TC22_02 INFOMAR Survey Report
Area: Celtic Sea

For:
Marine Institute & Geological Survey Ireland

RV *Tom Crean*

September 2022

Prepared by Kevin Sheehan & INFOMAR Survey Team

Marine Institute Reference No:	Survey Report: TC22_02

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Issue	Date	Description	Author	Approved
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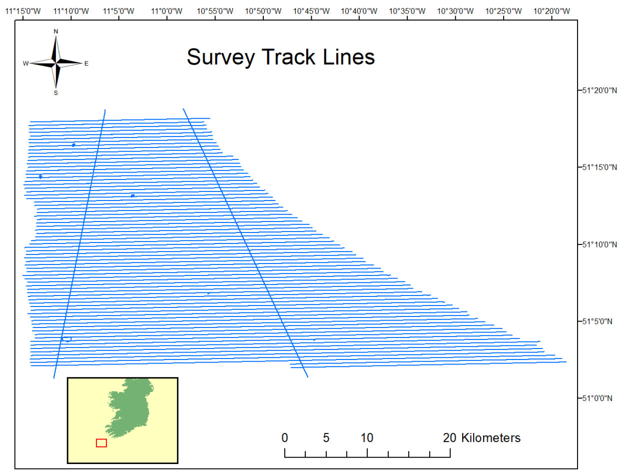
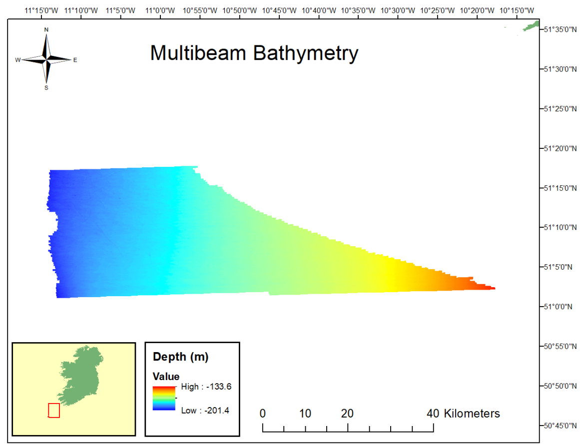
2	14/09/2023	Final	Kevin Sheehan	Fabio Sacchetti

Executive Summary			
Survey Summary			
Survey Vessel:	RV *Tom Crean*	**Survey Leg:**	TC22_02
Mobilisation:	Galway	**Demobilisation:**	Cork
Survey Areas:	Celtic Sea	**Start Date:** **End Date:**	12/09/2022 22/09/2022
Northwest Boundary	51º 17.228 N -11º 13.887 W	**Southeast Boundary**	51º 02.210 N -10º 17.819 W
UKHO Admiralty	0002 (1:1,500,000) & 1123 (1:500,000)		
Key References	TC22_02 Survey Leg Report & TC22_02 Executive Report		
Equipment Used	Kongsberg EM2040D MKII MBES, Knudsen 3260 Chirp sub-bottom profiler, SeaSpy magnetometer, AML MVP30-350, Valeport SVP Mini, C-Nav 3050 GNSS, Seapath 380 R.		

Survey Statistics			
Minimum Water Depth (LAT)	133.6 m	**Maximum Water Depth (LAT)**	201.4 m
Area Covered:	1177 km^2	**Survey Line Kilometres:**	2866 km
Operational Time:	75.7 %	**Weather Standby:**	0 %
Ground Truthing Stations:	0	**Wrecks**	6
H525 forms issues (wrecks)	6	**H102 forms issued (shoals)**	0

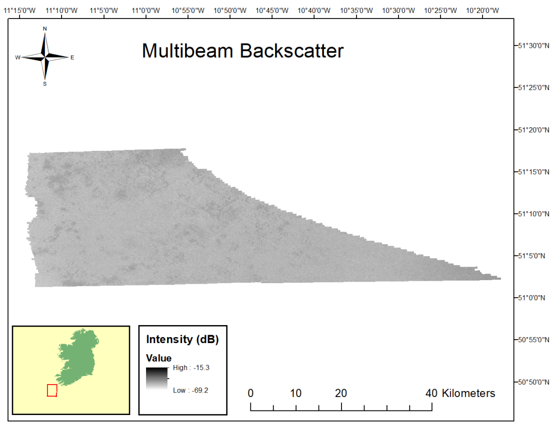
Survey Track Lines	**MBES Bathymetry Overview**



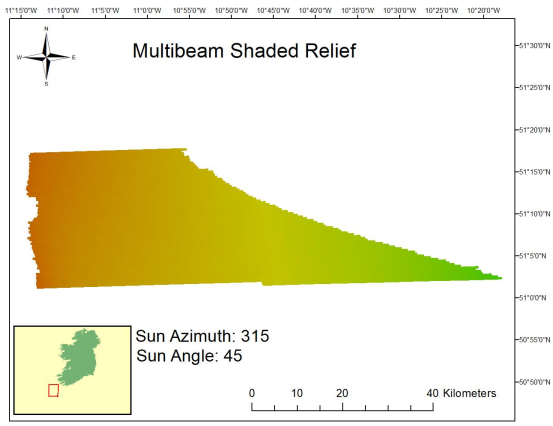


Survey Images

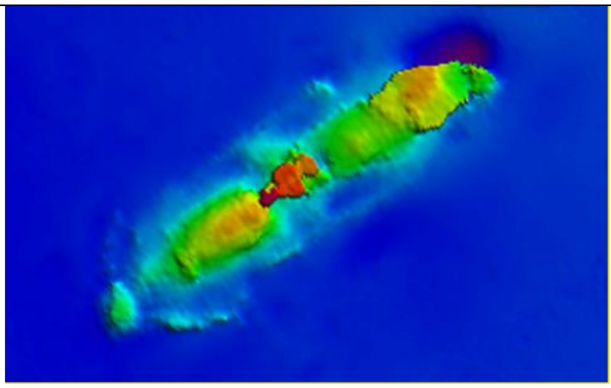
MBES Backscatter



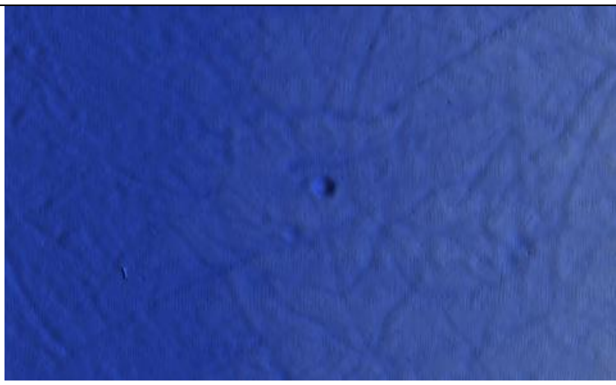
MBES Shaded Relief



Wreck Number 3



Iceberg Scars and Depression Feature



Chirp Profiles

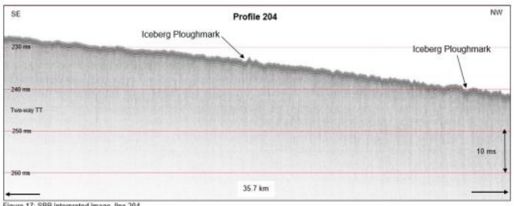


Figure 17: SBP interpreted image, line 204.

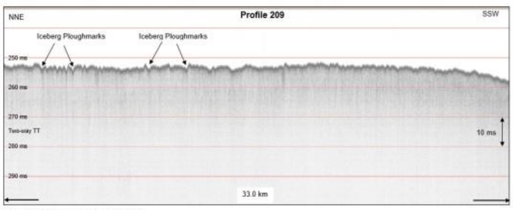
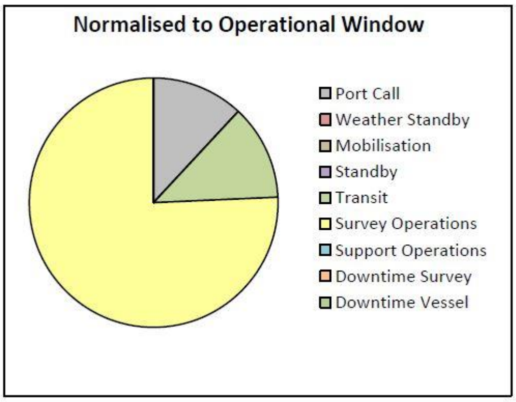


Figure 18: SBP interpreted image, line 209.

Survey Statistics



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List of Acronyms Used Within This Report

Acronym	Full Name
AML	AML Oceanographic
CUBE	Combined Uncertainty and Bathymetry Estimator
DECC	Department of the Environment, Climate and Communications
DGNSS	Differential Global Navigation Satellite Systems
DPR	Daily Progress Report
FMGT	Fledermaus Geocoder Tool
GIS	Geographic Information System
GNSS	Global Navigation Satellite Systems
GSI	Geological Survey Ireland
HVF	Hips Vessel File
IHO	International Hydrographic Organisation
IMO	International Maritime Organisation
IMU	Inertial Measurement Unit
INFOMAR	INtegrated Mapping FOr the Sustainable Development of Irelands MArine Resource
INSS	Irish National Seabed Survey
ITRF	International Terrestrial Reference Frame 2014 (ITRF2014)
LAT	Lowest Astronomical Tide
MVP	Moving Vessel Profiler
MBES	Multibeam Echo-Sounder
MI	Marine Institute
MGC	Motion Gyro Compass
MRU	Motion Reference Unit
NPWS	National Parks & Wildlife Service
PPE	Personal Protective Equipment
PPS	Pulse per Second
PPP	Precise Point Positioning
QINSy	Quality Integrated Navigation System
RTG	Real Time Gypsy
RV	Research Vessel
SBP	Sub Bottom Profiler
SIS	Seafloor Information System
SVP	Sound Velocity Profiler
TPU	Total Propagated Uncertainty
UKHO	UK Hydrographic Office
UTC	Coordinated Universal Time
VORF	Vertical Offshore Reference Frame
WGS	World Geodetic System

1. Introduction

1.1 Project Overview and Objectives

Geological Survey Ireland (GSI) and Marine Institute (MI) conducted seabed mapping between 2003 and 2005 under the auspices of the Irish National Seabed Survey (INSS) and mapping continued from 2006 to present day under the INtegrated mapping FOr the sustainable development of Irelands MArine Resource (INFOMAR) programme. INSS, which commenced in 1999 under the GSI was one of the largest marine mapping programmes ever undertaken globally, with a focus on deep water mapping. INFOMAR is a joint venture between the GSI and the MI and is funded by the Irish GoverNMent through the Department of the EnviroNMent, Climate and Communications (DECC).

INFOMAR Phase 1, 2006 to 2015 focused on mapping 26 priority bays and 3 priority areas around Ireland and creating a range of integrated mapping products of the physical, chemical and biological features of the seabed in those areas. INFOMAR Phase 2, 2016 to 2026 intends to map the remainder of Ireland's entire seabed. Figure 1 shows the extent of the continental shelf mapped area under INSS and INFOMAR and the outstanding areas as of January 2022. Grey areas have already been mapped and blue coloured areas are unmapped. Coloured hatched areas are designated for mapping in 2022

In 2018, the remaining survey area was split at the 30 nautical mile (NM) limit. The inshore survey fleet, managed by GSI is responsible for mapping inshore of the 30 NM limit and the MI vessels are responsible for mapping the offshore. Survey areas are defined into gridded survey units known as INFOMAR Survey Units (ISUs). ISUs are all 1000 km^2 in size and are uniquely identifiable by a letter on the x-axis and number on the y-axis. Each ISU are coloured in a shade of blue, which indicates the modal water depth within that ISU. Colour scales are used, to denote the three depth bands; 50 to 100m, 100 to 150m and 150m plus.

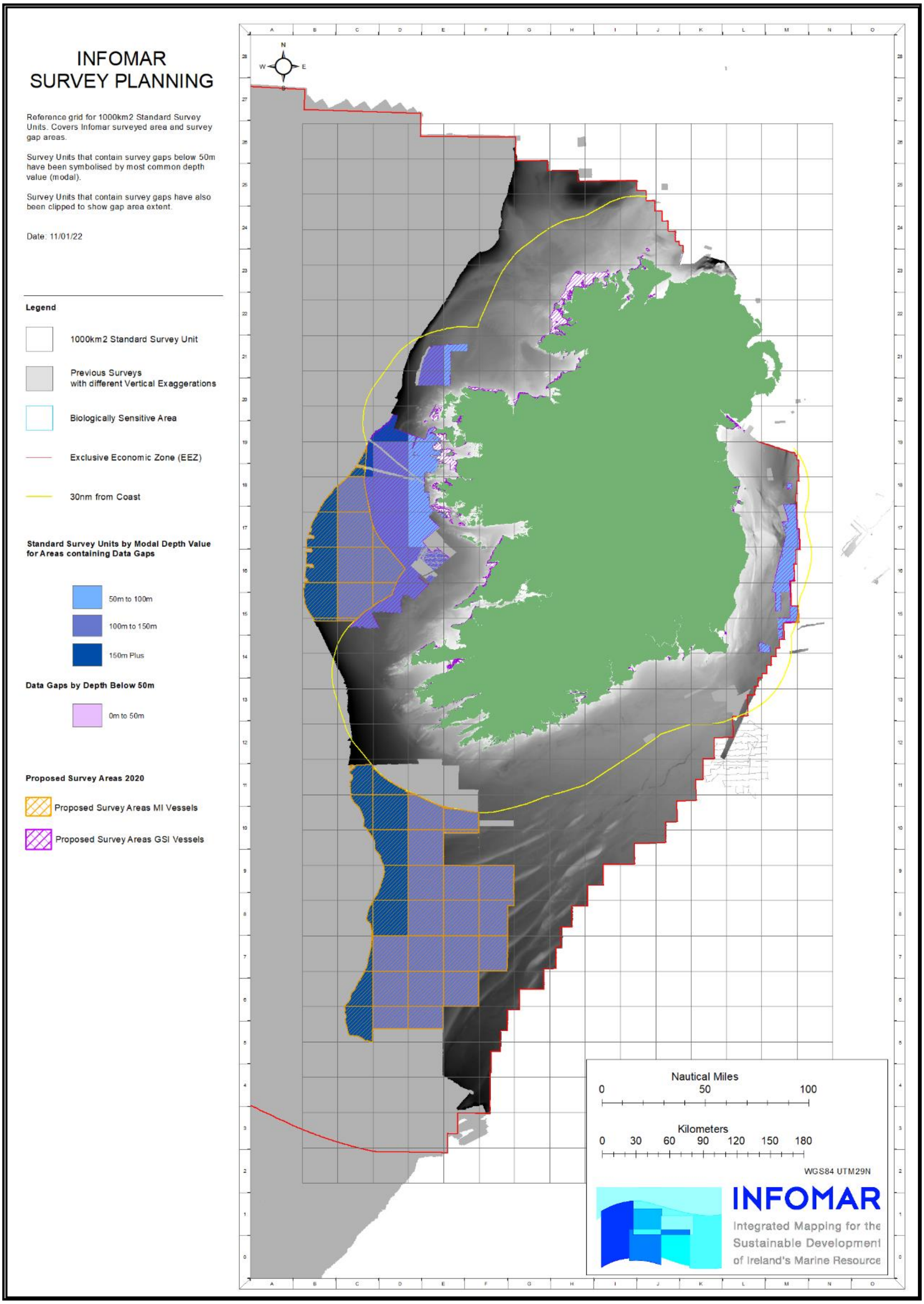


Figure 1: Survey coverage and 2022 designated operations areas.

MI supplied the research vessel RV *Tom Crean* and experienced personnel for the survey.

The scientific aims of the survey were to:
(i) Undertake a Multibeam Echo Sounder (MBES) hydrographic survey to a minimum standard of International Hydrographic Organisation (IHO) Order 1A in water depths less than 100 metres and Order 2 in water depths greater than 100 metres.

(ii) Produce bathymetry, shaded relief and backscatter mosaic products to provide depth, seabed features and seabed hardness/roughness information.

(iii) Acquire Sub Bottom Profiler (SBP) data of the shallow sub-seabed to determine the existence of buried objects and ascertain the sub-seabed character.

(iv) Acquire magnetometer data to investigate the sub-seabed geology and provide information on man-made seafloor debris.

(v) Map in detail and provide hydrographic wreck reports for all encountered wrecks.

1.2 Proposed Survey Area

The 2022 INFOMAR Operations Plan was agreed between MI and GSI at the start of the year, circulated to stakeholders and published online at https://www.infomar.ie.

Figure 2 shows the designated Celtic Sea mapping area, bounded to the north by the 30 NM limit. Predicted survey coverage for the RV *Tom Crean* survey season was 1792 km^2 based on the number of charter days (26) and from analysis of historical survey statistics in this part of the Celtic Sea.

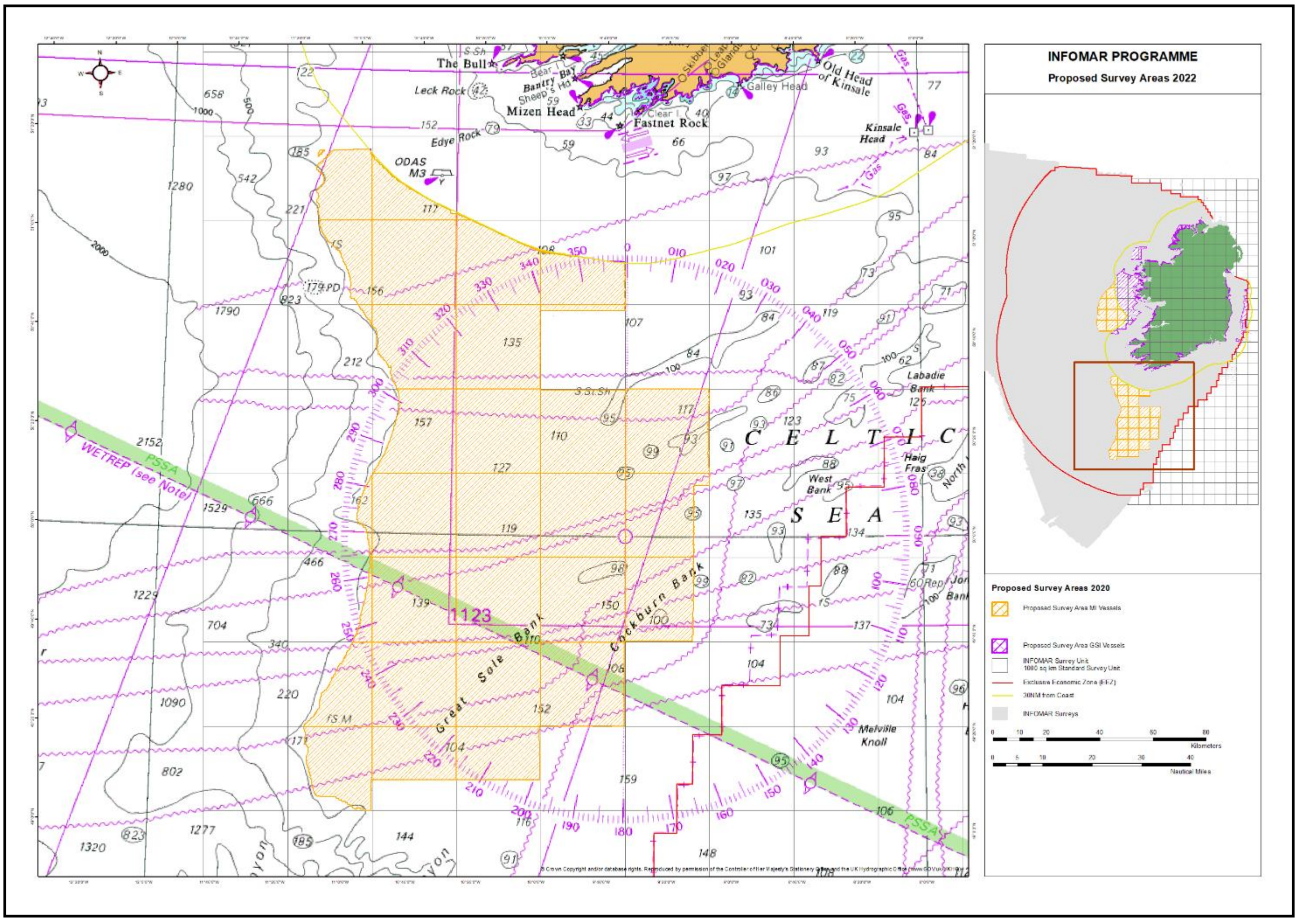


Figure 2: Proposed RV *Tom Crean* 2022 survey area in the Celtic Sea.

2. Operations & Survey Setup

Mobilisation took place in Galway on 12th September. Hydrographic and geophysical survey acquisition too place between 13th and 21st September. Kevin Sheehan of the MI acted as Party Chief. The survey team comprised skilled personnel from the MI and a research student from University College Cork (UCC).

2.1 Survey Track Lines

The final survey track lines image in Figure 3 is produced in ArcGIS software, after export of an initial shapefile from Teledyne Caris HIPS & SIPS™ software. Data acquisition occurred in one contiguous area of the Celtic Sea. Main lines were acquired on East-West reciprocal headings.

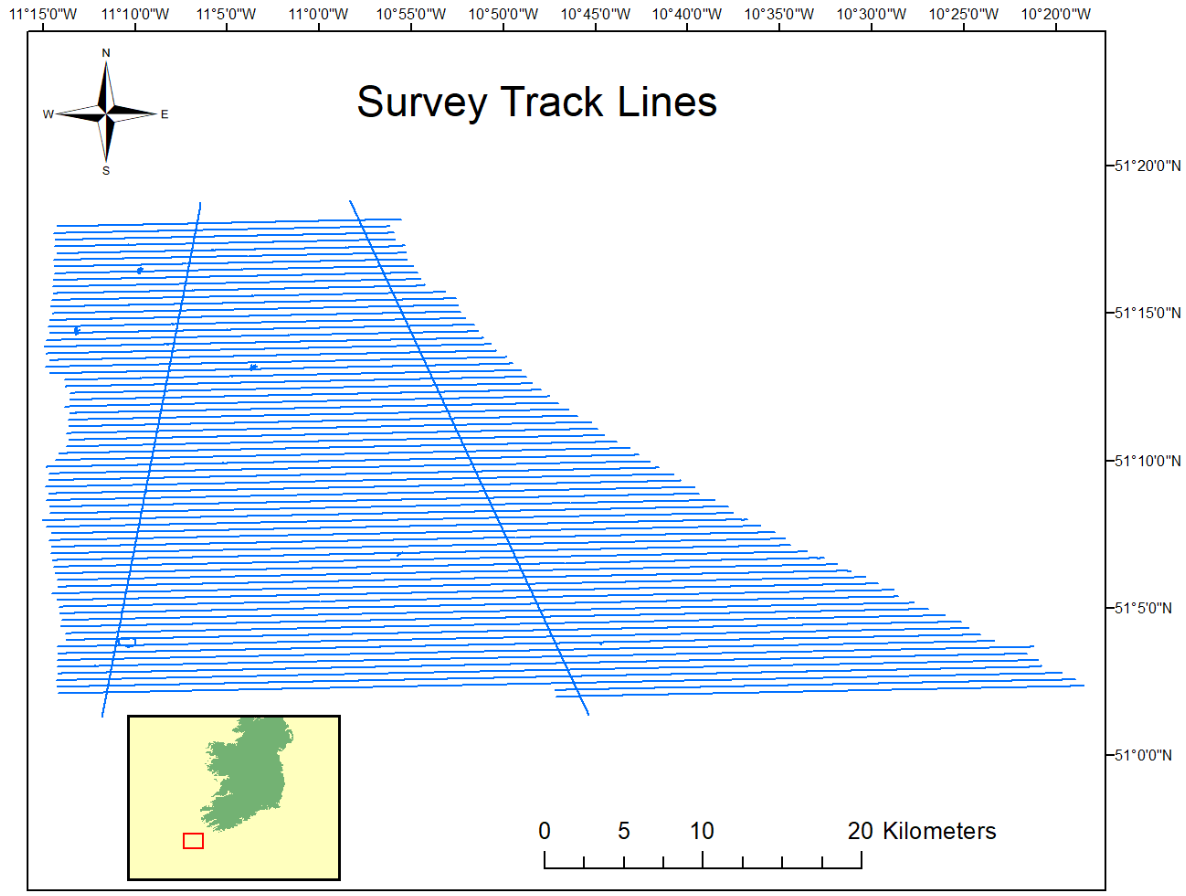


Figure 3: Survey track line plot produced in Caris and ArcGIS software.

2.2 Summary of Events

A summary of the key events is presented in Table 1. Times are in Coordinated Universal Time (UTC). Daily Progress Reports (DPRs) were distributed to management and INFOMAR personnel on a daily basis.

Date and time	Activity
12/09/2022 00:00	Mobilisation Galway Docks
12/09/2022 17:30	Departed Galway. Transit to site 60 km SW of Dursey Island.
13/09/2022 11:10	Commenced Survey Operations
21/09/2022 19:00	Finished Survey Operations and commenced Transit to Cork.
22/09/2022 10:00	Alongside Cork.
22/09/2022 23:59	Demobilisation Complete.

Table 1: Summary of survey events.

2.3 Survey Personnel

Survey personnel, their affiliation and roles are listed in Table 2.

Name	Affiliation	Dates	Role
Kevin Sheehan	MI	12th - 22nd Sept	Party Chief
Fabio Sacchetti	MI	12th - 22nd Sept	Surveyor
Oisin McManus	MI	12th - 22nd Sept	Data Processor
Thomas Furey	MI	12th - 22nd Sept	INFOMAR Rep
Felix Butschek	UCC	12th - 22nd Sept	Surveyor

Table 2: Survey personnel details.

2.4 Health, Safety and Environment

All personnel joining the vessel were given a safety induction tour, which was recorded by the Second Mate. Medical and Personal Sea Survival certifications for all personnel were checked for validity prior to departure. A number of ship policy forms were signed by all personnel. A Muster drill was held within 24 hours of departure from port. Magnetometer and Moving Vessel Profiler (MVP) operations were performed by vessel crew and without incident, with personnel wearing correct Personal Protective Equipment (PPE).

2.5 Marine Mammal Observations

National Parks and Wildlife Service (NPWS) published a *Code of Practice for the Protection of Marine Mammals during Acoustic Seafloor Surveys in Irish Waters* in 2007. An updated document titled “Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters” was published in January 2014. Full details of both documents are published on the NPWS website: https://www.npws.ie/. The code and guidance are applicable to all SBP (pinger or chirp), MBES and sidescan sonar surveys in bays, inlets or estuaries and within 1500 m of the entrance of enclosed bays/inlets/estuaries. All operations were outside of the areas covered under the above guidelines. No Sightings were observed during the survey.

2.6 General Survey Information

A summary of key survey statistics is contained in Table 3.

Total Line Length (km)	2866
Area Covered (km^2)	1177
Operational (%)	75.7
Transit (%)	12.4
Port Call (%)	11.9
Weather Standby (%)	0

Table 3: Key survey statistics.

The pie chart in Figure 4 illustrates the cumulative survey activity statistics taken from the final DPR. Survey data acquisition accounts for approximately 76% of the time.

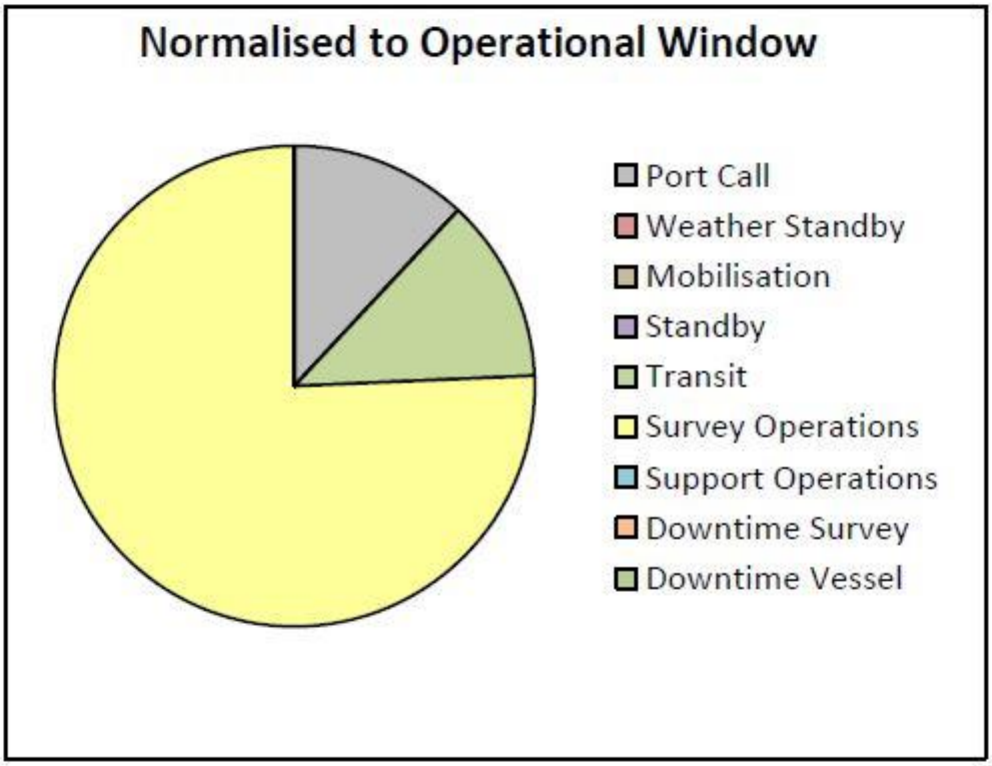


Figure 4: Survey statistics pie chart.

3 Survey Vessel Offsets, Equipment and Data Acquisition

The RV *Tom Crean* (Figure 5) is a multipurpose research vessel owned by MI and managed by P&O Maritime. The vessel has wet, dry and chemical laboratories, which are permanently fitted with standard scientific equipment and can accommodate 13 scientists with a maximum endurance of 21 days. It has a high resolution dual head EM2040D MKII MBES system fitted on a retractable pole, hull-mounted chirp source SBP, two C-NAV Differential Global Navigation Satellite Systems (DGNSS) units as primary navigation and a Seapath 380-R as secondary navigation. The vessel has two Motion Gyro Compasses (MGC) used within the Seapath 380-R as Inertial Measurement Unit (IMU) and as stand-alone International Maritime Organisation (IMO) type approved gyrocompass. All necessary geophysical and DGPS positioning equipment were pre-installed, calibrated and tested prior to commencement of survey activities.

Figure 5: The RV *Tom Crean*.

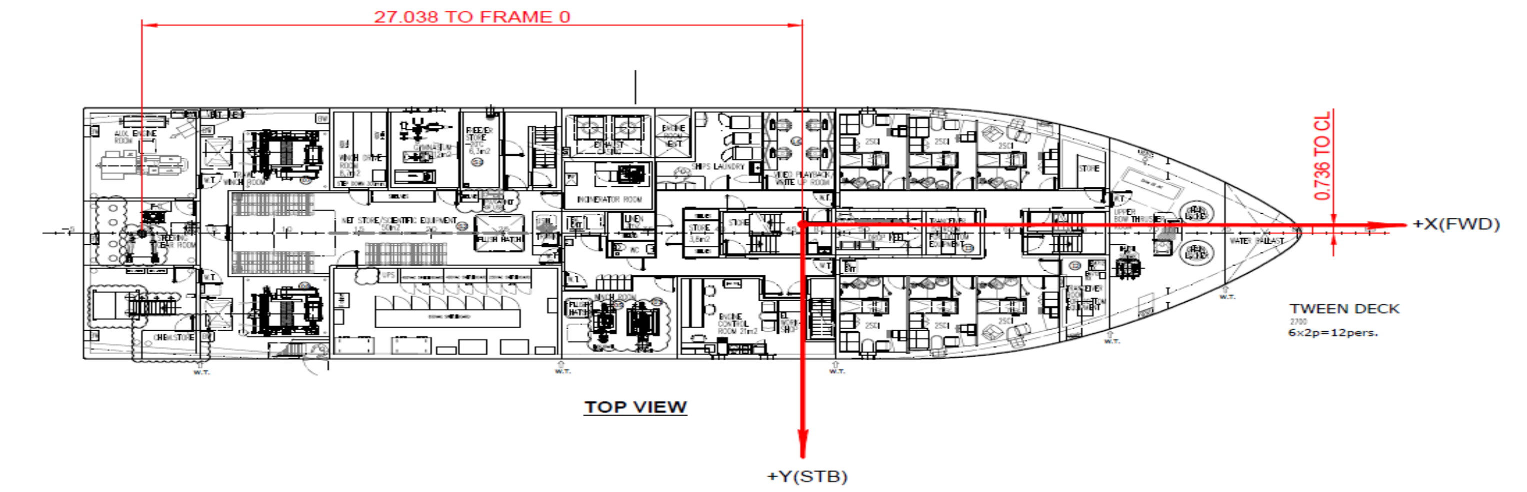
Detailed vessel information is contained in Table 4.

Parameter	Numeric
Length	52.8 m
Beam	14.0 m
Draught	5.2 m
Power Generation	2 x 1350 kw, 1 x 400 kw
Main Propulsion Motor	2000 kw
Speed	10 knots
Max Scientists	13
Crew	12
Endurance	21 Days
Other	DP1 Dynamic Positioning

Table 4: RV *Tom Crean* vessel information.

3.1 Vessel Offsets

Anko Maritime AS performed an offset survey of the RV *Tom Crean* in May 2022 while in dry dock in Vigo, Spain. The coordinate reference system is shown in Figure 6.



NOTES:
- Sketch not to scale
- All coordinates in meters
- All angles in 360 degree system
- Vessel centerline is defined by keeltip aft towards keel tip bow
- Vessel reference plane is defined by 6M draft marks around the vessel
- Positive X-Axis is Forward
- Positive Y-Axis is Starboard
- Positive Z-Axis is Downwards
- CRP, where X=0.000 Y=0.000 Z=0.000 is at MGC R3 accelerometer cross point
- Frame 0 is 27.038 M behind CRP
- CL is 0.736 M starboard of CRP
- Underside keel is 5.232 M below CRP

REV.NO.	REASON FOR ISSUE	DATE	DRAWN	PREPARED	CHECKED	APPROVED
1	FOR USE	25.01.23	KR	AD	AD	RH

ANKO
ANKO MARITIME AS
DIMENSIONAL CONTROL

TITLE:
COORDINATE REFERENCE SYSTEM

CLIENT: P&O Maritime Services Ireland
PROJECT: TOM CREAN
LOCATION: VIGO, SPAIN
DOC. REF.: 2106033
ENCL: 1
REF. DRAWING NO. V129-101-001-F
PAGE: 1

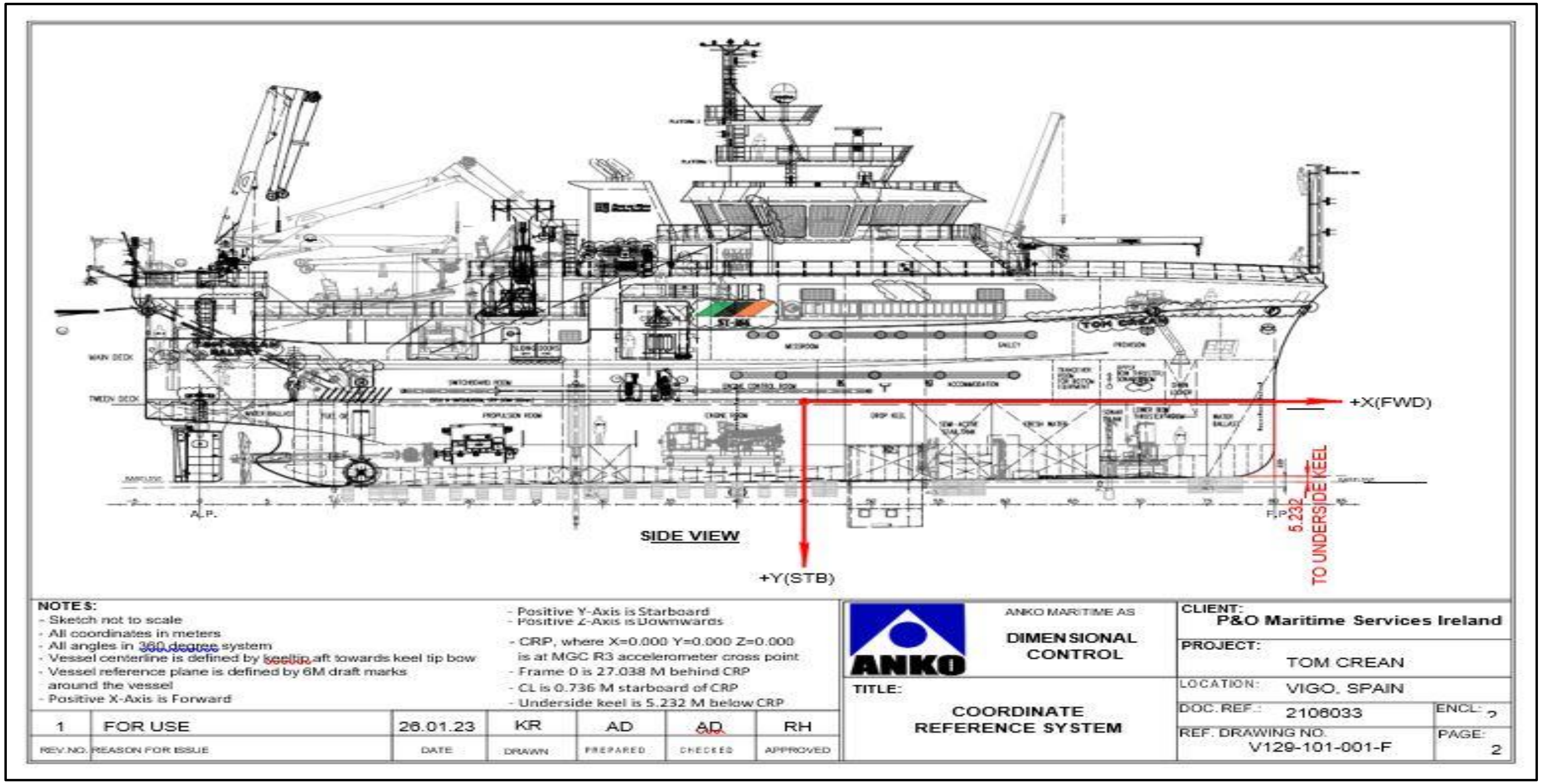


Figure 6: Coordinate Reference System.

Vessel offsets are presented in Table 5 below.

Item	Y (+ Stb)	X (+ Fwd)	Z (+ Down)	Description
MGC R3	0.000	0.000	0.000	Accelerometer Cross Point
MGC R2	0.492	-0.008	0.000	Accelerometer Cross Point
Seapath Aft	0.717	-4.229	-23.313	Geometrical Centre
Seapath Fwd	0.734	-1.729	-23.301	Geometrical Centre
CNAV Port No. 1	-0.144	-3.019	-23.462	Geometrical Centre
CNAV Stb No. 2	1.604	-2.975	-23.458	Geometrical Centre
Wind Sensor Stb	8.415	-0.355	-16.813	Geometrical Centre
Wind Sensor Port	-6.942	-0.396	-16.803	Geometrical Centre
2040 TX	0.728	8.654	6.343	Centre Face
2040 RX STB	1.077	8.776	6.177	Centre Face
2040 RX Port	0.388	8.798	6.177	Centre Face
TX Frame	0.520	3.298	5.131	Centre Face
RX Frame	0.821	3.405	5.128	Centre Face
Test Hole aft	0.249	5.141	5.254	Centre Face
ES38	0.748	4.863	5.259	Centre Face
Empty Hole Drop Keel	0.473	4.612	5.258	Centre Face
ES333	0.432	4.408	5.260	Centre Face
ES120	0.662	4.469	5.259	Centre Face
ES70	0.980	4.471	5.260	Centre Face
ES18	0.746	3.999	5.262	Centre Face
Net Hydrophone port	0.291	3.743	5.230	Centre Face
Net Hydrophone stb	1.207	3.737	5.232	Centre Face
ADCP	0.731	2.669	5.252	Centre Face
Sensor Bow Square	1.015	16.303	5.235	Centre Face
Sensor Bow Round	0.425	16.259	5.236	Centre Face
Hole Bow	0.583	16.495	5.238	Centre Face
Ranger2	0.425	-10.340	8.060	Fully Extended
SU92	2.033	13.471	6.629	Fully extended
SubBottom profiler	1.043	9.707	5.248	Centre Face
SubBottom Sensor 1	0.332	9.502	5.247	Centre Face
SubBottom Sensor 2	0.534	9.503	5.247	Centre Face
SubBottom Sensor 3	0.738	9.501	5.248	Centre Face
SubBottom Sensor 4	0.333	9.707	5.248	Centre Face
SubBottom Sensor 5	0.536	9.709	5.248	Centre Face
SubBottom Sensor 6	0.740	9.707	5.248	Centre Face
SubBottom Sensor 7	0.333	9.907	5.248	Centre Face
SubBottom Sensor 8	0.535	9.908	5.248	Centre Face
SubBottom Sensor 9	0.740	9.910	5.248	Centre Face
TX712	0.737	12.125	5.227	Centre Face
RX712	0.732	10.704	5.231	Centre Face

Draft Sensor Aft/Port	-1.764	-28.520	0.789	Centre Face
Draft Sensor Aft/Stb	3.225	-28.530	0.789	Centre Face
Draft Sensor Fwd/Stb	2.423	17.800	3.333	Centre Face
Draft Sensor Fwd/Port	-0.948	17.798	3.335	Centre Face
A-Frame Pad Eye Stb	2.127	-19.195	-8.195	Centre Hole
A-Frame Pad Eye Mid	0.731	-19.196	-8.191	Centre Hole
A-Frame Pad Eye Port	-0.662	-19.191	-8.189	Centre Hole
T-Bar Pad Eye Aft	6.839	-13.742	-10.997	Centre Hole
T-Bar Pad Eye Mid Aft	6.842	-13.080	-10.981	Centre Hole
T-Bar Pad Eye Mid Fwd	6.850	-11.797	-10.965	Centre Hole
T-Bar Pad Eye Fwd	6.847	-11.148	-10.957	Centre Hole
CTD Derek Pad Eye Aft	6.054	-7.648	-6.053	Centre Hole
CTD Derek Pad Eye Fwd	6.088	-6.452	-5.840	Centre Hole

Table 5: Vessel offsets.

Vessel inclinations are listed in Table 6 below.

Item	Roll	Pitch	Yaw
MGC R3	-0.27	-0.61	0.57
MGC R2	0.72	-0.25	0.35
Seapath	N/A	N/A	0.40
TX 2040	-0.02	-0.37	1.70
RX 2040 STB	-39.96	-1.82	1.68
RX 2040 Port	39.94	1.14	1.98
ES38	-0.17	0.52	0.45
ES333	0.13	0.44	-0.05
ES120	-0.16	0.79	-0.12
ES70	-0.14	0.33	-0.05
ES18	-0.11	0.18	-0.19
ADCP	-0.07	1.07	1.66
Ranger2	0.06	-0.69	-0.08
SU92	-0.10	-0.96	289.06

Table 6: Vessel inclinations.

3.1.1 Multibeam Patch Test

Offsets calculated during a patch test on the 22nd of July 2022 were utilised on this survey. Figure 7 shows the angular offsets after the patch test.

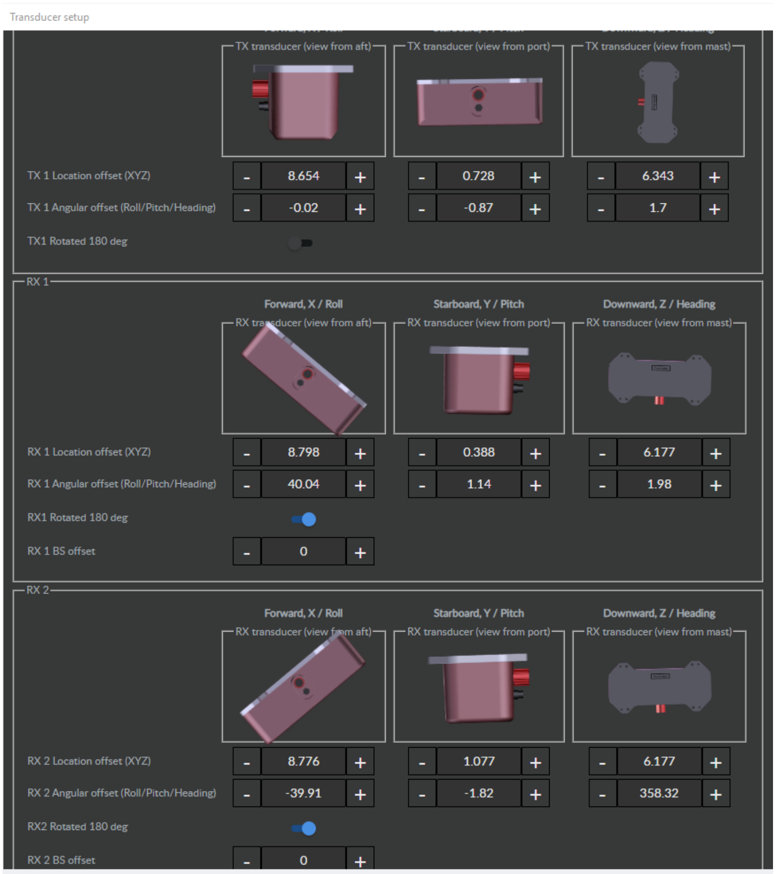


Figure 7: Angular offsets in SIS after patch test.

3.2 Survey Equipment

Table 7 contains information on the survey equipment both permanently installed and available for mobilisation on board the RV *Tom Crean*.

System	Type	Comment
Multibeam Echo-Sounder	Kongsberg EM2040D MKII	200, 300 & 400 kHz
Sub-Bottom Profiler	Knudsen Chirp 3260	3.5 and 12 kHz
Sidescan Sonar	Edgetech 4200	100 and 500 kHz
Positioning	C-Nav DGNSS (two units)	Seapath 380-R secondary
Motion Gyro Compass	Seapath 380-R	2nd MGC as backup
USBL	Sonardyne Ranger 2	
Sound Velocity Profiler	Valeport SVP Mini	Valeport Midas as backup
Moving Velocity Profiler	AML MVP30-350	Sound Velocity
Realtime Sound Velocity	Valeport or AML	Sound Velocity
Magnetometers	SEASPY	Overhauser Effect

Table 7: RV *Tom Crean* available survey equipment.

3.2.1 Technical Issues

SIS Survey Grid

Survey grid stopped building every couple of hours due to a memory issue. Kongsberg sent a patch to and this resolved the issue once installed.

SIS Geotiff Projections

Background geotiffs used for planning purposes were not importing into the correct location. A SIS update is required post survey in order to solve this issue.

SIS Crashes

“Bottom Depths not found” error appeared twice during the survey. Several Numerical display indicators stopped updating after acknowledging the error, necessitating a SIS restart on both occasions. No data were lost although minor time was lost while turning the vessel to reshoot the relevant sections.

Chirp Heave

The heave feed was rewired so that the Chirp receives a dedicated heave correction for its own lever arms. This resolved the residual heave issues.

MVP

The MVP stopped recovering during casts on several occasions. The software operator had to hit “Recover” each time in order to recover the probe to its normal towing location.

Deck crew were required to reset the winch several times during the survey as the cable stopped recovering and attempts at software recoveries did not work. The delay time in the software, where the cable is changing from paying out to recovering was switched from 1 to 2 seconds and this appeared to resolve the issue.

3.3 Data Acquisition

3.3.1 Geodetic Parameters

Table 8 contains the geodetic parameters used.

Local Datum Geodetic Parameters	
Datum	ITRF2014
Spheroid	World Geodetic System 1984 (WGS-84)
Semi-Major Axis (a)	6378137.000 m
Semi-Minor Axis (b)	6356752.314 m
First Eccentricity Squared (e^2)	0.0066943800
Inverse Flattening (1/f)	298.257223563
Projection Parameters	

Grid Projection	Universal Transverse Mercator
Central Meridian Zone 29 (CM)	009º West
Origin Latitude (False Lat.)	00.0°
Hemisphere	North
False Easting (FE)	500000.0 m
False Northing (FN)	0.0 m
Scale Factor on CM	0.999600
Units	M

Table 8: Geodetic parameters.

3.3.2 Survey Datum, GNSS Tides and VORF Model

Table 8 above provides details of the vertical and horizontal datum applied during operations. Global Navigation Satellite Systems (GNSS) tides do not require to account for vessel draft or vessel squat values, as recorded depths are related directly to the Word Geodetic System (WGS) 84 Ellipsoid. These values were reduced to Lowest Astronomical Tide (LAT) using GNSS tidal measurements and by then applying the Vertical Offshore Reference Frame (VORF) model (Lowest Astronomical Tide (LAT)/WGS84 separation) as illustrated in Figure 8 below.

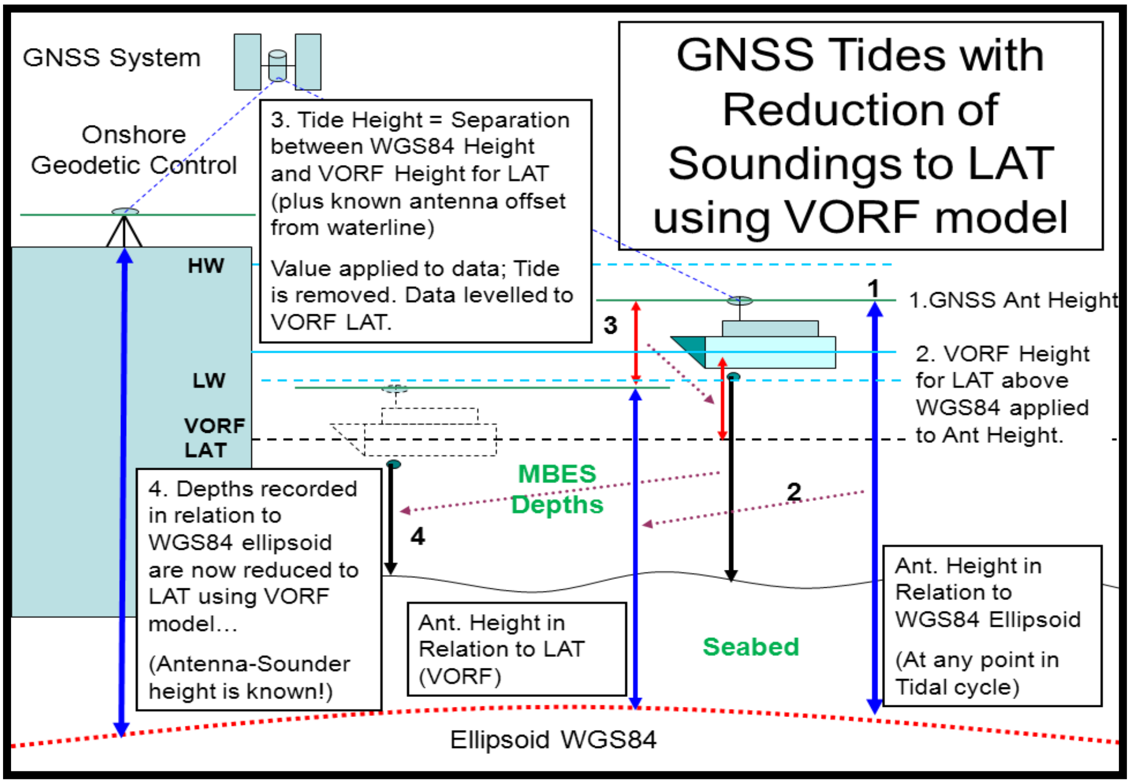


Figure 8: GNSS tides to LAT using VORF model.

3.3.3 Vessel Draft

A constant value of 0.35 was entered for the waterline in the installation parameters in SIS. This value was calculated from the dimensional survey during dry dock.

3.3.4 Acoustic Systems

A Kongsberg EM2040 MKII high resolution MBES mounted on a retractable pole was used for swath acoustic acquisition. First bottom returns from the MBES produce highly accurate bathymetric data. Additionally, backscatter acquired by MBES sonars contains important information about the seafloor and its physical properties. Backscatter provides valuable data to aid in seafloor classification and important auxiliary information for a bathymetric survey.

The configuration consists of dual RX transducers and a single TX transducer 1.5º beamwidth each when operating at 200 kHz frequency and 0.7º beamwidth each when operating at 400 kHz. The system operates at frequency ranges of 200, 300 or 400 kHz with 800 soundings per ping and allows coverage of up to 10 times water depth on a flat bottom. It has a maximum ping rate of 50 Hz. The 200 kHz frequency was used for this survey. Primary positioning was provided by C-Nav 5000 DGNSS. Seapath 380-R provided secondary positioning. Kongsberg Motion Gyro Compass (MGC) R3 provided real time heading, heave, pitch, roll and velocity to the MBES system.

MBES data was recorded in *.kmall format using Kongsberg's Seafloor Information Software. Raw files were continuously backed up on the vessel server at EOL. Table 9 contains MBES metadata.

Descriptor	**Metadata**
Survey lines	Mainlines, Crosslines and Wrecks
Data Files	239
Date Created	13-09-2022 to 21-09-2022
Dataset Size	131.3 GB
File Formats	.kmall

Table 9: MBES metadata.

United Kingdom Hydrographic Office (UKHO) guidelines were implemented when carrying out wreck investigations. Three survey lines along the wreck's primary axis with high overlap and one or more lines across its secondary axis to ensure full wreck coverage along both axes were acquired. Water column data logging functionality in SIS was used throughout the investigation. Beam angles, survey speed, operational frequency and pulse length were configured for maximum resolution. Wrecks were reported to the UKHO using the standard UKHO "H-Forms". A total of six wrecks were surveyed in detail.

A Knudsen hull-mounted chirp source SBP operating at 3.5 kHz was used for sub-bottom profiler data acquisition. The range and phase settings were varied appropriately with water depth to maximise ping rate and resolution. The chirp source is most effective in high resolution investigations of the top 20 or 30 m sub-seabed and where sediments are fine and medium grained. The signal does not penetrate bedrock. The Chirp 3260 is a blackbox system that interfaces to a standard PC via a USB connection. SounderSuite Windows application software controls data acquisition. Raw data were recorded in native Knudsen format along with industry standard SEGY data. Positioning and MRU data were fed directly from the Seapath 380-R. QC was maintained by the online surveyors, with reference to the digital display; with power, range, gains, filter parameters and transmit pulse adjusted as required for optimal imaging. All data were backed up to the vessel server. Table 10 contains SBP metadata.

Descriptor	Metadata
Survey lines	All
Data Files	444
Date Created	14-09-2022 to 21-09-2022
Dataset Size	18.1 GB
File Formats	.kea, .keb & .sgy

Table 10: SBP metadata.

3.3.5 Magnetometer

A Marine Magnetics Corporation SeaSPY towed Overhauser Magnetometer was used to acquire magnetic field data. The system comprises a towfish, tow cable, deck lead and transceiver interfaced to a standard Windows based PC. Acquisition parameters and QC were controlled via Marine Magnetics BOB™ software.

The magnetometer was towed 100 m behind the vessel at a depth of less than 5 m beneath sea surface. Magnetometer data from the towfish and GPS data from Seapath were input to the control PC via separate serial ports and synchronised. Initial QC was performed via real-time graphing of the magnetic field trace and by monitoring real-time GPS data. Magnetometer data were recorded in a database using BOB and output in proprietary BOB format as a .mms file. The data were also output in text format. Metadata is contained in Table 11.

Descriptor	Metadata
Survey lines	NA
Data Files	2
Date Created	14-09-2022 to 21-09-2022
Dataset Size	742 MB

File Formats	.mms, .txt

Table 11: Magnetometer metadata.

3.3.6 DGPS Systems

C-Nav DGNSS provided the primary navigation. The C-Nav 5000 is a dynamic DGNSS Precise Point Positioning (PPP) system providing accuracy of 5 cm horizontally and 8 cm vertically. It provides 252 channel tracking, including multi-constellation support for GPS and GLONASS. C-Nav provided the primary navigation feed for the MBES and SBP. C-Nav also provided a reliable GPS tide correction.

C-Nav has a range of QC output displays that were monitored in real-time including number of satellites in use, satellite attitude and angles, vertical accuracy, vessel speed, heading and precise position. GPS signal was always very good and the system never lost the Real Time Gypsy (RTG) solution. Navigation data were recorded in *.cnav5000 format using C-Nav software. One file per day was created.

Seapath 380-R provided the secondary navigation for the MBES and primary navigation for the magnetometer. Seapath and C-Nav data were monitored continuously in Quality Integrated Navigation System (QINSy) software to ensure data integrity and comparison between the primary and secondary navigation systems remained within tolerance. DGPS metadata information is contained in Table 12.

Descriptor	Metadata
Survey lines	All
Data Files	10
Date Created	13-09-2022 to 22-09-2022
Dataset Size	0.84 GB
File Formats	.cnav5000

Table 12: CNAV metadata.

3.3.7 Online Navigation

QINSy software was used for navigation acquisition and QC. QINSy performs visual and QA data-feeds from the key acquisition systems. A project template database was created containing all survey configuration parameters relevant to the project. The project template contains the datum, projections, vessel shape, administrative information, as well as vessel offsets and I/O parameters. QINSy uses a sophisticated timing routine based on the Pulse Per Second (PPS) option from the GNSS receiver. All incoming and outgoing data are accurately stamped with a UTC time label. Survey line positioning and MVP location data were recorded in QINSy software in .db and .txt format. QINSy file metadata is provided in Table 13.

Descriptor	Metadata
Survey lines	All
Data Files	296
Date Created	12-09-2022 to 22-09-2022
Dataset Size	63.2 GB
File Formats	Various

Table 13: QINSy navigation metadata.

3.3.8 Sound Velocity

An AML Oceanographic MVP 30-350 was the primary instrument for acquiring sound velocity profile data and a Valeport Mini Sound Velocity Profiler (SVP) instrument was used as backup. Both instruments are equipped with sound velocity sensors that directly measure sound velocity. The dual benefit of the MVP is uninterrupted survey and greater frequency of casts. Fresh sound profiles were input to the MBES as required. A Valeport SVS sensor provided real-time sound velocity data at the MBES transducers.

MVP deployment was controlled from the vessel Dry Lab using Rolls Royce MVP software. The probe was continually towed in the water at between 2 and 6 metres depth and deployed to a maximum of c. 80 metres depth during casts. Sound velocity profiles in *.asvp format were sent to SIS where they were checked and extended for import into the MBES. Metadata is contained in Table 14.

Descriptor	Metadata
Survey lines	NA
Data Files	76
Date Created	13-09-2022 to 21-09-2022
Dataset Size	1.08 MB
File Formats	.asvp,

Table 14: Sound velocity metadata.

4 Online QC, Data Processing, Results and Interpretation

The hydrographic survey was performed to IHO survey standards. Rigorous standards for position, depth accuracy, feature search, feature detection and bathymetric coverage were achieved during data acquisition and processing. IHO Order 1a and Order 2 requirements are presented in Table 15.

	Order 1a (S-44)	**Order 2 (S-44)**
Description of Areas	Areas where underkeel clearance is considered not to be critical but features of concern to shipping may exist.	Areas generally where a general description of the sea floor is considered adequate.
Max THU allowable (95%C)	Total Horizontal Uncertainty (THU) 5m+5% of depth	Total Horizontal Uncertainty (THU) 20 m+10% of depth
Max TVU allowable (95%C)	Total Vertical Uncertainty (TVU) a = 0.5 metre b = 0.013 $\pm\sqrt{a^2+(bxd)^2}$	Total Vertical Uncertainty (TVU) a = 1.0 metre b = 0.023 $\pm\sqrt{a^2+(bxd)^2}$
Feature Search	100%	Recommended but not required
Feature Detection	Cubic Features > 2m (Depths < 40m) 10% depth > 40m	Not specified
Bathymetric Coverage	≤100%	5%

Table 15: IHO standards for hydrographic surveys

4.1 MBES Online Quality Control

4.1.1 Acquisition Parameters

Most of the important acquisition parameters are set in the Runtime module of SIS. Figure 9 shows the Runtime settings used. Max angle and max coverage parameters were maintained constant as depth, sea state, sound velocity conditions and seafloor character differences were within a low range. Pulse type was set to FM. Frequency was set to 200 kHz, which maintained good signal to noise ratio.

Max coverage, sector mode, detector mode, vessel speed and frequency were adjusted to attain maximum resolution for wreck inspections. Water Column data were acquired for all survey lines.

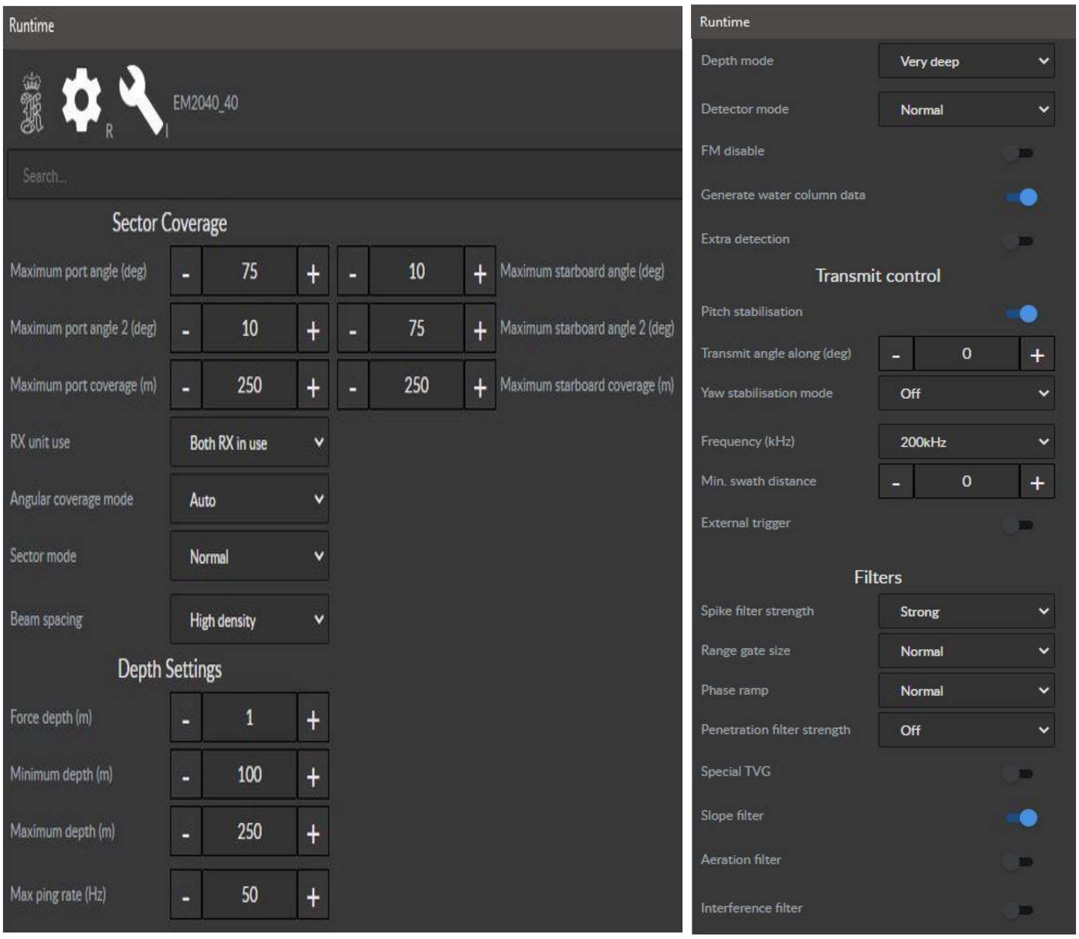


Figure 9: Runtime parameters window in SIS.

4.1.2 Cross Line Versus Main Line Statistics

Crossline data were acquired for QC of depth soundings. A total of two cross lines were acquired for statistical analysis in Caris Hips^{TM}. Cross line data were compared with main line data. All cross line data indicated that the soundings exceeded the 95% certainty required for Order 1a specification. Results from the statistical analyses are presented in Tables 16 and 17, where the 800 beams have been divided into subsets of 20.

Beam Number	Count	Max (+)	Min (-)	Mean	Std Dev	Special Order (%)	Order 1a (%)	Order 2 (%)
1-21	305,186	0.933	1.359	-0.015	0.228	100	100	100
21 - 41	305,585	0.88	0.948	0.014	0.203	100	100	100
41 - 61	305,602	0.97	1.034	0.043	0.184	100	100	100
61 - 81	305,819	1.132	0.759	0.059	0.171	100	100	100
81 - 101	306,210	0.907	0.89	0.057	0.168	100	100	100
101 - 121	306,281	0.92	0.819	0.051	0.168	100	100	100
121 - 141	306,432	0.864	0.755	0.054	0.157	100	100	100
141 - 161	306,716	0.785	0.86	0.058	0.147	100	100	100
161 - 181	306,725	0.947	0.722	0.055	0.144	100	100	100
181 - 201	306,779	0.826	0.786	0.045	0.142	100	100	100
201 - 221	306,719	0.791	0.866	0.047	0.138	100	100	100
221 - 241	306,760	0.896	0.8	0.047	0.136	100	100	100
241 - 261	306,761	0.873	0.744	0.046	0.136	100	100	100
261 - 281	306,765	0.826	0.708	0.041	0.135	100	100	100
281 - 301	306,751	0.875	0.832	0.041	0.137	100	100	100
301 - 321	306,660	0.982	0.848	0.04	0.14	100	100	100
321 - 341	306,045	1.222	1.012	0.045	0.169	100	100	100
341 - 361	304,872	1.36	0.837	0.053	0.158	100	100	100
361 - 381	305,985	1.08	0.98	0.05	0.168	100	100	100
381 - 401	306,655	0.92	0.864	0.028	0.143	100	100	100
401 - 421	300,069	0.748	0.767	0.04	0.138	100	100	100
421 - 441	299,688	1.064	1.123	0.047	0.164	100	100	100
441 - 461	297,772	1.267	0.873	0.056	0.16	100	100	100
461 - 481	296,681	1.239	0.911	0.063	0.176	100	100	100
481 - 501	299,110	1.177	1.047	0.05	0.146	100	100	100
501 - 521	299,947	0.856	0.763	0.048	0.14	100	100	100
521 - 541	299,929	0.92	0.732	0.05	0.142	100	100	100
541 - 561	300,031	0.847	0.713	0.057	0.144	100	100	100
561 - 581	300,043	0.916	0.736	0.063	0.147	100	100	100
581 - 601	300,066	0.943	0.791	0.053	0.15	100	100	100
601 - 621	300,044	0.951	0.741	0.052	0.157	100	100	100
621 - 641	300,056	1.057	0.834	0.032	0.161	100	100	100
641 - 661	299,999	0.931	0.916	0.01	0.164	100	100	100
661 - 681	299,870	1.091	0.99	0.012	0.175	100	100	100
681 - 701	299,652	1.066	0.859	0.036	0.201	100	100	100
701 - 721	299,728	1.028	1.033	-0.026	0.194	100	100	100
721 - 741	299,755	1.025	0.953	-0.019	0.191	100	100	100
741 - 761	299,644	1.076	1.074	-0.036	0.199	100	100	100
761 - 781	299,601	0.869	1.161	-0.026	0.213	100	100	100
781 - 800	284,197	1.141	1.195	-0.02	0.233	100	100	100

Table 16: Combined MBES statistics for cross lines 204, 205, 206, 207 and 208.

Beam Number	Count	Max (+)	Min (-)	Mean	Std Dev	Special Order (%)	Order 1a (%)	Order 2 (%)
01-21	273,437	1.267	1.263	0.0	0.3	100	100	100
21 - 41	274,869	1.174	1.203	0.1	0.3	100	100	100
41 - 61	275,233	1.122	1.085	0.1	0.2	100	100	100
61 - 81	275,242	1.01	0.992	0.1	0.2	100	100	100
81 - 101	275,197	1	0.845	0.1	0.2	100	100	100
101 - 121	274,943	0.982	0.773	0.1	0.2	100	100	100
121 - 141	275,030	0.886	0.747	0.1	0.2	100	100	100
141 - 161	275,245	0.812	0.736	0.1	0.2	100	100	100
161 - 181	275,213	0.765	0.71	0.1	0.2	100	100	100
181 - 201	275,282	0.736	0.638	0.1	0.2	100	100	100
201 - 221	275,325	0.673	0.608	0.1	0.2	100	100	100
221 - 241	275,381	0.718	0.578	0.1	0.2	100	100	100
241 - 261	275,370	0.717	0.626	0.0	0.2	100	100	100
261 - 281	275,418	0.95	0.669	0.0	0.2	100	100	100
281 - 301	275,366	0.778	0.763	0.0	0.2	100	100	100
301 - 321	274,586	0.921	0.96	0.0	0.2	100	100	100
321 - 341	266,291	0.757	0.697	0.0	0.2	100	100	100
341 - 361	264,328	0.831	1.044	0.1	0.2	100	100	100
361 - 381	267,754	0.933	1.007	0.0	0.2	100	100	100
381 - 401	274,954	0.845	0.811	0.0	0.2	100	100	100
401 - 421	271,522	0.691	0.649	0.0	0.2	100	100	100
421 - 441	264,762	0.7	0.708	0.0	0.2	100	100	100
441 - 461	258,613	0.802	1.005	0.1	0.2	100	100	100
461 - 481	257,011	0.747	1.049	0.1	0.2	100	100	100
481 - 501	268,515	0.713	0.723	0.0	0.2	100	100	100
501 - 521	271,465	0.691	0.904	0.1	0.2	100	100	100
521 - 541	271,629	0.743	0.9	0.1	0.2	100	100	100
541 - 561	271,554	0.7	0.72	0.1	0.2	100	100	100
561 - 581	271,544	0.765	0.669	0.1	0.2	100	100	100
581 - 601	271,490	0.777	0.851	0.1	0.2	100	100	100
601 - 621	271,204	0.789	0.86	0.1	0.2	100	100	100
621 - 641	271,118	0.825	0.788	0.0	0.2	100	100	100
641 - 661	271,062	0.764	0.88	0.0	0.2	100	100	100
661 - 681	270,177	0.821	0.959	0.0	0.2	100	100	100
681 - 701	266,746	0.973	1.006	0.1	0.2	100	100	100
701 - 721	268,244	0.951	1.01	0.0	0.2	100	100	100
721 - 741	270,888	0.976	1.068	0.0	0.2	100	100	100
741 - 761	271,427	1.123	1.116	0.0	0.2	100	100	100
761 - 781	271,387	1.075	1.266	0.0	0.3	100	100	100
781 - 800	257,056	1.229	1.413	0.0	0.3	100	100	100

Table 17: Combined MBES statistics for cross lines 209, 210, 211 and 212.

4.1.3 Feature Detection

The minimum standard for feature detection for an Order 1a survey are cubic features > 2 metres in depths up to 40 metres and cubic features >10% of depth beyond 40 metres. In 40 metres water depth 9 soundings are required in a 2 m^2 bin and in 100 metres water depth 9 soundings are required in a 10 m^2 bin. Feature detection criteria are not specified in the IHO standards for Order 2 surveys. A data density traffic light plot and associated statistics were produced for the area.

Water depths range from 137 to 201 m. The data were analysed for feature detection assuming a minimum water depth of 100 m, i.e. a more stringent bin size than would be required for the actual minimum depth of 137 m. The minimum sized cubic features that require detection are 10 m, i.e. 10% of the 100 m theoretical minimum water depth. A minimum of 9 soundings per 10 m^2 bins are required in order to attain the feature detection criteria. A bin size of 10 m^2 was selected to QC the data density and the results are shown in Figure 10. Green indicates where 9 soundings per bin were achieved, i.e. almost everywhere, and red where the 9 soundings were not attained. Red areas are sporadic and limited to the outer fringes of coverage where adjacent data from other surveys has not been included in the data density calculations.

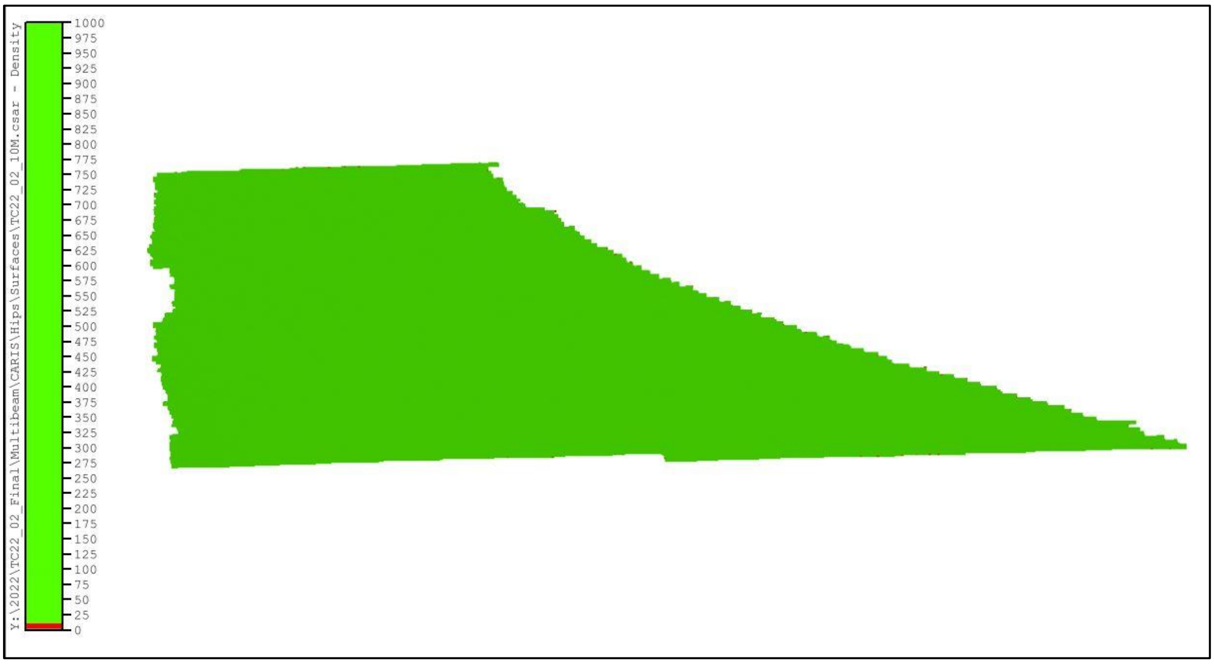


Figure 10: Sounding density traffic light plot.

Number of sounding per bin varied from 1 to 3305 with a mean of 184 soundings. The mean number of soundings per bin easily exceeded the 9 soundings required per bin. Full statistics are presented in Figure 11.

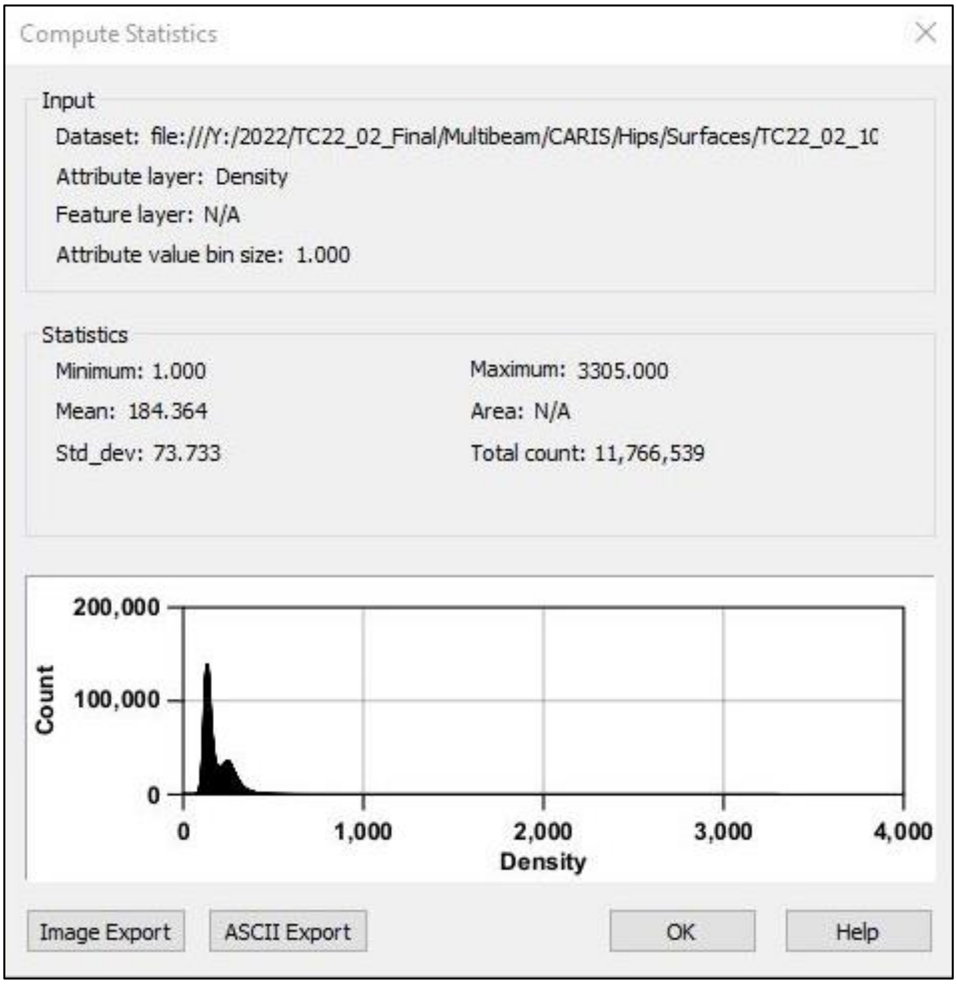


Figure 11: Sounding density statistics.

4.1.4 Error Budget and Uncertainty Model

Manufacturer values for positioning and sounding errors were factored into the vessel error budget. Vessel offsets were established through an onshore dimensional control survey (see section 3.1). In addition; uncertainty levels over positions of soundings were improved through good sound velocity control while surveying. Calibration of the MBES through a standard patch test, combined with good online quality control, ensured that the vessel's error budget fell within IHO 1a specifications.

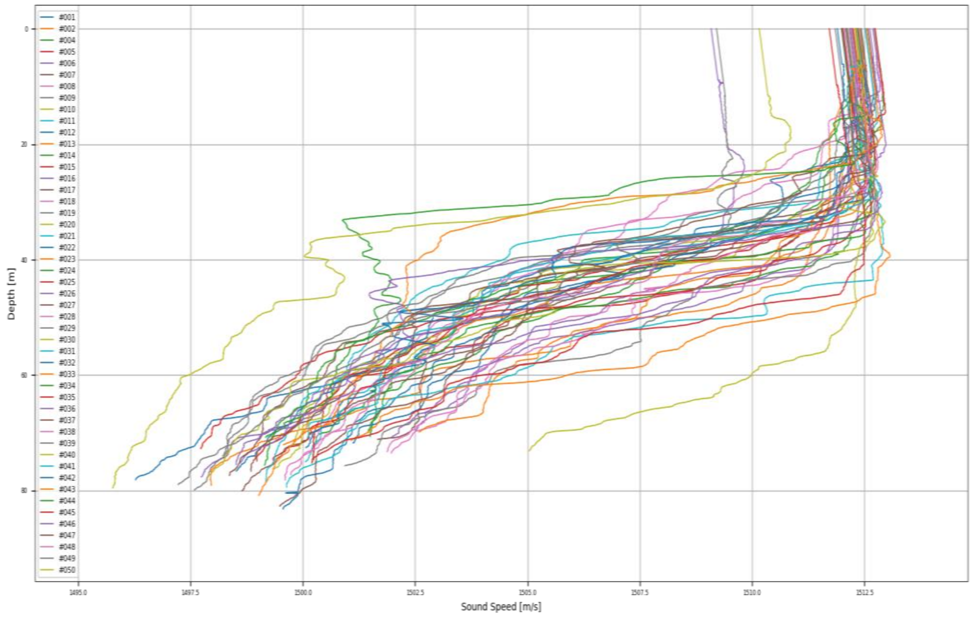
Table 18 below details standard deviation values applied in the calculation of the vessel's Total Propagated Uncertainty (TPU) model. TPU is an estimate of the uncertainty of any individual sounding, taking into account the uncertainty estimates of the component measurements (tide, sound speed, draft, range measurement, angle measurement, attitude, offsets etc). TPU is expressed as a separate value in horizontal and vertical planes. The uncertainty of each sensor was entered in the HIPS Vessel File (HVF) and the TPU calculated.

Heading Accuracy	0.02º
Heave	5 cm or 5 % Amplitude
Roll	0.01º
Pitch	0.01º
Pitch Stabilised	0.01º
Position Navigation	0.1 m
Timing Transducer	0.00 s
Timing Navigation	0.00 s
Timing Gyro	0.00 s
Timing Heave / Pitch / Roll	0.00 / 0.00 / 0.00 s
Sound Velocity Measured	0.1 m/s
Sound Velocity Surface	0.1 m/s
Offsets X / Y /Z	X=0.01 / Y=0.01 / Z=0.01
MRU Alignment	Gyro=0.1 / Pitch=0.1 / Roll=0.1
Vessel Speed	0.1
Vessel Loading	0.00
Vessel Draft	0.00 (Use of GPS tides)
Delta Draft	0.00

Table 18: Standard deviation values used in TPU calculation.

4.1.5 Sound Velocity Control

MBES data processors continuously monitored the effect of sound velocity variations on the processed MBES data and advised on the frequency and geographical distribution of MVP casts based on this analysis. Sound velocity variations were also monitored by QC of the SIS Crosstrack window. Figure 12 shows the MVP composite plots.



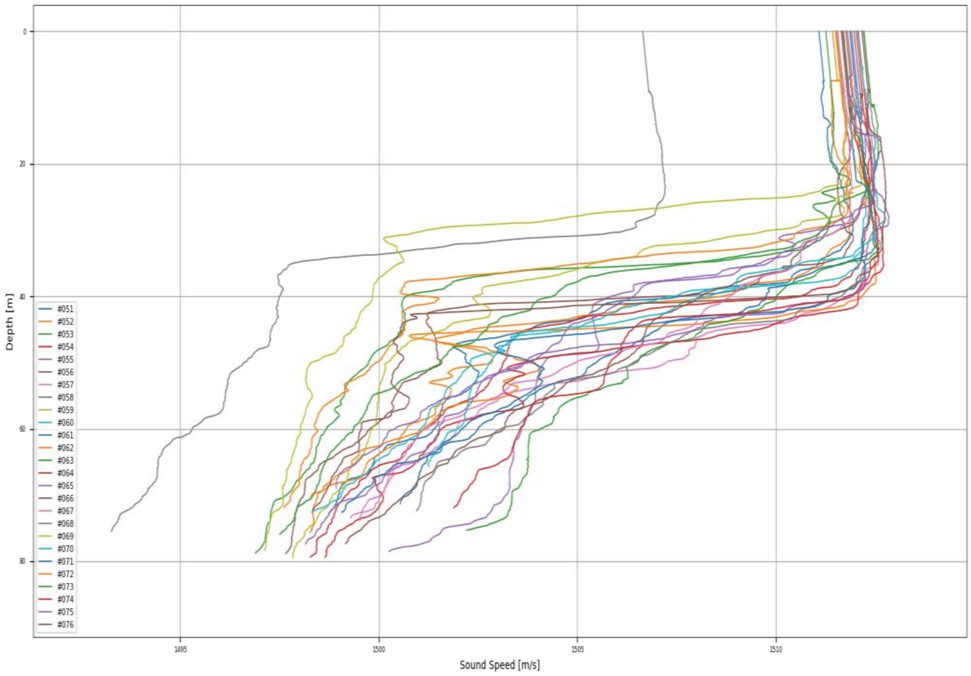


Figure 12: MVP composite plots.

Sound velocity ranges from ~ 1493 m/s to ~ 1513 m/s. The near surface waters down to 25 metres are very well mixed and show near constant velocity on most profiles. There is a thermocline between ~ 25 metres depth down to between 50 and 70 metres where sound velocity rapidly decreases. The weight of the MVP coupled with constraints on shooting and recovery speeds due to the load on the winch and limits within the software meant that the sensor was unable to go deeper than ~ 80 metres.

4.2 Post Processing Methods

4.2.1 Navigation

Navigation data were logged in standard C-Nav format. Real-time positioning data quality from C-Nav was of sufficient quality to exceed IHO Order 1a standard requirements. Vertical errors on the GPS heights were low (+/- 20 cm) and provide a robust solution for computation of GPS tide.

Navigation data and in particular GPS heights were de-spiked and smoothed in Caris HIPS. GPS tide was computed using the separation model between International Terrestrial Reference Frame (ITRF) datum and VORF LAT.

4.2.2 Depth Soundings Data Processing

Soundings were edited in Caris HIPS software against an existing chart background. Combinations of automated and manual processing procedures were applied by experienced data processors to remove systematic errors and obvious outliers. Uncertainty results were examined to ensure soundings fell within IHO specifications for Order 1a and Order 2 surveys. Processed and cleaned data were subject to final validation by an experienced and qualified hydrographer. The following is a simplified list of steps undertaken during sounding data processing:

1. Navigation data were checked and spikes removed.
2. GPS tides were computed using the UKHO's VORF model. This reduced the MBES depth soundings to LAT. GPS tide results were then checked for quality and consistency.
3. TPU values were calculated.
4. SVP data were applied to correct for refraction errors caused by water column heterogeneity. A range of SV algorithms were used to determine the most suitable method of applying SV corrections, for example: nearest in distance versus nearest in time.
5. Subset Editing was performed in CARIS to clean large "noise" spikes from the data. Additional delta draft and refraction corrections where applied in order to correct residual issues.
6. A CARIS Combined Uncertainty and Bathymetry Estimator (CUBE) base surface was created to allow CUBE automatic filtering.
7. Final verification of sounding consistency and absence of spikes was done using subset editing.
8. Bathymetry data were then exported as gridded data at multiple spatial resolutions (*.asc, *.xyz, *.bag, *.Geotiff) and as survey line pointclouds. Ancillary exports included trackline shapefile and XL QC reports.

4.2.3 Backscatter Mosaic Generation

Backscatter is a function of the hardness and roughness of the seafloor. Raw MBES data was put through the Geocoder engine in QPS Fledermaus^{TM} (FMGT) to produce backscatter mosaics at 2 and 5 m resolutions.

4.3 Survey Results and Data Interpretation

A preliminary interpretation of MBES data was used to assess bathymetry, seabed texture and seabed features. SBP data was used to assess the shallow geology.

4.3.1 MBES Images

MBES bathymetry grids and shaded relief geotiff images at both 5 and 10 m respectively were created in Teledyne Caris HIPS & SIPS™ software. Backscatter mosaics were created at 2 and 5 m in QPS FMGT™. Geotiffs, mosaics and grids were imported into ArcGIS™ and images (Figures 13 to 15) output for this report.

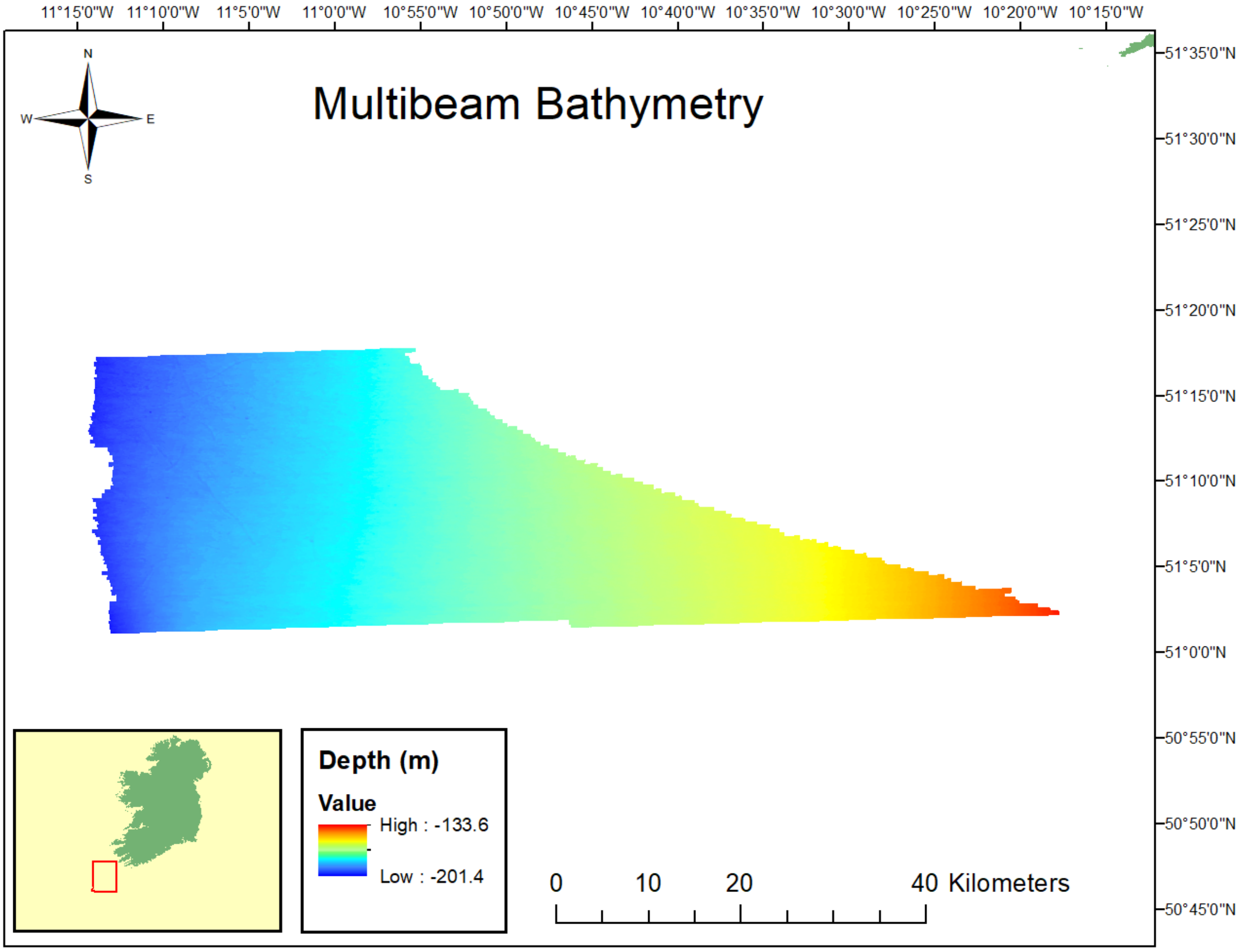


Figure 13: MBES bathymetry.

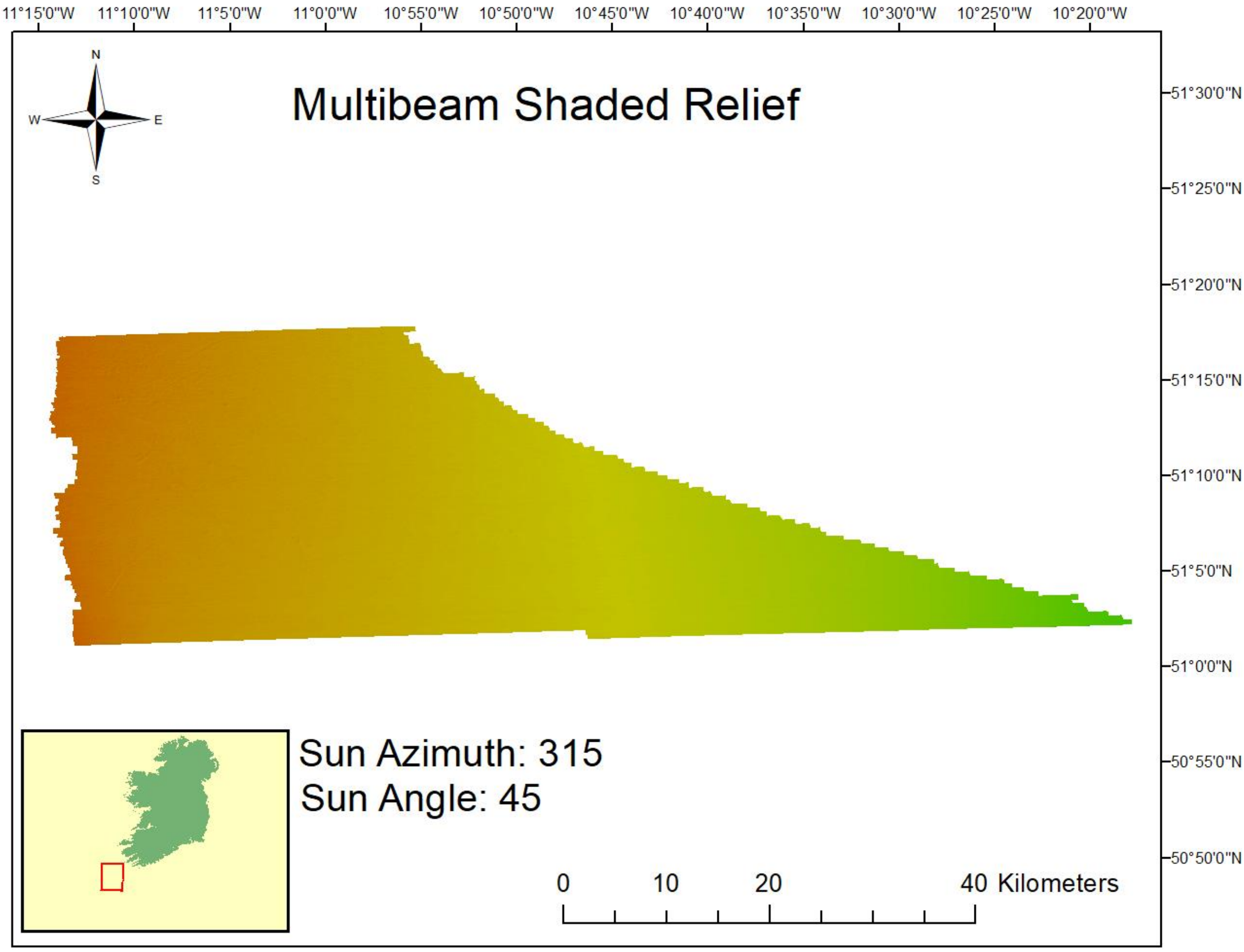


Figure 14: MBES shaded relief.

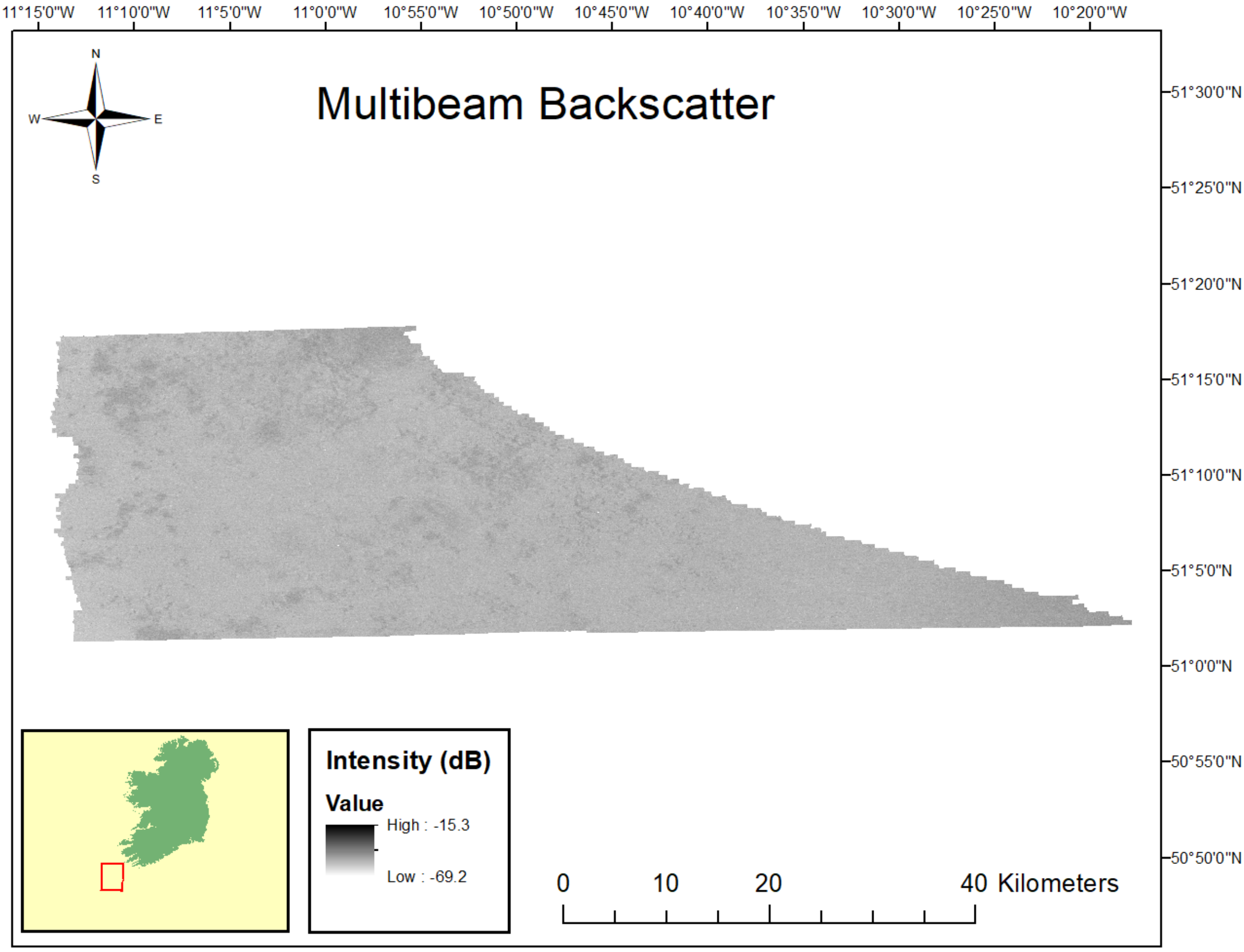


Figure 15: MBES backscatter mosaic.

4.3.2 Shallow Geology Analysis

Chirp SBP data quality and penetration varied due to environmental factors relating to sea state and sub-bottom conditions. There were also issues with the heave compensation, residual heave and navigation on certain profiles. Survey speed (4-9 knots) was dictated by the ability of the MBES to meet its data density and data quality requirements. This is usually faster than the optimal maximum speed of 4 knots for high quality SBP data acquisition. Sea state varied significantly during the survey. Taking all of the above into account the overall data quality was poor.

Knudsen SounderSuite™ software recorded sub-bottom data in proprietary Knudsen kea and keb formats and sgy format. SGY data were converted to coda format using Coda File Utilities™ software. These Coda format files were replayed in Coda GeoSurvey™ software, where TVG and bandpass filtering were applied and tiff images created. Cross line profiles 204 and 209 are selected for discussion here. Their geographical locations are shown in the track line plot in Figure 16.

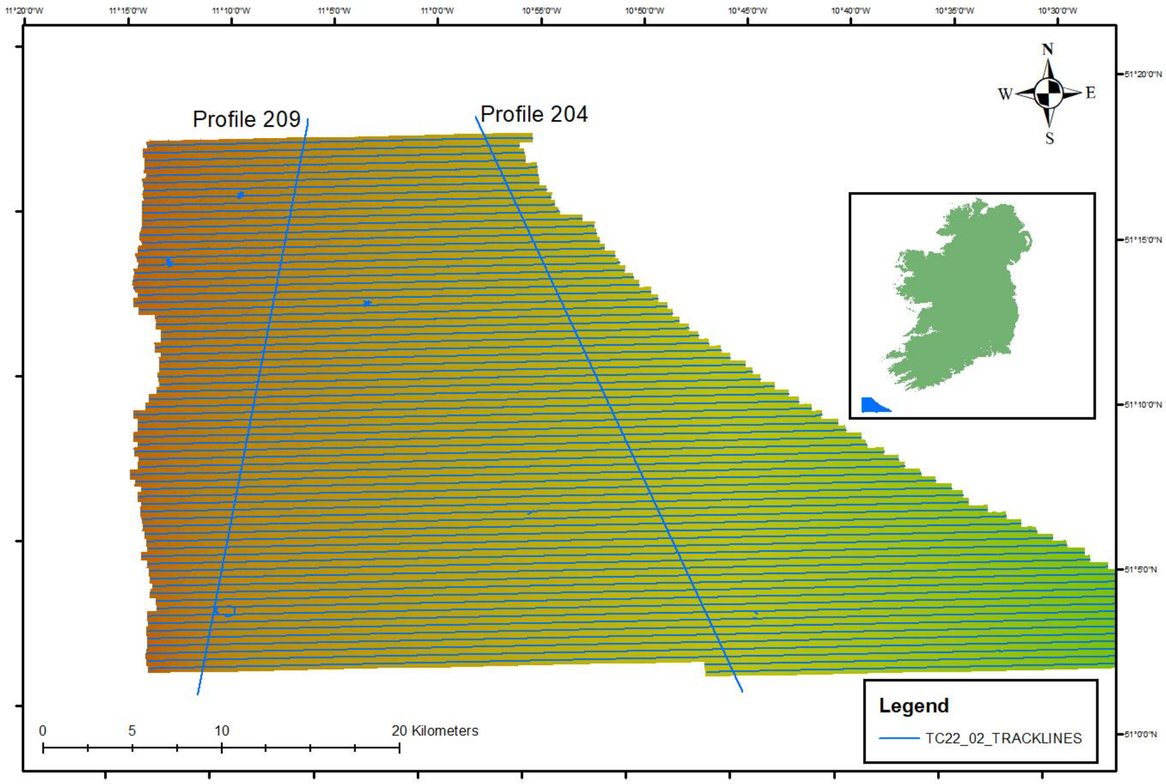


Figure 16: SBP lines 204 & 209 extents.

Interpreted SBP tiff images of profiles 204 and 209 are shown in Figures 17 and 18 respectively. A bandpass filter with low cut 1.5 kHz and high cut 4.7 kHz was applied in processing. Heave compensation is applied to the images although some residual heave remains. Horizontal scale lines are at 8 m (10 ms) intervals. Note that the vertical scale is greatly exaggerated.

Profile 204 in Figure 17 is 35.7 km in length. The profile was acquired from SE to NW. Data quality is good. Signal penetration is very poor due to the hard substrate. No sub bottom reflectors are observed. The seabed is mostly smooth with occasional furrows associated with iceberg ploughmarks. These ploughmarks are clearly evident on MBES data also.

Profile 209 in Figure 18 is 33.0 km in length. The profile was acquired from NNE to SSW as a QC cross line. Data quality is good. Signal penetration is very poor due to the hard substrate. The topography of this profile is gently sloping. Numerous iceberg ploughmarks are observed on the seabed. Ploughmarks are up to 2 m depth and over 300 m in width.

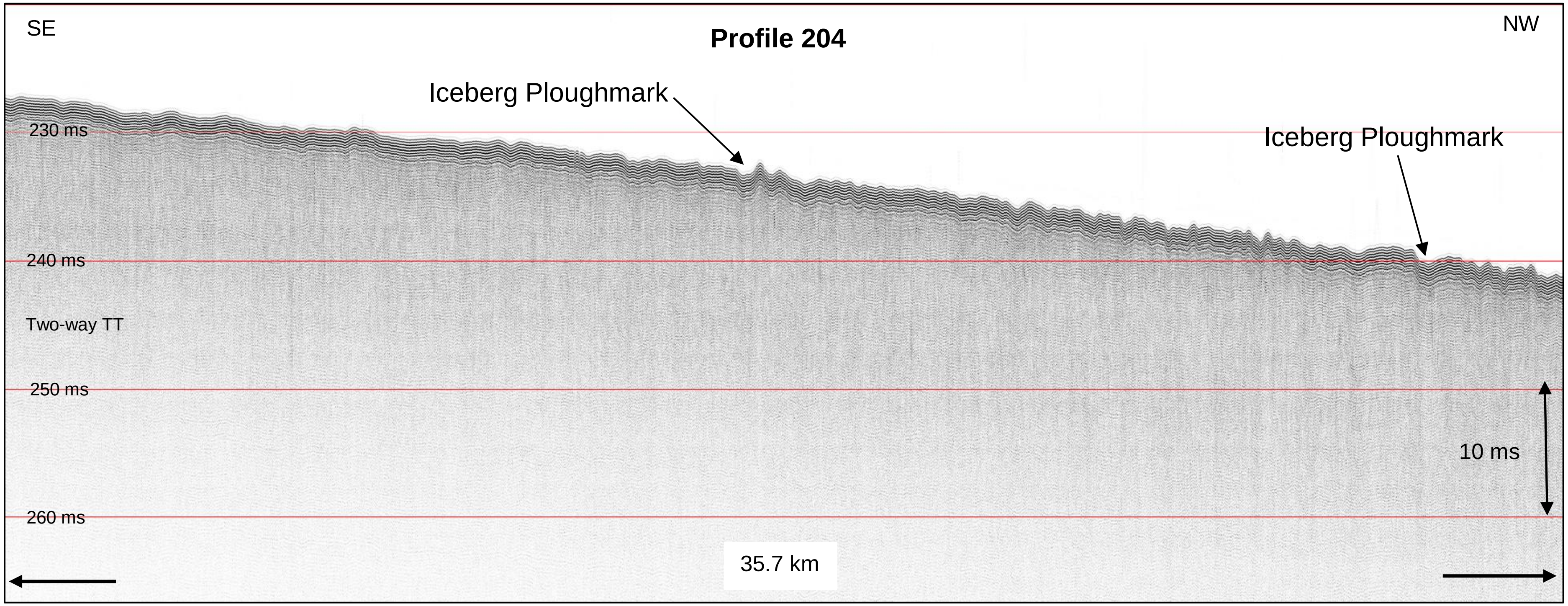


Figure 17: SBP interpreted image, line 204.

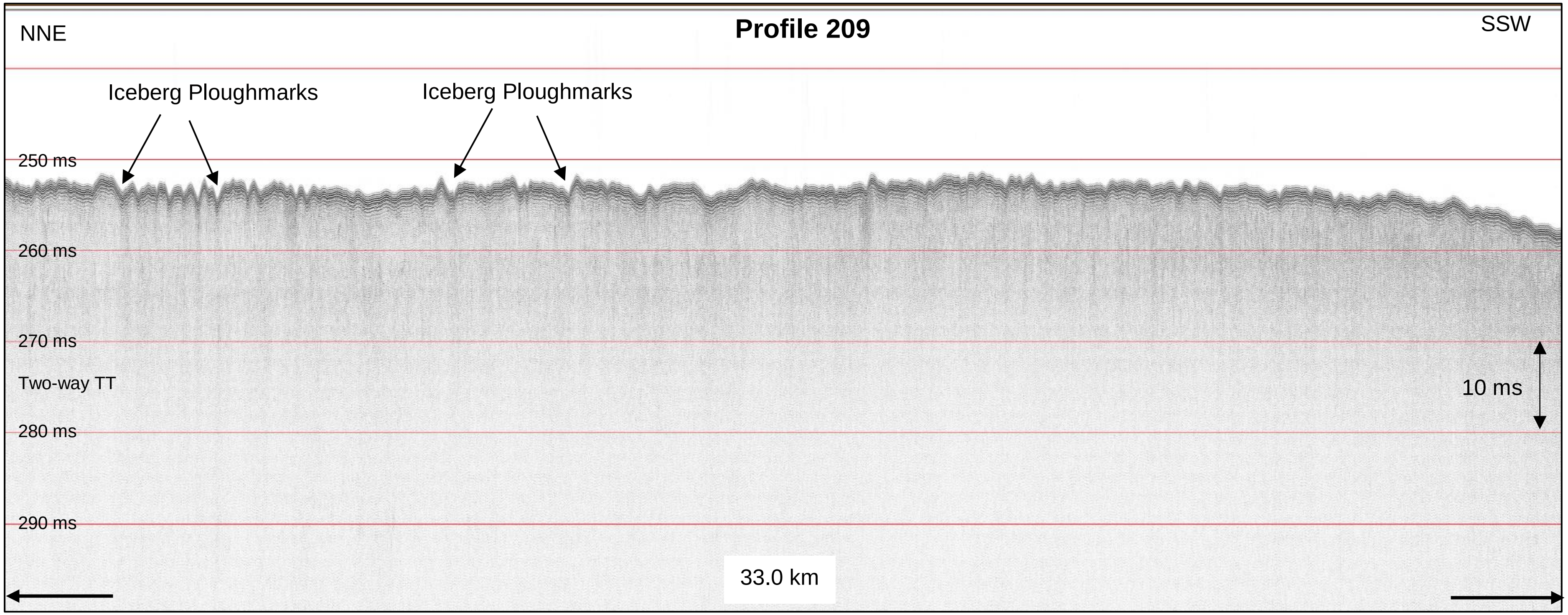


Figure 18: SBP interpreted image, line 209.

4.3.3 Bathymetry

Figure 19 is a colour coded MBES bathymetry image. Water depth varies from 112.8 to 201.3 m. Depth increases from east to west. The western edge of the survey coverage denotes the shelf edge. Seabed gradients are gentle throughout.

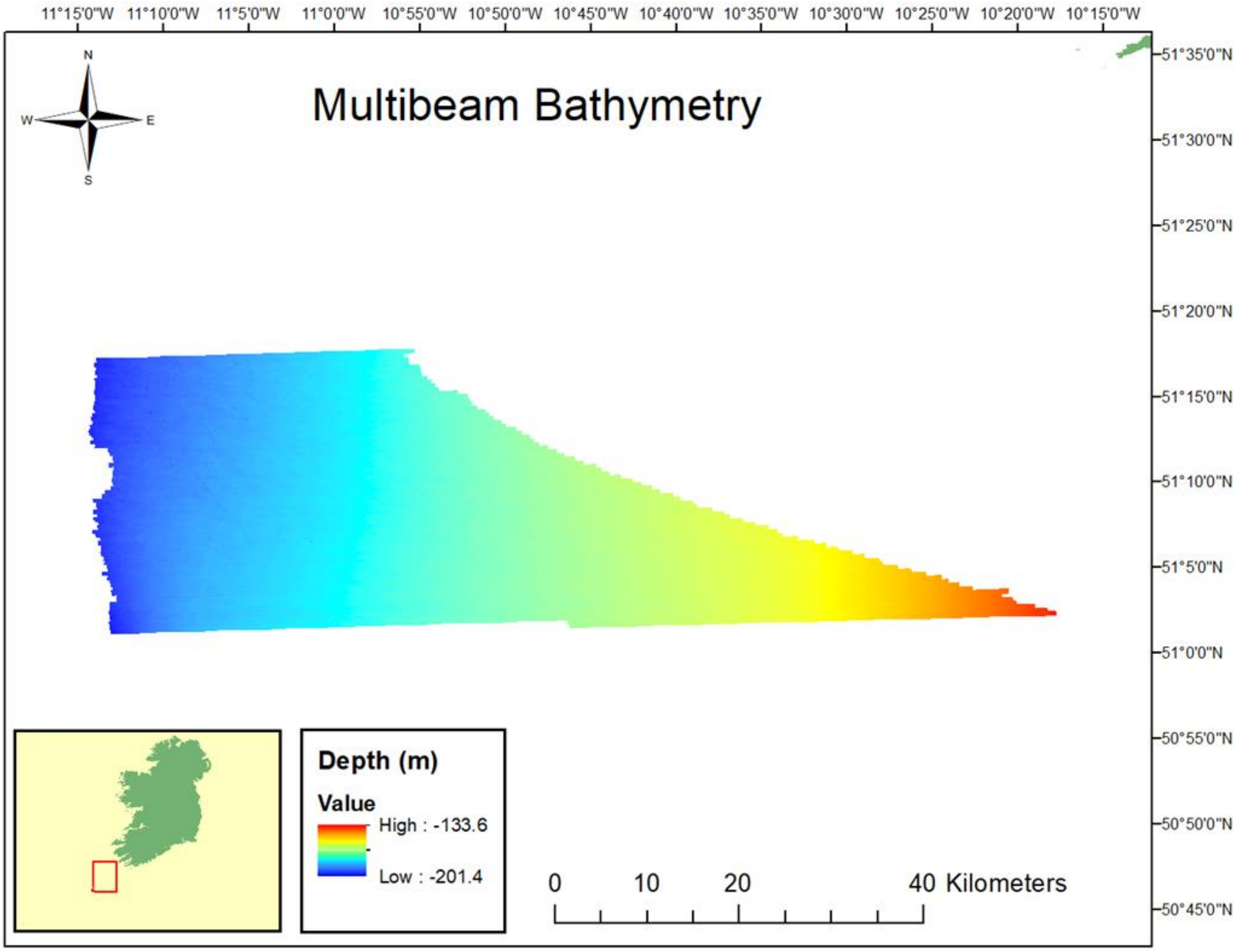


Figure 19: MBES bathymetry overview.

4.3.4 Seabed Texture

MBES backscatter is the strength of acoustic energy received by the sonar after a complex interaction with the seafloor. By analysing the amplitude of the returning sound waves, it is possible to extract information about bottom structure and hardness, allowing for identification of bottom types. Seabed reflectivity properties depend on the hardness and roughness of the seafloor surface. In simple terms, a strong return signal indicates a hard and/or rough surface and a weak return signal indicates a soft and/or smooth surface.

Backscatter values referenced in this report are relative intensities and not absolute. The convention used in this report is that dark coloured areas represent relatively higher backscatter intensity than light coloured areas. Backscatter intensity values vary from - 15.3 to - 69.2 db.

The backscatter mosaic, gridded at 2 m is shown in Figure 20. Two broad backscatter intensity categories are identified. Low backscatter intensity dominates. Higher backscatter seabed is found mostly in the north and sporadically in the centre. The SE is homogeneously low backscatter.

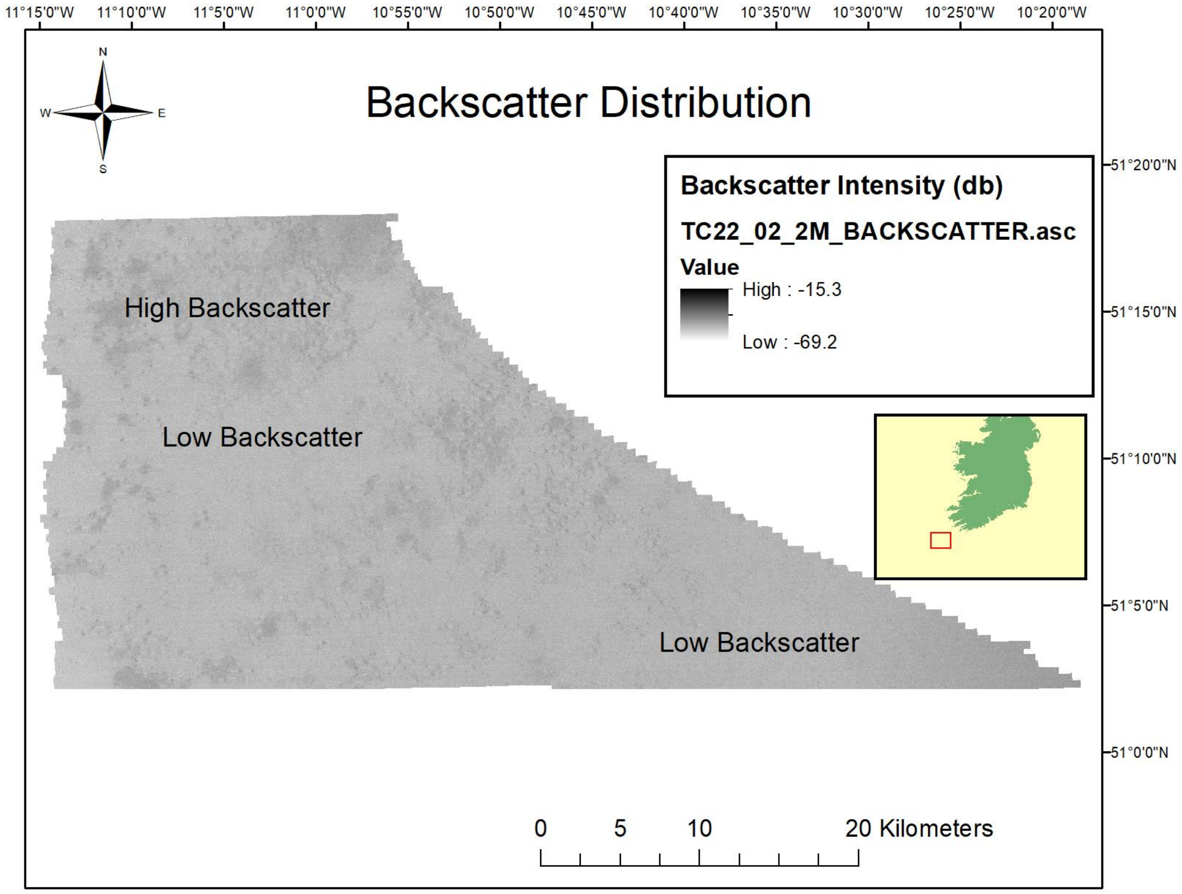


Figure 20: Relative backscatter intensity distribution.

Figure 21 illustrates a section of seabed where high intensity backscatter is prominent. The high intensity backscatter is often associated with iceberg ploughmarks, which are typically less than 100 m in width and C. 2 m in relief. The higher backscatter areas correlate with the bathymetric lows.

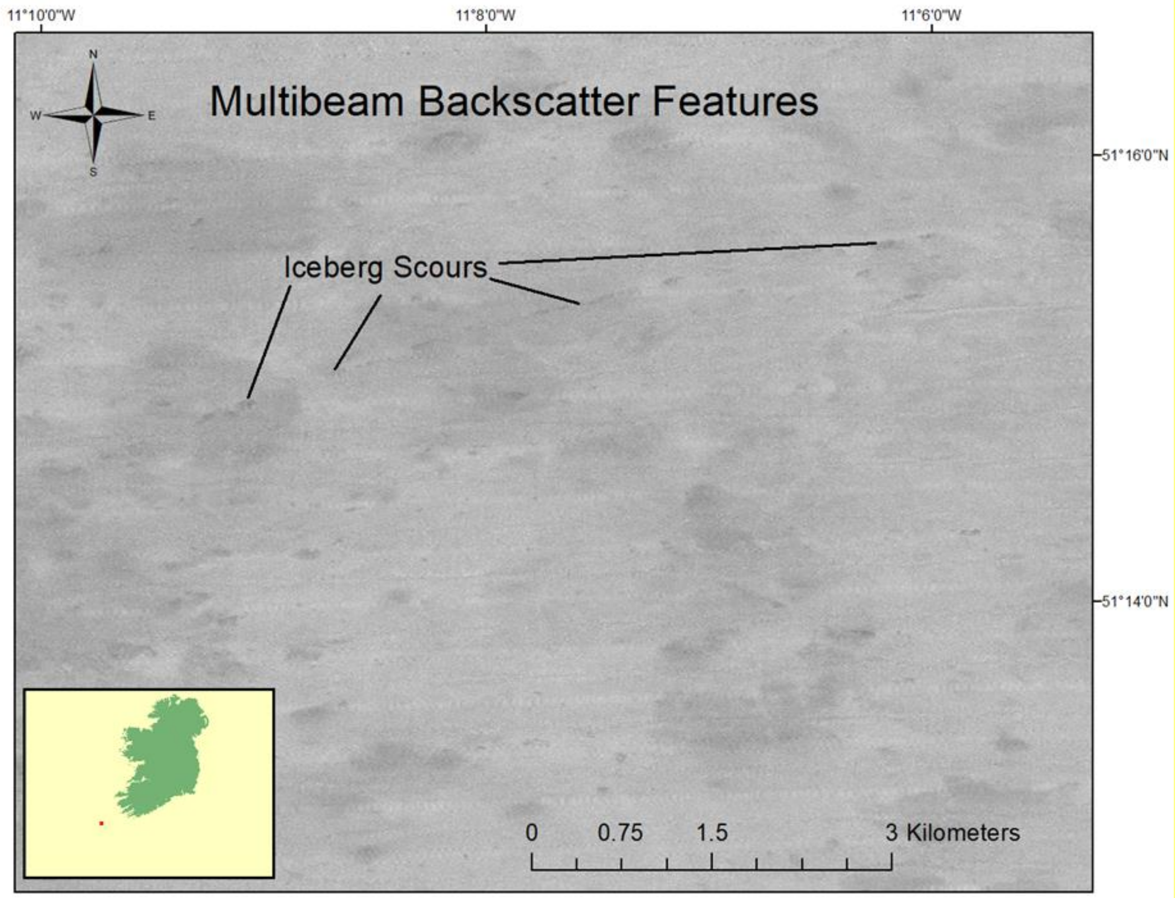


Figure 21: High backscatter intensity channel features.

4.3.5 Seabed Features

Description of seabed features are based on analysis of bathymetric, shaded relief and backscatter data. It is possible to make valid inferences on seabed character and composition by correlating these datasets. Shaded relief data are used to illustrate the features discussed in this section. Shaded relief imagery is produced in Teledyne Caris HIPS & SIPS^{TM} software by shining an imaginary sun at 45º angle over the depth colour coded MBES bathymetry dataset. Data illustrated below are gridded at 5 m and with sun illumination from the NW.

Figure 22 is a MBES shaded relief image illustrating a large circular depression discovered in the NW. It is circa 5 m deep and 200 m in diameter. Similar scale depression found in the Pacific have been attributed to gas escaping from sub surface and disturbing the seabed sediments. Extensive iceberg ploughmarks and a wreck are also located in the image.

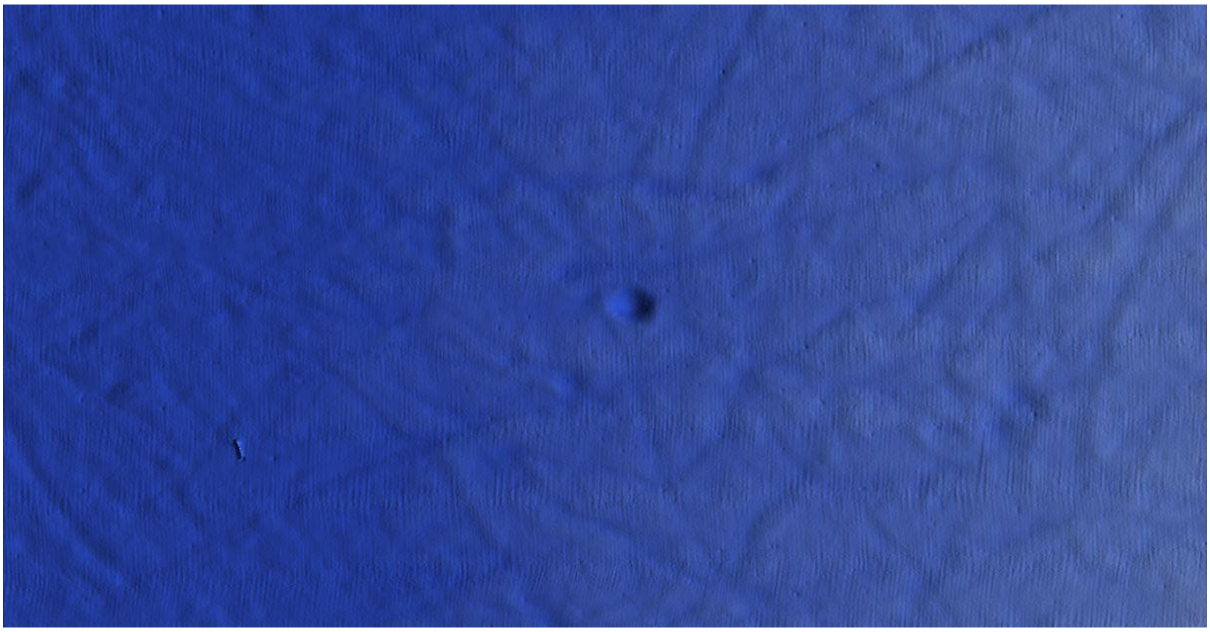


Figure 22: MBES shaded relief image illustrating circular depression.

Figure 23 is a shaded relief image illustrating iceberg ploughmarks. Some ploughmarks are over 200 m in width, up to 1.5 m deep and extend for over 8 km. Largest ploughmarks have NW-SE and NE-SW orientations. Two pockmarks are also evident in the image below.

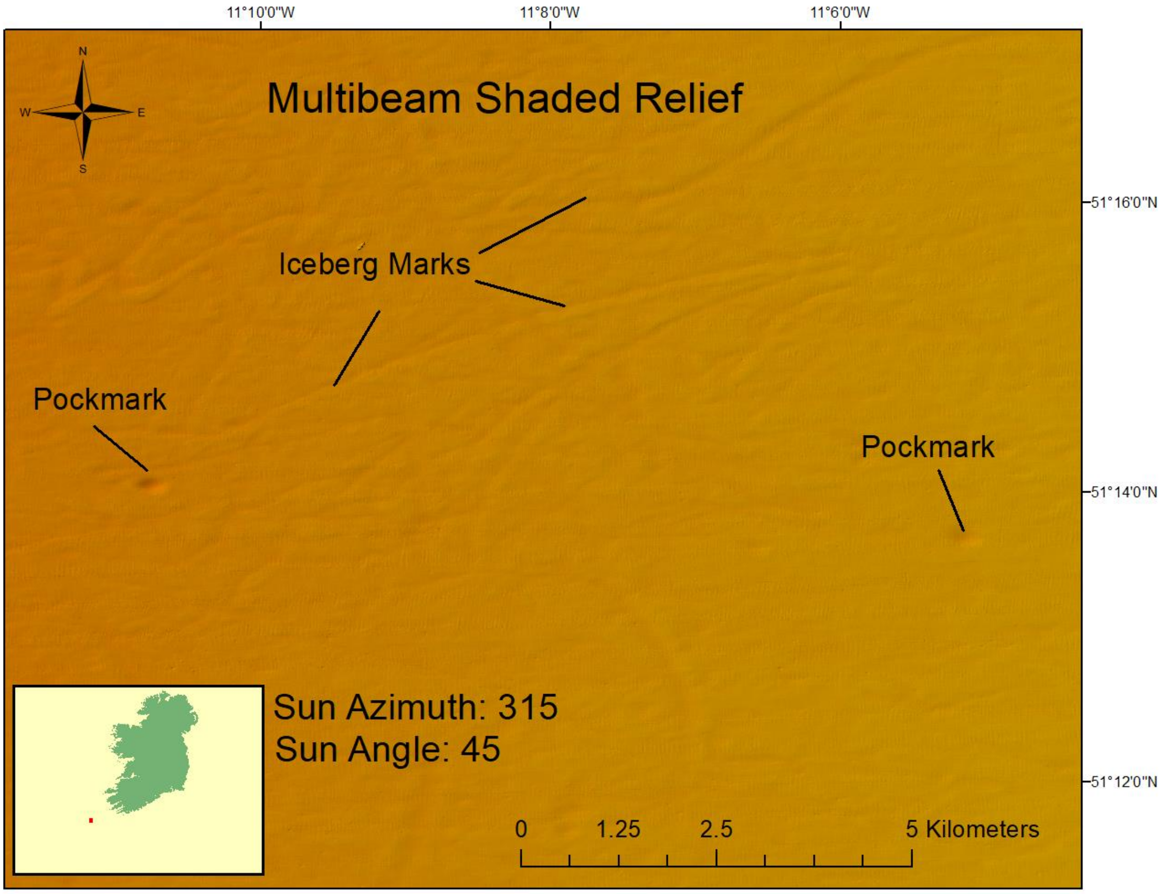


Figure 23: MBES shaded relief image illustrating seabed features.

4.4 Ground Truthing

Ground truthing will be performed at a later date.

4.5 Wrecks

Six wrecks was located and then mapped in detail. A H525 form was completed and sent to the UKHO. Admiralty charts will be updated in due course. Table 19 provides the wreck location and basic information.

Number	Latitude	Longitude	Length	Date
1	51º 15.6986 N	-011º 09.3045 W	114 m	14/09/2022
2	51º 13.5675 N	-011º 12.6585 W	116 m	15/09/2022
3	51º 12.5140 N	-011º 03.0625 W	115 m	15/09/2022
4	51º 14.8296 N	-010º 57.8028 W	31 m	14/09/2022
5	51º 06.3173 N	-010º 54.8749 W	84 m	18/09/2022
6	51º 03.4448 N	-010º 43.9229 W	90.5 m	20/09/2022

Table 19: Wreck investigation metadata.

Figure 24 shows the location of the mapped wreck overlain on shaded relief data.

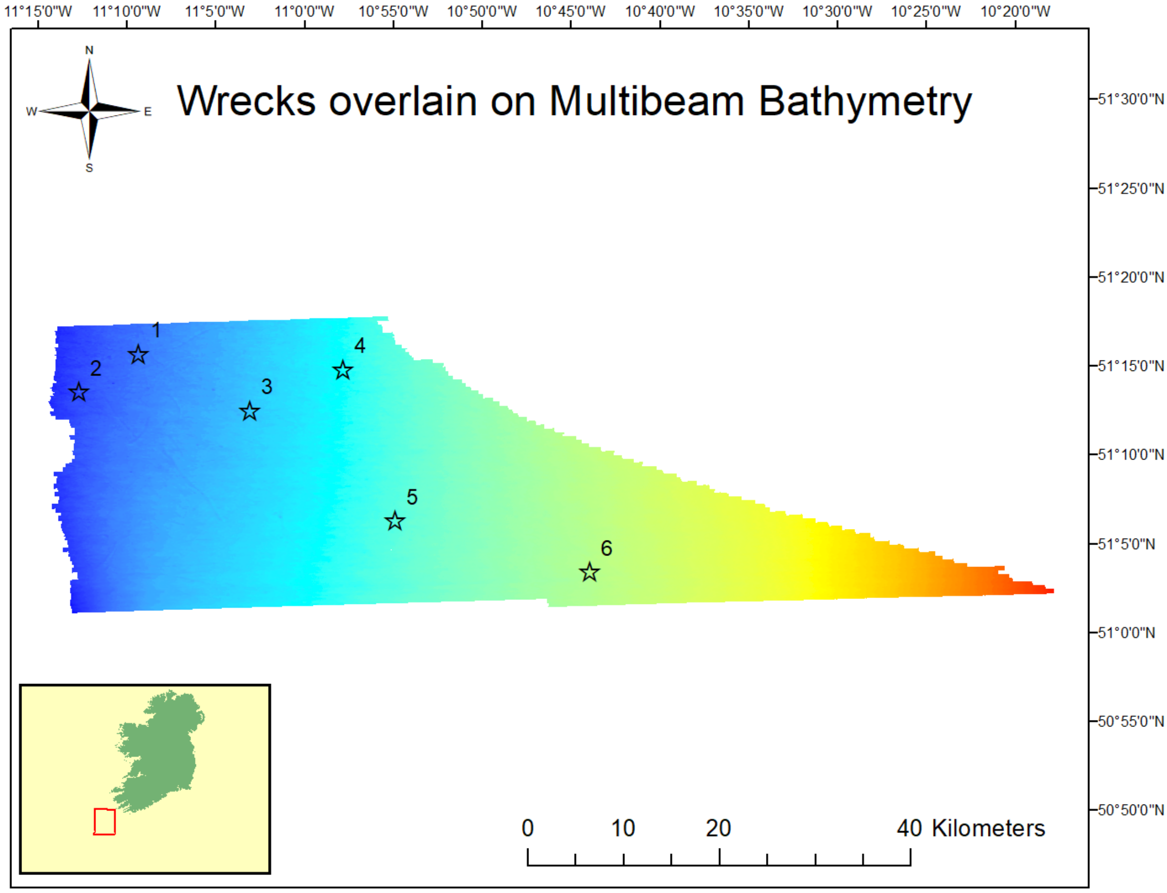
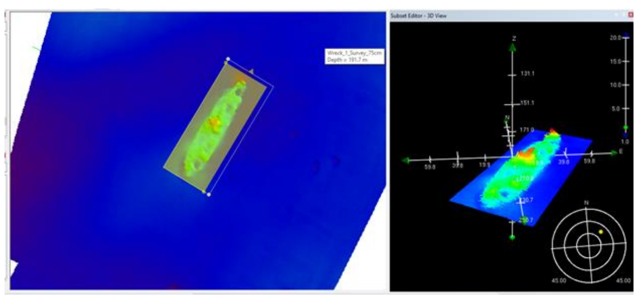
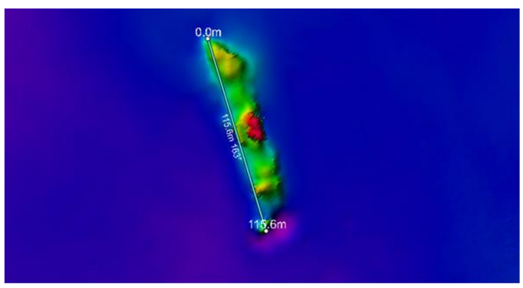


Figure 24: Mapped wreck location plot.

Figure 25 shows a MBES data image of the mapped wrecks.

Wreck 1	Wreck 2
	

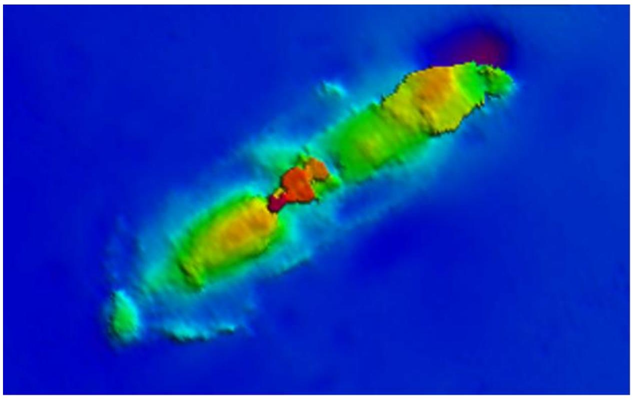
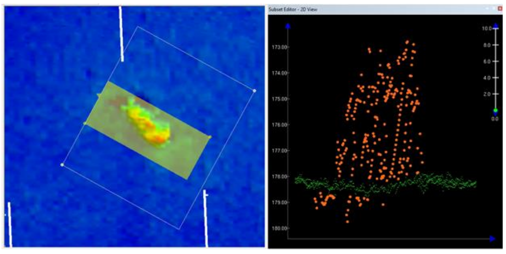
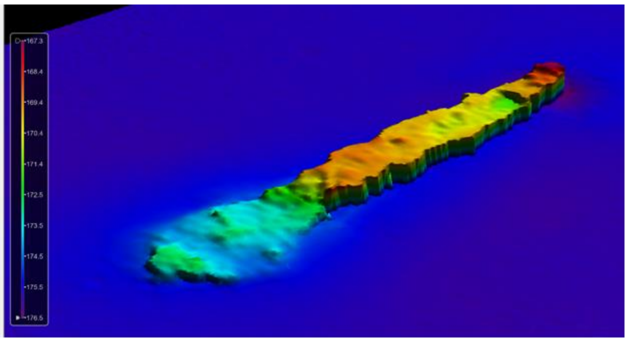
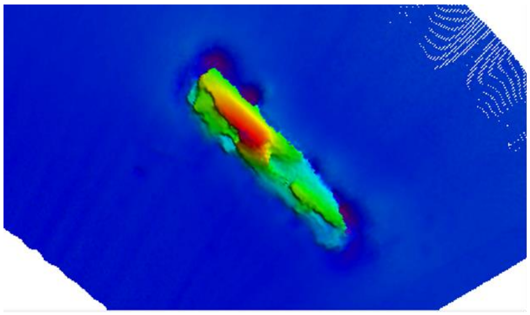
Wreck 3	Wreck 4
	
Wreck 5	Wreck 6
	

Figure 25: MBES wreck images.