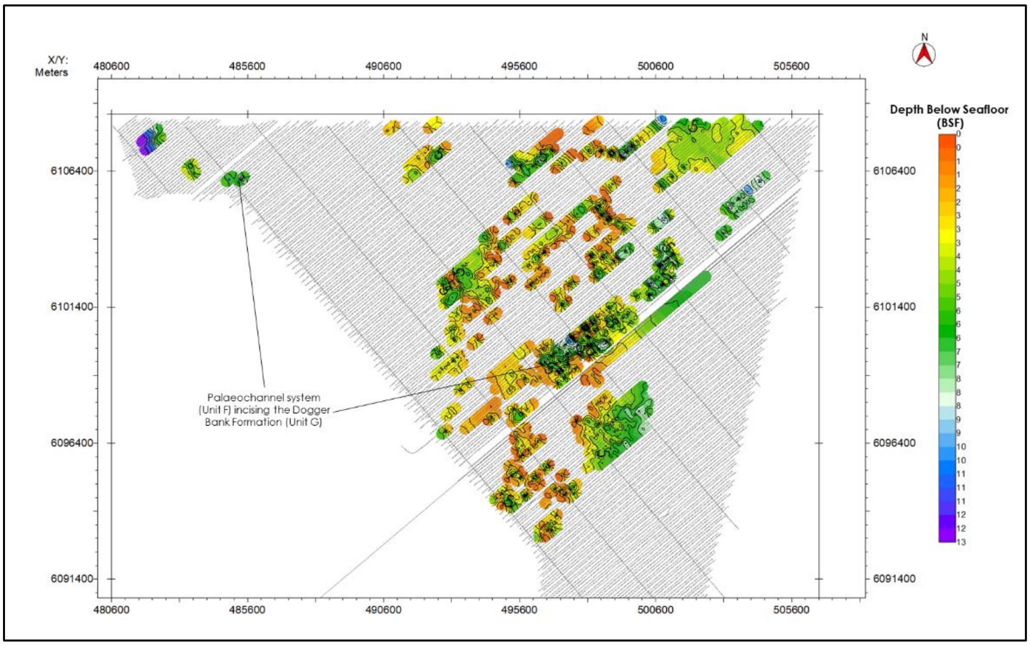


Figure 22: Overview of the random distribution of palaeochannel system (Unit F) incising the Dogger Bank Formation (Unit G) within the DBD survey area.

4.5.2.3. Shallow Gas

No clear evidence of gas was observed from the sub-bottom profiler data throughout the DBD survey area.

4.5.2.4. Faults

No evidence of faulting events was observed on the sub-bottom profiler data within the DBD survey area.

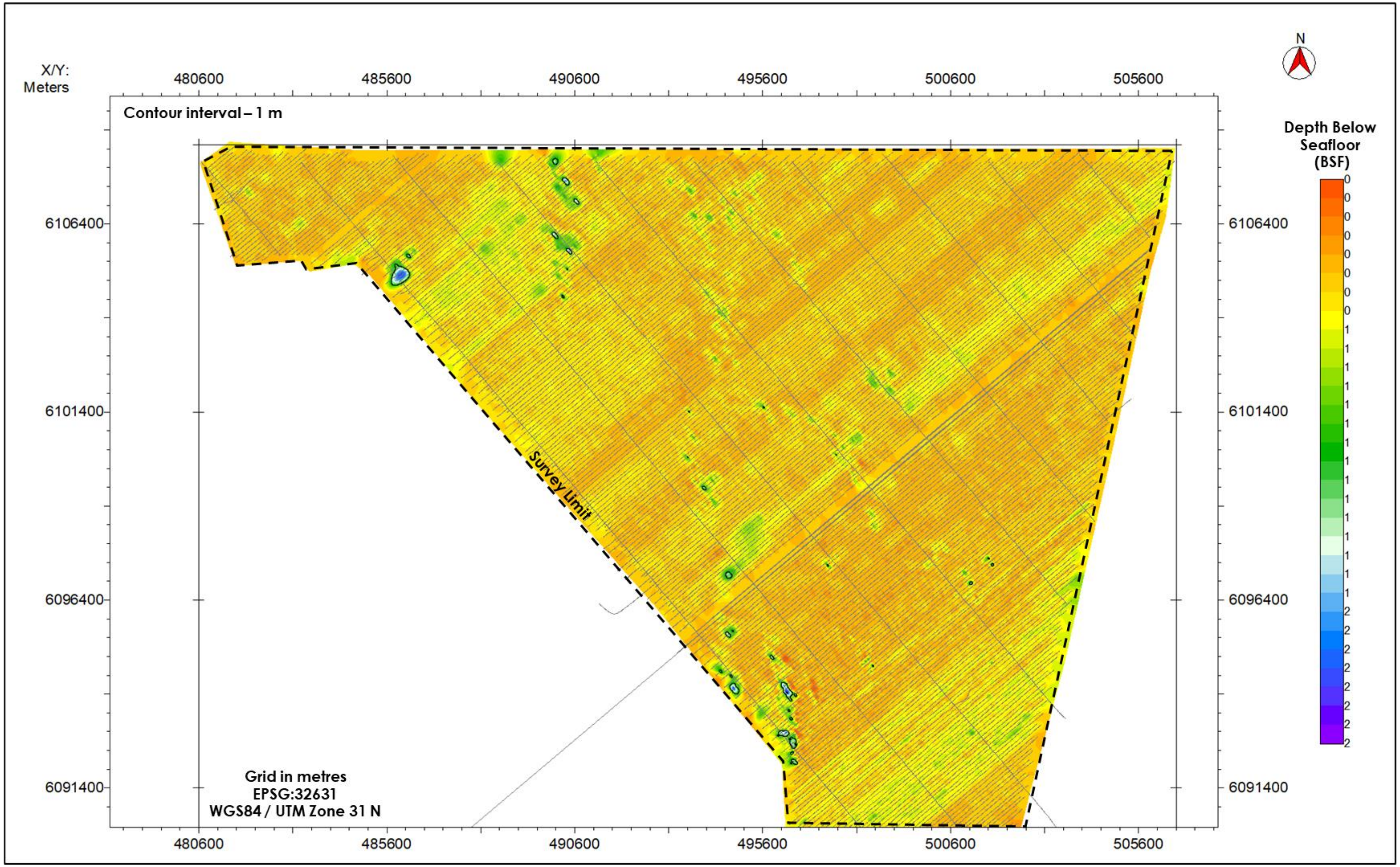


Figure 23: Isopach map of Unit A (Reflector R1) within the DBD survey area.

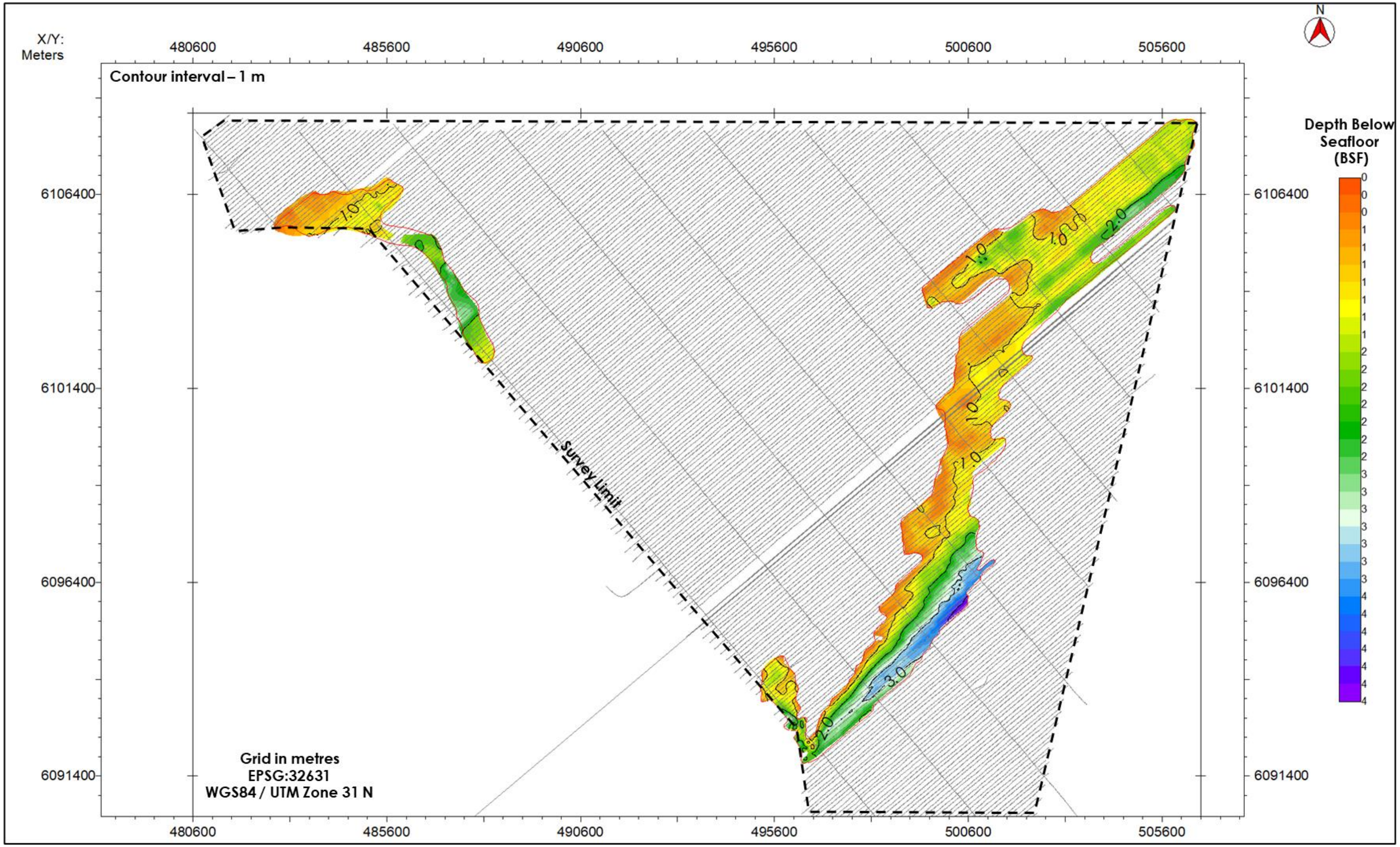


Figure 24: Isopach map of Unit B (Reflector R2) within the DBD survey area.

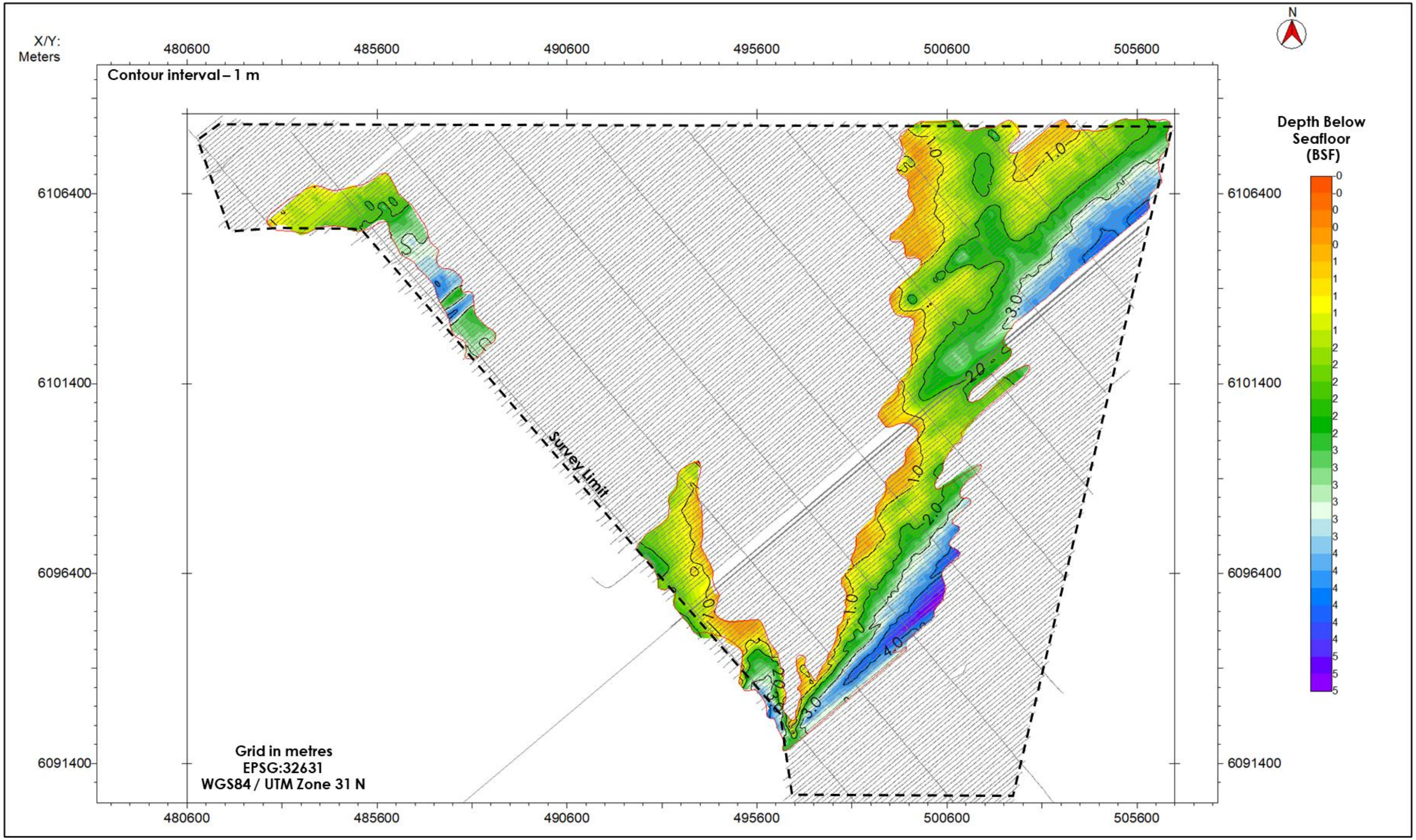


Figure 25: Isopach map of Unit C (Reflector R3) within the DBD survey area.

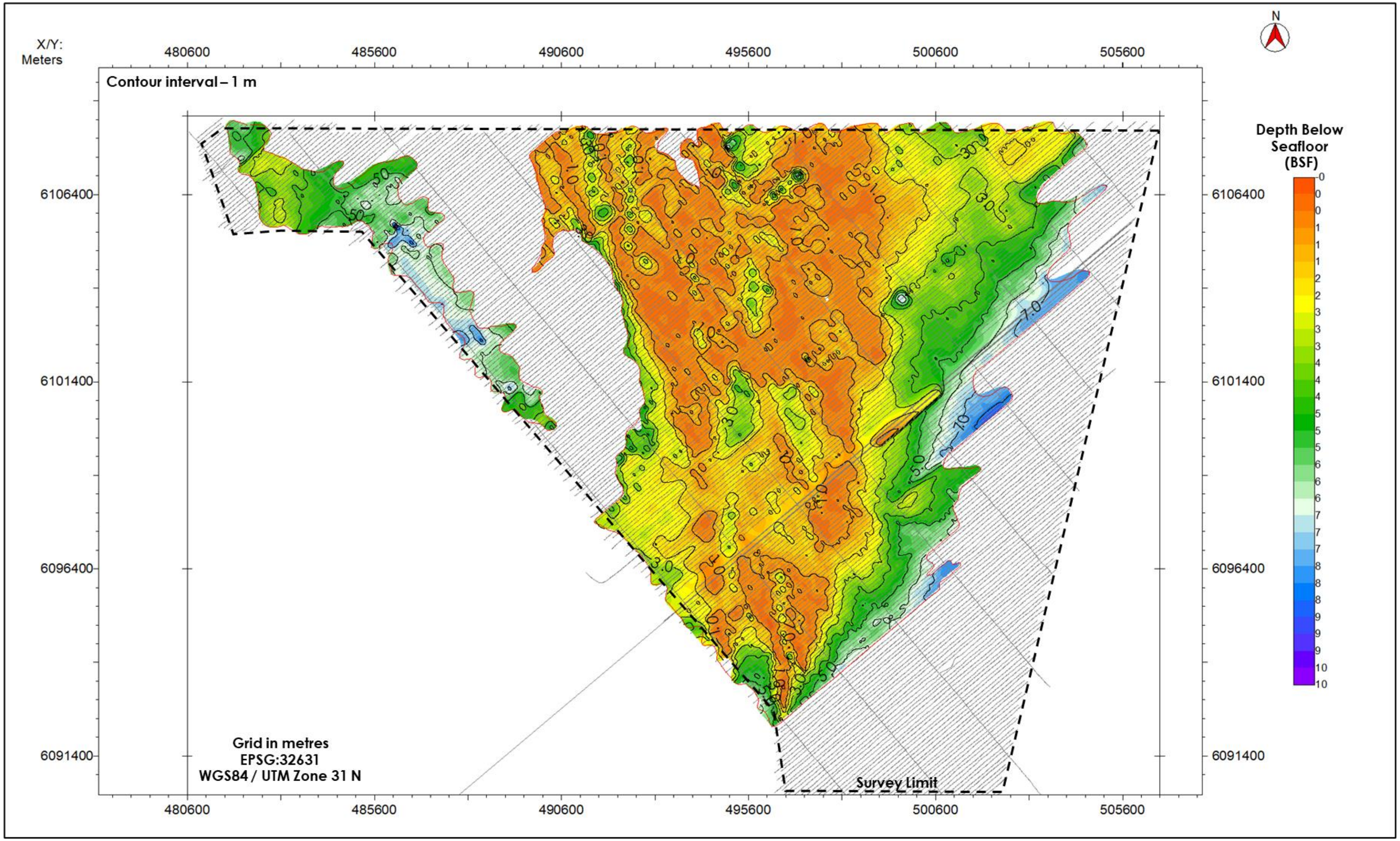


Figure 26: Isopach map of Botney Cut Formation (Reflector R5) within the DBD survey area.

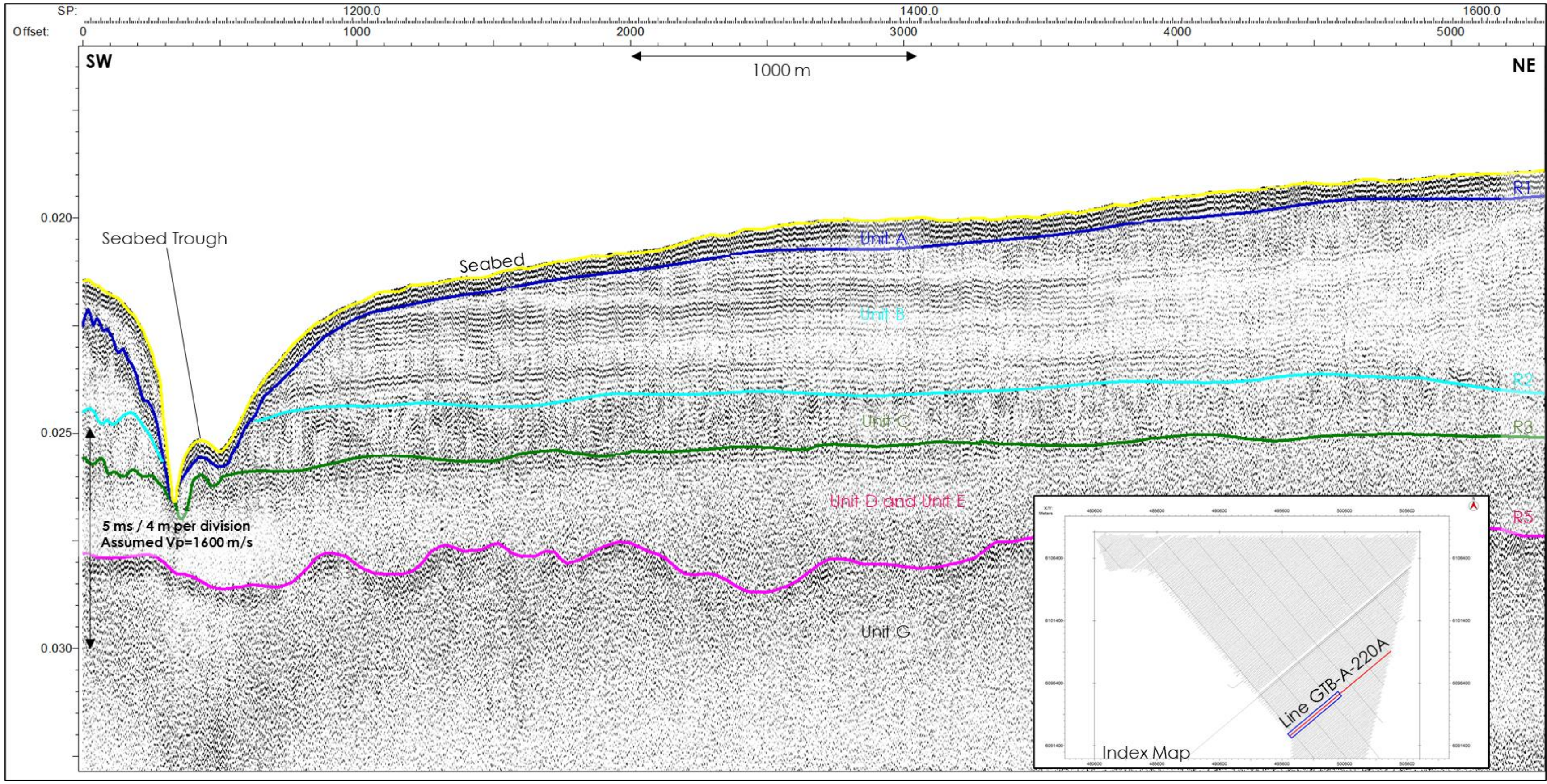


Figure 27: Sub-Bottom Profiler Data Line GTB-A-220A, showing the general shallow geology within the DBD survey area.

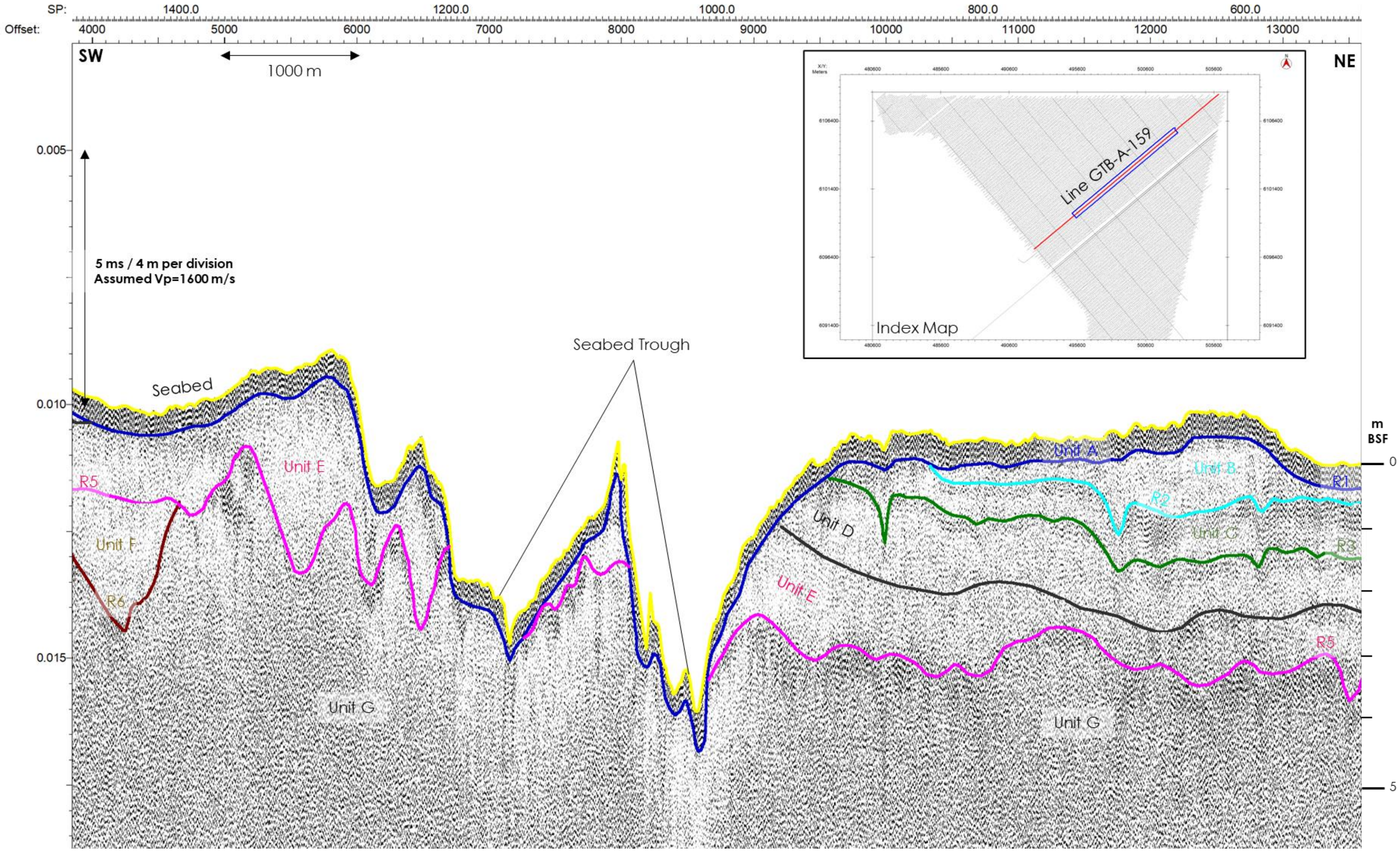


Figure 28: Sub-Bottom Profiler Data Line GTB-A-159, showing the general shallow geology within the DBD survey area.

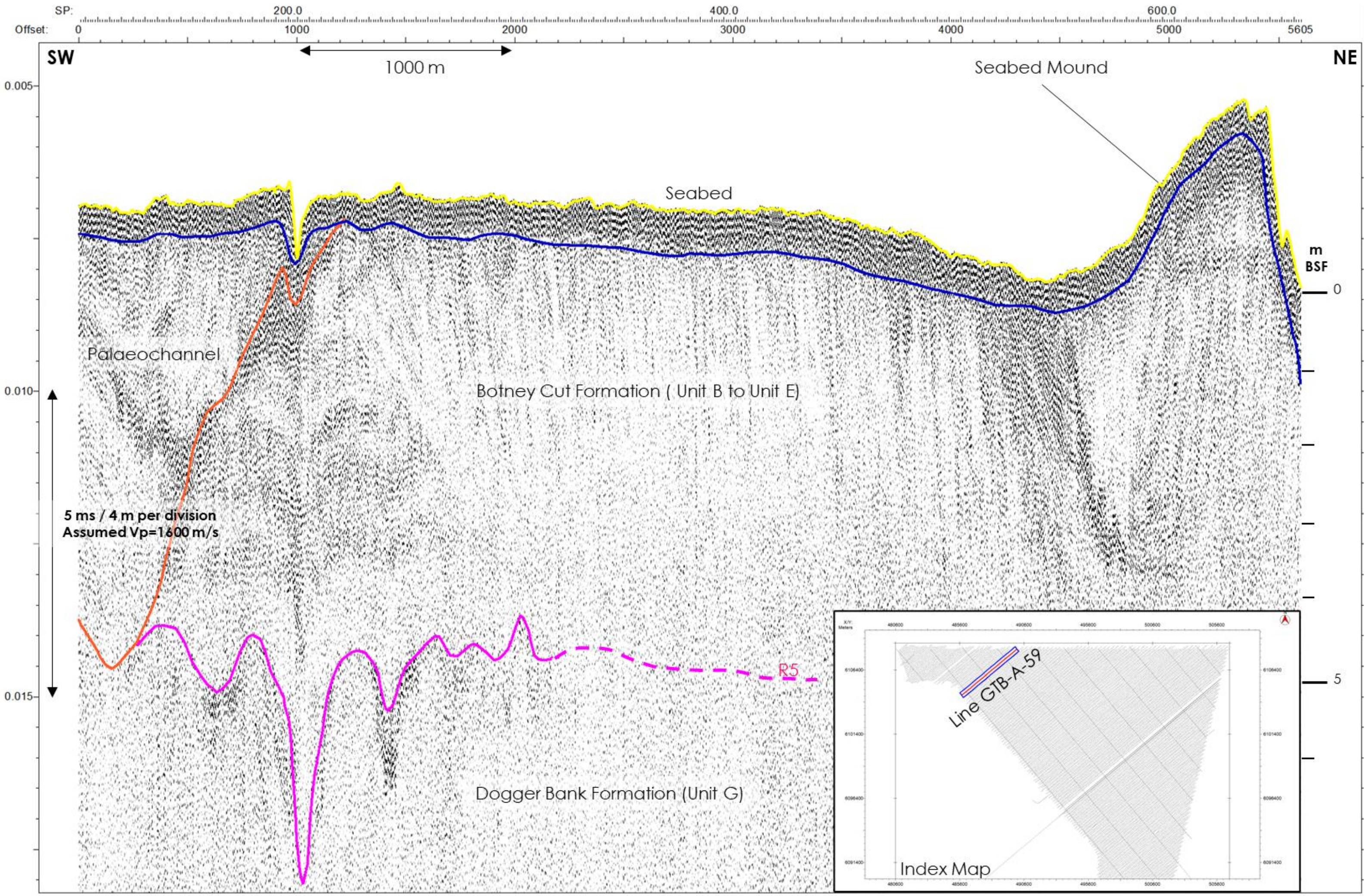


Figure 29: Sub-Bottom Profiler Data Line GTB-A-59, showing the general shallow geology within the DBD survey area.

5. GEOHAZARDS ANALYSES

5.1. Water depths

The water depths within the site vary between 21.6m LAT and 34.6m LAT.

5.2. Marine Slope Stability

The seafloor within the DBD survey area is generally gentle with average seafloor gradient of 1°. Localised steep slopes of greater than 15° are observed along the slopes of megaripples and seabed troughs. Very steep slopes (>15°) can be susceptible to localised sediment collapse when disturbed and may pose a constraint to some seabed engineering activities within the DBD survey area.

5.3. Sediment Transport

The dominant seafloor sediment within the DBD survey area is loose to medium dense SAND. Numerous megaripples are observed throughout the survey area. These features are generally oriented in east-north-east to west-south-west direction indicative of strong water bottom currents flowing in the north-north-west to south-south-east direction. Strong current may have adverse impact on the efficiency of the installation operations within the survey area.

5.4. Scouring

Seabed troughs across the DBD area are thought to results from wide scale water bottom currents with scouring effects that led to over 4m of drop in seabed levels. Scouring should be considered during final design of turbines foundation and inter-array cables.

5.5. Palaeochannels

Palaeochannels system were observed within the Botney Cut and Dogger Bank Formation throughout the DBD survey area with the bases of these palaeochannels may reach up to 15.0 m below seafloor. The paleochannel infill sediments are characterised by chaotic, undulating to irregular medium to high amplitude internal reflectors, interpreted to comprise mixture of clay, sand and silt with variable soil properties. Caution is advised as the paleochannels infill sediments may present variable strength and therefore pose constraint to the engineering activities within the DBD survey area.

5.6. Seabed obstructions

Boulders, debris and shipwreck are mapped within the site. These shall be considered prior to construction activities.

5.7. Faulting

No evidence of faulting events was observed within the DBD survey area.

5.8. Shallow Gas

No clear evidence of gas was observed within the DBD survey area.

5.9. Archaeology Artifacts

A shipwreck is depicted on the side scan sonar and MBES data and this feature should be investigated further by the archaeologists to establish its historical significance.

6. CONCLUSION

The sediment distribution throughout the survey area varies from sand to clay. Potential habitat within the survey area covers region with shallow water depth that is located further away from the rock outcrops.

The local conditions that should be taken into account during design and operations are:

- Water depths
- Marine Slopes exceeding 15°
- Strong water bottom currents
- Paleochannels
- Seabed obstructions ie boulders/debris
- Archaeology artefacts ie shipwreck
- Buried UXOs

7. REFERENCES

- British Geological Survey (BGS), 1991, California, Sheet 53°N-00°E, 1:250,000 Series, Quaternary Geology.
- Cotterill C. P. et al, 2017, The evolution of the Dogger Bank, North Sea: A complex history of terrestrial, glacial and marine environmental change
- David H. R. et al, 2018. Ice marginal dynamics of the last British-Irish Ice Sheet in the southern North Sea: Ice limits, timing and the influence of the Dogger Bank.

Appendices

APPENDIX A GUIDELINES ON USE OF REPORT

This report (the "Report") was prepared as part of the services (the "Services") provided by ENVIROS Survey & Consultancy Limited ("ENVIROS") for its client (the "Client") under terms of the relevant contract between the two parties (the "Contract"). The Services were performed by ENVIROS based on requirements of the Client set out in the Contract or otherwise made known by the Client to ENVIROS at the time.

ENVIROS's obligations and liabilities to the Client or any other party in respect of the Services and this Report are limited in time and value as defined in Contract (or in the absence of any express provision in the Contract as implied by the law of the Contract) and ENVIROS provides no other representation or warranty whether express or implied, in relation to the Services or for the use of this Report for any other purpose. Furthermore, ENVIROS has no obligation to update or revise this Report based on changes in conditions or information which emerge following issue of this Report unless expressly required by the Contract.

The Services were performed by ENVIROS exclusively for the Client and any other party identified in the Contract for the purpose set out therein. Any use and/or reliance on the Report or the Services for purposes not expressly stated in the Contract, by the Client or any other party is that party's risk and ENVIROS accepts no liability whatsoever for any such use and/or reliance.

APPENDIX B GEODETIC PARAMETERS

APPENDIX C BOULDERS LISTINGS

APPENDIX D CHARTS