Rampion 2 Wind Farm

Category 6: Environmental Statement

Volume 4, Appendix 9.4 Geophysical survey (Part 6 of 7)

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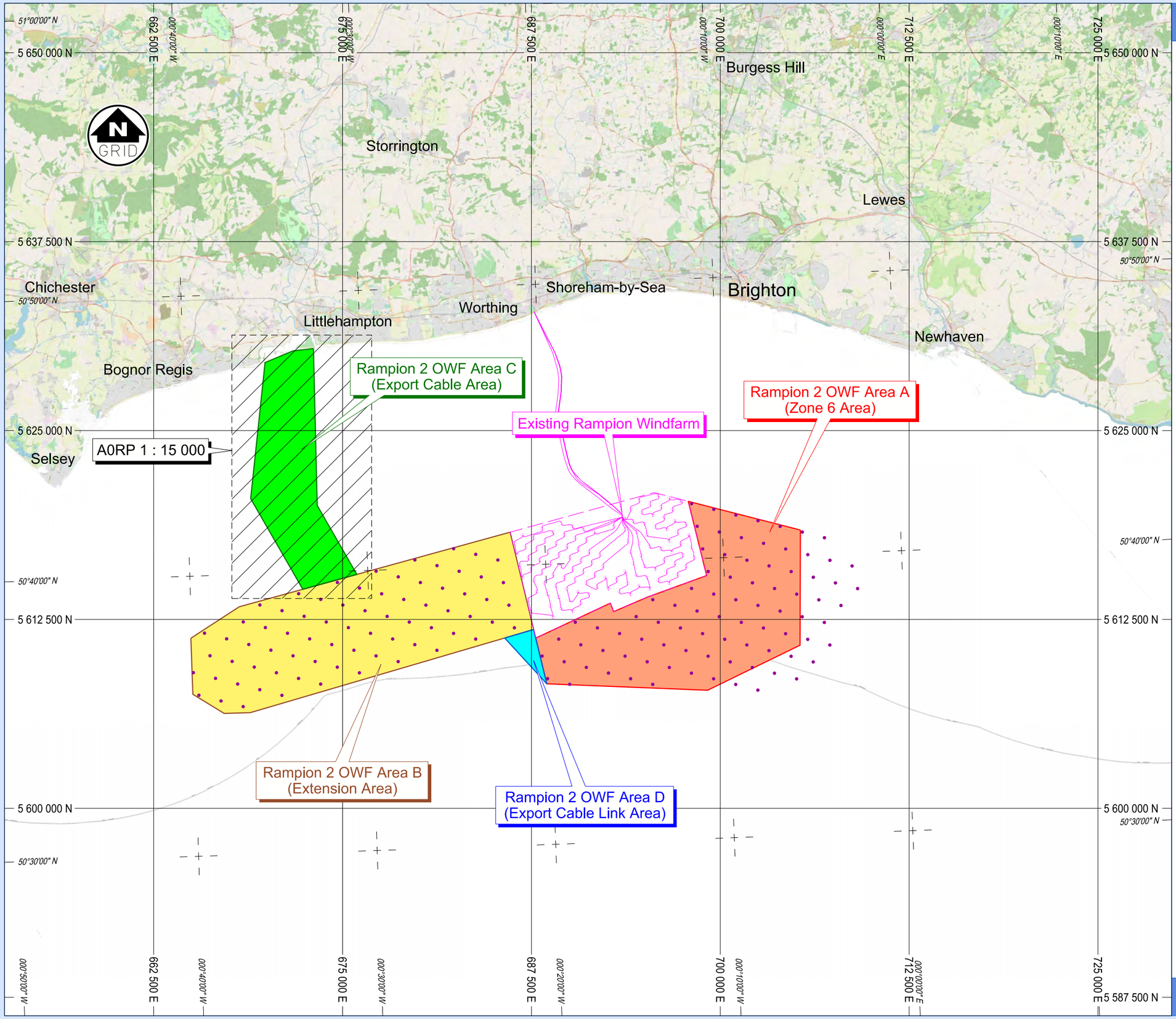


LOCATION MAP
RAMPION 2 OFFSHORE WINDFARM DEVELOPMENT

- PROPOSED RAMPION 2 OWF AREA A (ZONE 6 AREA)
- PROPOSED RAMPION 2 OWF AREA B (EXTENSION AREA)
- PROPOSED RAMPION 2 OWF AREA C (EXPORT CABLE AREA)
- PROPOSED RAMPION 2 OWF AREA D (EXPORT CABLE LINK AREA)
- PROPOSED RAMPION 2 WIND TURBINE GENERATOR LAYOUT (SOURCE: CLIENT PROVIDED)
- EXISTING RAMPION WIND TURBINE GENERATOR LAYOUT (SOURCE: CLIENT PROVIDED)
- EXISTING RAMPION WIND FARM CABLE (SOURCE: CLIENT PROVIDED)
- EXISTING RAMPION SURVEY AREA (SOURCE: CLIENT PROVIDED)

Scale 1 : 250 000
WGS84/UTM Zone 30N (3°W)

Job No. 11521.4

TABLE OF CONTENTS

LIST OF CHARTS

Charts are enclosed at a scale of 1:15,000:

LIST OF FIGURES

LIST OF TABLES

GLOSSARY OF ABBREVIATIONS

AVO	Amplitude Versus Offset
BASE	Bathymetry Associated with Statistical Error
BGS	British Geological Survey
BS	British Standards
BSB	Below Seabed
cm	Centimetre(s)
CMP	Common Mid Point
CoG	Centre of Gravity
CPT(U)	Cone Penetrometer Testing (Unit)
cu. in.	Cubic Inch(es)
d	Delta
dB	Decibel(s)
deg	Degree(s)
(D)GNSS	(Differential) Global Navigation Satellite System
EBS	Environmental Baseline Survey
EC	European Commission
EGNOS	European Geostationary Navigation Overlay Service
EPSG	European Petroleum Survey Group
f	Focal Length
ft	Foot/Feet
h	Hours (times expressed hh:mmh e.g. 12:45h)
H	Height
HDOP	Horizontal Dilution of Precision
ISO	International Organisation for Standardisation
J	Joule(s)
(k)Hz	(Kilo)Hertz
kg	Kilogram(s)
km	Kilometre(s)
kN	Kilonewton(s)
kPa	Kilopascal(s)
kW	Kilowatt(s)
L	Length
LAT	Lowest Astronomical Tide
m	Metre(s)
M	Megapixels
MBES	Multi-Beam Echo Sounder
MDAC	Methane Derived Authigenic Carbonates
MHWI	Mean High Water Interval
ml	Millilitre(s)
mm	Millimetre(s)
MPa	Megapascals
MRU	Motion Reference Unit
ms	Millisecond(s)
m/s	Metres per Second
MSL	Mean Sea Level
MSR	Mean Spring Range
M.V.	Motor Vessel
N,E,S,W	North, East, South, West
nT	NanoTesla
oct	Octave
OGP	International Association of Oil and Gas Producers
OSPAR	Oslo and Paris Commissions
PC	Piston Core
PDOP	Positional Dilution of Precision
ppm	Parts Per Million
QC	Quality Control
QPRO	Quality Procedure
r	Rotation
RMS	Root Mean Square
RPL	Route Positioning List
Rx	Receive
S	Second(s)
SBES	Single Beam Echo Sounder
sd	Standard Deviation
SEGY	Society of Exploration Geophysicists storage format
SNR	Signal to Noise Ratio
SP	Shot Point
SRME	Surface Related Multiple Elimination
SV	Sound Velocity
SWNA	Surface Wave Noise Attenuation
TWT	Two Way Time
Tx	Transmit
UHRS	Ultra High Resolution Seismic
UKCS	United Kingdom Continental Shelf
USBL	Ultra Short Base Line
(U)TM	(Universal) Transverse Mercator
VC	Vibrocore
(V)GPS	(Voyager) Global Positioning System
VORF	Vertical Offshore Reference Frames
WGS84	World Geodetic System 1984

1. PROJECT SUMMARY

1.1 Scope of Work

Gardline Limited carried out a shallow geophysical and UHRS survey for RWE Renewables UK Ltd off the coast of Brighton, Sussex. The objective was to investigate three areas being considered for development using multi-beam echo sounder, side scan sonar, magnetometer, sub-bottom profiler and UHRS equipment.

The three extension areas were designated:

- Area A: “Zone 6 Area” to the south-east of the existing Rampion offshore wind farm. Part of this area was previously surveyed during the original development and there was no requirement for re-surveying at this stage of the development.
- Area B: “Extension Area” to the west of the existing Rampion offshore windfarm.
- Area C: “Export Cable Area” to the north of Area B, with landfall between Littlehampton and Bognor Regis. No UHRS acquisition was required for Area C.

The purpose of the survey was to:

- To provide accurate bathymetry of the site regions and cable routes region
- To identity natural seabed features and any obstructions, man-made objects, debris, or wrecks
- To produce isopach charts to show sediment thickness of the upper, loose, and any mobile material, and of any other significant reflector levels which might impact on the engineering design to 50m below seabed for Areas A and B, and to 10m below seabed for Area C
- To locate any structural complexities or geohazards within the shallow geological succession such as faulting, accumulations of shallow gas, buried channels etc to 50m below seabed for Areas A and B, and to 10m below seabed for Area C
- Locate and identify sites of near surface soft material pertinent to jack-up operations
- To provide detailed geological interpretation to show strata variations and structural feature changes via appropriate maps and sections
- To provide interpretation to assist design of the offshore foundations / structures and cable routing and burial
- To identity items through correlation of magnetic anomalies and sonar contacts that may require further physical survey, for example UXO and wrecks

The offshore work scope was carried out by the Gardline vessel M.V. Vigilant, with additional work undertaken by M.V. Ocean Observer. The M.V. Vigilant acquired full coverage with MBES and SSS of Areas A, B and the offshore part of Area C. In addition, it acquired SBP and magnetometer data on all of the offshore part of Area C with a line spacing of 60m, and 4 out of every 5 main lines in Areas A and B, with a line spacing of 77m.

The M.V. Ocean Observer acquired UHRS, SBP and magnetometer data on Areas A and B at a line spacing of 385m, and on each of the cross lines in Areas A and B at a line spacing of 1336m. Both the main and cross lines are orientated and positioned so as to acquire UHRS data through the proposed locations of the turbines in Areas A and B.

The nearshore work scope was covered by the M.V. Titan Discovery and a Titan owned Unmanned Aerial Vehicle (UAV). Details of operational activities is included in the Operations Report, 11521.1.

All coordinates quoted in the report are with respect to **World Geodetic System 1984 (WGS84), UTM Grid Zone 30N (3° West)**. All water depths are reduced to **Lowest Astronomical Tide (LAT).** Full details of the geodetics used during the project are contained in Appendix A.

The grid of survey lines as acquired for Rampion Area C is illustrated on Charts 1, Chart 2 and Chart 3.

This report is the Rampion Area C Survey Report.

1.2 Equipment Summary

Table 1.1 Survey Equipment – M.V. Vigilant

System	Make/Model
Positioning system	Oceaneering C-Nav DGNSS
	Sonardyne Ranger USBL
Navigation System	Voyager5
Echo Sounder (MBES system)	Simrad EM2040D
Echo Sounder (SBES system)	Simrad EA400
Side Scan Sonar	EdgeTech 4200FS
Magnetometer	Geometrics G882
Sub-Bottom Profiler	GeoAcoustics Pinger

Table 1.2 Survey Equipment – Titan Discovery

System	Make/Model
Positioning Systems	Applanix POS MV WaveMaster
	Trimble SPS855 GNSS Receiver
	Sonardyne Mini Ranger 2
Navigation System	QPS QINSy 9
Echo Sounder (SBES system)	Odom Echotrac MK III
Echo Sounder (MBES system)	Reson T20-P Dual Head
Side Scan Sonar	Edgetech 4200FS
Magnetometer	Geometrics G882
Sub-Bottom Profiler	Applied Acoustics CSP300 Bang Box Applied Acoustics 20 Element Hydrophone
UAV	Sensefly eBee

2. ACCURACY AND TERMS FOR SEISMIC INTERPRETATION

2.1 Resolution and Limitations for Site Survey Data

2.1.1 Bathymetry

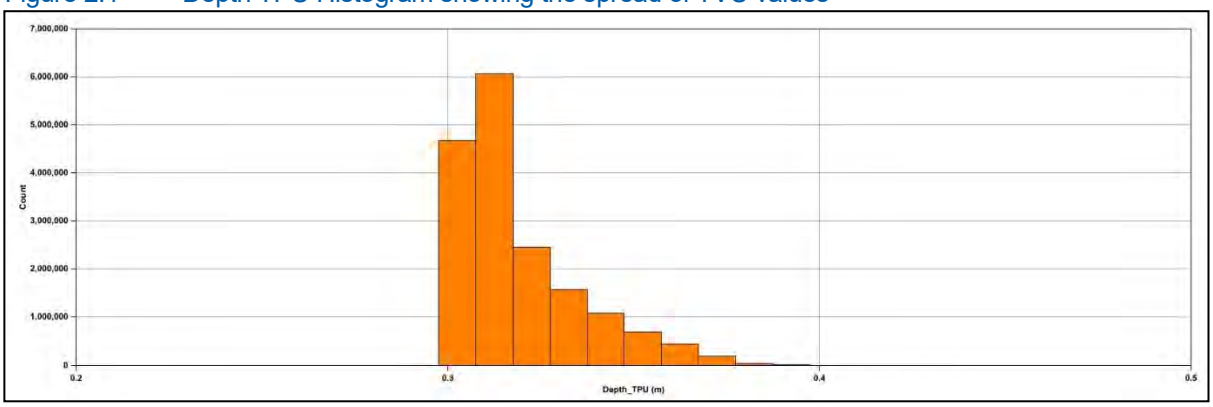
Several factors influence the accuracy of the bathymetric data:

- Variations in sound velocity
- Instrument accuracy (typically 0.2-0.5% of depth depending on beam angle)
- Weather effects/vessel movement
- Morphology of seabed

The uncertainty requirement of the survey to achieve International Hydrographic Organisation's (IHO) Order 1. In the guidelines produced by the IHO, a formula is outlined to derive an accuracy level depending on the depth of water the survey is being carried out in. This Total Vertical Uncertainty (TVU) value is used to ensure the data collected meets the standard required to meet Order 1a. Using water depths of 15m and 60m as the rough range within which Gardline acquired data, the MBES TVU must be better than +/- 0.537m and +/- 0.926m, respectively.

The data were analysed using the Total Propagated Uncertainty (TPU) engine in CARIS. A depth TPU surface created within CARIS to identify the TVU range. The figure below shows that the TVU values meet the minimum level required to me the IHO Order1.

Figure 2.1 Depth TPU Histogram showing the spread of TVU values



In addition to standard processing flow of the data, post processing was carried out on the raw GNSS records to produce a more accurate tidal profile to be applied to the data.

Multi-beam echo sounder data have been processed with a 1m bin size. As such, localised gradients of features with a smaller lateral extent will be underestimated.

2.1.2 Seabed Features

Side scan sonar data were collected for the purpose of mapping and imaging features and hazards on the seabed. Collected data from the Vigilant have frequencies of 122kHz and 410kHz and a range of 100m per channel. Collected data from the Titan Discovery have frequencies of 122kHz and 550kHz and a range of 75m per channel.

From corrections made to the sonar mosaic, and comparing the sonar data with the swathe data, USBL positioning accuracy is expected to be in the order of ±2m, and horizontal resolution between adjacent objects is expected to be approximately 0.5m. Vertical protrusions above the seabed of 0.1m

should be detectable (and flat-lying objects above 0.1m diameter) depending on range, and measurable to the nearest 0.1m.

2.1.3 Magnetic Survey

Magnetometer data were inspected for potential anomalies with the results being presented on the enclosed Seabed Features chart.

Records were of average quality with background noise apparent due to the relative close proximity of the survey vessel to the magnetometer due to the shallow water depths on site, as well as induced noise from the underlying geology.

Positioning of ferrous bodies from magnetic anomalies is problematical. Errors are introduced from uncertainties on raw navigation data and on offset errors, as well as from the inherent ambiguity of determining body shape from magnetic anomalies. Where possible magnetic anomalies are cross referenced against other datasets (e.g. bathymetry, side scan sonar, sub-bottom profiler, database records etc), in order to assign a likely centre of the magnetic deviation. Where this is not possible the positioning accuracy will be largely dependent on the acquired line spacing.

2.1.4 Sub-Seabed Data

Boomer and Pinger data were of good quality and exhibit an average penetration of 10m and 15m respectively and depending on the local geological conditions. An assumed seismic velocity of 1650m/s was used for time/depth conversion in the shallow sediments. Maximum vertical resolution may be determined theoretically by one quarter of the wavelength, which would give a maximum vertical resolution of the Boomer and Pinger data is approximately 0.1m and 0.3m respectively, assuming a dominant frequency of approximately 1300Hz and 3500Hz. Theoretical minimum detectable layer, estimated at 1/30th the dominant wavelength, is calculated to be approximately 0.016m and 0.043m respectively at seabed.

2.2 Criteria for Horizon Picking

Interpretation of the sub-seabed data has been aided using BGS records and previous reports which are detailed in Section 4.

Horizons were picked where they separated distinct seismo-stratigraphic units. Generally, they were picked on the peak, but where the horizons represented a velocity inversion, they were picked on the trough.

3. GEOPHYSICAL SURVEY RESULTS

3.1 Bathymetry

Rampion Area C bathymetry is illustrated on Chart 4 as a colour shaded relief image with contours at 1m intervals. An overview of the bathymetry is presented as Figure 3.1.

A shaded relief image of the bathymetry is illustrated on Chart 5. An overview of the shaded relief is presented as Figure 3.2.

Seabed Gradient is illustrated on Chart 6. An overview presented as Figure 3.3.

Within the survey area, the shallowest depth is -18.9m LAT (observed above sea level) to the north of the site where the Titan UAV (Sensefly Ebee) surveyed the dryline. Water depths reach 28.2m LAT within a possible dredging extraction area to the south of the site. Seabed gradients across the survey area are generally <1°, dipping towards the south. Localised gradients reach up to 10° within the depression caused by possible dredging extraction.

Megaripples are present towards the southern end of the site with heights of 0.2m and wavelengths reaching 7m. The seabed undulates across much of the site, influenced by the underlying geology. The dipping strata in the bedrock frequently approach seabed and are orientated from northwest to southeast. Occasional rocky outcrops are observed across the centre and north of Area C, with seabed gradients reaching 10°.

A significant seabed depression is present in the far south of Area C. This measures approximately 285m across and 11m deep, with gradients reaching 20° on its flanks. This has been interpreted as a possible dredging extraction area.

The difference between LAT and MSL within the survey area is approximately 3.3m.

BATHYMETRY OVERVIEW FOR RAMPION 2 OWF AREA C

PROPOSED RAMPION 2 OWF AREA C (EXPORT CABLE AREA)

PROPOSED RAMPION 2 OWF AREA B (EXTENSION AREA)

PROPOSED RAMPION 2 WIND TURBINE GENERATOR LAYOUT (SOURCE: CLIENT PROVIDED)

15 BATHYMETRIC CONTOURS SHOWN AT 5 METRE INTERVALS LAT

DEPTH IN METRES BELOW LAT
-20
-10
0
10
20
30
36

Littlehampton

Bognor Regis

5 632 500 N
5 628 750 N
5 625 000 N
5 621 250 N
5 617 500 N
5 613 750 N

663 750 E
667 500 E
671 250 E
675 000 E
678 750 E
682 500 E

50°48'00" N
50°45'00" N
50°42'00" N
50°39'00" N

000°42'00" W
000°38'00" W
000°33'00" W
000°30'00" W
000°27'00" W
000°24'00" W

Scale 1 : 75 000
WGS84/UTM Zone 30N (3°W)

Figure 3.1

Job No. 11521.4

SEABED SHADED RELIEF OVERVIEW FOR RAMPION 2 OWF AREA C

PROPOSED RAMPION 2 OWF AREA C
(EXPORT CABLE AREA)

PROPOSED RAMPION 2 OWF AREA B
(EXTENSION AREA)

PROPOSED RAMPION 2
WIND TURBINE GENERATOR LAYOUT
(SOURCE: CLIENT PROVIDED)

DEPTH IN METRES BELOW LAT
-20
-10
0
10
20
30
36

Littlehampton

Bognor Regis

5 632 500 N
5 628 750 N
5 625 000 N
5 621 250 N
5 617 500 N
5 613 750 N

663 750 E
667 500 E
671 250 E
675 000 E
678 750 E
682 500 E

50°48'00" N
50°45'00" N
50°42'00" N
50°39'00" N

000°42'00" W
000°39'00" W
000°36'00" W
000°33'00" W
000°30'00" W
000°27'00" W
000°24'00" W

Scale 1 : 75 000
WGS84/UTM Zone 30N (3°W)

Figure 3.2

Job No. 11521.4

SEABED GRADIENT OVERVIEW FOR RAMPION 2 OWF AREA C

PROPOSED RAMPION 2 OWF AREA C
(EXPORT CABLE AREA)

PROPOSED RAMPION 2 OWF AREA B
(EXTENSION AREA)

PROPOSED RAMPION 2
WIND TURBINE GENERATOR LAYOUT
(SOURCE: CLIENT PROVIDED)

GRADIENT IN DEGREES
>10
7.5
5.0
2.5
0.0

Littlehampton

Bognor Regis

5 632 500 N
5 628 750 N
5 625 000 N
5 621 250 N
5 617 500 N
5 613 750 N

663 750 E
667 500 E
671 250 E
675 000 E
678 750 E
682 500 E

50°48'00" N
50°45'00" N
50°42'00" N
50°39'00" N

000°42'00" W
000°39'00" W
000°36'00" W
000°33'00" W
000°30'00" W
000°27'00" W
000°24'00" W

Scale 1 : 75 000
WGS84/UTM Zone 30N (3°W)

Figure 3.3

Job No. 11521.4

3.2 Seabed Features

Seabed features are illustrated on Chart 7, with an overview provided as Figure 3.4. A side scan sonar mosaic is presented on Chart 8, with an overview provided as Figure 3.5.

Seabed sediments are expected to comprise predominately gravel and sand. with sandy gravel primarily to the north and gravelly sand primarily to the south, with occasional outcrops of rock located in the centre of the site, trending northwest to southeast.

Megaripples are prevalent over much of the south of the site, and are trending northwest to southeast. The crests extend up to 0.2m in height relative to the surrounding seabed. Localised gradients up to 5° are present on the flanks of the megaripples. A side scan sonar data example of the megaripples is illustrated on Figure 3.6.

5434 contacts exceeding 0.5m in any dimension are interpreted across Area C, the majority of which are interpreted as boulders. The largest measures 1.7m in height, and is located in the south of the survey area. 21 contacts are interpreted as debris with largest measuring 2.6m in height, located to the south of the site. 23 contacts are interpreted as fishing pots and are associated with fishing gear across the site.

Areas of numerous boulders cover much of the site with the majority being associated with rock outcrops, and have been categorised as boulder fields. These can be observed in Figure 3.7, Figure 3.8 and Figure 3.9. Boulders found within boulder fields have not been individually picked.

Linear debris is observed sporadically across the site. 14 items of linear debris measuring >1m are interpreted within the site limits. The largest item of linear debris is 378m in length, located in the south of the survey area, illustrated in Figure 3.10. Five linear contacts are interpreted as fishing gear; an example of these can be seen in Figure 3.11, Figure 3.12 and Figure 3.13. The largest item of potential fishing gear is 382m in length, located in the northwest of the survey area.

One possible pipeline/cable has been observed in the centre of the site, with an associated magnetometer anomaly, seen in Figure 3.14. This feature is observed on both side scan sonar and bathymetry data, however no background information is available to positively identify this.

Three wrecks occur within Area C, predominantly located in the southern section of the survey area, and all of which are identified on the geophysical data. These are all located on admiralty charts. All of the observed wrecks are located to the south of the site. All have been observed on side scan sonar, magnetometer and bathymetric records. The largest wreck, illustrated on Figure 3.15, has a length of 120m, width of 32m and a height of 2.3m. The two remaining wrecks are illustrated on Figure 3.16 and Figure 3.17.

54 magnetometer contacts are observed across the site. Magnetometer contacts generally do not correlate with any object identified at seabed. Due to the relative distance to underlying geology, most of the smaller anomalies may be associated with geological features. Seven magnetometer contacts are associated with the observed wrecks.

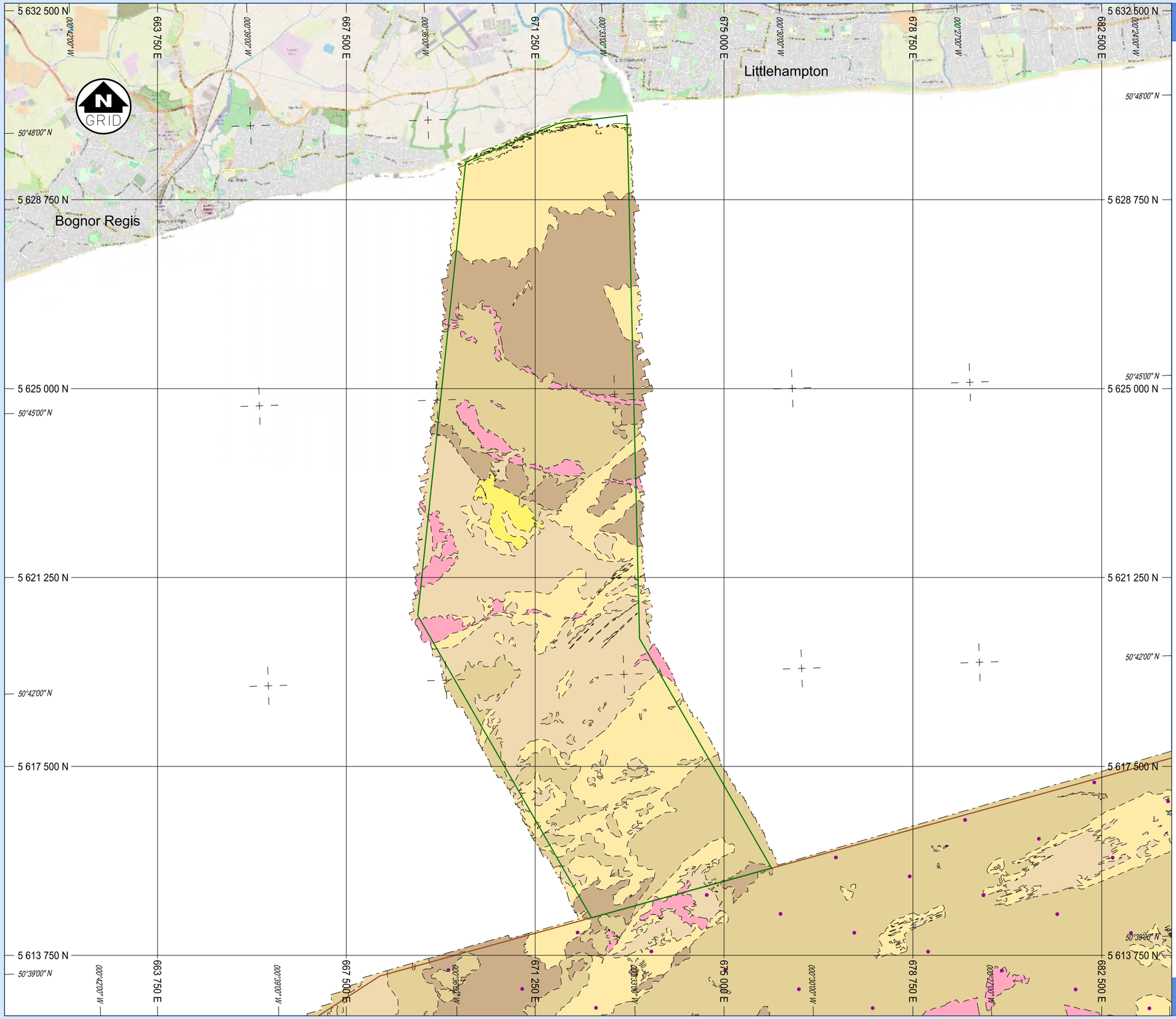
Several areas of the seabed appear as patchy areas of raised sonar reflectivity with shallow depressions measuring approximately 0.5m in diameter, to the north of the site. Such a texture on side scan sonar data is often indicative of *Biogenic Structures,* illustrated on Figure 3.18 . The extents of these areas have been delineated on Chart 6 as *possible black bream nest aggregations*. Ground truthing is required to confirm the presence of these nesting areas.

Table 3.1 Table of Wrecks

Name	Easting	Northing	Length (m)	Width (m)	Height (m)
Wreck 1	672 748	5 619 009	13.6	3.5	3.1
Wreck 2 A	670 696	5 617 303	4.2	2.3	4.0
Wreck 2 B	670 703	5 617 298	3.4	2.1	3.7
Wreck 3	672 045	5 616 545	119.7	31.9	2.3

MBES and side scan sonar montages of Wreck 2 and Wreck 3 are illustrated on Figure 3.19 and Figure 3.20, respectively.

SEABED SEDIMENTS OVERVIEW FOR RAMPION 2 OWF AREA C



PROPOSED RAMPION 2 OWF AREA C (EXPORT CABLE AREA)

PROPOSED RAMPION 2 OWF AREA B (EXTENSION AREA)

PROPOSED RAMPION 2 WIND TURBINE GENERATOR LAYOUT (SOURCE: CLIENT PROVIDED)

SAND (NO BEDFORMS)

SAND (MEGARIPPLED)

SLIGHTLY GRAVELLY SAND (NO BEDFORMS)

SLIGHTLY GRAVELLY SAND (MEGARIPPLED)

SANDY GRAVEL (NO BEDFORMS)

SANDY GRAVEL (MEGARIPPLED)

SANDY GRAVEL (OUTCROP)

ROCK (OUTCROP)

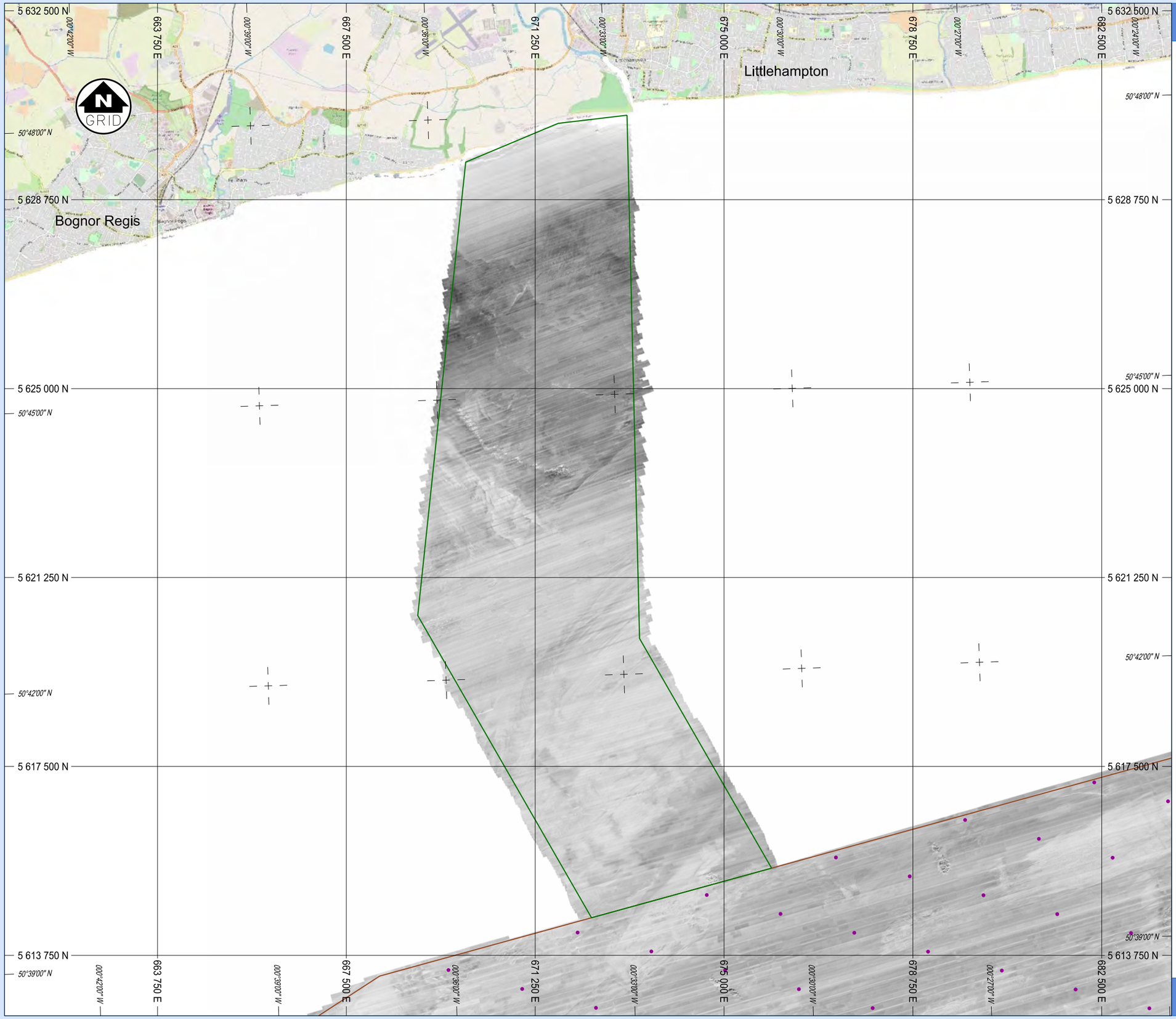
LIMIT OF SIDE SCAN SONAR COVERAGE

Scale 1 : 75 000
WGS84/UTM Zone 30N (3°W)

Figure 3.4

Job No. 11521.4

SIDE SCAN SONAR MOSAIC OVERVIEW FOR RAMPION 2 OWF AREA C



PROPOSED RAMPION 2 OWF AREA C
(EXPORT CABLE AREA)

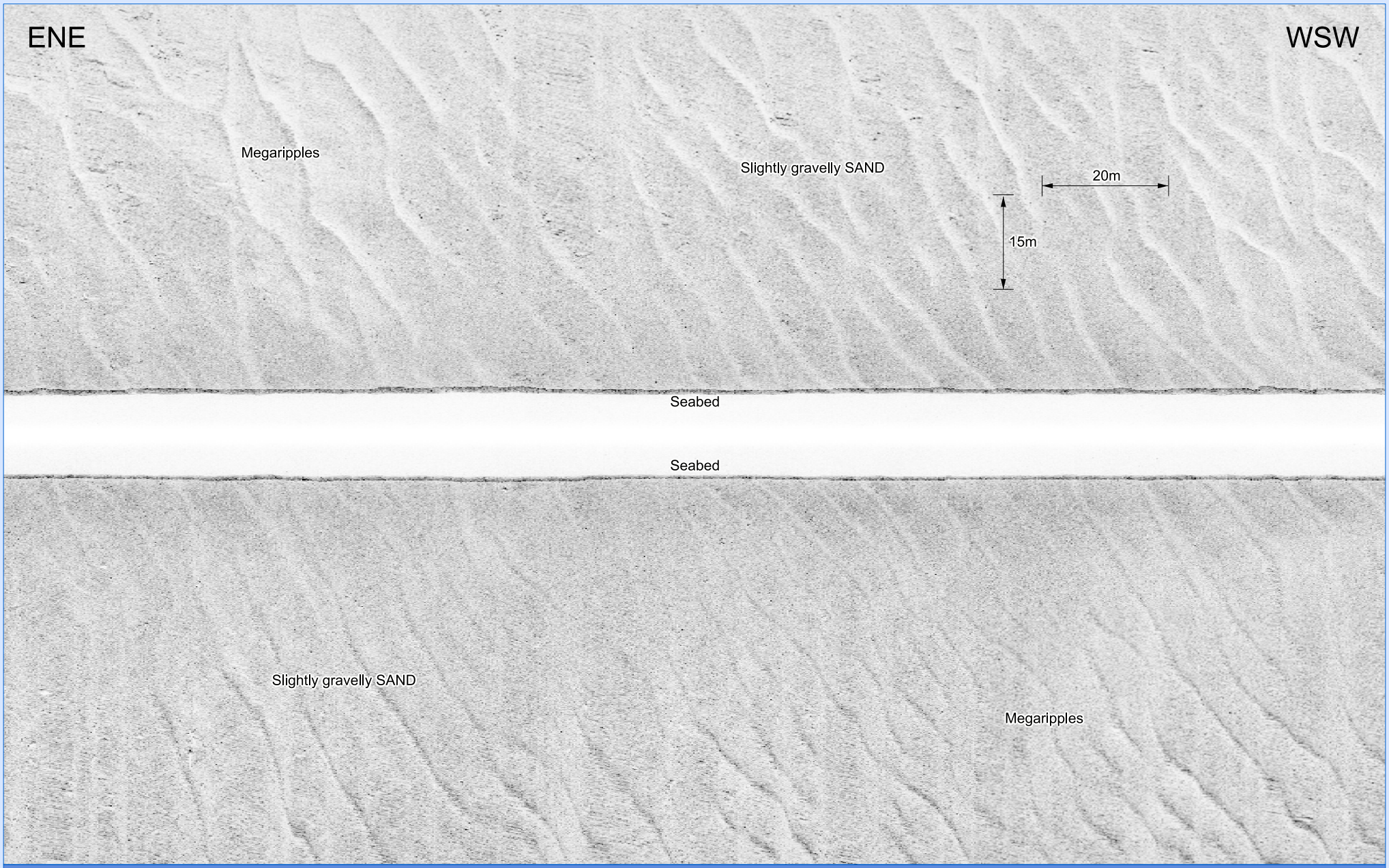
PROPOSED RAMPION 2 OWF AREA B
(EXTENSION AREA)

PROPOSED RAMPION 2
WIND TURBINE GENERATOR LAYOUT
(SOURCE: CLIENT PROVIDED)

Scale 1 : 75 000
WGS84/UTM Zone 30N (3°W)

Figure 3.5

Job No. 11521.4

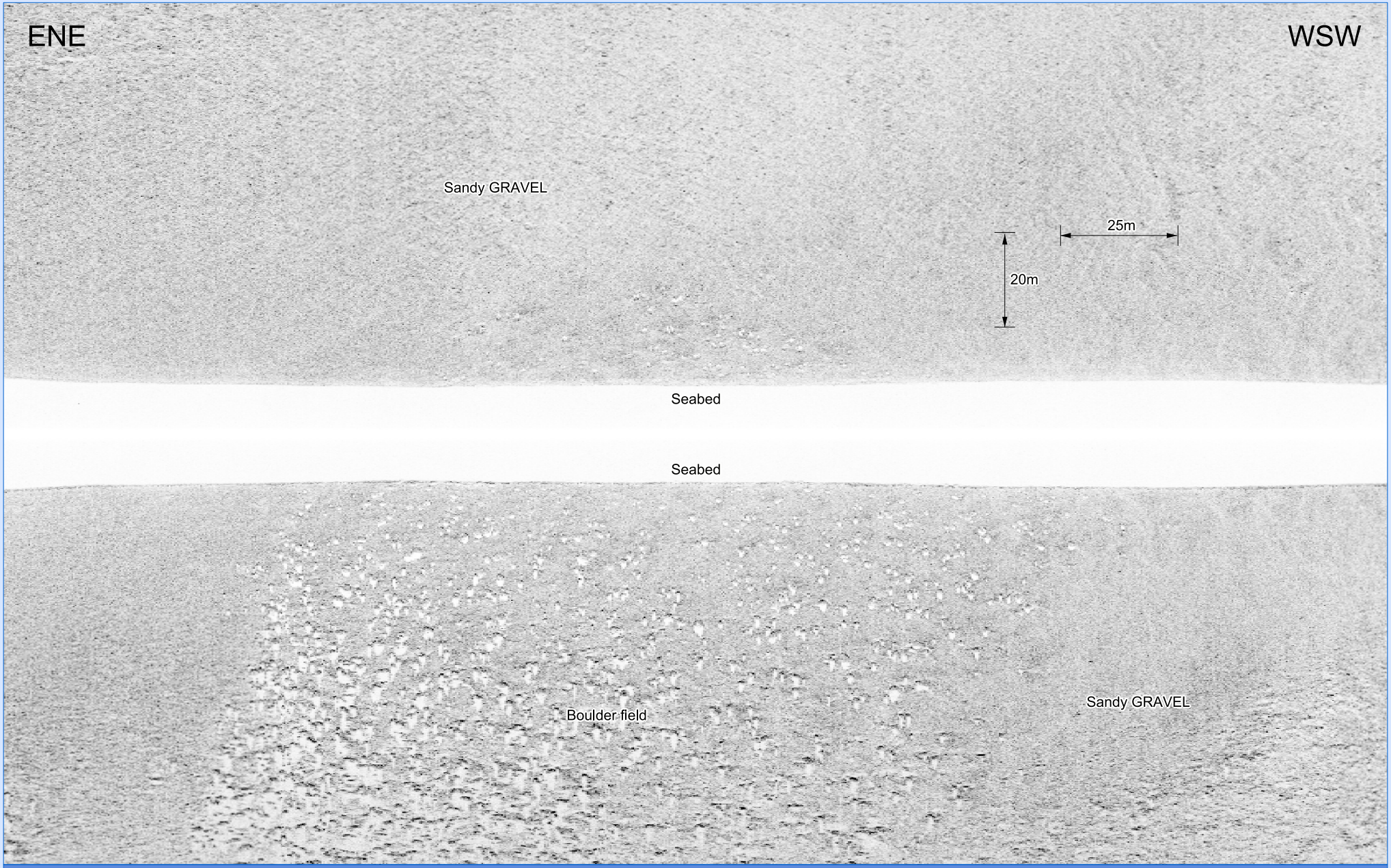


Line M39

SIDE SCAN SONAR
Illustrating megaripples

Figure 3.6

Job No. 11521.4

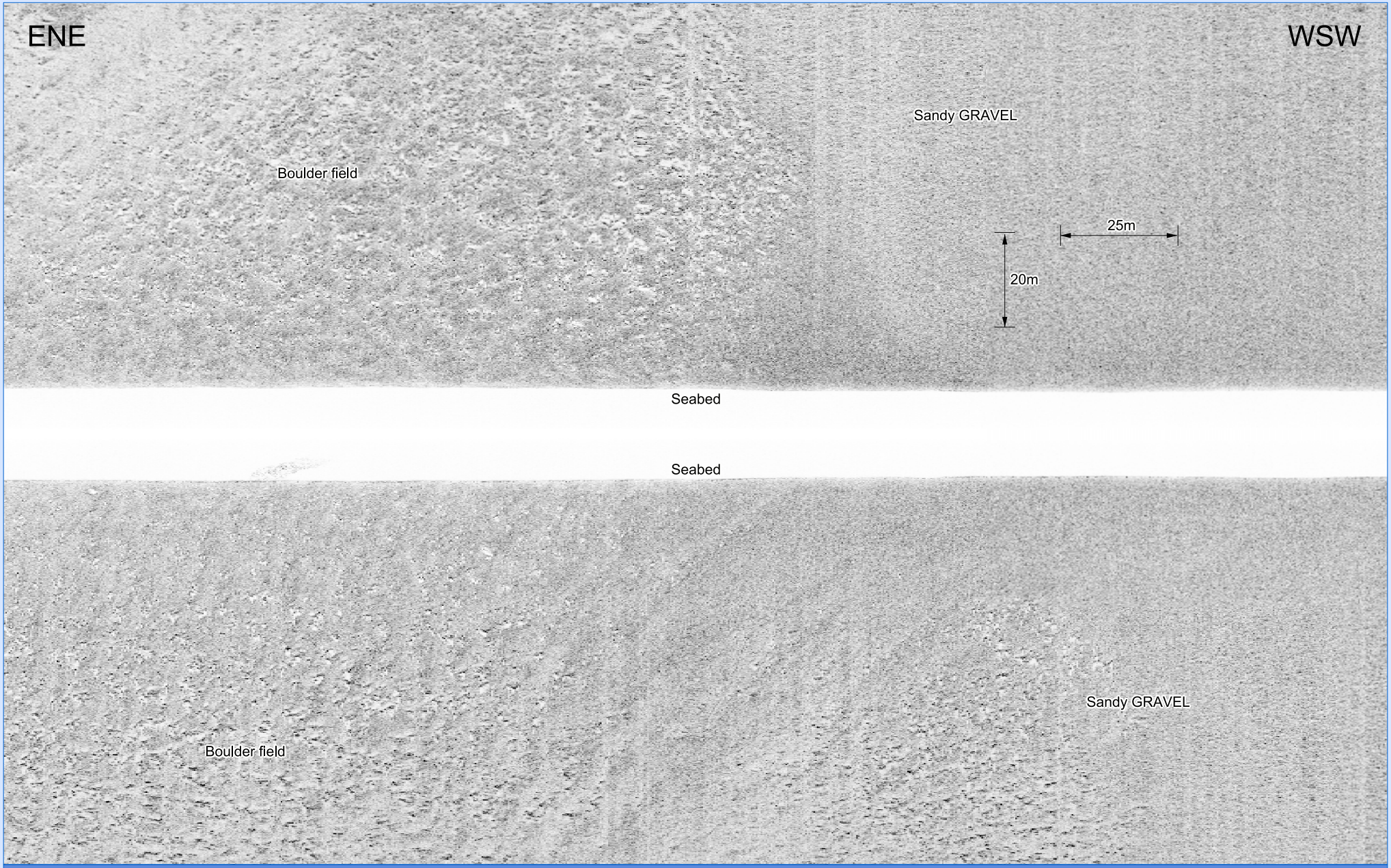


Line C_M-60

SIDE SCAN SONAR
Illustrating boulder field area

Figure 3.7

Job No. 11521.4

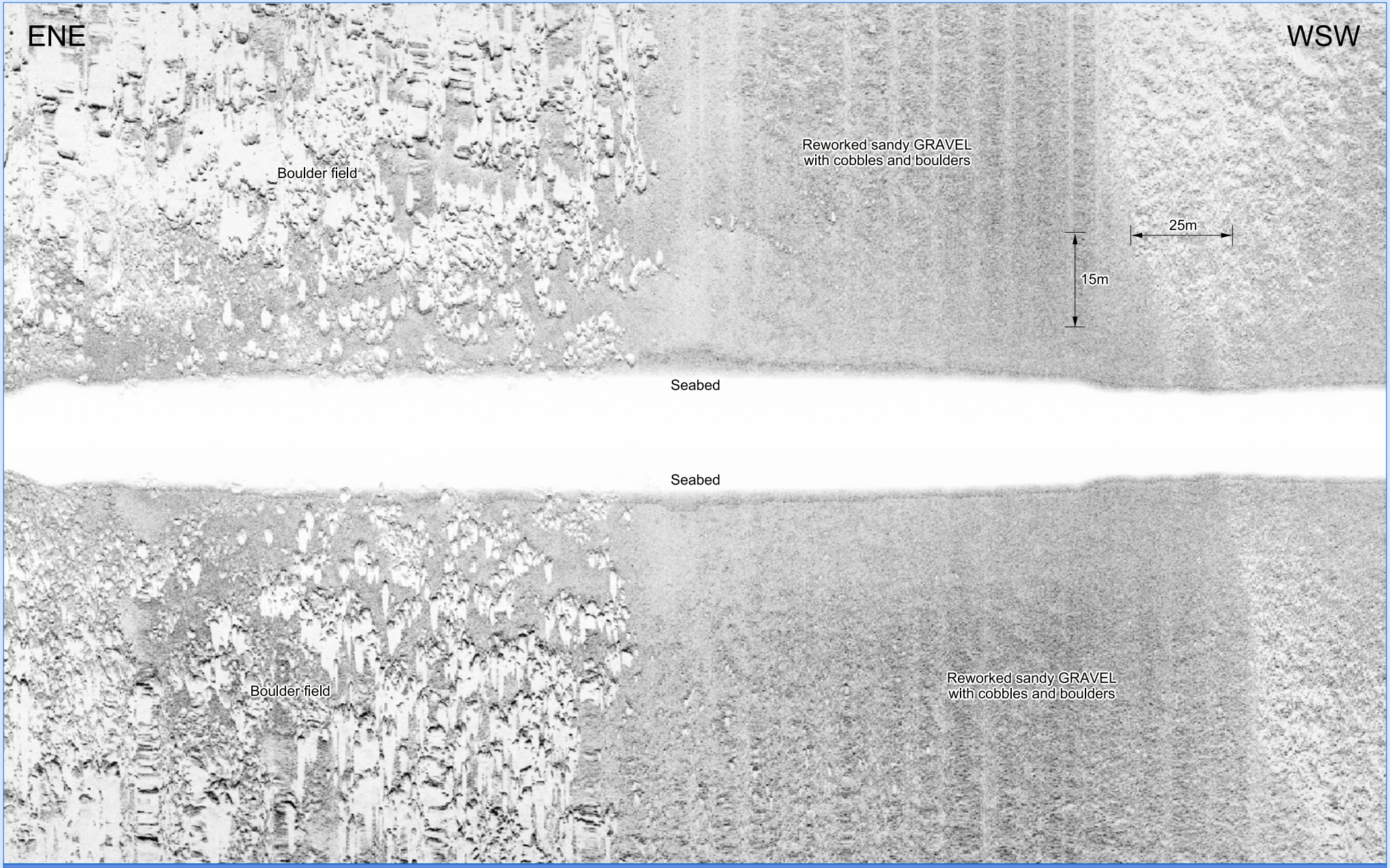


Line C_M-37

SIDE SCAN SONAR
Illustrating boulder field area

Figure 3.8

Job No. 11521.4

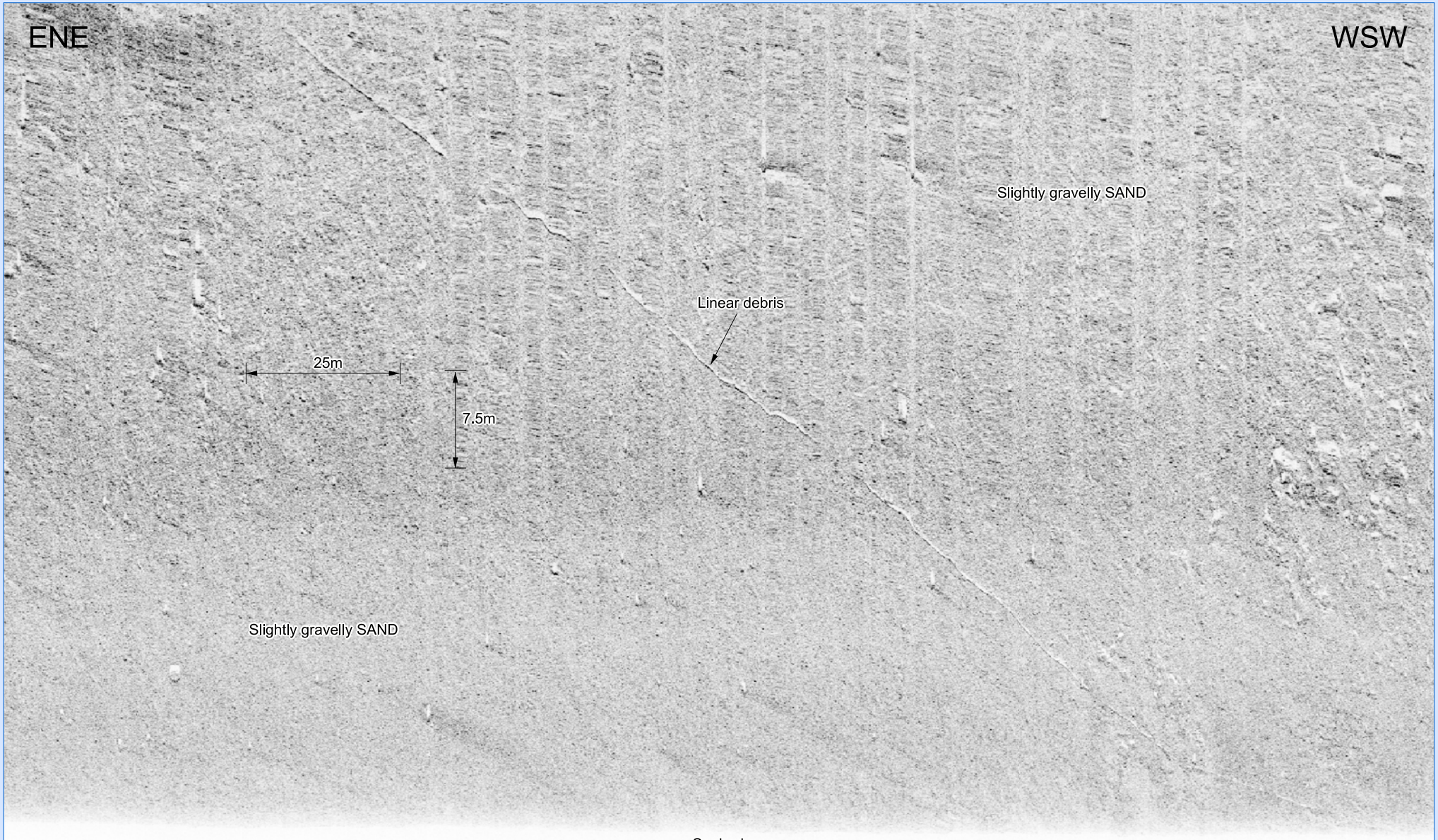


Line M91

SIDE SCAN SONAR
Illustrating boulder field area

Figure 3.9

Job No. 11521.4

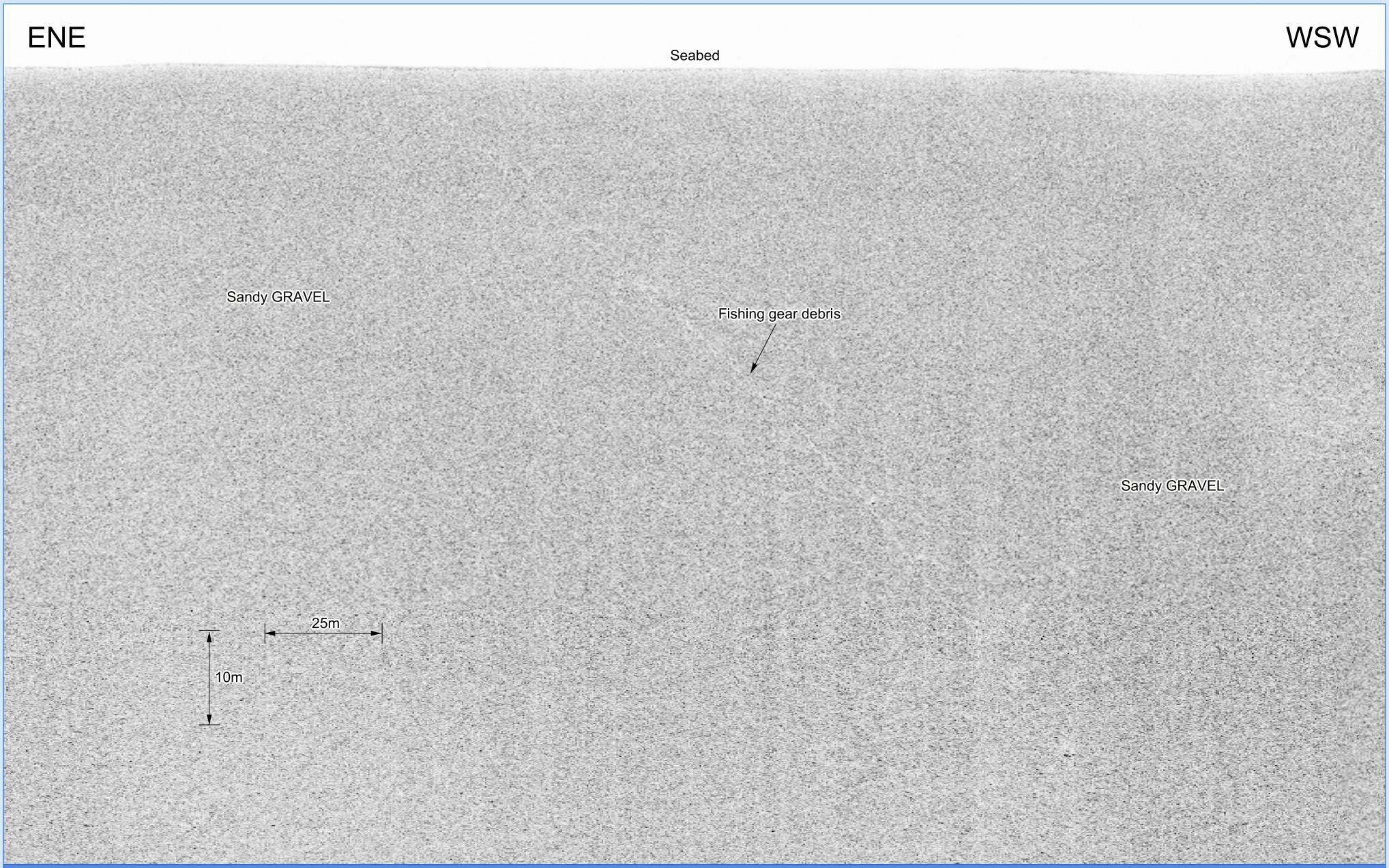


Line M24

SIDE SCAN SONAR
Illustrating linear debris

Figure 3.10

Job No. 11521.4



Line C_M-77

SIDE SCAN SONAR
Illustrating fishing gear debris

Figure 3.11

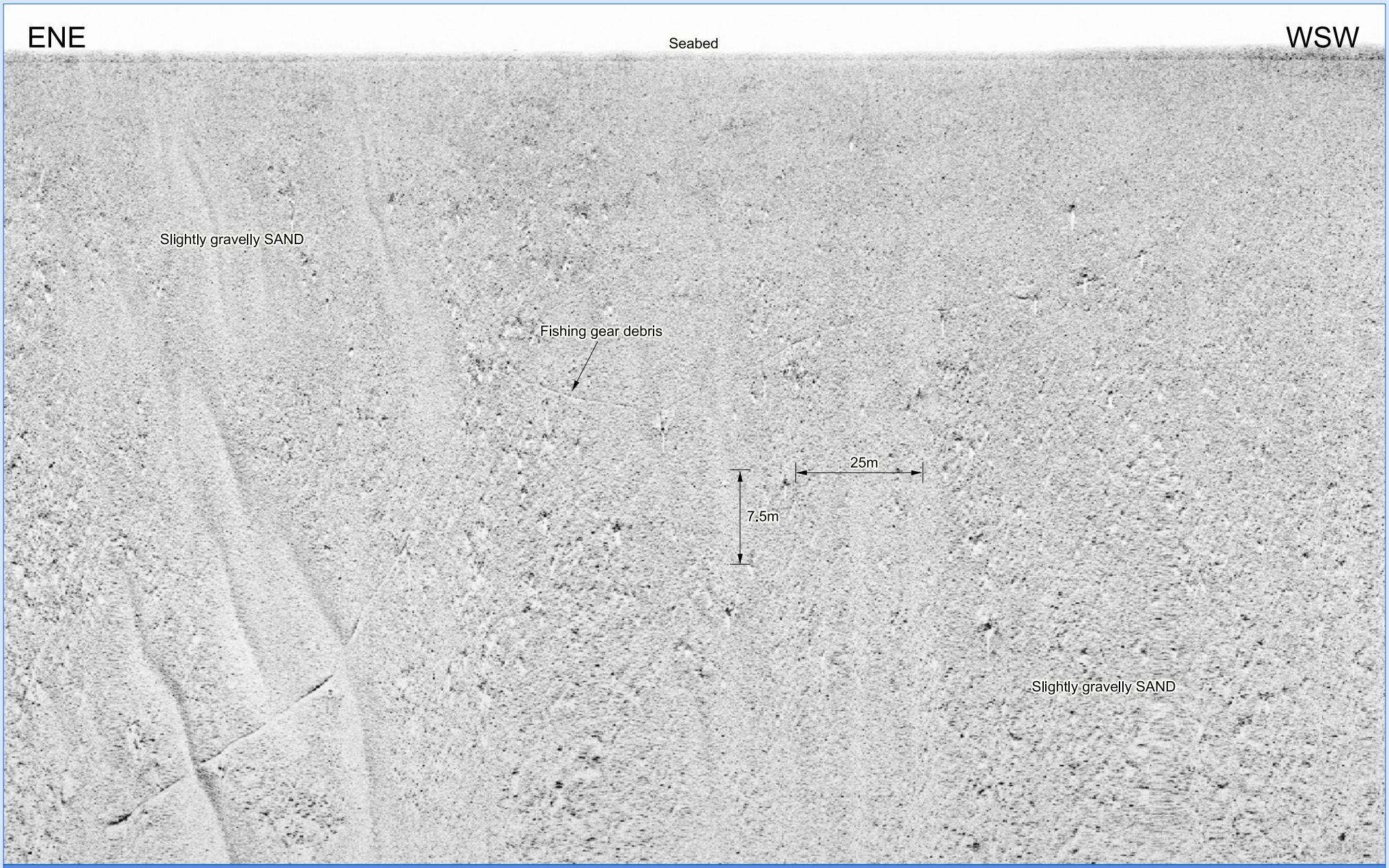
Job No. 11521.4

Line C_M-42

SIDE SCAN SONAR
Illustrating fishing gear debris

Figure 3.12

Job No. 11521.4

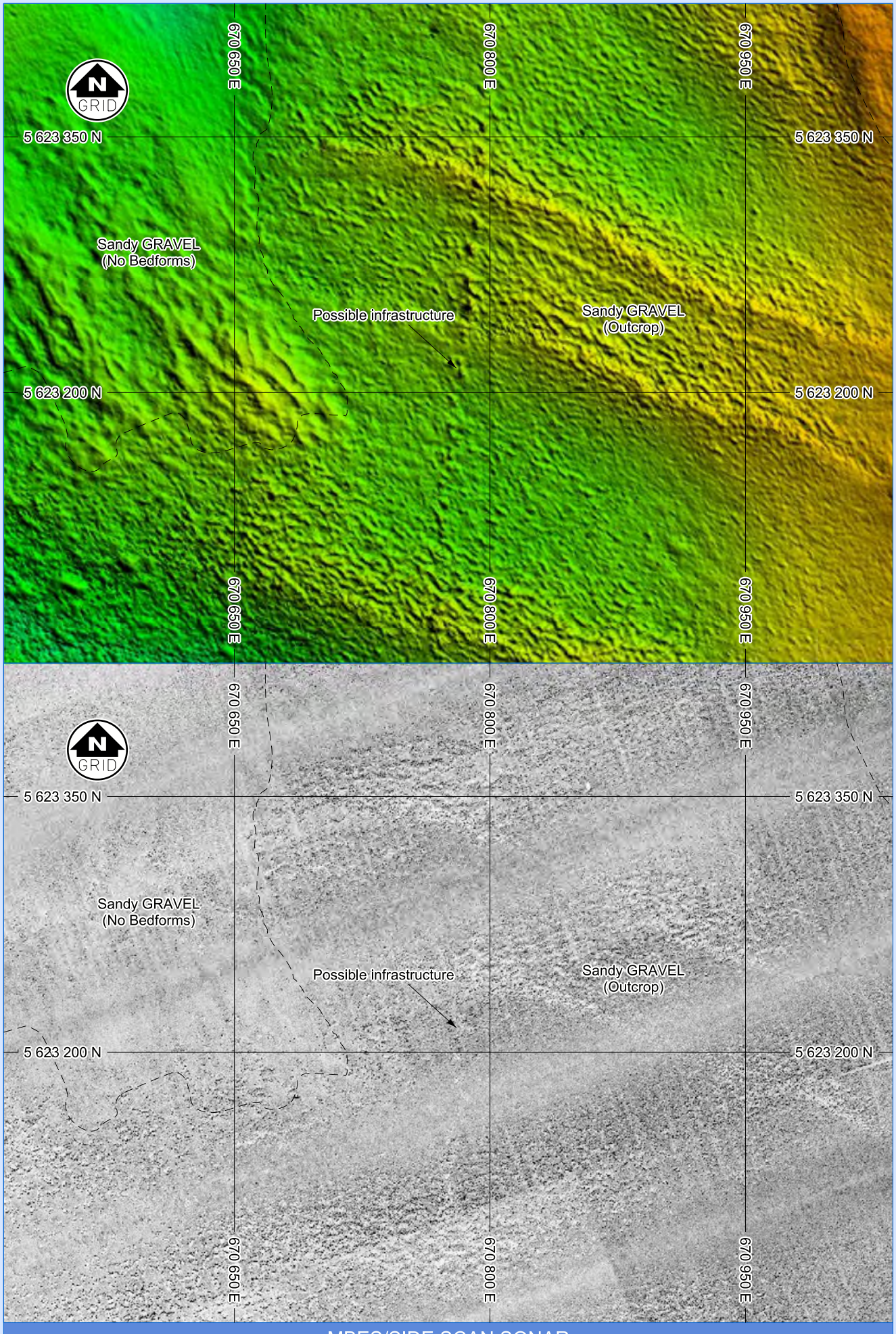


Line M69

SIDE SCAN SONAR
Illustrating fishing gear debris

Figure 3.13

Job No. 11521.4

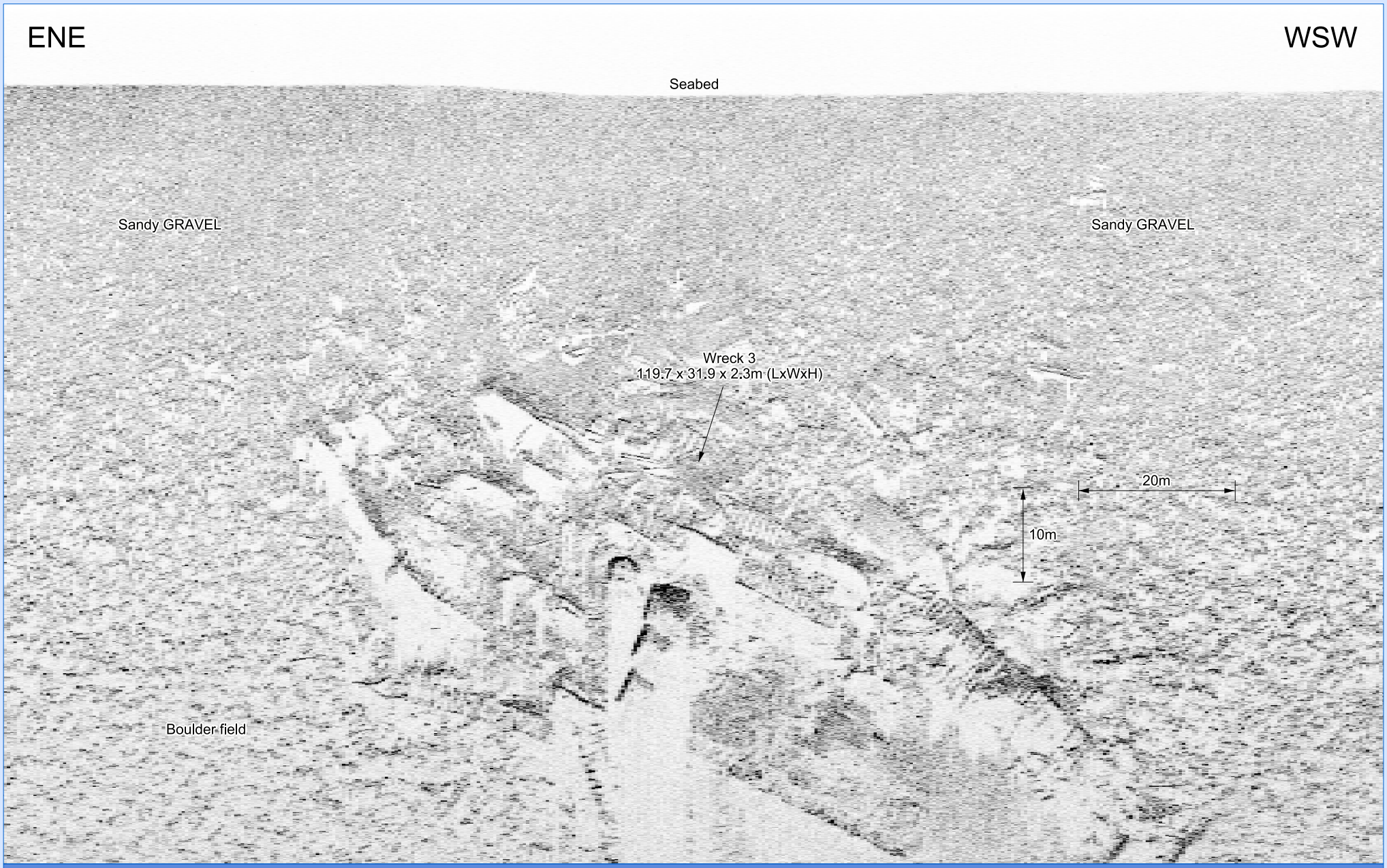


Scale 1 : 3 000
WGS84/UTM Zone 30N (3°W)

MBES/SIDE SCAN SONAR
Illustrating possible infrastructure

Figure 3.14

Job No. 11521.4

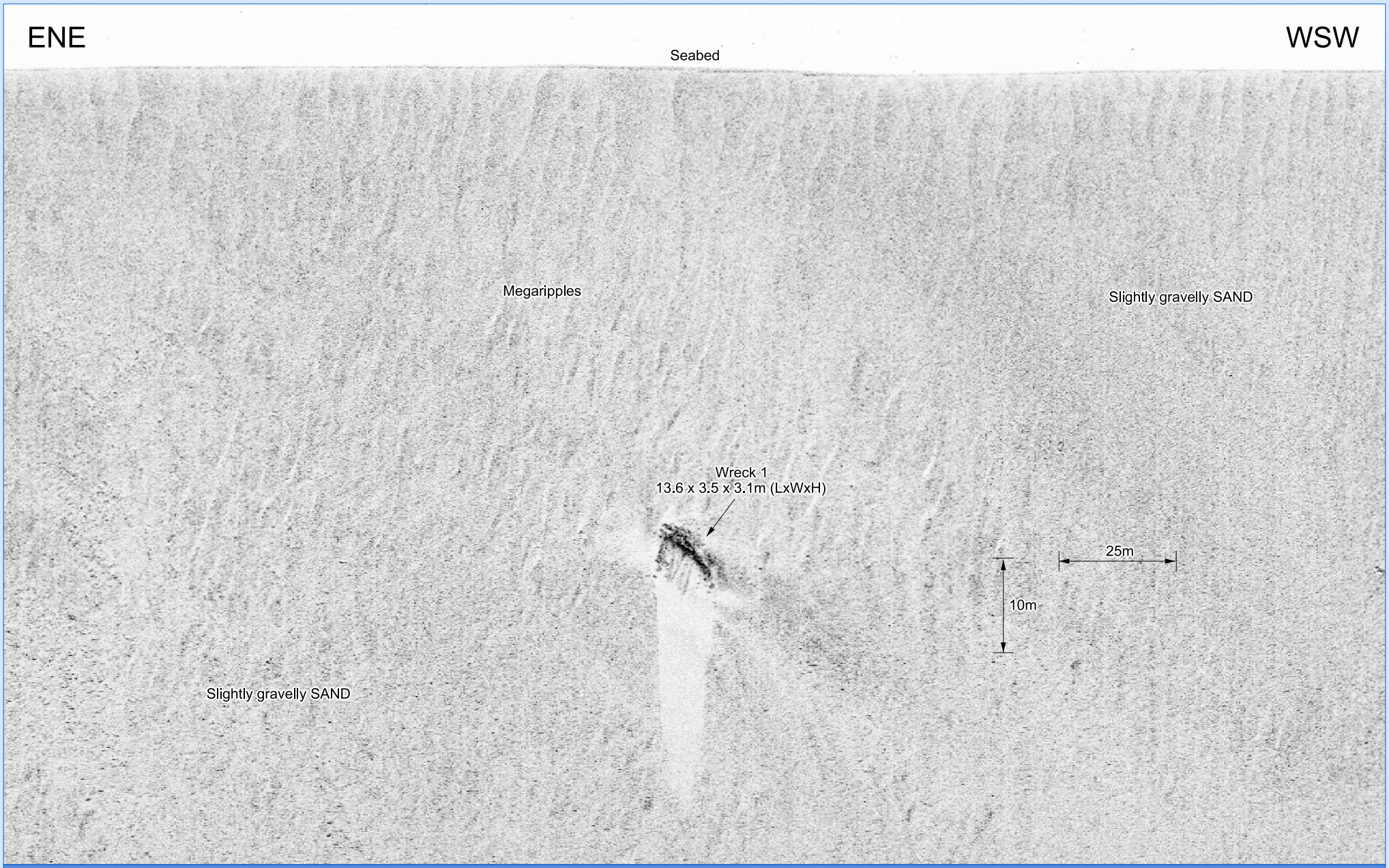


Line C_M-55

SIDE SCAN SONAR
Illustrating Wreck 3

Figure 3.15

Job No. 11521.4



Line C_M-21

SIDE SCAN SONAR
Illustrating Wreck 1

Figure 3.16

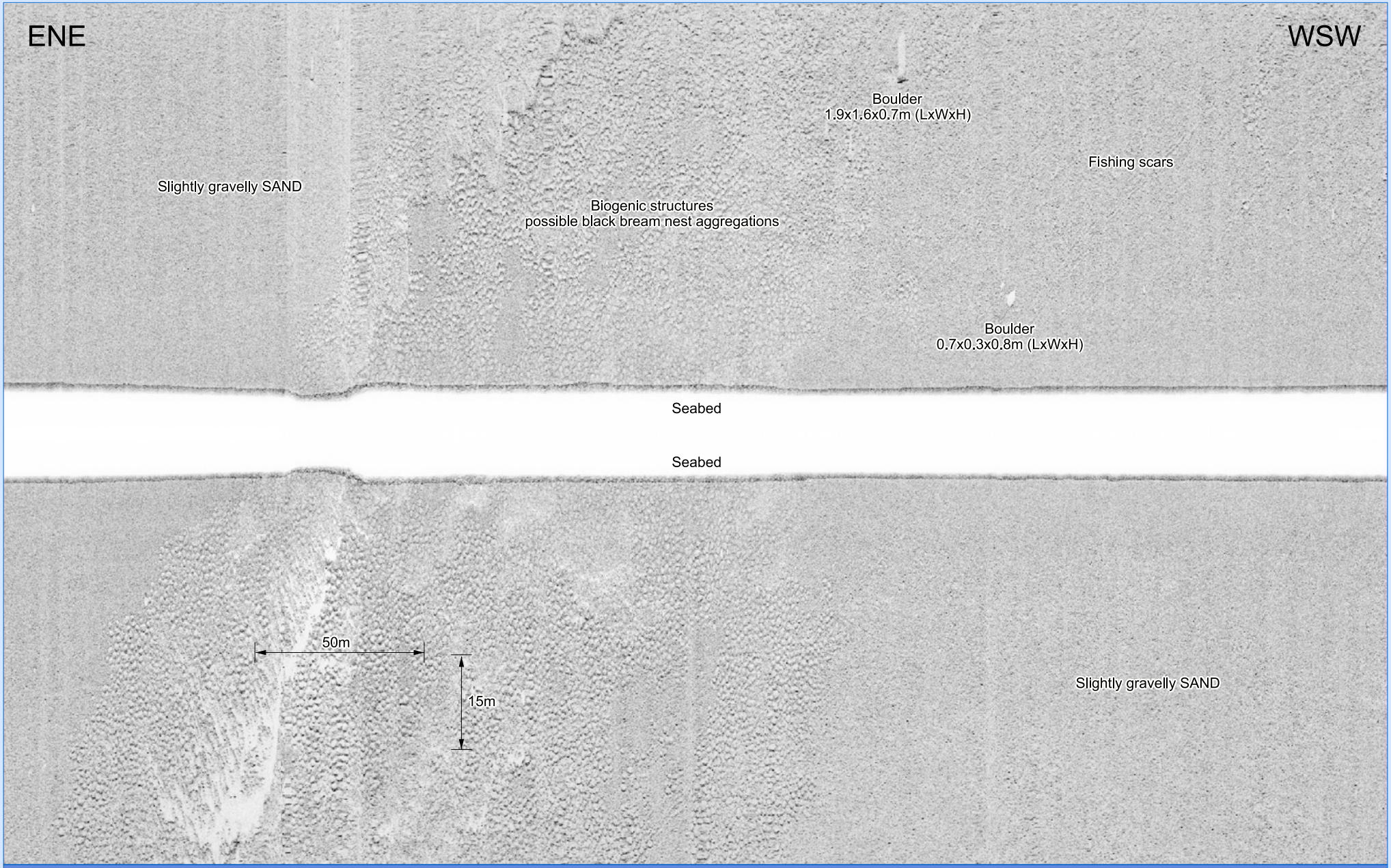
Job No. 11521.4

Line C_M-37

SIDE SCAN SONAR
Illustrating Wreck 2

Figure 3.17

Job No. 11521.4

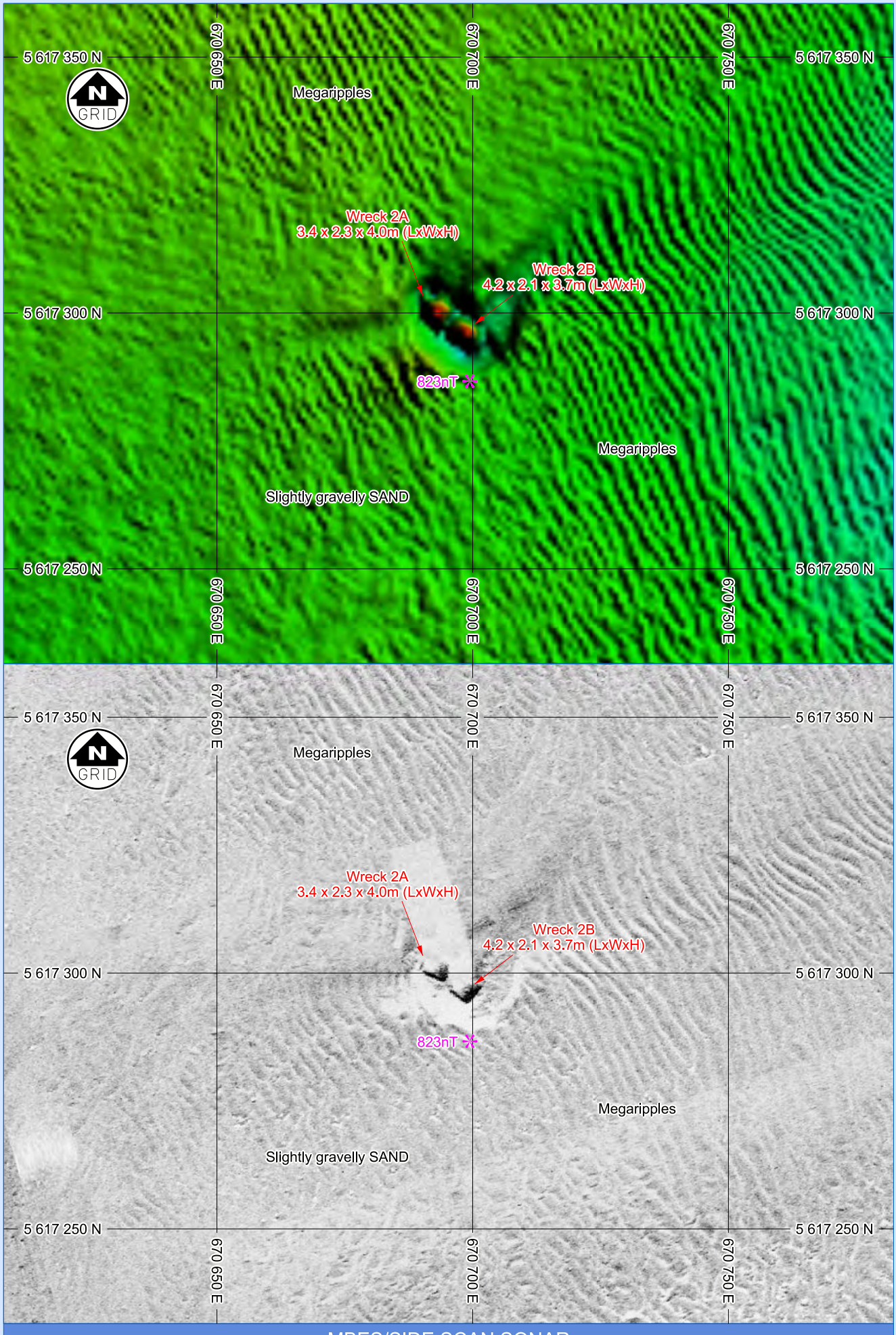


Line M102

SIDE SCAN SONAR
Illustrating biogenic structures - possible black bream nest aggregations

Figure 3.18

Job No. 11521.4

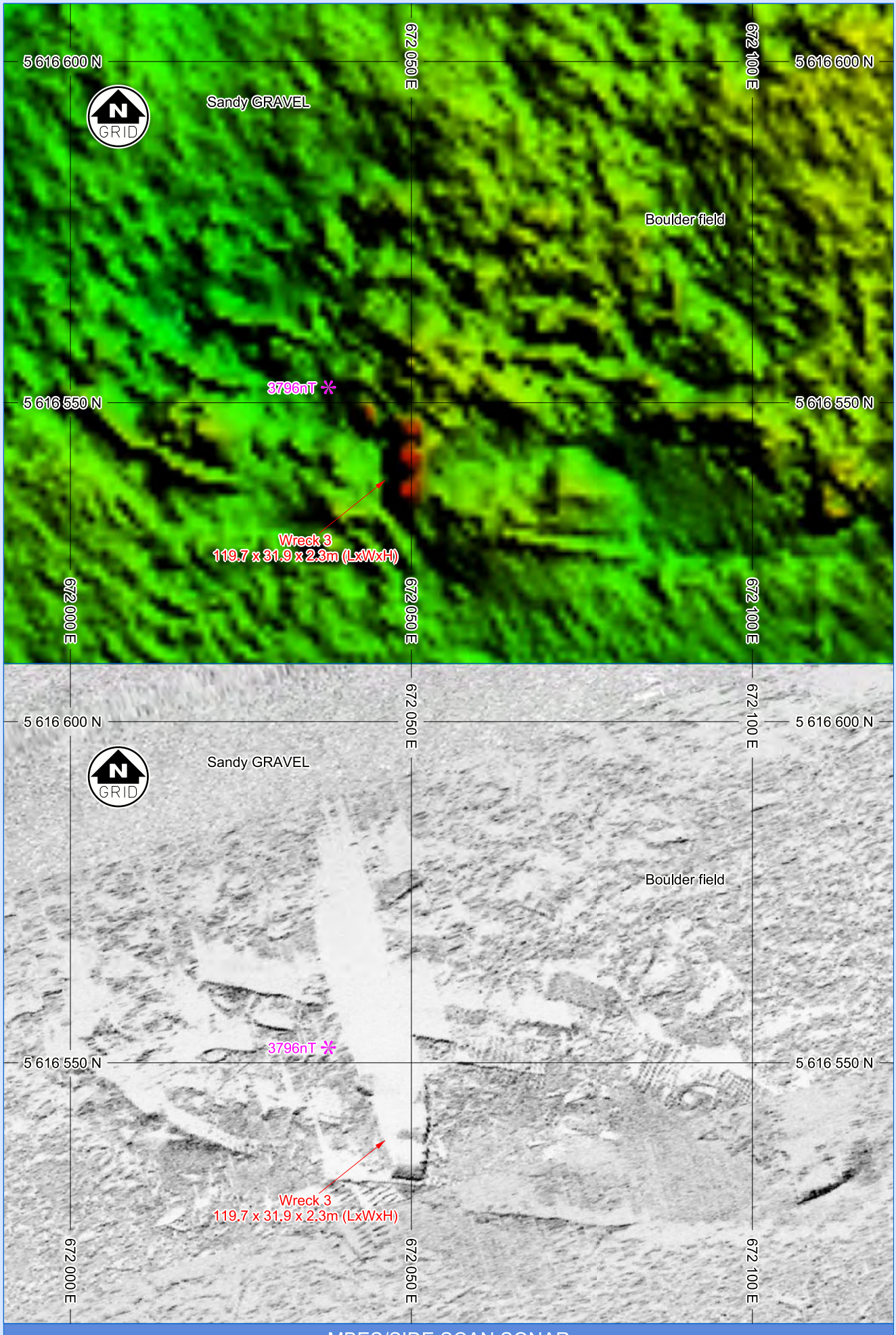


Scale 1 : 1 000
WGS84/UTM Zone 30N (3°W)

MBES/SIDE SCAN SONAR
Illustrating overview of Wreck 2

Figure 3.19

Job No. 11521.4



Scale 1 : 750
WGS84/UTM Zone 30N (3°W)

MBES/SIDE SCAN SONAR
Illustrating overview of Wreck 3

Figure 3.20

Job No. 11521.4

3.3 Sub-Surface Geology

Boomer and Pinger data were acquired on the nearshore and offshore sections of Rampion Area C, respectively. The Boomer and Pinger data were in good agreement with the bathymetry and side scan sonar data and hence aided the interpretation of both the seabed sediments and shallow soils. Correlation with previous reports allows for the correspondence to be drawn from previously acquired ground truthing results. It should be noted that previously acquired ground truthing results are not covered by the current 2020 survey data.

Referenced reports include:

- RAM-GAR-SIF-REP-0003_00--Geophysical Investigations Additional Areas Report, Gardline ref: 9370, 2013
- RAM-GAR-SMG-REP-0002_00--Export Cable Routes Report, Gardline ref: 9371, 2013
- RAM-OSI-SMG-SUR-0001_01-at02--Definitive Geophysical Survey Volume 2 Section 1 Report, 2010

Within Rampion 2 OWF Area C three units have been identified and mapped. The base and distribution of each have illustrated on Chart 9. An overview is presented in Figure 3.21.

3.3.1 Geological Background

The Rampion windfarm is located offshore of Worthing, on the West Sussex coast. The Rampion windfarm site lies within the English Channel and contains a variable sequence of Cretaceous and Tertiary bedrock, Palaeochannels and younger Quaternary sediments. The general stratigraphy in this section is expected to be bedrock cut through by Palaeochannels, all overlain by Pleistocene and Holocene deposits.

During the Pleistocene the English Channel comprised shallow marine environments periodically drying associated with glacial advances and retreats. Extensive fluvial delta systems were able to develop during this period. These rivers cut into the underlying bedrock.

At the end of the Pleistocene, marine conditions returned, infilling the river channels with estuarine then marine sediments. During this transgression period lag sediments subsequently covered the majority of the seabed.

Throughout the Holocene, marine sediments have built up in areas of the seabed. These are more prevalent further offshore.

A full description is listed in Table 3.4, detailing the horizons mapped and expected geological conditions for the units bounded by them.

3.3.2 Geological Overview

Quaternary deposits are interpreted as comprising predominantly gravel and sand, deposited during open marine environments. These deposits are sometimes too thin to map using the sub-bottom data. They overlie the Cretaceous and Tertiary bedrock and occasionally the Palaeochannels. Bedrock is interpreted to comprise Tertiary Claystones to Cretaceous Chalk strata. The strata are simply layered and often gently folded creating dipping beds. These bedding planes subcrop the majority of the site, occasionally outcropping.

The Quaternary deposits represented by H05 and H07 are found throughout much of the site, although are often too thin to identify on seismic data. Where these are absent, bedrock bedding plane are seen

to outcrop and tie with bathymetric data. Areas of increased surface boulders are also found to tie with thinning Quaternary deposits. The younger Holocene deposits, represented by H05 are found to have sandwaves and megaripples associated with them, see Figure 3.22.

Palaeochannels cut through the bedrock, and within Rampion Area C there are three main channels all trending NNW to SSW with smaller tributary channels, see Figure 3.21. Channels are interpreted to comprise interbedded clay, sands and gravels, with peat layers and basal gravels. Figure 3.23 and Figure 3.24 illustrate these channels within the nearshore section on the boomer data and offshore section on the pinger data. They are associated with glacial advances and the associated falls in sea level. This allowed for an extensive river delta system to develop. At the end of the Pleistocene, marine conditions returned, infilling the channels with estuarine then marine sediments. Within Rampion Area C these channels are found up to 27m deep, however the base of channels are often blanked by what is likely to be peat or gravel layers, see Figure 3.25.

Within the central to southern part of Rampion Area C, older channels are seen below the mapped Palaeochannels. The origin of these channels is unclear, but likely to be fluvial deposits of predominately sand and gravel. Multiple channel units are seen to be cutting into each other suggesting a system that has moved position numerous times. These appear to cut across the Rampion Area C site from west to east, suggesting a different origin from the Palaeochannels which cut south from the coast. These units can be seen in Figure 3.22.

Bedrock is found throughout Rampion Area C close to surface except when cut through by channel systems. Tertiary rock to Cretaceous Chalk strata, are simply layered and often gently folded creating bedding plains dipping downwards towards the west. Tertiary bedrock strata are interpreted to consist of rocks, comprising mainly sands, gravels and clays. Older Cretaceous strata comprise typically limestone.

A description of each interpreted horizon is given in Table 3.4.

Table 3.4 Summary of Interpreted Horizons within Rampion Area C

Horizon	Phase	Description	Expected Geological Conditions
H05	Holocene Sediments	Found In the western part of Rampion Area C, ranging from seabed to 3m depth BSB, is characterised as largely homogeneous and acoustically transparent with faint, discontinuous internal horizons.	Unconsolidated sediments, largely sand and gravel. Potentially mobile in places.
H07	Quaternary Sediments	Found largely in the southeast of Rampion Area C, ranging from seabed to 3m depth BSB, is characterised as largely homogeneous and acoustically transparent with faint internal horizons.	Consolidated sediments, largely sand and gravel.
H10	Palaeochannels	Found throughout Rampion Area C. A channel infill sequence ranging from seabed to 27m depth BSB. Layered sediments, transparent facies are common, with higher amplitudes sometimes blanking the base	Fluvial, estuarine and marine deposits. Predominantly sands and gravels overlying normally consolidated sands and clays, with some peat layers and basal gravels
H11	Older Complex Channelling	Found in the central part of Rampion Area C. Characterised as layered infill channel sequences.	Origin unclear, but likely to be fluvial deposits of predominately sand and gravel.

Horizon	Phase	Description	Expected Geological Conditions
Bedding Strata	Tertiary and Cretaceous bedrock	Found throughout Rampion Area C. Tertiary Claystones to Cretaceous Chalk strata. Simply layered and often gently folded creating dipping beds.	Tertiary bedrock strata consist of softer rocks, comprising mainly sands, gravels and clays, with the older Cretaceous strata comprising typically limestone.

SOILS (H10 - PALAEOCHANNEL) OVERVIEW FOR RAMPION 2 OWF AREA C

5 632 500 N
5 628 750 N
5 625 000 N
5 621 250 N
5 617 500 N
5 613 750 N
50°48'00" N
50°45'00" N
50°42'00" N
50°39'00" N
000°42'00" W
663 750 E
000°39'00" W
667 500 E
000°36'00" W
671 250 E
000°33'00" W
675 000 E
000°30'00" W
678 750 E
000°27'00" W
682 500 E
000°24'00" W

Littlehampton

Bognor Regis

Veneer of Holocene sediments overlying Tertiary Rock to Cretaceous Chalk strata. These are simply layered and often gently folded creating bedding plains dipping downwards towards the west, which occasionally outcrop

PROPOSED RAMPION 2 OWF AREA C (EXPORT CABLE AREA)

PROPOSED RAMPION 2 OWF AREA B (EXTENSION AREA)

PROPOSED RAMPION 2 WIND TURBINE GENERATOR LAYOUT (SOURCE: CLIENT PROVIDED)

10 DEPTH IN METRES BELOW SEABED TO BASE OF H10 - PALAEOCHANNEL, CONTOURED AT 10 METRE INTERVALS

AREA OF BLANKING

DEPTH IN METRES BELOW SEABED TO BASE HORIZON H10

0 2 4 6 8 10 12 14 16 18 20 22 24 26

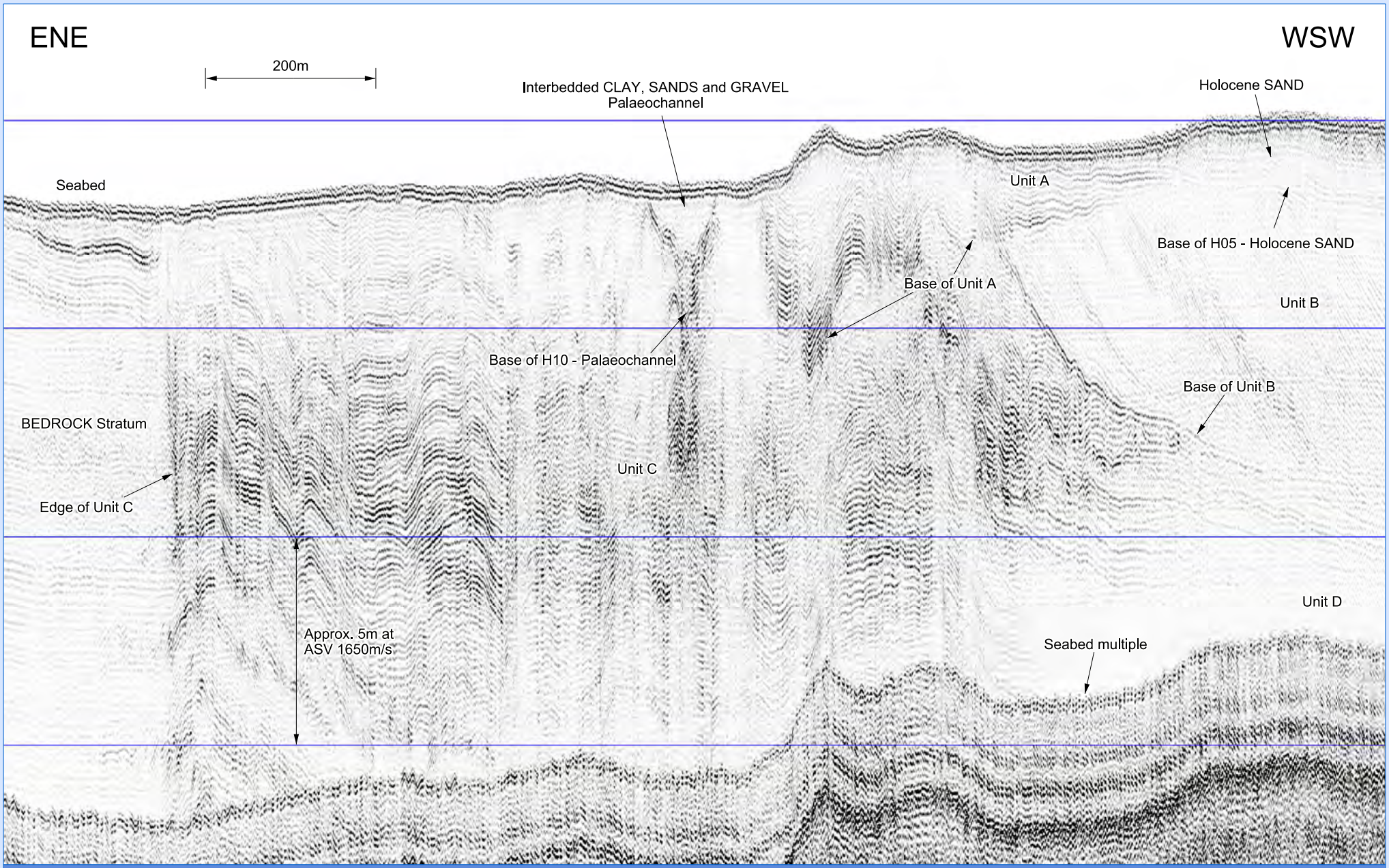
NOTE:

H10 = PALAEOCHANNELS ARE SEEN CUTTING THROUGH THE BEDROCK. THESE CHANNELS ARE INTERPRETED TO COMPRISE INTERBEDDED CLAY, SANDS AND GRAVELS, WITH PEAT LAYERS AND BASAL GRAVELS AND ARE ASSOCIATED WITH GLACIAL ADVANCES AND THE ASSOCIATED FALLS IN SEA LEVEL

Scale 1 : 75 000
WGS84/UTM Zone 30N (3°W)

Figure 3.21

Job No. 11521.4

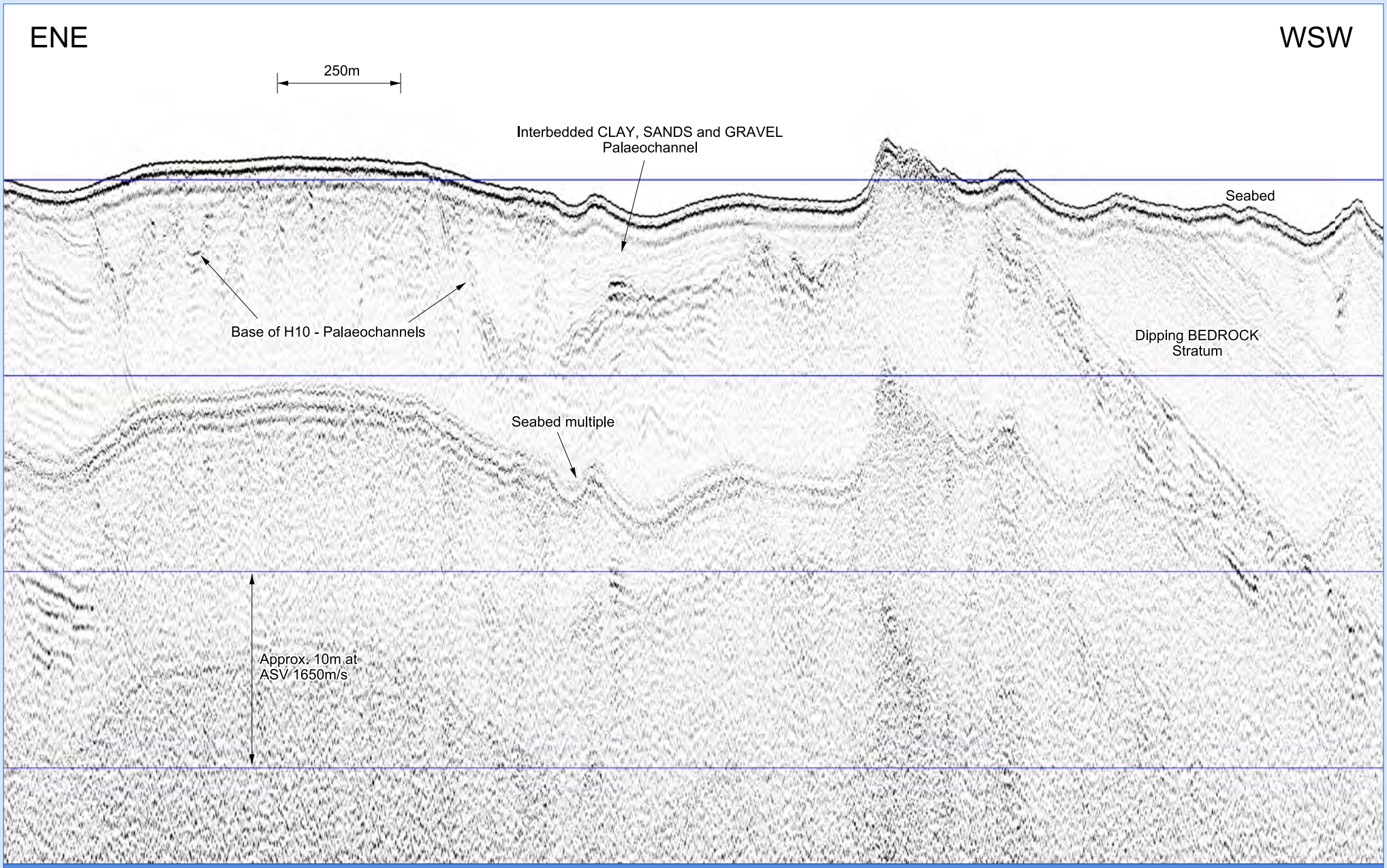


Line C_M-22

PINGER
Illustrating sand unit above complex channel deposits

Figure 3.22

Job No. 11521.4

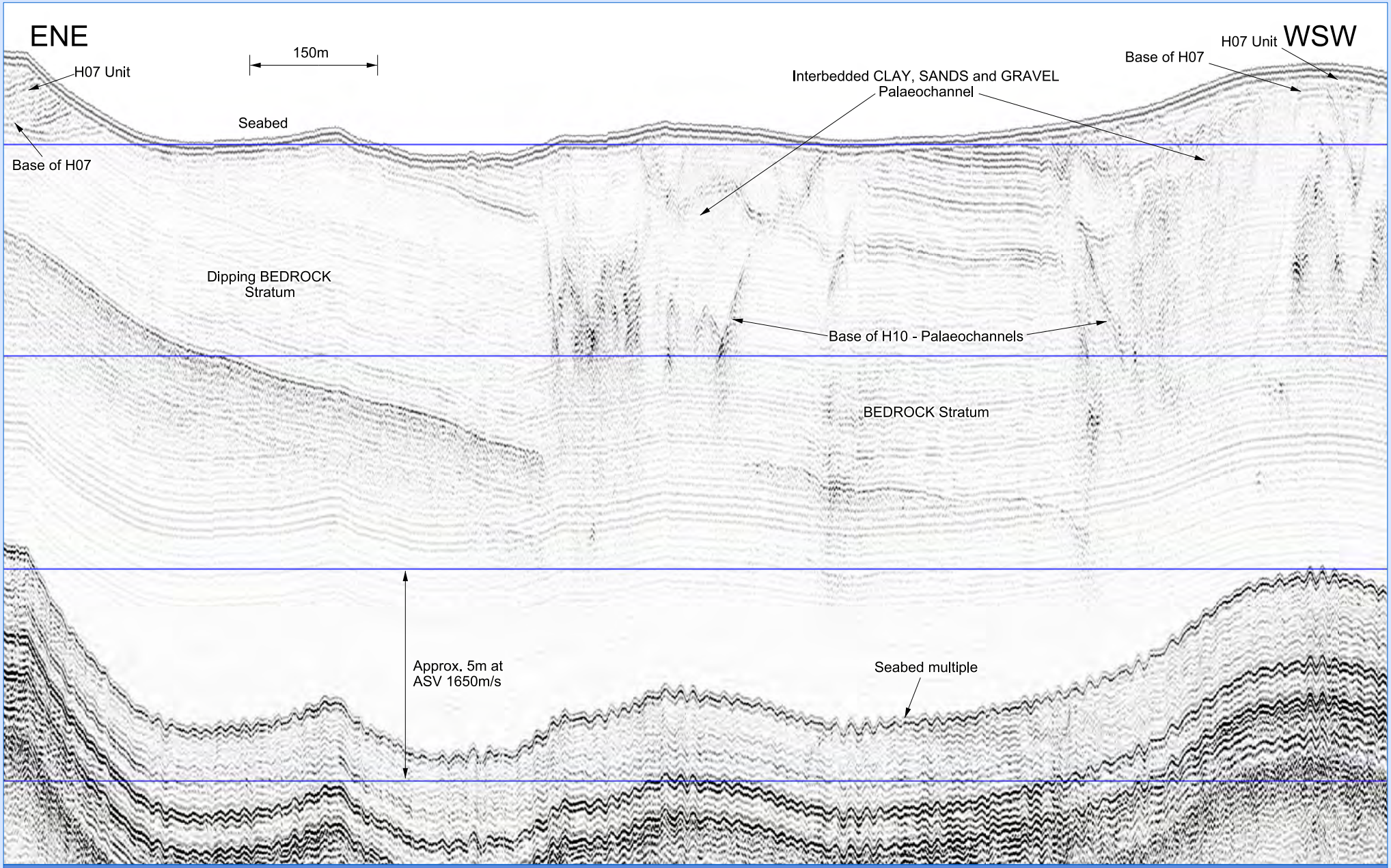


Line M66

BOOMER
Illustrating palaeochannels within the bedrock stratum

Figure 3.23

Job No. 11521.4

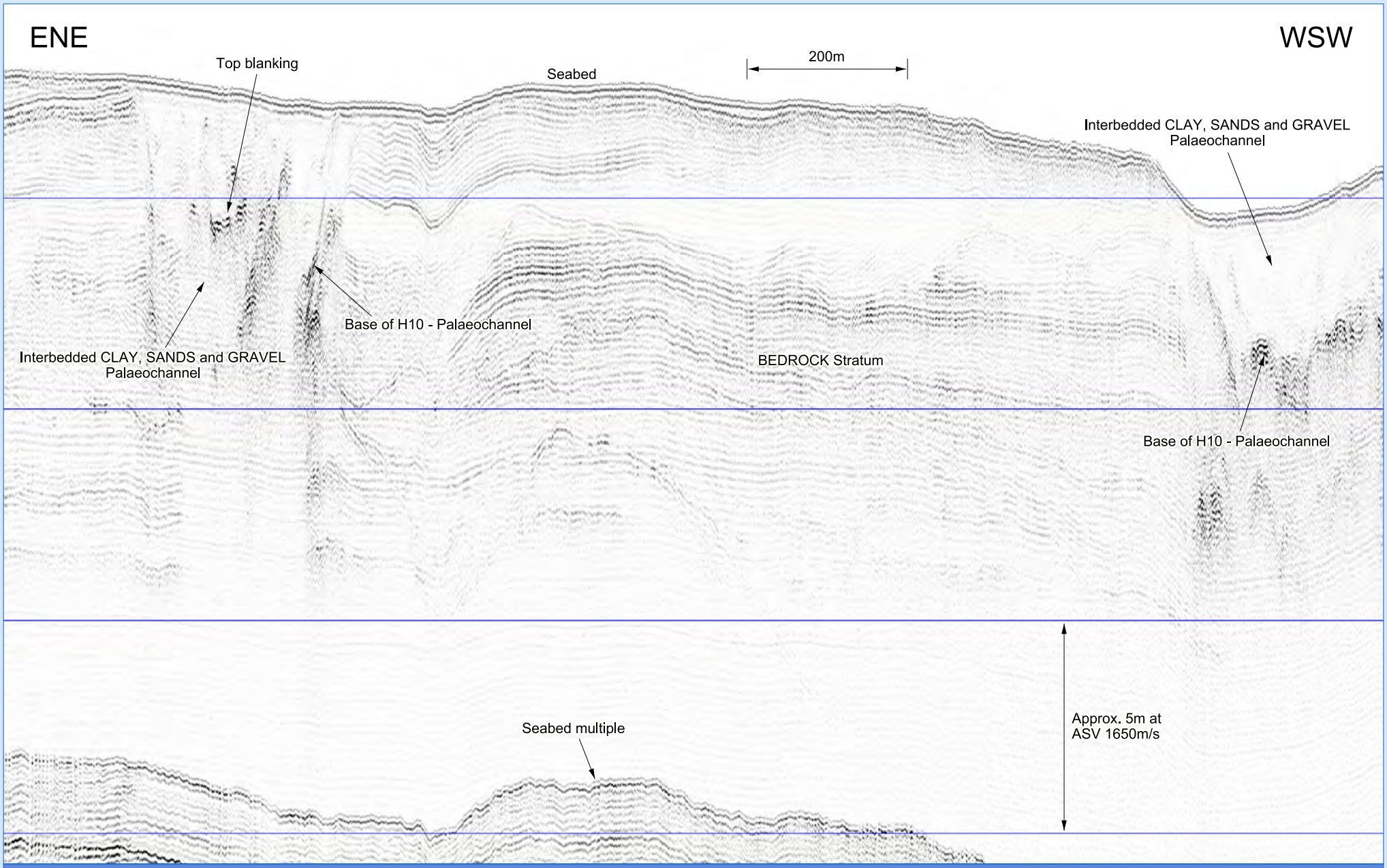


Line C_M-79

PINGER
Illustrating palaeochannels within the bedrock stratum

Figure 3.24

Job No. 11521.4



Line C_M-58

PINGER
Illustrating blanking within the palaeochannels

Figure 3.25

Job No. 11521.4

4. BACKGROUND INFORMATION

Geophysical data have been interpreted with reference to BGS charting for the area as follows:

Wight BGS Chart, Sheet 50°N - 02°W,
British Geological Survey, 1:250,000 Series,
Published by Ordnance Survey.

The following versions are available:

Sea Bed Sediments
Quaternary Geology
Solid Geology

Useful information was also obtained from the following sources:

Osiris Hydrographic & Geophysical Projects Ltd. 2010. E.ON Climate & Renewables, Rampion Offshore Wind Farm, Definitive Geophysical Survey.

Osiris Hydrographic & Geophysical Projects Ltd. 2011. E.ON Climate & Renewables, Rampion Offshore Wind Farm, Extension and BH13 UXO Survey.

Fugro GeoConsulting Ltd. 2013. E.ON Climate & Renewables, Rampion Offshore Wind Farm, Geotechnical Investigation Quadrant 99.

Gardline Ltd. 2013. E.ON Climate & Renewables, Rampion Offshore Wind Farm, Additional Areas Geophysical Survey.

APPENDICES

APPENDIX A. GEODETIC REFERENCE SYSTEM

Geodetic Datum	
Geodetic Datum	World Geodetic System 1984
EPSG Code	6326

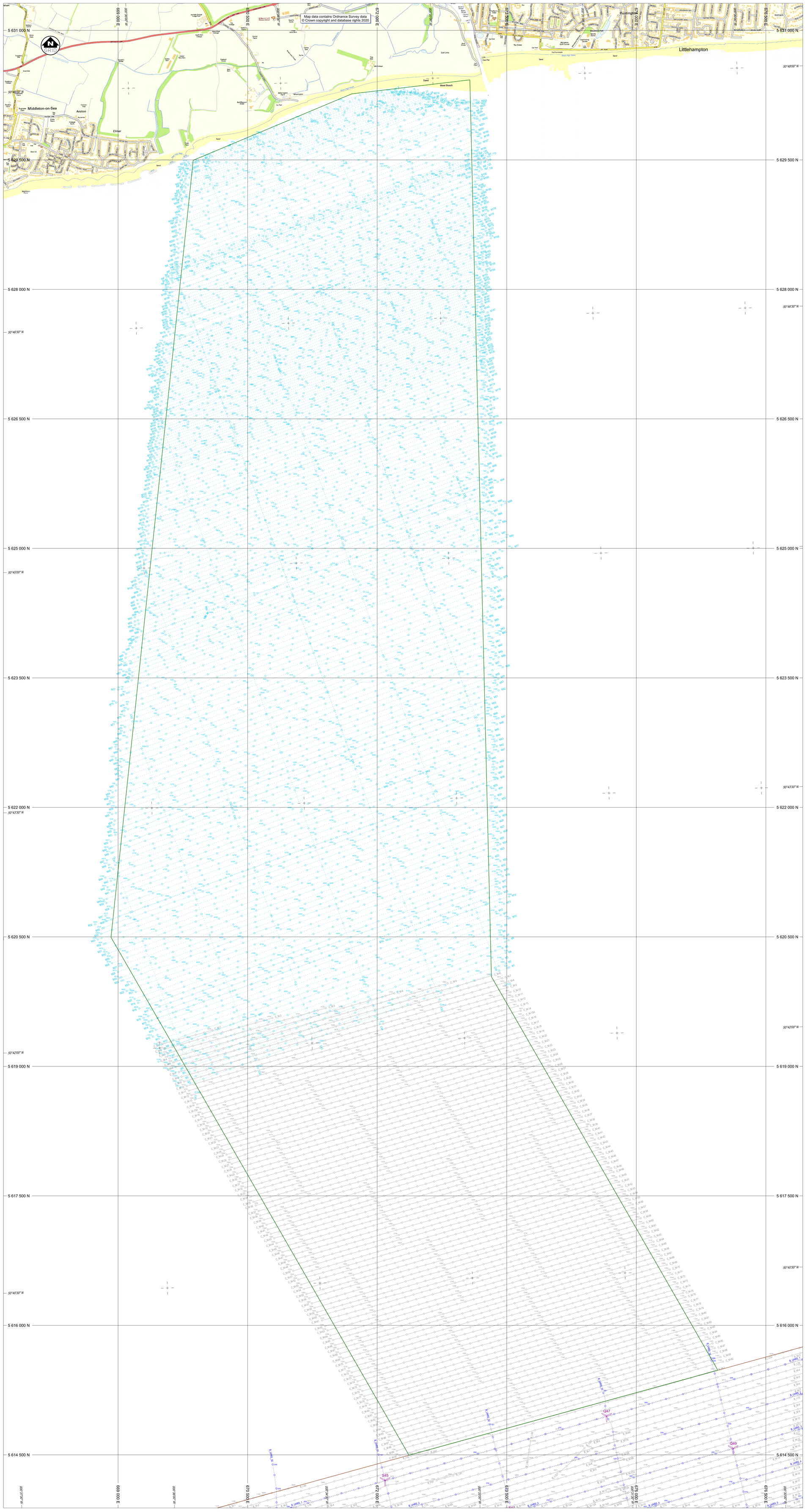
Ellipsoid	
Ellipsoid	WGS 84
EPSG Code	7030
Semi-major Axis (a)	6 378 137.000m
Semi-minor Axis (b)	6 356 752.314m
Inverse Flattening (1/f)	298.257 223 560
Eccentricity sq. (e^2)	0.006 694 379 990

Projection	
Projection	UTM Zone 30N
Projection Type	Transverse Mercator
EPSG Code	16030
Origin Latitude	00° 00' 00.000" North
Origin Longitude	003° 00' 00.000" West
Origin False Easting	500 000.000
Origin False Northing	0.000
Scale Factor	0.9996
Grid Unit	Metres
EPSG Code	9001

Source of Information: EPSG geodesy parameters dataset version 9.9.

ENCLOSURES

CHARTS 11521.4.01 –11521.4.10

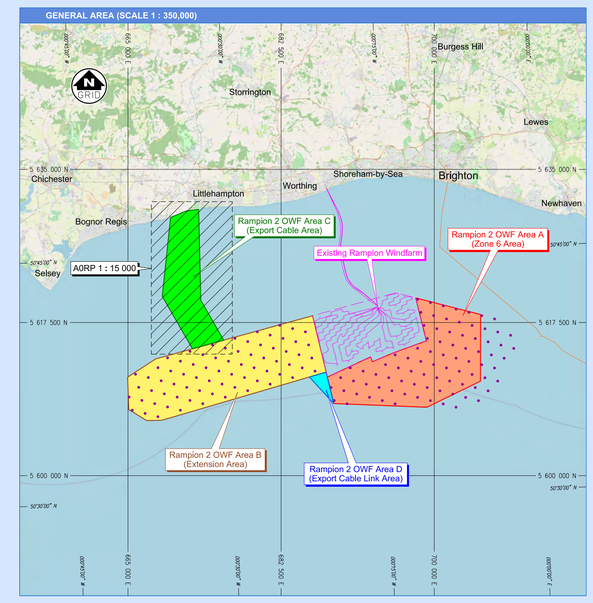


LEGEND

- PROPOSED RAMPION 2 OWF AREA C (EXPORT CABLE AREA)
- PROPOSED RAMPION 2 OWF AREA B (EXTENSION AREA)
- PROPOSED RAMPION 2 WIND TURBINE GENERATOR LAYOUT (SOURCE: CLIENT PROVIDED)
- REFERENCE POINT TRACK - SHALLOW GEOPHYSICAL LINES (M.V. VIGILANT)
- REFERENCE POINT TRACK - SHALLOW GEOPHYSICAL LINES (M.V. TITAN DISCOVERY)
- REFERENCE POINT TRACK - 2D UHRS LINES (M.V. OCEAN OBSERVER)

NOTES

GENERAL AREA (SCALE 1 : 350,000)



GEODETIC REFERENCE SYSTEM

GEODETIC DATUM:	WGS84
ELLIPSOID:	WGS84
PROJECTION:	UTM ZONE 30 N (CENTRAL MERIDIAN 3° W)

SURVEY INFORMATION

SURVEY VESSEL:	M.V. VIGILANT	M.V. TITAN DISCOVERY	M.V. OCEAN OBSERVER
SURVEY DATE:	30-JUN-2020 TO 01-AUG-2020	01-JUL-2020 TO 12-AUG-2020	16-SEP-2020 TO 13-OCT-2020
POSITIONING SYSTEM:	OCEANERRING C-NAV DGNSS	APPLANIX POS MV WAVEMASTER	FUGRO STARFIX DGNSS
	SONARDYNE RANGER USBL	SONARDYNE RANGER USBL	SONARDYNE RANGER USBL
NAVIGATION SYSTEM:	VOYAGER 5	VOYAGER 5	VOYAGER 5
ECHO SOUNDER (MULTI-BEAM SYSTEM):	SIMRAD EM2040D	RESON T20-P DUAL HEAD	SIMRAD EM2040
ECHO SOUNDER (SINGLE-BEAM SYSTEM):	SIMRAD EA400	ODOM ECHOTRAC MKIII	SIMRAD EA400
SIDE SCAN SONAR:	EDGETECH 4200FS	EDGETECH 4200FS	EDGETECH 4200FS
MAGNETOMETER:	GEOMETRICS G882	GEOMETRICS G882	GEOMETRICS G882
SUB-BOTTOM PROFILER:	GEOACOUSTICS PINGER	SURFACE TOW BOOMER	GEOACOUSTICS PINGER
ULTRA HIGH RESOLUTION SEISMIC (UHRS):			1 x 10 cu.in. T.I. SLEEVE GUN 75m TELEDYNE STREAMER

SCALE (A0 ORIGINAL)

1 : 15 000 (Horizontal)

150 0 750 1500

METRES

TITLE

SURVEY CONTRACTOR

GARDLINE LIMITED
ENDEAVOUR HOUSE, ADMIRALTY ROAD, GREAT YARMOUTH, NORFOLK NR30 3NG. ENGLAND
TELEPHONE +44 (0) 1493 845600 FAX +44 (0) 1493 852106 WEBSITE WWW.GARDLINE.COM

CLIENT

PROJECT TITLE

RAMPION 2 OFFSHORE WINDFARM DEVELOPMENT GEOPHYSICAL SITE SURVEY FOR AREA C

DRAWING TITLE

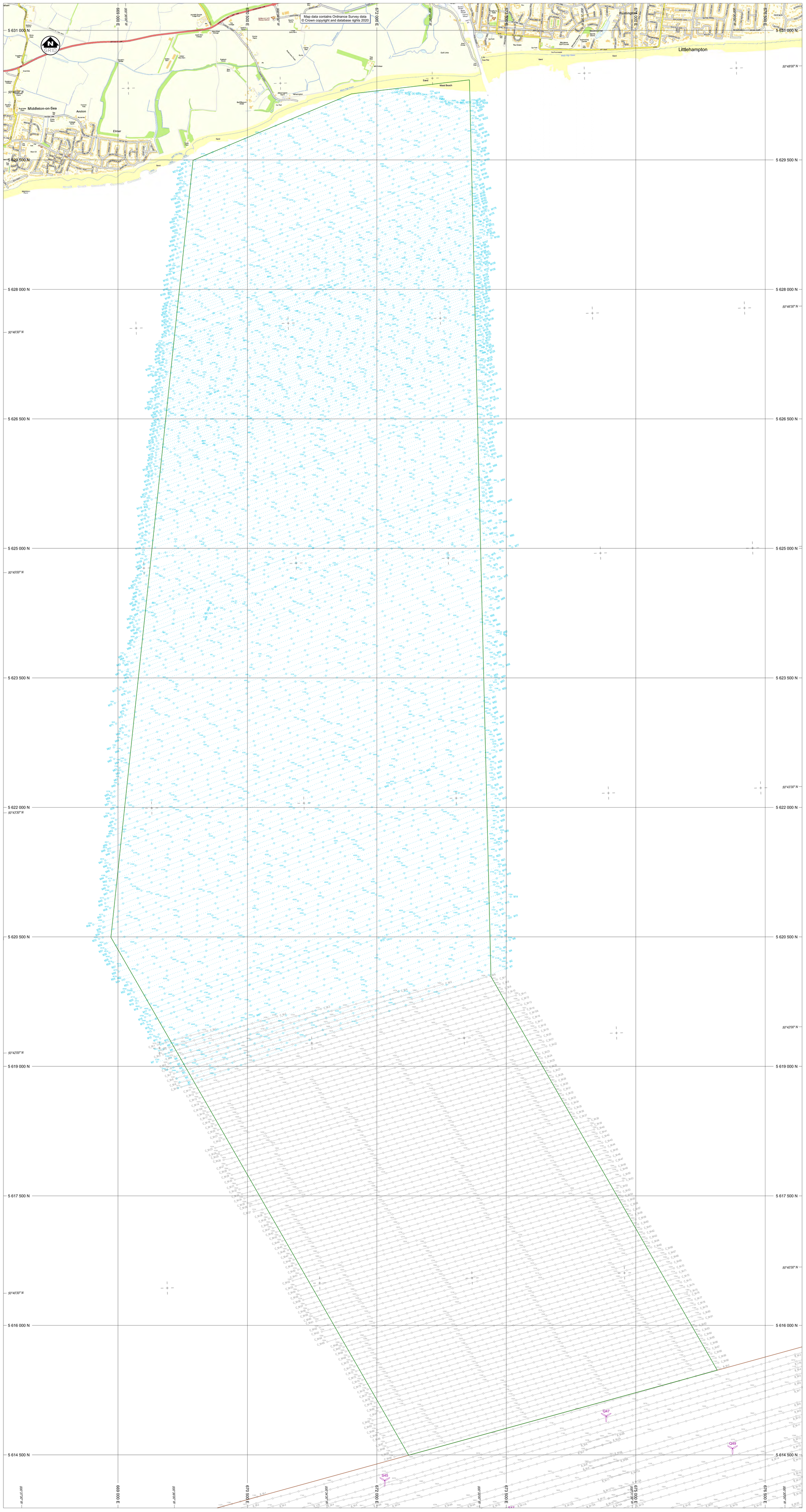
REFERENCE POINT TRACK

CHART 1

REVISION

REV.	DATE	TITLE	DESCRIPTION	AUTHOR	DRAWN	CHECKED	APPROVED
0	03-NOV-2020	DRAFT	FIRST ISSUE FOR CLIENT REVIEW, PDF ONLY	MC	JS	MK	DIG

CLIENT REFERENCE | **REPORT REFERENCE** 11521.4 | **DRAWING NUMBER** 11521.4.01

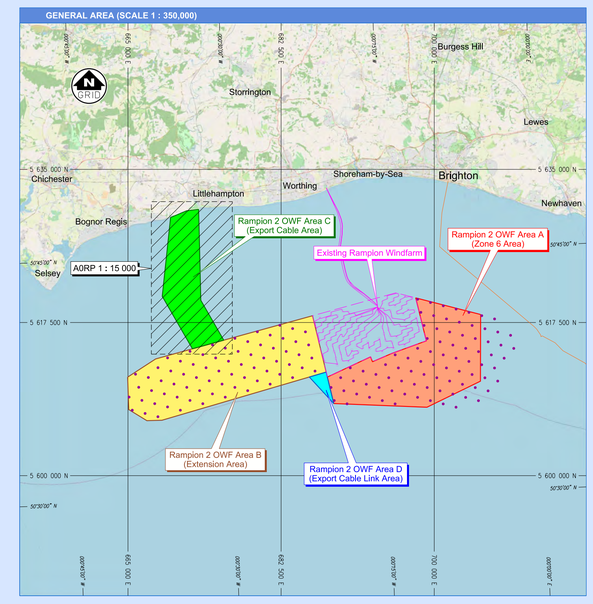


LEGEND

- PROPOSED RAMPION 2 OWF AREA C (EXPORT CABLE AREA)
- PROPOSED RAMPION 2 OWF AREA B (EXTENSION AREA)
- PROPOSED RAMPION 2 WIND TURBINE GENERATOR LAYOUT (SOURCE: CLIENT PROVIDED)
- SIDE SCAN SONAR TRACK - SHALLOW GEOPHYSICAL LINES (M.V. VIGILANT)
- SIDE SCAN SONAR TRACK - SHALLOW GEOPHYSICAL LINES (M.V. TITAN DISCOVERY)

NOTES

GENERAL AREA (SCALE 1 : 350,000)



GEODETIC REFERENCE SYSTEM

GEODETIC DATUM:	WGS84
ELLIPSOID:	WGS84
PROJECTION:	UTM ZONE 30 N (CENTRAL MERIDIAN 3° W)

SURVEY INFORMATION

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POSITIONING SYSTEM:	OCEANERRING C-NAV DGNSS	APPLANIX POS MV WAVEMASTER	FUGRO STARFIX DGNSS
NAVIGATION SYSTEM:	SONARDYNE RANGER USBL	SONARDYNE RANGER USBL	SONARDYNE RANGER USBL
ECHO SOUNDER (MULTI-BEAM SYSTEM):	VOYAGER 5	VOYAGER 5	VOYAGER 5
ECHO SOUNDER (SINGLE-BEAM SYSTEM):	SIMRAD EM2040D	RESON T20-P DUAL HEAD	SIMRAD EM2040
SIDE SCAN SONAR:	SIMRAD EA400	ODOM ECHOTRAC MKIII	SIMRAD EA400
MAGNETOMETER:	EDGETECH 4200FS	EDGETECH 4200FS	EDGETECH 4200FS
SUB-BOTTOM PROFILER:	GEOMETRICS G882	GEOMETRICS G882	GEOMETRICS G882
ULTRA HIGH RESOLUTION SEISMIC (UHRS):	GEOACOUSTICS PINGER	SURFACE TOW BOOMER	GEOACOUSTICS PINGER 1 x 10 cu.in. T.I. SLEEVE GUN 75m TELEDYNE STREAMER

SCALE (A0 ORIGINAL)

1 : 15 000 (Horizontal)

150 0 750 1500

METRES

TITLE

SURVEY CONTRACTOR

GARDLINE LIMITED
ENDEAVOUR HOUSE, ADMIRALTY ROAD, GREAT YARMOUTH, NORFOLK NR30 3NG. ENGLAND
TELEPHONE +44 (0) 1493 845600 FAX +44 (0) 1493 852106 WEBSITE WWW.GARDLINE.COM

CLIENT

PROJECT TITLE

RAMPION 2 OFFSHORE WINDFARM DEVELOPMENT GEOPHYSICAL SITE SURVEY FOR AREA C

DRAWING TITLE

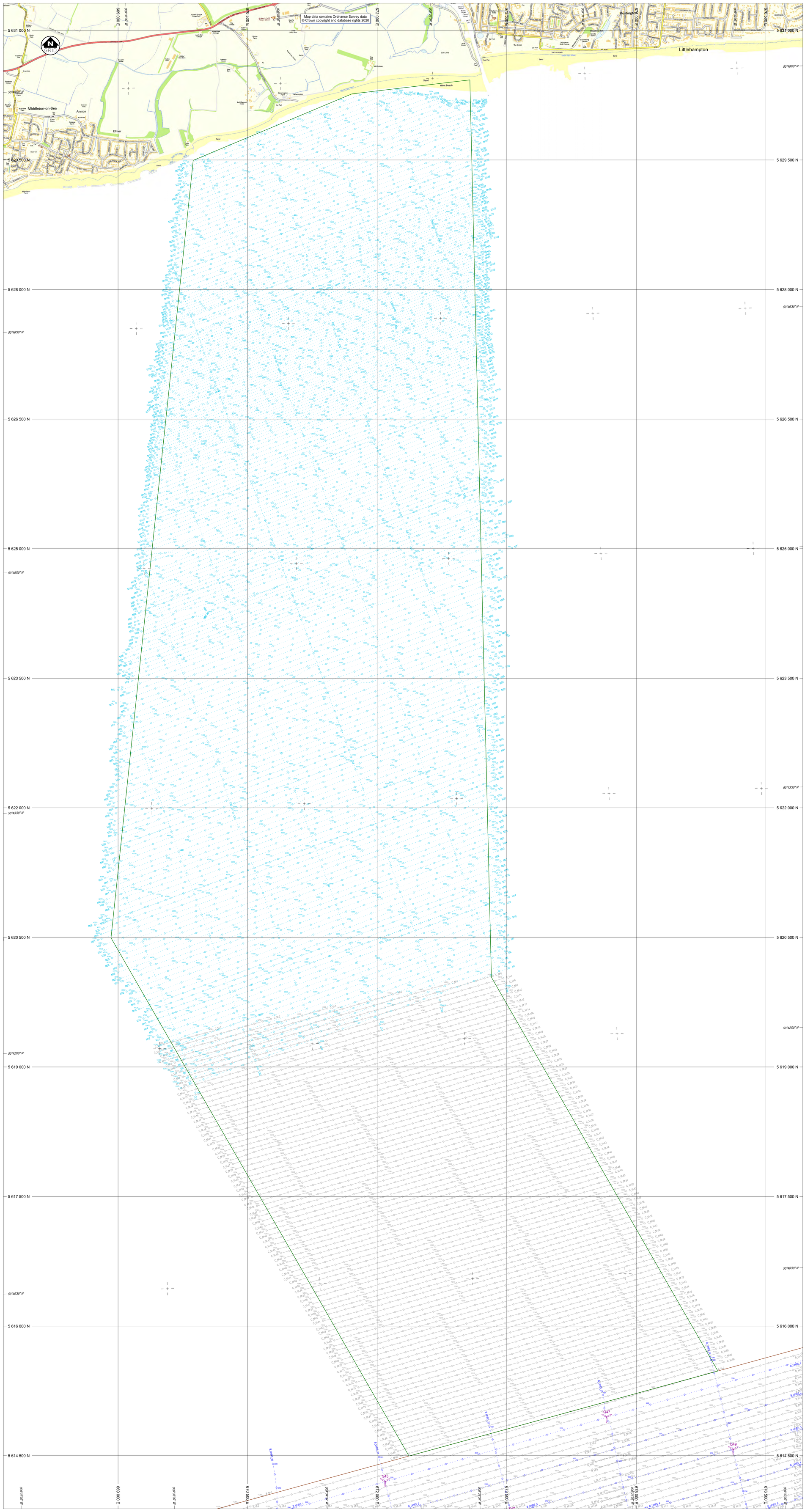
SIDE SCAN SONAR TRACK

CHART 2

REVISION

REV.	DATE	TITLE	DESCRIPTION	AUTHOR	DRAWN	CHECKED	APPROVED
0	03-NOV-2020	DRAFT	FIRST ISSUE FOR CLIENT REVIEW, PDF ONLY	MC	JS	MK	DIG

CLIENT REFERENCE	**REPORT REFERENCE** 11521.4	**DRAWING NUMBER**	11521.4.02



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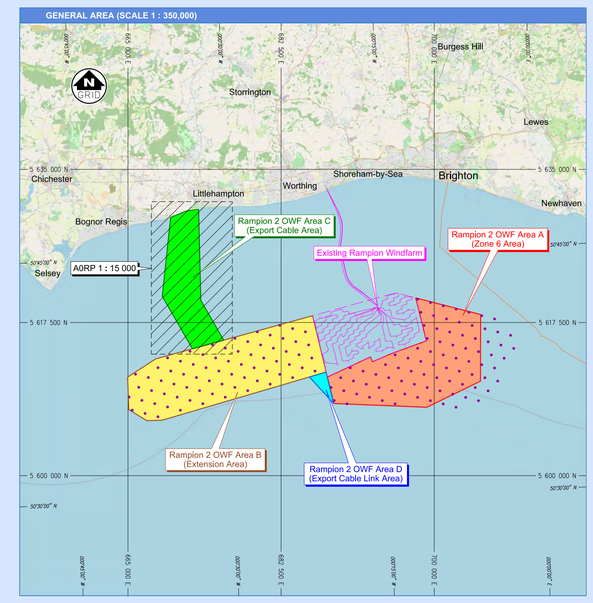
- PROPOSED RAMPION 2 WIND TURBINE GENERATOR LAYOUT (SOURCE: CLIENT PROVIDED)
- PINGER TRACK - SHALLOW GEOPHYSICAL LINES (M.V. VIGILANT)
- SURFACE TOW BOOMER TRACK - SHALLOW GEOPHYSICAL LINES (M.V. TITAN DISCOVERY)
- PINGER TRACK - 2D UHRS LINES (M.V. OCEAN OBSERVER)

NOTES

GENERAL AREA (SCALE 1 : 350,000)



GEODETIC REFERENCE SYSTEM

GEODETIC DATUM:	WGS84
ELLIPSOID:	WGS84
PROJECTION:	UTM ZONE 30 N (CENTRAL MERIDIAN 3° W)

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	SONARDYNE RANGER USBL	SONARDYNE RANGER USBL	SONARDYNE RANGER USBL
NAVIGATION SYSTEM:	VOYAGER S	VOYAGER S	VOYAGER S
ECHO SOUNDER (MULTI-BEAM SYSTEM):	SIMRAD EM2040D	RESON T20-P DUAL HEAD	SIMRAD EM2040
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SCALE (A0 ORIGINAL)

1 : 15 000 (Horizontal)

150 0 750 1500

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TELEPHONE +44 (0) 1493 845600 FAX +44 (0) 1493 852106 WEBSITE WWW.GARDLINE.COM

CLIENT

PROJECT TITLE

RAMPION 2 OFFSHORE WINDFARM DEVELOPMENT GEOPHYSICAL SITE SURVEY FOR AREA C

DRAWING TITLE

SUB-BOTTOM PROFILER TRACK

CHART 3

REVISION

REV.	DATE	TITLE	DESCRIPTION	AUTHOR	DRAWN	CHECKED	APPROVED
0	03-NOV-2020	DRAFT	FIRST ISSUE FOR CLIENT REVIEW, PDF ONLY	MC	JS	MK	DIG

CLIENT REFERENCE		**REPORT REFERENCE** 11521.4	**DRAWING NUMBER** 11521.4.03