



Roinn Cumarsáide, Gnómhaithe
ar son na hAeráide & Comhshaoil
Department of Communications,
Climate Action & Environment



Geological Survey
Suirbhéireacht Gheolaíochta
Ireland | Éireann



Marine Institute
Foras na Mara



CHERISH

Newid Hinsawdd a Threftadaeth yr Afodir
Climate Change and Coastal Heritage
Athrú Aeráide agus Oidhreacht Chultúrtha



Report of Survey

Geological Survey Ireland
North Wales 2019



INFOMAR
Integrated Mapping for the
Sustainable Development
of Ireland's Marine Resource

Geological Survey Ireland, founded in 1845, is the national earth science agency. It is responsible for providing geological advice and information and for the acquisition of data for this purpose. GSI produces a range of products including maps, reports and databases and acts as a knowledge centre and project partner in all aspects of Irish geology. GSI is a division of the Department of Communications, Climate Action & Environment (DCCAE).

Geological Survey of Ireland
 Beggars Bush
 Haddington Road
 Dublin 4
 Tel. +353-1-678 2000
 Fax +353-1-668 1782
 LoCall 1890 449900
 www.gsi.ie

CHERISH Project

CHERISH (Climate, Heritage and Environments of Reefs, Islands and Headlands) is a 6 year (2017-2022) European-funded Ireland-Wales project between the Royal Commission on the Ancient and Historical Monuments of Wales, the Discovery Programme: Centre for Archaeology and Innovation Ireland, Aberystwyth University: Department of Geography and Earth Sciences and Geological Survey Ireland. The project will receive €5.1 million through the Ireland-Wales 2014-2020 Interreg Programme.

CHERISH is a cross-disciplinary project. It aims to raise awareness and understanding of the past, present and near future impacts of climate change, storminess and extreme weather events on the rich cultural heritage of the Irish and Welsh regional seas and coast. It employs innovative techniques to study some of the most iconic coastal locations in Ireland and Wales. www.cherishproject.eu

Disclaimer

The data presented in this report, particularly hydrographic data, is acquired as part of a baseline study and should not be used for navigational purposes.

Although every effort has been made to ensure the accuracy of the material contained in this report, complete accuracy cannot be guaranteed. Neither the Geological Survey of Ireland, Marine Institute nor the author accepts any responsibility whatsoever for loss or damage occasioned, or claimed to have been occasioned, in part or in full as a consequence of any person acting or refraining from acting, as a result of a matter contained in this report.



General Area	North Cardigan Bay, Caernarfon Bay Wales
Name of Survey	KRY19_CHERISH: Wales Marine Survey 2019
Area/Block number	N/A
Unit Names	R.V. Keary (KRY)
Survey Leg Reference Numbers	KRY19_02
Company	INFOMAR (Geological Survey of Ireland)
Charge Surveyor	Sean Cullen
Start Date of Survey	1 st July 2019
End Date of Survey	12 th July 2019
Recommended survey category	N/A
Report version	Final



Glossary

INFOMAR: Resource	Integrated Mapping for the Sustainable Development of Ireland's Marine
GSI:	Geological Survey of Ireland
IHO:	International Hydrographic Organisation
JNCC:	Joint Nature Conservation Committee
UKHO:	United Kingdom Hydrographic Office
DCCAE:	Dept of Communications Climate Action & Environment
STCW95:	Standards of Training Certification and Watch-keeping
MBES:	Multibeam Echosounder
SBES:	Singlebeam Echosounder
SBP:	Sub-bottom Profiler
SSS:	Sidescan Sonar
H-NOTE:	Hydrographic Note
HI:	Hydrographic Instruction
TPU:	Total Propagated Uncertainty
LAT:	Lowest Astronomical Tide
GNSS:	Global Navigation Satellite System
VORF:	Vertical Offshore Reference Frame
PPE:	Personal Protective Equipment
MMO:	Marine Mammal Observer
QC&QA	Quality Control & Quality Assurance



Document Information

Project title: Report of Survey – CHERISH: Wales Marine Survey 2019

Current Document version: Draft

Date 27/02/2019

Lead Authors	Position
Kieran Craven	Consultant CHERISH Project Co-ordinator, GSI
James Barry	Consultant Project Geologist, GSI

Contributing Authors	Position
Sean Cullen	Hydrographer/Charge Surveyor
Rose Jebb	Processor

Distribution List	Organisation
Koen Verbruggen	GSI
Sean Cullen	GSI
	UK Foreign and Commonwealth Office
Claire Bunyan	UKHO
Paul McGarrigle	BODC
Jane Thompson	NERC RSU
Programme Manager	JNCC
	MLA
	Maritime Coastguard Agency
Other:	

Reviewed By	Position	Date
David Hardy	Geologist	25/02/20

Approved By	Position	Date
Sean Cullen	GSI INFOMAR Programme Manager	18/08/2020

Version History

Ver. No.	Ver. Date	Comment	Revised By
KRY19_02d1	14/02/2020	First draft written by Kieran Craven	
KRY19_02d2	16/08/2020	Final draft written by Kieran Craven	



Executive Summary

Survey Summary			
Survey Vessels:	R.V. Keary (GSI)	Survey Legs:	KRY19_02
Mobilisation Port:	Dun Laoghaire, Co. Dublin	Demobilisation Port:	Dun Laoghaire, Co. Dublin
Survey Area/s:	Cardigan Bay, Wales Caernarfon Bay, Wales	Survey Duration:	01/07/2019 – 12/07/2019
N Boundary:	53.66597° N	} WGS1984	
S Boundary:	53.22410° N		
E Boundary:	04.09805° W		
W Boundary:	04.54838° W		
UKHO Admiralty Charts	0002, 1121, 1123, 1410, 1411, 1464, 1970, 1972,		
Key References			
Survey Statistics			
Minimum Water Depth (LAT):	1.5 m above LAT	Maximum Water Depth (LAT):	22 m below LAT
Area Covered (Km ²):	15.8	Survey Line Kilometres:	572.4
Operational (based on 24h days):	KRY – 3d 20h	Downtime (based on 24h days):	KRY – 2d 08h
Groundtruthing Stations:	0	Incidents to Report	0



Table of Contents

Document Information	iv
Version History.....	iv
Executive Summary.....	v
Table of Contents.....	vi
List of Figures	viii
List of Tables	ix
1 Introduction	1
2 Survey Overview and Activity.....	2
2.1 Project Overview	2
2.2 Survey Area.....	2
2.3 Survey Team	4
2.4 Survey Statistics	5
2.5 Health, Safety, Environment (HSE) and Licensing / Permissions.....	6
2.6 Incidents & Near-misses	7
3 Survey Systems and Setup.....	8
3.1 Survey Platforms.....	8
3.1.1 R.V. Keary	8
3.1.2 Survey Software Utilised	10
3.2 Geodetic Parameters	10
3.3 Vessel Dimension Control	10
3.3.1 R.V. Keary	11
3.4 Calibration and Validation Work.....	14
3.5 Survey Order and Objectives	14
3.6 Survey Datum, GNSS Tides and VORF Model	14



4	Survey Data Summary (Data Rendered)	16
4.1	MBES Data	16
4.2	SBES Data	16
4.3	Shallow Seismic Data	16
4.4	Navigation Data	17
4.5	Water Column, Sound Velocity and Oceanographic Data	17
4.6	Backscatter Data	17
4.7	QINSy Online Navigation Data	17
4.8	Final Data Delivery	18
5	Data Processing	19
5.1	Data Processing	19
5.2	Navigation Processing.....	19
5.3	MBES Data Processing Methodology	19
5.3.1	Sounding Data Processing Workflow	19
5.3.2	Backscatter Mosaic Generation	20
6	Quality Control and Quality Assurance	21
6.1	QA and QC Procedures Overview	21
6.2	Operational and Online QA Procedures.....	21
6.3	Post Data Acquisition QC Procedures	21
6.4	Survey Standard	22
6.5	CARIS Hips & Sips Total Propagated Uncertainty Models	23
6.6	Sound Velocity Regime and Environmental Control	23
6.7	Cross-line Statistics	24
6.8	System Checks and Calibration	26
6.8.1	Calibration Patch Tests.....	26



6.9	Sounding Density	27
6.10	Ground truthing	29
7	Data Deliverables.....	30
7.1	Data Structure and Management	30
7.2	Data Deliverables	30
8	Survey Results	32
8.1	Bathymetry	32
8.1.1	Sarn Badrig	32
8.1.2	St Tudwal’s Islands	33
8.1.3	Dinas Dinlle	34
8.1.4	Rhosneigr	36
8.2	Backscatter Data	38
8.3	Shallow Seismic Data	40
8.4	Wreck Surveys	40
8.5	Seabed Contacts	41
8.6	Shoal Investigations (H102 Forms).....	41
8.7	Marine Mammal Observations	42
8.8	Seabed Sampling and Ground-truthing.....	42
9	Conclusion.....	43
9.1	Conclusions and Final Remarks.....	43
10	References.....	44

List of Figures

Figure 1: Survey Coverage Polygons of RV Keary during KRY19_02.....	2
---	---



Figure 2: Overall Bathymetry – Surveyed Area (depths reduced to LAT).....	3
Figure 3: Assessed wrecks (circles) and surveyed wrecks (squares) within surveyed area	4
Figure 4: KRY19_02 Survey Statistics Pie Chart normalised to Operational Window.....	6
Figure 5: R.V. Keary.....	8
Figure 6: R.V. Keary MBES System Installation Offsets - Overview	12
Figure 7: R.V. Keary MBES System Installation Offsets – Sensor Detail	13
Figure 8: VORF-GNSS Reduction of Soundings.....	15
Figure 9: Example of data over a region of Sarn Badrig. A) Acquired sounding data exhibiting “noise” above and below seabed; B) the same data following cleaning. Inset is bathymetry of area with yellow line illustrating where sounding data originates.	20
Figure 10: Maximum Allowable Total Vertical Uncertainty at 95% Confidence.....	22
Figure 11: KRY19_02 Sounding Density from Sarn Badrig region: 2m ² Base Surface	27
Figure 12: KRY19_02 Sounding Density from St Tudwal’s Islands region: 2m ² Base Surface	28
Figure 13: KRY19_02 Sounding Density from Dinas Dinlle region: 2m ² Base Surface.....	28
Figure 14: KRY19_02 Sounding Density from Rhosneigr region: 2m ² Base Surface	29
Figure 15: Vessel tracklines for Sarn Badrig, including crosslines	33
Figure 16: Bathymetry coverage for Sarn Badrig	33
Figure 17: Vessel tracklines for St Tudwal’s Islands, including crosslines	34
Figure 18: Bathymetry coverage for St Tudwal’s Islands	34
Figure 19: Vessel tracklines for Dinas Dinlle, including crosslines.....	35
Figure 20: Bathymetry coverage for Dinas Dinlle.....	36
Figure 21: Vessel tracklines for Rhosneigr, including crosslines	37
Figure 22: Bathymetry coverage for Rhosneigr	37
Figure 23: Backscatter coverage (2m grid) for Sarn Badrig	38
Figure 24: Backscatter coverage (2m grid) for St Tudwal’s Islands	39
Figure 25: Backscatter coverage (2m grid) for Dinas Dinlle	39
Figure 26: Backscatter coverage (2m grid) for Rhosneigr	40
Figure 27: Example of shallow seismic data from Line 0301. Vertical scale bar 5m, horizontal scale bar 100m.....	40
Figure 28: Locations of Wreck survey of the Diamond. See Figure 3 for location.....	41

List of Tables

Table 1: Survey Team.....	4
Table 2: Event Descriptor Breakdown.....	5
Table 3: KRY19_02 Operations Summary	5
Table 4: KRY19_CHERISH North Wales Operational Statistics	6
Table 5: R.V. Keary Vessel Specifications	9
Table 6: Software Utilised.....	10
Table 7: Survey Geodetic Parameters (processed data)	10
Table 8: R.V. Keary Installation Parameters Applied in SIS	13
Table 9: R.V. Keary Installation Parameters Applied in POS-MV.....	14
Table 10: MBES Data logged during CHERISH North Wales Survey 2019.....	16
Table 11: SBES Data logged during CHERISH North Wales Survey 2019	16
Table 12: Shallow Seismic Data logged during CHERISH North Wales Survey 2019.....	16
Table 13: Navigation Data logged during CHERISH North Wales Survey 2019.....	17
Table 14: Sound Velocity Data logged during CHERISH North Wales Survey 2019	17
Table 15: Backscatter Data logged during CHERISH North Wales Survey 2019	17
Table 16: QINSy Project Data logged during CHERISH North Wales Survey 2019	17
Table 17: Final Data Delivery from CHERISH North Wales Survey 2019	18
Table 18: IHO Standards for Hydrographic Surveys	22



Table 19: 2016 Standard Deviation values used in TPU calculation	23
Table 20: KRY19_02 Cross-line Statistics for Sarn Badrig	24
Table 21: KRY19_02 Cross-line Statistics for regions excluding Sarn Badrig	25
Table 22: Standard Patch Test Calibration Run Lines	26
Table 23: Survey Data Directory Structure	30
Table 24: Survey Deliverables	30
Table 25: Wrecks surveyed in North Wales	41



1 Introduction

This Report of Survey document represents survey work carried out by Geological Survey of Ireland vessel RV Keary in CHERISH areas in Cardigan and Caernarfon Bays, Wales in 2019. Authorisation for the survey was received from the Maritime Policy Unit of the Foreign & Commonwealth Office (Ref 57/2019). There was no requirement for a marine licence for the activities conducted (multibeam geophysical surveys) as outlined by the Marine Management Organisation guidance.

This document is intended to provide a thorough overview of survey specifications, standards and quality control measures implemented during survey operations. It provides a record of the datasets acquired during operations and a description of how this data was modified (processed) and managed before leaving the vessel for final validation and distribution to the end user.

The CHERISH project identified a number of sites within Cardigan and Caernarfon Bays for which the project required detailed bathymetric surveys. Four main type of sites were targeted; headlands, reefs, islands and shipwrecks. Headlands included Rhosneigr, Anglesey and Dinas Dinnle; Reefs included Sarn Badrig in Cardigan Bay, Islands included St Tudwall's Islands in Tremadog Bay; and shipwrecks included "The Diamond" in Cardigan Bay. The objectives of targeting these sites were to both further understand their evolution and to join bathymetric data with existing LiDAR and UAV data for analyses.

Multibeam surveying was to be carried out in depths <25m using the Geological Survey RV Keary which is equipped with a Kongsberg EM 2040D multibeam echosounder between the 1st and 12th July 2019. Sub-bottom profiling using a hull-mounted Edgetech CHIRP 3200 was conducted along all survey lines.

While survey results are presented in the final section of this document, it is designed to be used in conjunction with a standard set of additional reports which are included **as annexes**. Accordingly, when taken together with this Report of Survey document, **the annexes** form the overall CHERISH North Wales 2019 survey report.



2 Survey Overview and Activity

2.1 Project Overview

The purpose of this survey was to create an integrated bathymetric and geophysical dataset for CHERISH areas off selected sites in North Wales, using a range of platforms and sonar equipment. Bathymetry was to be acquired to IHO S-44 Order 1a Standard. One GSI vessels was mobilised for the survey by the Geological Survey of Ireland (R.V. Keary).

2.2 Survey Area

The distribution of survey effort by R.V. Keary is shown in Figure 1 below, comprising of 15.8 km² at four locations.



Figure 1: Survey Coverage Polygons of RV Keary during KRY19_02.



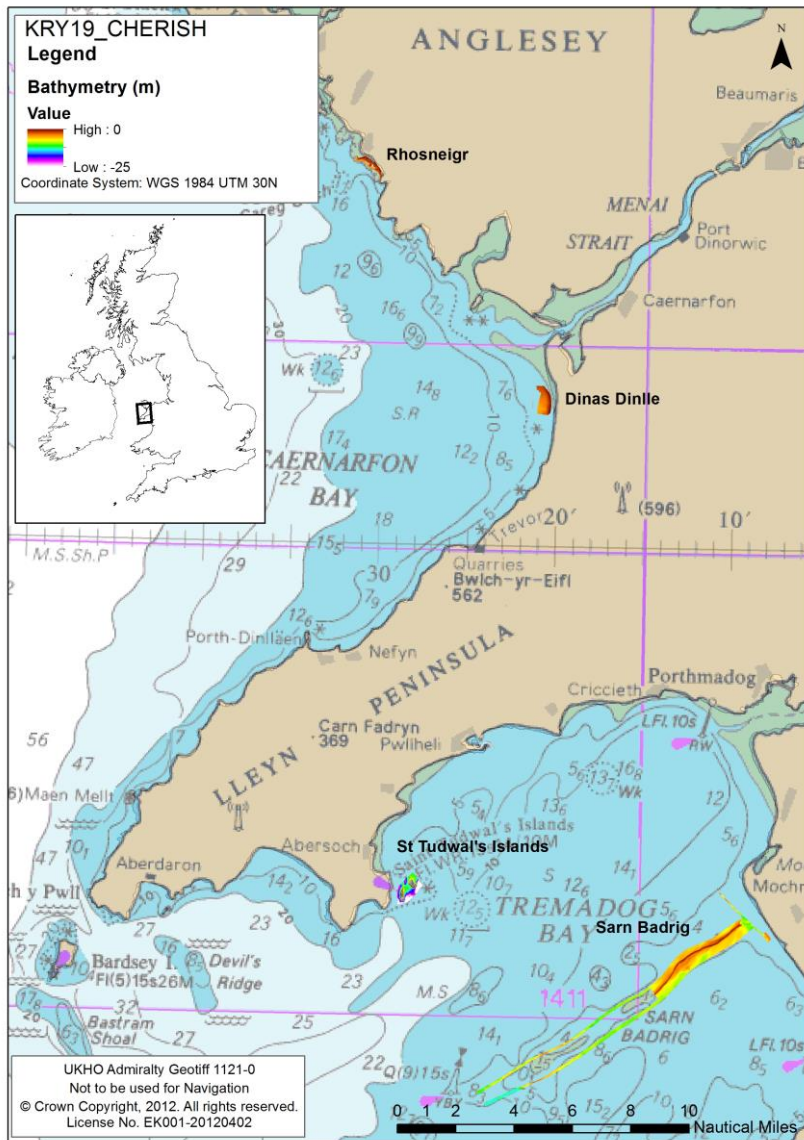


Figure 2: Overall Bathymetry - Surveyed Area (depths reduced to LAT)



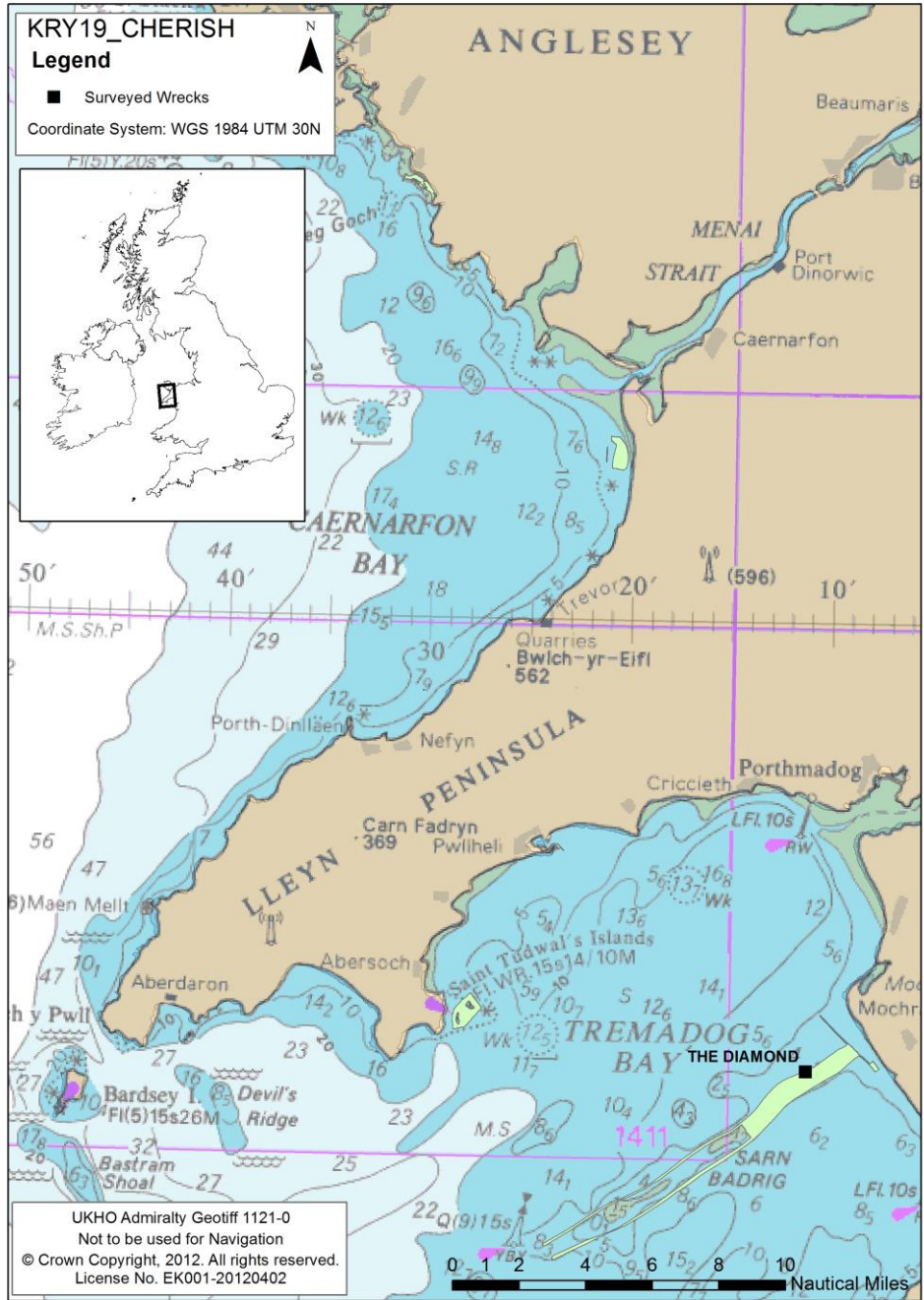


Figure 3: Assessed wrecks (circles) and surveyed wrecks (squares) within surveyed area

2.3 Survey Team

2019 CHERISH survey operations off North Wales were crewed by a team comprised of contracted staff from the GSI. Table 1 table below lists all personnel involved with these survey operations.

Table 1: Survey Team

Crew Member	Capacity	Organisation
Agust Magnusson	Vessel Master	Contractor
Padraig Cronin	Data Processor/Surveyor	GSI-Contract



James Barry	Party Chief / Data Processor	GSI-Contract
-------------	------------------------------	--------------

2.4 Survey Statistics

Operations tables for the 2019 CHERISH North Wales survey are provided along with an over-arching summary of activity conducted. Should an individual day by day breakdown be required, this information is contained in the digital DPR (Daily Progress Report) issued each day and within the final project data delivery.

Table 2 provides a breakdown of how daily events are categorised for reporting purposes. For INFOMAR survey operations, the inshore survey vessels operate a 12 hour working day with 12 hours scheduled every 24 hours, for an overnight port-call.

Table 2: Event Descriptor Breakdown

Event Descriptor	Events Covered
Port Call	Vessel alongside, usually for night hours, PR events and mobilisation/demobilisation.
Standby	Survey staff are working but vessel is not acquiring survey data
Downtime Vessel	Operations ceased due to problem with vessel systems
Downtime Survey	Operations ceased due to problem with survey systems
Data Acquisition	Vessel is acquiring data and or validation data
Weather Standby	Operations ceased due to poor weather
Ground-truthing	Seabed sampling, video/stills imagery ground-truthing
Transit	Vessel is operational and travelling to destination
Other	Non-standard work within the scope of normal operations

Table 3: KRY19_02 Operations Summary

	Stats: Hours	Stats: Days	Stats: Percentages
Port Call	111.36	4.64	46.42
Weather Standby	0.00	0.00	0.00
Extra Work	0.00	0.00	0.00
Standby	9.12	0.38	3.78
Transit	30.72	1.28	12.81
Operational	72.24	3.01	30.04
Other	12.48	0.52	5.21
Downtime Survey	0.48	0.02	0.24
Downtime Vessel	3.6	0.15	1.46
Calibrations		0.00	0.00
	Stats: Total Hours	Stats: Total Days	Stats: Total Percentage
	240.00	10.00	100



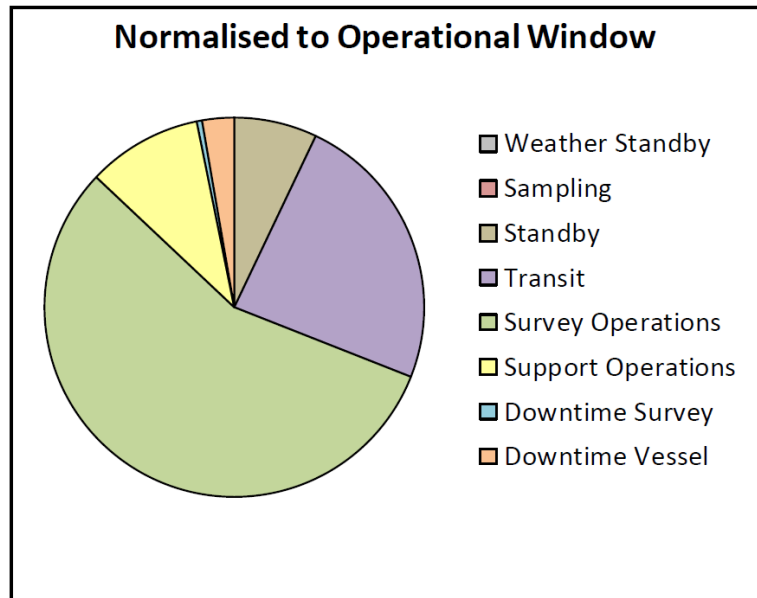


Figure 4: KRY19_02 Survey Statistics Pie Chart normalised to Operational Window

Table 4: KRY19_CHERISH North Wales Operational Statistics

Survey Leg	Line Kilometres (km)	Area Covered (km ²)
KRY19_02	572.36	15.78

2.5 Health, Safety, Environment (HSE) and Licensing / Permissions

Responsibility for all personnel and equipment in relation to damage, loss or injury incurred in the mapping of CHERISH North Wales areas in 2019 was assumed by the GSI. GSI Hydrographer, Sean Cullen assumed the role of “Charge Surveyor” for the overall project, with all policies put into practice by senior surveyors/party-chiefs during each leg of survey operations.

The GSI operated a Safety Management Plan for all vessels during the course of the 2019 CHERISH North Wales survey. A “no drugs or alcohol” policy was in place for all survey operations on all platforms throughout.

Daily meetings were conducted as often as possible during the 2019 CHERISH North Wales survey on the aft deck of the R.V. Keary each morning.

Due to the shallow-water environment being surveyed as part of this project, responsibility for safe navigation rested solely with the Master/Skipper of each individual vessel all of whom were familiar with shallow water surveying techniques.

All offshore personnel working on the project required valid ENG11 Medical certification, STCW95 sea-survival and other relevant certification as required by their role.

Safety induction and familiarisation exercises were carried out on all survey platforms prior to the commencement of the survey leg. Safety drills were conducted periodically and logged in the vessel’s log books.

To operate in CHERISH North Wales areas, approval was granted by the UK Foreign and Commonwealth office (NV 57/2019). All conditions outlined in that document were abided by including all applicable UK and EU laws.



2.6 Incidents & Near-misses

The project partner's survey reporting policy provides a framework for the reporting of incidents and near-misses as they arise during operations.

During the course of the 2019 CHERISH North Wales survey, no major incidents requiring reporting occurred.



3 Survey Systems and Setup

3.1 Survey Platforms

The CHERISH project utilised one survey vessel, operated by GSI, in the implementation of survey work in CHERISH North Wales in 2019 – the R.V. Keary,.

3.1.1 R.V. Keary

The Irish state research vessel R.V. Keary is an aluminium catamaran designed for near shore survey work. She is ideally suited in this role due to her stable twin hull construction, shallow draft, retractable equipment pod and hydraulically operated A-Frame and winch. The R.V. Keary is typically crewed by a team of 3 individuals. Table 7 provides information on her design specifications and survey equipment on board.



Figure 5: R.V. Keary



Table 5: R.V. Keary Vessel Specifications

Specification / System	Information
Length OA	15.5 m
Length (hull)	14.6 m
Beam (moulded)	5.6 m
Draught	1.9 m
Draught with pod deployed	2.4 m
Engines	2 x Cummins QSC 8.3 – 500 INT
Power output	368 kW/2600 RPM/Triple Phase
Transit Speed / Survey Speed	22 knots / 7.5 knots
Fuel	2000 lt Diesel
Generator	Cummins Onan 13.5 kva
Max passenger and crew	12 persons
Passenger Licence	P5
MBES	Kongsberg Simrad EM2040D
SBES	Kongsberg Simrad EA400
Subbottom Profiler	Edgetec 3200XS Chirp (pod mounted)
R/T SV	AML smart probe (pod mounted)
CTD/SVP	Valeport SWiFT SVP
Sparker	Geo-Resources Geo-Spark 200
Positioning System and IMU	POS-MV OceanMaster
DGPS	EGNOS Corrections
Sediment Samplers	Duncan & Associates Day and Hand grabs
USBL	Sonardyne Scout
SSS	Edgetec 4200



3.1.2 Survey Software Utilised

The table below provides details on the primary software tools utilised by INFOMAR survey vessels during the 2019 CHERISH North Wales. Further information is provided in section 3 of this document under Survey Data Summary.

Table 6: Software Utilised

Survey Aspect	Vessel	Software
MBES Data Acquisition	R.V. Keary	Kongsberg SIS
Online Survey Planning	R.V. Keary	QPS QINSy
Online Navigation QC	R.V. Keary	Applanix POSview
SBES Data Acquisition	R.V. Keary	Simrad EA400
Shallow Seismic Data Acquisition	R.V. Keary	Edgetec Discovery
Data Processing	R.V. Keary	Applanix POSpac, QPS Qimera, Caris HIPS & SIPS
Survey Reporting and Statistics	R.V. Keary	Custom Excel Worksheets
SVP Data Acquisition	R.V. Keary	QPS QINSY & Datalog Express

3.2 Geodetic Parameters

Table 7: Survey Geodetic Parameters (processed data)

Local Datum Geodetic Parameters	
Datum	ETRS89
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 30 (CM)	003° 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	Metres

3.3 Vessel Dimension Control



Vessel and equipment offsets and sensor mounting angles utilised during the course of the 2019 survey season were determined for each survey vessel through a dimension control survey. Dimension control reports and documentation are available from GSI project management on request.

It is important to note that the application of offset / installation angle / correction values were applied to raw survey data using a variety of methods, specific to the RV Keary's setup, often using a combination of software programs in order to achieve the best results for the application of position and motion corrections to sounding data. A full discussion of these processes falls outside the scope of this document, however further information can be provided by GSI on request.

The tables presented in the subsections below give details of the various offsets as they were input to the main survey systems (i.e. offset and angular values according to the software programs with which they were applied). For clarity; installation diagrams are provided demonstrate the combined effects of these values on the survey system set-up.

Where fractional adjustments of the values presented in this section were deemed necessary through patch-test and calibration work and during final data processing, these values were modified in the CARIS HIPS & SIPS vessel file and are as a result, recorded in this file which is part of the final data delivery.

3.3.1 R.V. Keary

Installation offsets and angles for the R.V. Keary's primary survey hardware were re-determined through dimension control survey in 2019. These values were applied to survey systems using Kongsberg SIS and Applanix POSview software.

Values derived from the original dimension control survey were verified through standard calibration tests and refined where necessary.



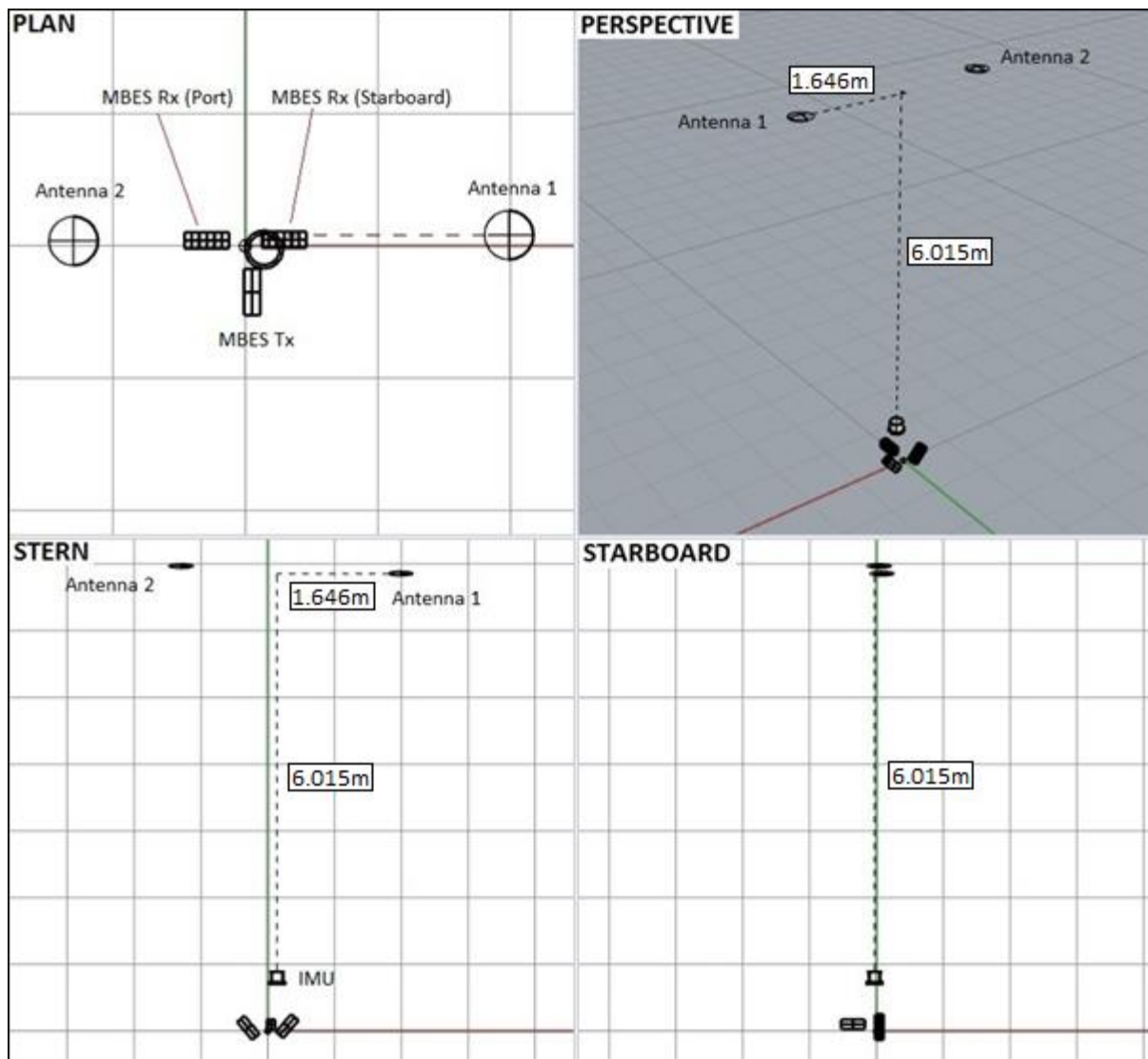


Figure 6: R.V. Keary MBES System Installation Offsets - Overview



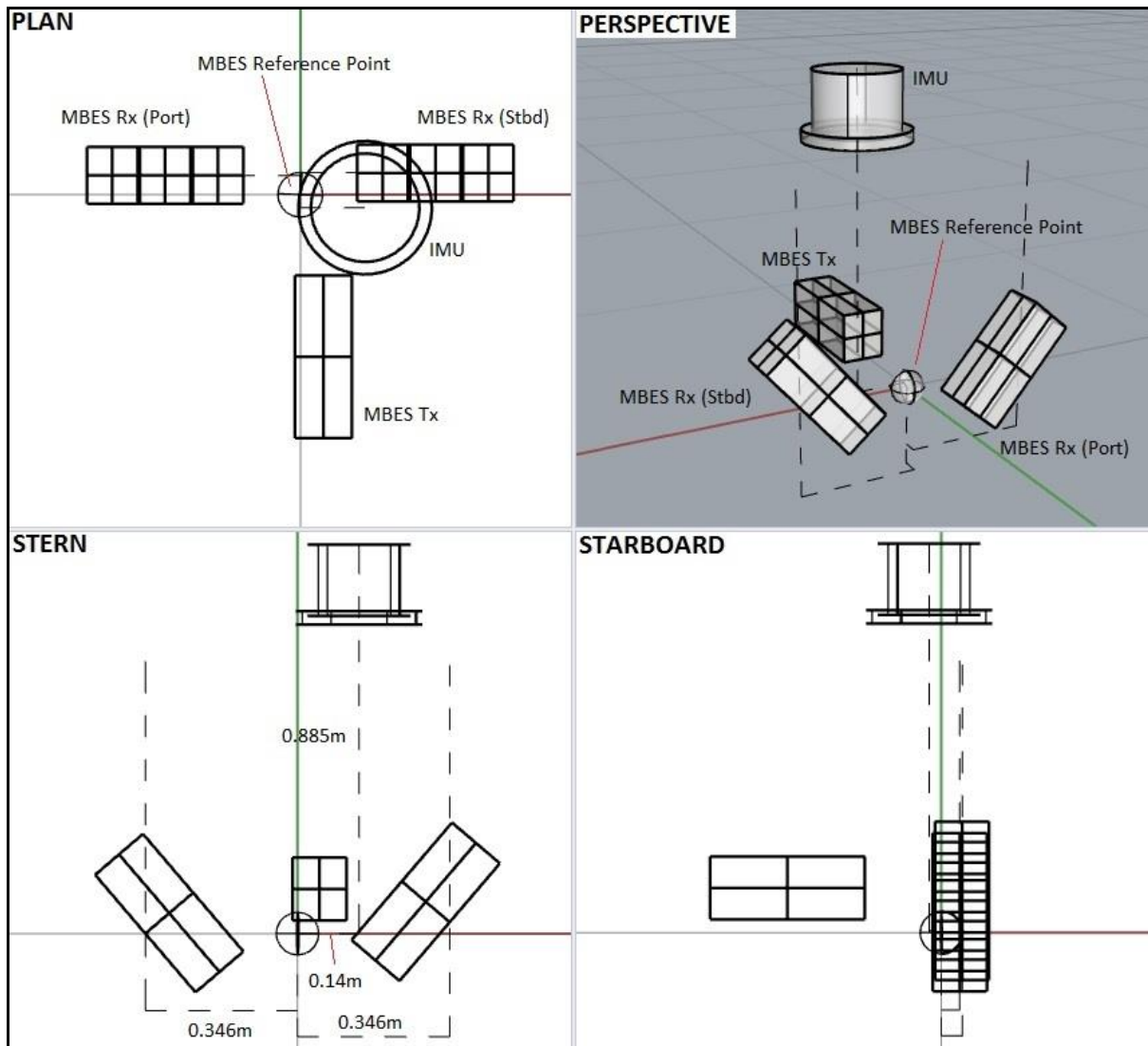


Figure 7: R.V. Keary MBES System Installation Offsets – Sensor Detail

Table 8: R.V. Keary Installation Parameters Applied in SIS

R.V. Keary Offsets in SIS(metres)	X (Stbd +)	Y (Bow +)	Z (Up +)
MBES Reference Point	0	0	0
EM2040 MBES Sonar Head 1 (Port)	-0.341 m	0.046 m	-0.087
EM2040 MBES Sonar Head 2 (Stbd)	0.352 m	0.041 m	-0.085 m
POS-MV IMU relative to ref. point	0.14 m	-0.028 m	0.885 m
Waterline Value (0,0,0)	-1.940 m		
Installation Angles (degrees)	Roll	Pitch	Heading
EM2040 MBES Sonar Head 1 (Port)	-40.012°	1.504°	-0.388°
EM2040 MBES Sonar Head 2 (Stbd)	-39.908°	1.557°	1.240°
POS-MV IMU	0	0	0



Table 9: R.V. Keary Installation Parameters Applied in POS-MV

R.V. Keary Applanix POS-MV Software (IMU as Origin)			
Heave & Sensor 1 & 2 Install Params.	Roll	Pitch	Heading
Sensor 1 alignment angles in degrees	0	0	0
Sensor 2 alignment angles in degrees	0	0	0
	X (Bow +)	Y (+ Stbd)	Z (+ Down)
Sensor 1 lever arm in meters	0.11	0.004	0.990
Sensor 2 lever arm in meters	0	0	0
Centre of Rotation in meters	0.000	0.000	-1.300
GAMS Install Parameters			
Ant 1 – Ant 2 antenna separation (m)	3.289		
Ant 1 – Ant 2 baseline vector (m)	0.004	-3.289	-0.002
Heading error for calibration	0.35		
Ant 1 – Ant 2 azimuth correction	0		
	Roll	Pitch	Heading
Vehicle to reference alignment angles	0	0	0
Reference to IMU alignment angles	-1.875	-2.282	-0.304
	X (Bow +)	Y (+ Stbd)	Z (+ Down)
Reference to IMU lever arm (m)	0.016	-0.006	0.102
Reference to primary GNSS lever arm (m)	0.290	1.646	-6.015

3.4 Calibration and Validation Work

Survey platforms undertook individual calibration exercises and validation checks prior to the commencement of the survey season. Further information relating to this work can be found in Section 6 of this document and full details are available from GSI management on request.

3.5 Survey Order and Objectives

Survey work was carried out to International Hydrographic Organisation (IHO) Special Publication (S-44) Order 1a. The objective for the survey was to acquire high resolution MBES bathymetry and backscatter data within the designated survey areas.

3.6 Survey Datum, GNSS Tides and VORF Model

All depth soundings delivered by GSI survey vessels were reduced to LAT using the UKHO's VORF model. The model provides a separation value between the WGS84/ETRS89 Ellipsoid and LAT.

Figure 8 provides a basic illustration of the reduction of soundings data using the UKHO VORF model value for LAT.



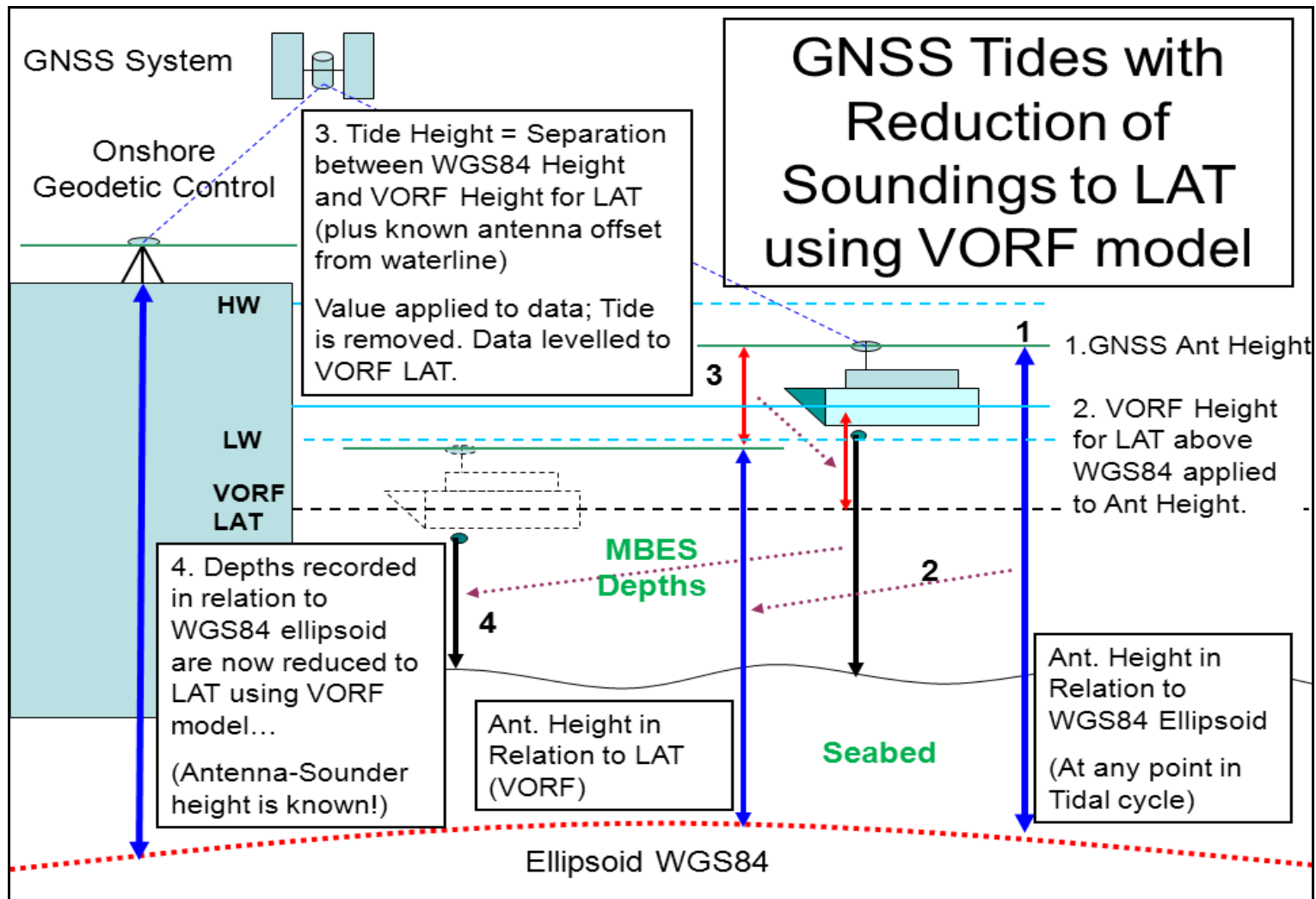


Figure 8: VORF-GNSS Reduction of Soundings

4 Survey Data Summary (Data Rendered)

Survey data acquisition conducted by GSI in the mapping of CHERISH North Wales in 2019 was carried out by R.V Keary. Details on survey activity and vessel set up are provided in sections 1 and 2 of this document. This section provides information on data rendered by the GSI vessels.

4.1 MBES Data

Table 10: MBES Data logged during CHERISH North Wales Survey 2019

Descriptor	Metadata
Vessel	R.V. Keary
Survey Leg	KRY19_02
MBES System	Kongsberg Simrad EM2040D
Survey Lines (including crosslines)	320
Data Files	329 (including test lines)
Date Created	02/08/2019
Dataset size	120 GB
File format	.ALL

4.2 SBES Data

Table 11: SBES Data logged during CHERISH North Wales Survey 2019

Descriptor	Metadata
Vessel	R.V. Keary
Survey Leg	KRY19_02
SBES	Simrad EA400
Survey Mainlines	6
Data Files	92
Date Created	02/08/2019
Dataset size	4.2 MB
File format	.asvp, .dg, .out, .raw, .txt, ..xyz

4.3 Shallow Seismic Data

Table 12: Shallow Seismic Data logged during CHERISH North Wales Survey 2019

Descriptor	Metadata
Vessel	R.V. Keary
Survey Leg & Year	KRY19_02
Chirp	Edgetec 3200XS
Survey Mainlines	311
Data Files	311
Date Created	01/08/2019
Dataset size	7.9 GB



File format	.JSF
-------------	------

4.4 Navigation Data

Table 13: Navigation Data logged during CHERISH North Wales Survey 2019

Descriptor	Metadata
Vessel	R.V. Keary
Survey Leg	KRY19_02
Navigation System	POS-MV
Data Files	123 (excluding USB backup)
Date Created	02/08/2019
Dataset size	7.3 GB
File format	.000/.001 etc. POS MV format

4.5 Water Column, Sound Velocity and Oceanographic Data

Table 14: Sound Velocity Data logged during CHERISH North Wales Survey 2019

Descriptor	Metadata
Vessel	R.V. Keary
Survey Leg	KRY19_02
Instrument	Valeport SWiFT SVP (Bluetooth)
Sound Velocity Data Files	9 CARIS Daily Files (each day's casts combined into one file)
Dataset size	164 KB (CARIS format)
Date Created	02/08/2019
File formats	CARIS .svp

4.6 Backscatter Data

Table 15: Backscatter Data logged during CHERISH North Wales Survey 2019

Descriptor	Metadata
Vessel	R.V. Keary
Survey Leg	KRY19_02
MBES System	Kongsberg Simrad EM2040D
Backscatter	ARA, GeoTIFFS, Lines, Statistics
Survey Lines	320
Data Files	360
Dataset size	4.85 GB
File format	.asc, .tiff, .txt,

4.7 QINSy Online Navigation Data

Table 16: QINSy Project Data logged during CHERISH North Wales Survey 2019

Descriptor	Metadata
Vessel	R.V. Keary



Survey leg	KRY19_02
Dataset size	107 MB
Data Files	431

4.8 Final Data Delivery

The table below details the total amount of data generated by R.V. Keary during CHERISH North Wales survey 2019.

Table 17: Final Data Delivery from CHERISH North Wales Survey 2019

Survey Leg	Dataset Size
KRY19_02	886 GB, 21727 files



5 Data Processing

5.1 Data Processing

During survey operations all datasets were subject to first pass data processing in the field in close to real-time by on board data processors. This work was carried out by the personnel listed in Section 1.3 of this document, in order to ensure the required standards were obtained.

Finalisation of all MBES datasets (1 survey leg) which encompasses the overall 2019 CHERISH North Wales survey delivery, was carried out prior to delivery of all data to UKHO. An overview of the data processing methodology employed is discussed below.

5.2 Navigation Processing

GSI operated vessels are equipped with Applanix POS-MV sensors which provide an integrated solution for positioning and motion reference information. Raw data from these systems are logged in Applanix propriety format and processed using Applanix POS-PAC software.

This data is processed by uploading the GNSS data to PPRTX for processing. The processed data is natively in ITRF14 and subsequently transformed to ETRS89, using Applanix Pospac before merging with MBES data.

5.3 MBES Data Processing Methodology

All Raw MBES data files acquired during the project were converted (via Qimera) and imported into CARIS HIPS & SIPS software. Once converted, survey datasets were then organised by Julian day. The following workflow was followed:

Data → Qimera → Processing → GSF → CARIS → Cleaning → Products

5.3.1 Sounding Data Processing Workflow

Data gets imported into Qimera and the following cleaning steps occur:

- Reprocessed navigation data from POS-PAC was applied to survey data.
- SVP (Sound Velocity Profile) Data was then 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. (Example: nearest in distance verses nearest in time).
- GNSS tides were computed and soundings reduced to LAT (Lowest Astronomical Tide) using the UKHO's VORF model. GNSS Tide Results were then checked for quality and consistency.
- Errors due to residual refraction effects or residual tide are resolved or corrected using the tools available in Qimera.
- Data is assessed for any remaining systemic issues and addressed as appropriate.
- Data is then exported to the GSF format

The GSF files are then loaded to a Caris HIPS & SIPS project structure.



Data cleaning was carried out using a range of tools in CARIS HIPS & SIPS to clean “noise” from the data. A CARIS base surface was then created to guide subset editing. A depth surface was produced during subset editing with erroneous depths removed.

The data over Sarn Badrig contained many artefacts that did not reflect seabed. There were removed during the cleaning process. An example of this is illustrated in Figure 9.

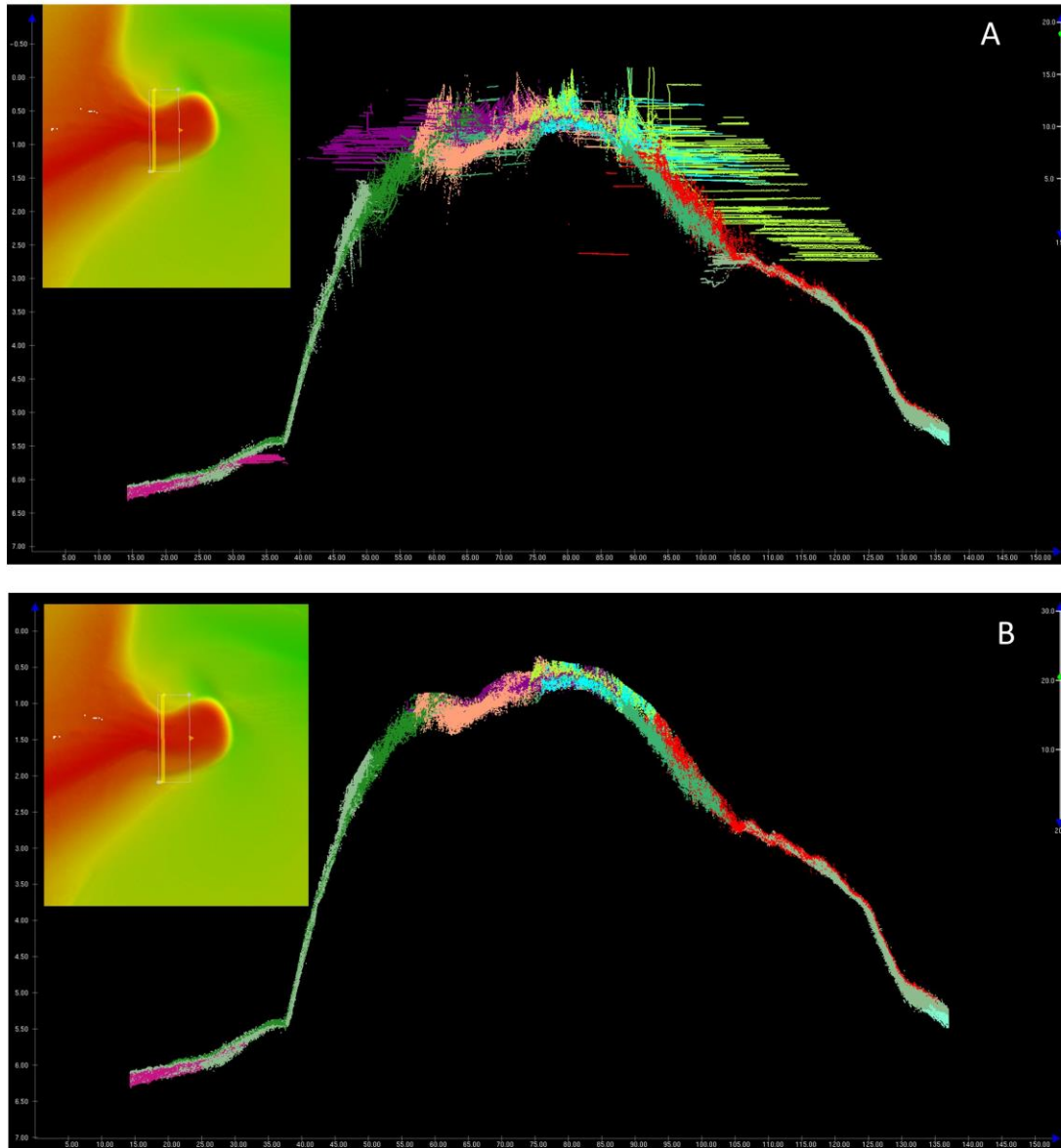


Figure 9: Example of data over a region of Sarn Badrig. A) Acquired sounding data exhibiting “noise” above and below seabed; B) the same data following cleaning. Inset is bathymetry of area with yellow line illustrating where sounding data originates.

5.3.2 Backscatter Mosaic Generation

Raw multibeam data was imported to QPS FMGT and processed using the geocoder algorithm.



6 Quality Control and Quality Assurance

6.1 QA and QC Procedures Overview

Data Quality Assurance (QA) was maintained during survey operations using a combination of techniques including vessel handling and online acquisition quality checks to ensure data acquisition is conducted to the required standard.

Post-data acquisition Quality Control (QC) checks were made during first pass data processing and more rigorously during final data processing. Quality Control processes and procedures employed during this survey are described in this section.

6.2 Operational and Online QA Procedures

1. During survey operations, MBES data quality was maintained by setting outer beam angles of not greater than 68 degrees for each transducer head (in certain cases the angles are increased for greater coverage, e.g. for vessel safety in hazardous areas).
2. Close attention was paid to sea state and weather conditions. Survey grounds were examined for sheltered areas to suit changing conditions.
3. Good swath overlap and correct survey speeds ensured good data quality and safe operation of the vessel within shallow areas.
4. A strong focus on acquiring sufficient sound velocity profiles during each day's data acquisition allowed the on-board data processor to adequately correct sounding data for MBES refraction errors.
5. POS-MV navigation data was logged statically for a minimum of 10 minutes prior to departure, then continuously throughout the day and for 10 minutes after arrival to port on completion of each day's survey operations. (In the event of a POS-MV failure and system restart; data must be logged for 10 minutes before resuming survey operations).
6. Cross lines are run to ensure good agreement of MBES data across the survey area and to generate cross-line statistics (Section 6.7) to demonstrate survey order achieved.
7. Data quality was monitored during acquisition by the vessel's online surveyor.
8. Close attention was paid to position accuracy thresholds during data acquisition.
9. Data was monitored online using the acquisition software listed in Table 6.
10. A series of alert displays were continuously monitored to ensure all data feeds and connections were active and functioning correctly throughout survey operations.

6.3 Post Data Acquisition QC Procedures

Navigation Data was checked for quality by the on-board data processor during first-pass QC processing.

Applanix POSPAC software was used to post-process the POS-MV data and resulting outputs were QC'd by evaluating plots of Altitude/Height, vertical RMS and satellite geometry.

MBES data was checked for quality using QPS Qimera & CARIS HIPS and SIPS software, in attitude editor and subset editor. Data density, survey statistics and error/uncertainty values were examined in this software to ensure IHO standards were maintained throughout (S44-Order 1a).



Final data processing work (outlined in Section 5 of this document) carried out on these survey datasets resulted in the delivery of a depth surface that was QC'd and corrected for erroneous positions and depths. Statistical analysis (presented in Section 6.7 of this document) was carried out on the dataset to demonstrate that the final product met all required specifications.

6.4 Survey Standard

The surveys reported on here were carried out to International Hydrographic Organization (IHO) Order 1a standard as per special publication S-44.

Table 18 describes the key requirements in order to meet these standards and represent the minimum standards for position and depth accuracy achieved during data acquisition.

Section 6.7 of this document presents the results of analysis carried out on survey cross-lines in order to determine the reliability/repeatability of depths obtained. The results provided demonstrate that the required IHO Order 1a standard was obtained for all survey legs during the INIS-Hydro project with greater than 95% confidence.

Table 18: IHO Standards for Hydrographic Surveys

	Order 1a (S-44)	Special Order (S-44)
Description of Areas	Shallower than 100m, features of concern to shipping.	Areas where under-keel clearance is critical
Max allowable THU (95%C)	Total Horizontal Uncertainty (THU) 5m+5% of depth	Total Horizontal Uncertainty (THU) 2 metres
Max allowable TVU (95%C)	See Figure 22	See Figure 22
Full Seafloor Search	Required	Required
Feature Detection	Cubic Features > 2m (Depths < 40m) 10% depth > 40m	Cubic Features > 1m

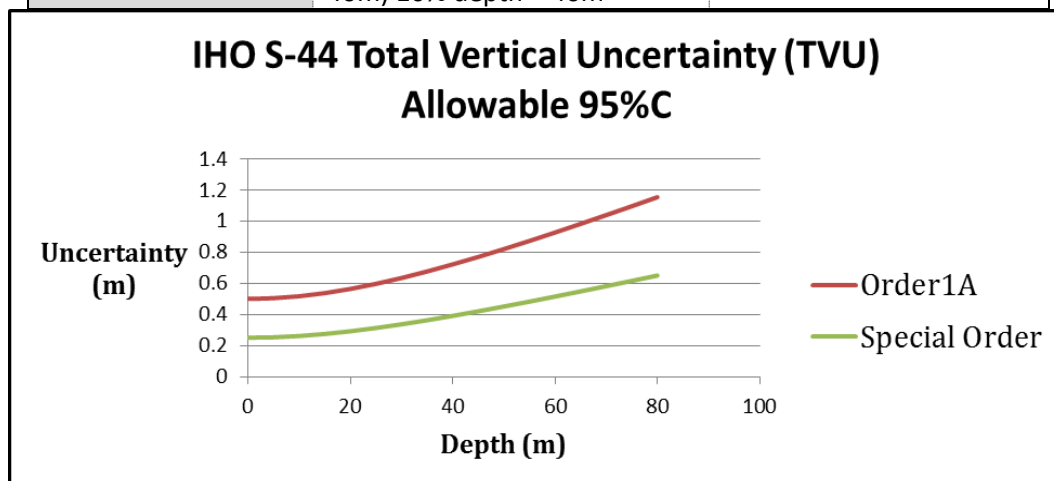


Figure 10: Maximum Allowable Total Vertical Uncertainty at 95% Confidence



6.5 CARIS Hips & Sips Total Propagated Uncertainty Models

Standard deviation values for offset, alignment and timing errors were applied to survey data as part of a Total Propagated Uncertainty (TPU) computation made in CARIS HIPS & SIPS software. This process allows TPU to be utilised during statistical data cleaning and surface generation as required.

The process in CARIS uses the same variables as described earlier. The main factor to note is the value applied for Sound Velocity Measurement Error (2.5 m/s). A further discussion on how environmental control was maintained over sound velocity conditions during survey operations is provided in Section 6.6.

Cross-Line Statistics presented in Section 6.7 which have been computed using levels of uncertainty listed in the subsections below have been demonstrated to be within IHO Order 1a standard at 95% confidence for all beam angles.

Table 19: 2016 Standard Deviation values used in TPU calculation

Propagator	Standard Deviation
Heave Error	2% of Heave Amplitude
Measurement Errors	0.005 m
Gyro Alignment Errors	0.05 deg
Pitch Alignment Errors	0.01 deg
Roll Alignment Errors	0.01 deg
Gyro Measurement Error	0.02 deg
Pitch Measurement Error	0.01 deg
Roll Measurement Error	0.01 deg
Navigation Measurement Error	0.03 m
Transducer Timing Error	0.002 s
Navigation Timing Error	0.002 s
Gyro Timing Error	0.002 s
Heave Timing Error	0.002 s
Pitch Timing Std Dev	0.002 s
Roll Timing Error	0.002 s
Sound Velocity Measurement Error	2 m/s
Surface Sound Velocity Measurement Error	0.1 m/s
Tide Measurement Error	0.08 m

6.6 Sound Velocity Regime and Environmental Control

To maintain control over the sound velocity regime in the survey area, frequent sound velocity profiles were acquired and generally survey lines were restricted to small geographic areas and survey blocks especially when closer to shore.

Target thresholds for sound velocity uncertainty in the order of 2m/s were deemed adequate for maintaining environmental control during survey operations. In areas of highly variable water column structure, this is not always possible.



6.7 Cross-line Statistics

Survey lines run perpendicular to the general trend of survey main-lines were acquired during the CHERISH North Wales 2019 survey. Due care was taken to run cross-lines in optimum weather conditions. Sound velocity profiles were acquired at the beginning or end of each line to ensure good environmental control was maintained over the water-column.

Where necessary, further filtering of outer beam angles was undertaken during data processing. The resultant data was fully processed and used to generate a “true” depth surface.

A quality control examination of the mainline data using CARIS HIPS & SIPS software was undertaken by comparing survey mainlines against the “true” surface computed using cross-line data.

Analysis was conducted across the entire range of potential beam angles (up to 150 degrees) in sectors of 5 degrees for each survey leg.

Results demonstrate the order of survey achieved and are presented below for the 2019 CHERISH North Wales dataset (Table 20 and Table 21). Vessel track-lines are illustrated in Results Section 8.1. This imagery illustrates the location of the cross-lines used for QC. Due to the shallow nature of Sarn Badrig (0—14m), these statistics have been separated from the others.

Table 20: KRY19_02 Cross-line Statistics for Sarn Badrig

Beam Angle (deg)	Count	Max (+)	Min (-)	Mean	Std Dev	Special Order (%)	Order 1a (%)
-75.0 - -70.0	174,267	0.220	0.372	-0.041	0.066	99.414	100.000
-70.0 - -65.0	704,683	0.312	0.431	-0.035	0.061	99.906	100.000
-65.0 - -60.0	512,249	0.263	0.447	-0.034	0.057	99.898	100.000
-60.0 - -55.0	387,732	0.435	0.466	-0.033	0.057	99.879	100.000
-55.0 - -50.0	303,365	0.577	0.486	-0.031	0.058	99.803	99.991
-50.0 - -45.0	246,255	0.308	0.495	-0.030	0.057	99.864	100.000
-45.0 - -40.0	208,323	0.239	0.414	-0.031	0.057	99.954	100.000
-40.0 - -35.0	179,514	0.264	0.455	-0.031	0.058	99.926	100.000
-35.0 - -30.0	159,973	0.267	0.497	-0.033	0.057	99.934	100.000
-30.0 - -25.0	144,860	0.241	0.312	-0.033	0.057	99.932	100.000
-25.0 - -20.0	132,620	0.239	0.319	-0.034	0.057	99.903	100.000
-20.0 - -15.0	124,699	0.238	0.357	-0.034	0.057	99.881	100.000
-15.0 - -10.0	118,879	0.333	0.373	-0.034	0.057	99.796	100.000
-10.0 - -5.0	169,886	0.264	0.358	-0.034	0.058	99.848	100.000
-5.0 - 0.0	224,776	0.238	0.375	-0.035	0.056	99.877	100.000
0.0 - 5.0	228,754	0.277	0.376	-0.035	0.056	99.916	100.000
5.0 - 10.0	165,362	0.272	0.360	-0.034	0.057	99.906	100.000
10.0 - 15.0	116,922	0.235	0.381	-0.035	0.058	99.855	100.000
15.0 - 20.0	121,686	0.370	0.387	-0.036	0.059	99.851	100.000



20.0 - 25.0	130,455	0.261	0.325	-0.036	0.058	99.919	100.000
25.0 - 30.0	142,644	0.283	0.360	-0.035	0.059	99.907	100.000
30.0 - 35.0	158,283	0.301	0.400	-0.035	0.059	99.846	100.000
35.0 - 40.0	178,036	0.224	0.381	-0.035	0.058	99.842	100.000
40.0 - 45.0	206,321	0.257	0.442	-0.035	0.059	99.745	100.000
45.0 - 50.0	245,198	0.324	0.483	-0.035	0.058	99.822	100.000
50.0 - 55.0	300,597	0.251	0.502	-0.036	0.058	99.782	100.000
55.0 - 60.0	379,748	0.250	0.425	-0.039	0.058	99.795	100.000
60.0 - 65.0	501,463	0.294	0.436	-0.042	0.057	99.849	100.000
65.0 - 70.0	671,118	0.397	0.396	-0.042	0.059	99.795	100.000
70.0 - 75.0	136,412	0.398	0.416	-0.050	0.067	98.700	100.000

Table 21: KRY19_02 Cross-line Statistics for regions excluding Sarn Badrig

Beam Angle (deg)	Count	Max (+)	Min (-)	Mean	Std Dev	Special Order (%)	Order 1a (%)
-75.0 - -70.0	553,806	0.296	1.315	-0.012	0.104	94.770	99.475
-70.0 - -65.0	823,275	0.249	0.935	-0.056	0.131	89.886	99.397
-65.0 - -60.0	575,345	0.194	1.241	-0.052	0.124	90.449	99.765
-60.0 - -55.0	434,357	0.200	0.736	-0.049	0.121	91.070	99.842
-55.0 - -50.0	346,398	0.487	1.364	-0.043	0.116	92.091	99.921
-50.0 - -45.0	285,581	1.228	1.325	-0.041	0.114	92.525	99.921
-45.0 - -40.0	241,606	0.816	1.238	-0.042	0.114	92.696	99.889
-40.0 - -35.0	208,611	0.790	0.714	-0.041	0.113	92.782	99.929
-35.0 - -30.0	185,571	0.216	0.965	-0.043	0.113	92.713	99.894
-30.0 - -25.0	167,134	0.167	0.909	-0.042	0.111	92.925	99.900
-25.0 - -20.0	154,151	0.194	0.767	-0.043	0.110	92.931	99.927
-20.0 - -15.0	144,446	0.182	1.042	-0.044	0.109	93.222	99.898
-15.0 - -10.0	137,966	0.183	1.093	-0.045	0.110	93.112	99.864
-10.0 - -5.0	180,335	0.182	1.015	-0.061	0.117	90.850	99.919
-5.0 - 0.0	248,890	0.202	0.670	-0.045	0.109	92.852	99.947
0.0 - 5.0	252,269	0.210	0.942	-0.045	0.109	92.916	99.905
5.0 - 10.0	174,532	0.248	0.915	-0.058	0.116	91.504	99.820
10.0 - 15.0	135,136	0.246	1.138	-0.044	0.109	93.149	99.845
15.0 - 20.0	142,423	0.312	1.260	-0.044	0.109	93.469	99.824
20.0 - 25.0	150,751	0.252	1.420	-0.042	0.111	93.318	99.804
25.0 - 30.0	164,197	0.902	1.375	-0.040	0.110	93.240	99.821
30.0 - 35.0	181,733	0.634	0.885	-0.040	0.109	93.268	99.874
35.0 - 40.0	204,990	0.823	1.131	-0.041	0.113	92.891	99.778
40.0 - 45.0	235,762	0.989	1.228	-0.043	0.116	92.688	99.691
45.0 - 50.0	277,435	0.495	1.409	-0.043	0.120	92.246	99.619
50.0 - 55.0	340,952	1.243	1.422	-0.045	0.122	92.199	99.610
55.0 - 60.0	436,589	1.216	1.470	-0.049	0.123	91.818	99.583
60.0 - 65.0	587,011	0.743	1.506	-0.051	0.123	91.644	99.683



65.0 - 70.0	843,806	0.794	1.233	-0.051	0.126	91.250	99.456
70.0 - 75.0	492,427	1.111	1.386	-0.014	0.111	94.703	99.125

6.8 System Checks and Calibration

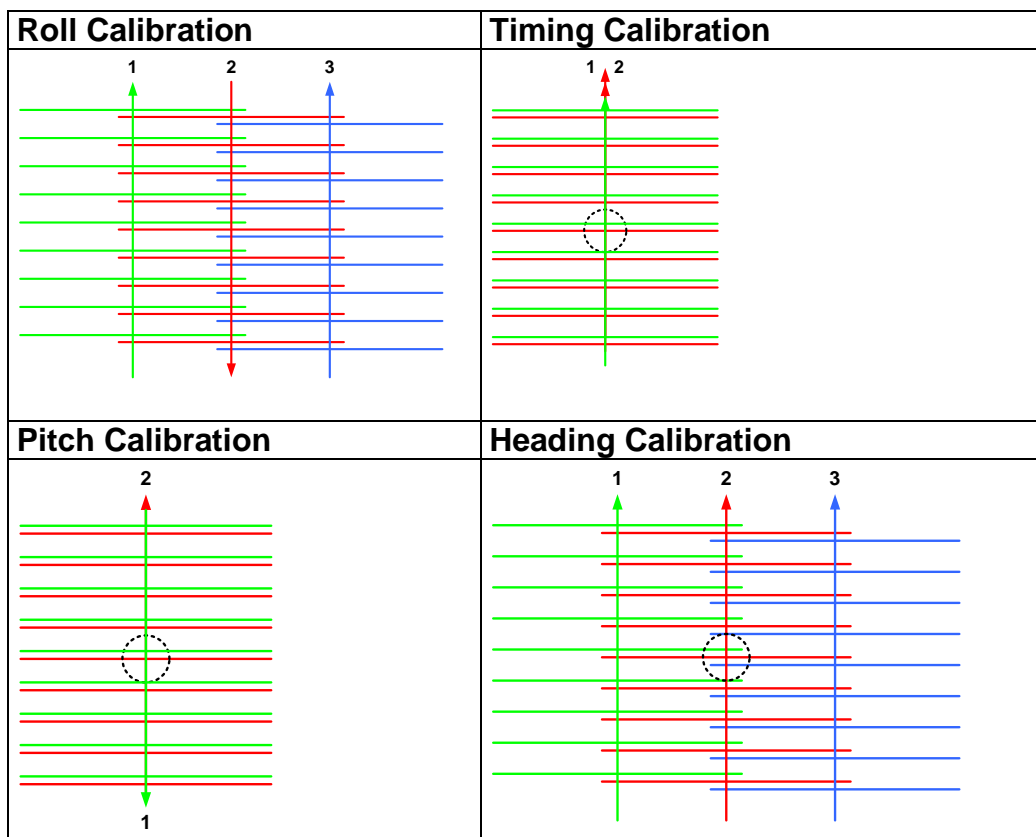
6.8.1 Calibration Patch Tests

A full set of tests and checks were carried out for each vessel at the outset of 2019 INFOMAR survey operations. The accuracies of these outcomes were validated periodically through standard patch tests and QA'd by the on board data processors as survey operations were being undertaken.

Where values for roll, pitch and heading were deemed to require modification, these changes were generally applied in the CARIS vessel file by the on-board data processor. A full record of these modifications may be accessed by opening the vessel file for each specific survey. A description of the work-flow applied during vessel patch tests is illustrated below.

Further details concerning calibration and validation checks implemented during the 2019 survey leg are provided in the individual survey leg reports which are available on request from INFOMAR project management.

Table 22: Standard Patch Test Calibration Run Lines



6.9 Sounding Density

Sounding densities for 2019 CHERISH North Wales survey were examined in CARIS HIPS & SIPS software as part of a standard QC process, ensuring that the density of soundings in the survey area met requirements. Correct sounding densities are achieved and QA'd during data acquisition through setting appropriate vessel speeds, high ping rates (up to 50Hz) and high swath overlap (typically 15-25%, yielding a total seafloor search). The final QC process was conducted as follows;

The final QC process was conducted as follows;

1. A "Base Surface" was created in CARIS HIPS & SIPS which was configured to display data density.
2. The surface was gridded at 2 metres and set to display areas with more than 9 "hits" per 2m² grid as GREEN, areas with 4-9 "hits" per cell as YELLOW and areas with less than 4 "hits" per cell as RED
3. The sounding density base surfaces are available as part of the final data delivery.
4. Through this QC process, UKHO sounding density requirements for shallow water surveys (9+ soundings within a 2 metre bin size) are demonstrated to meet the required specifications and figures illustrating the results of this QC analysis for each survey leg are provided in this section of this document.

Excluding cells at the extreme periphery of the data, there was complete coverage of >9 "hits" per 2m² grid.

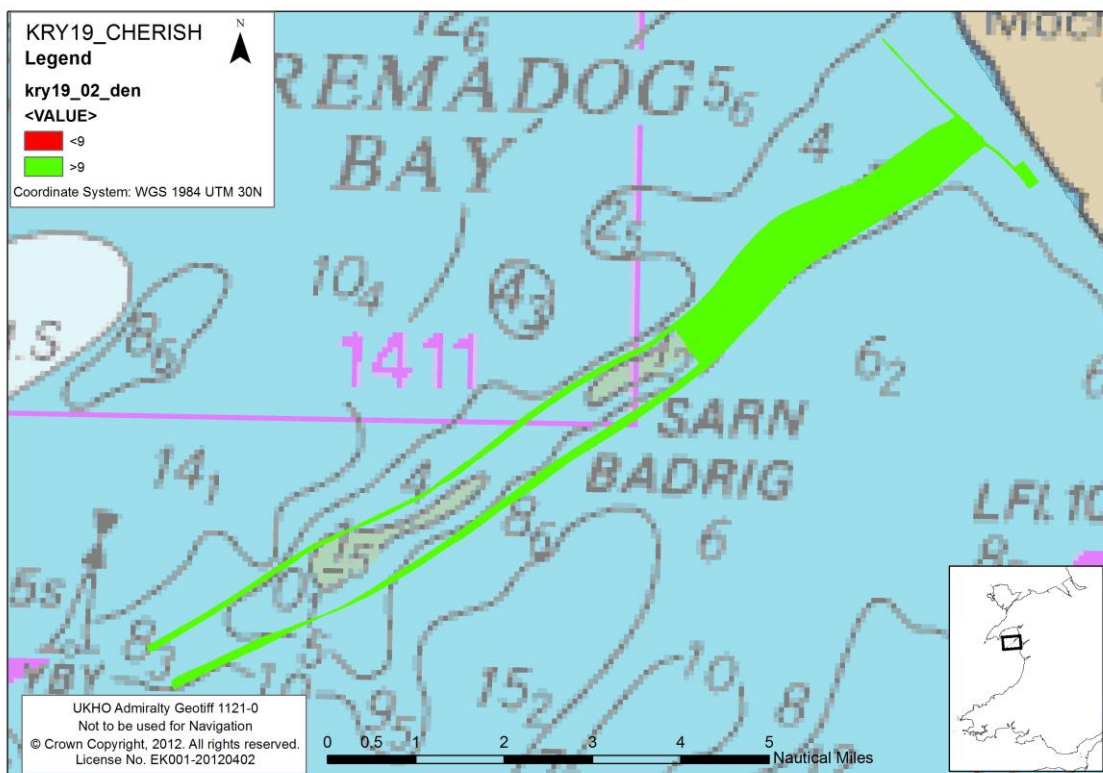


Figure 11: KRY19_02 Sounding Density from Sarn Badrig region: 2m² Base Surface



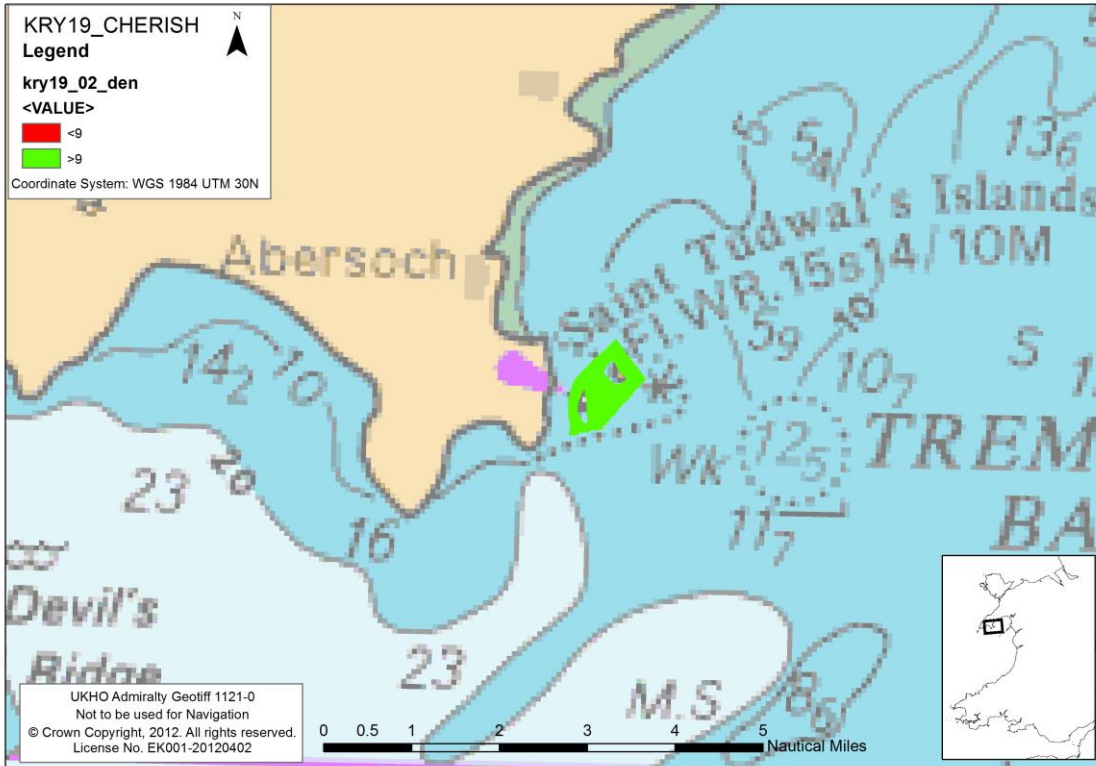


Figure 12: KRY19_02 Sounding Density from St Tudwal's Islands region: 2m² Base Surface

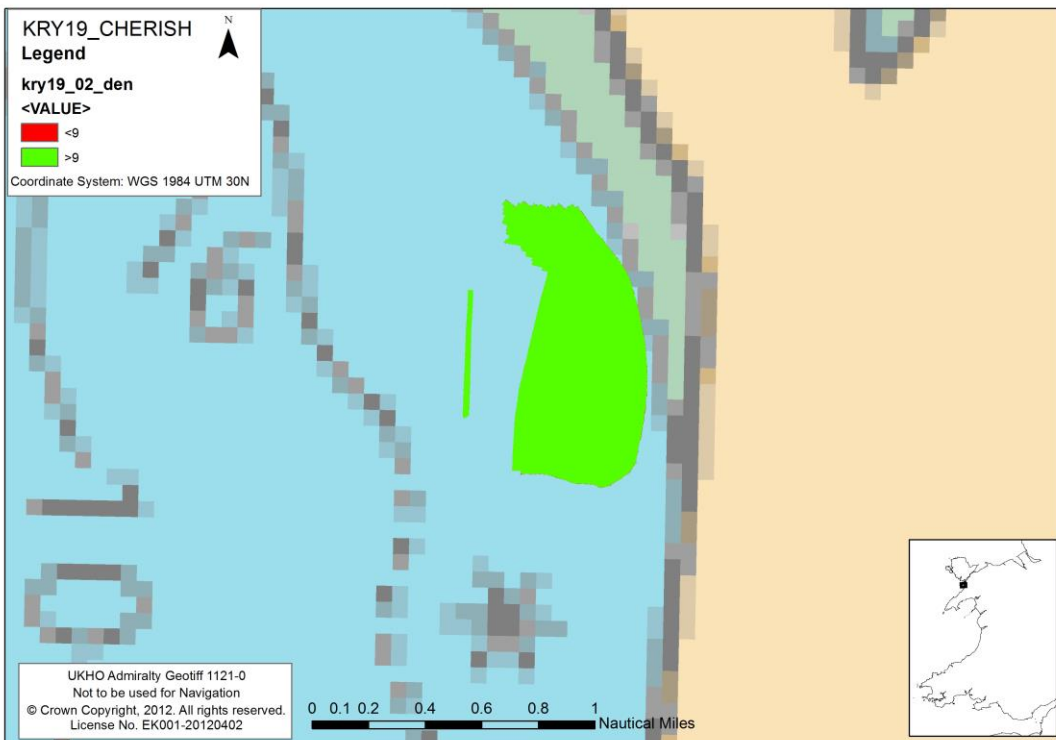


Figure 13: KRY19_02 Sounding Density from Dinas Dinlle region: 2m² Base Surface



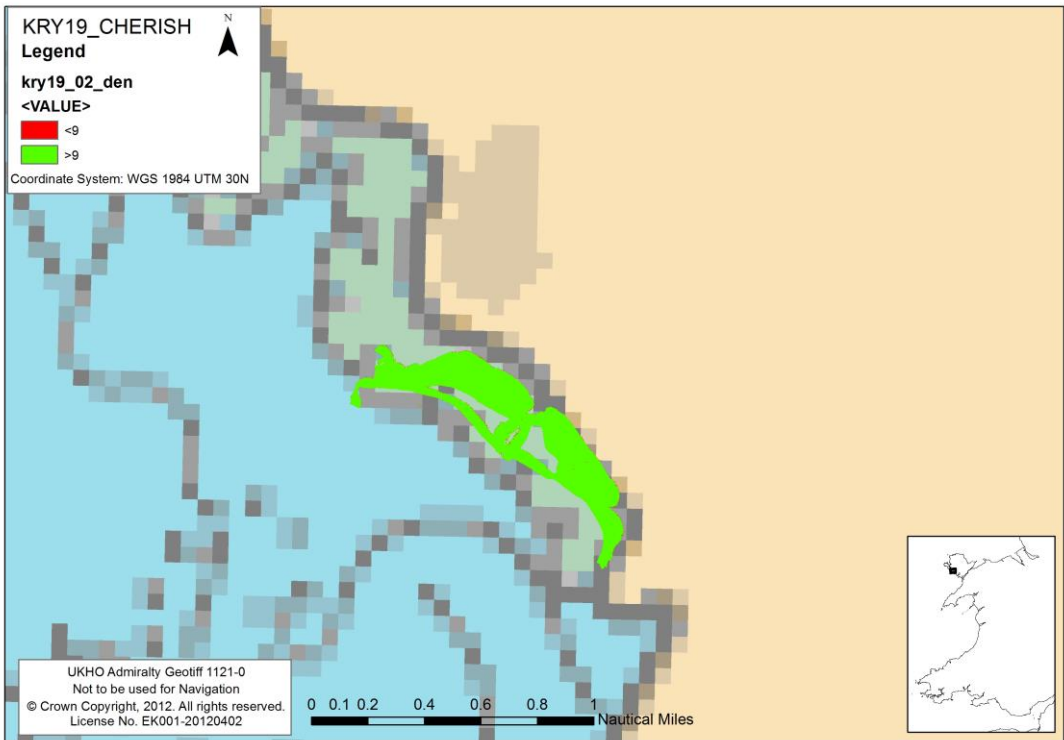


Figure 14: KRY19_02 Sounding Density from Rhosneigr region: 2m² Base Surface

6.10 Ground truthing

Ground truthing was not carried out as part of the 2019 CHERISH North Wales survey.



7 Data Deliverables

7.1 Data Structure and Management

Survey Data was stored on-board the survey vessels within a standardised directory structure system. The table below provides a generalised overview of the system. This structure can vary slightly on given survey legs due to varying requirements.

Table 23: Survey Data Directory Structure

Main Directory	Sub Directories	Comments
Administration	GIS	
	Images	
	Party-Chief	
	Reporting	
Geophysical	SBP	
Multibeam	CARIS	Final, fully-cleaned soundings
	Deliverables	Standard outputs
	GSF	All tidal and motion corrections applied, but may have spurious soundings
	MBES-Raw-Data	Raw data
	Processing Log	
Positioning	Navigation	
Singlebeam	EA400	
Sound-Velocity	CARIS-SVP	

7.2 Data Deliverables

The table below lists the standard deliverables that are available once final data processing is completed.

Table 24: Survey Deliverables

Data Deliverable	Description
CARIS Project	CARIS HIPS & SIPS project containing all finalised survey data separated by survey vessel and survey leg.
MBES xyz soundings	Hydrographically corrected depth soundings for charts
Grids and Raster images	Bathymetry Backscatter (Seabed Texture) Shaded Relief Fledermaus DTMs / Scene files



Geotiff imagery and Google Earth files.	Geo-referenced TIFF images KMZ files can be opened using Google Earth.
Shp files / Point information	Spatial coverage (Survey area) Ship tracklines. SVP locations Investigations (Wreck and Shoal)
Auxiliary Datasets	CHIRP Sub-bottom data SBES data Daily Progress Reporting H-Forms Crew Lists Incident Records
Report of Survey	Over-arching Report of Survey Document detailing survey methodologies and data delivery

To get a copy of data associated with the survey, please request it from the CHERISH project by contacting info@cherishproject.eu.



8 Survey Results

8.1 Bathymetry

The GSI acquired high resolution bathymetry using MBES mapping systems with the R.V. Keary in from four locations around North Wales from 01/07/2019 to 12/07/2019. The four locations are described for the purposes of this report as: Sarn Badrig, St Tudwal’s Islands, Dinas Dinlle and Rhosneigr. Due to the shallow water depths of Sarn Badrig, surveying was conducted only when water conditions permitted. During low tide levels, the vessel moved to the nearby region of St Tudwal’s Islands.

The resulting datasets were acquired to IHO Order 1a standard or higher. Figures illustrating the resultant bathymetry coverage and corresponding track-lines are provided below.

8.1.1 Sarn Badrig

12.7 km² was surveyed across 138 survey lines covering 394.2 km in the Sarn Badrig region. Depths ranged from -14.86 to 0.33 m, with a mean depth of -6.68 ± 2.59 m (s.d.). The whole length of the reef was surveyed as reconnaissance for this and any future surveying. Following reconnaissance, the shallow part of the reef was surveyed to provide context for the wreck of “The Diamond” and to permit seamless onshore/offshore maps to be conducted.

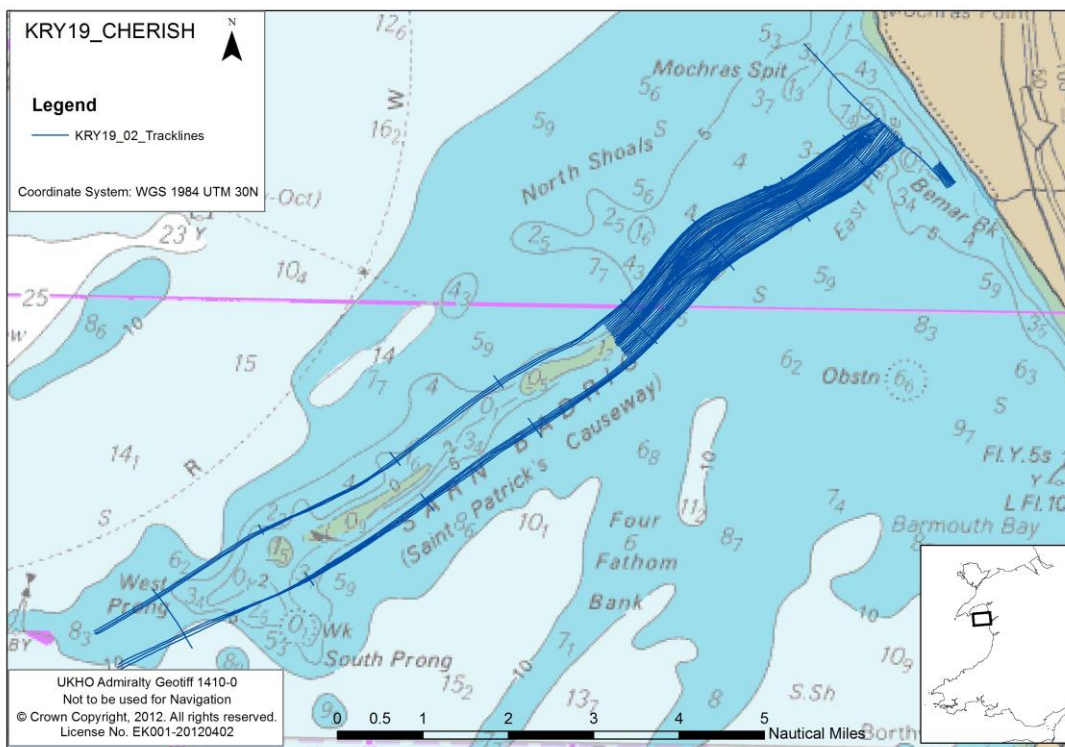


Figure 15: Vessel tracklines for Sarn Badrig, including crosslines

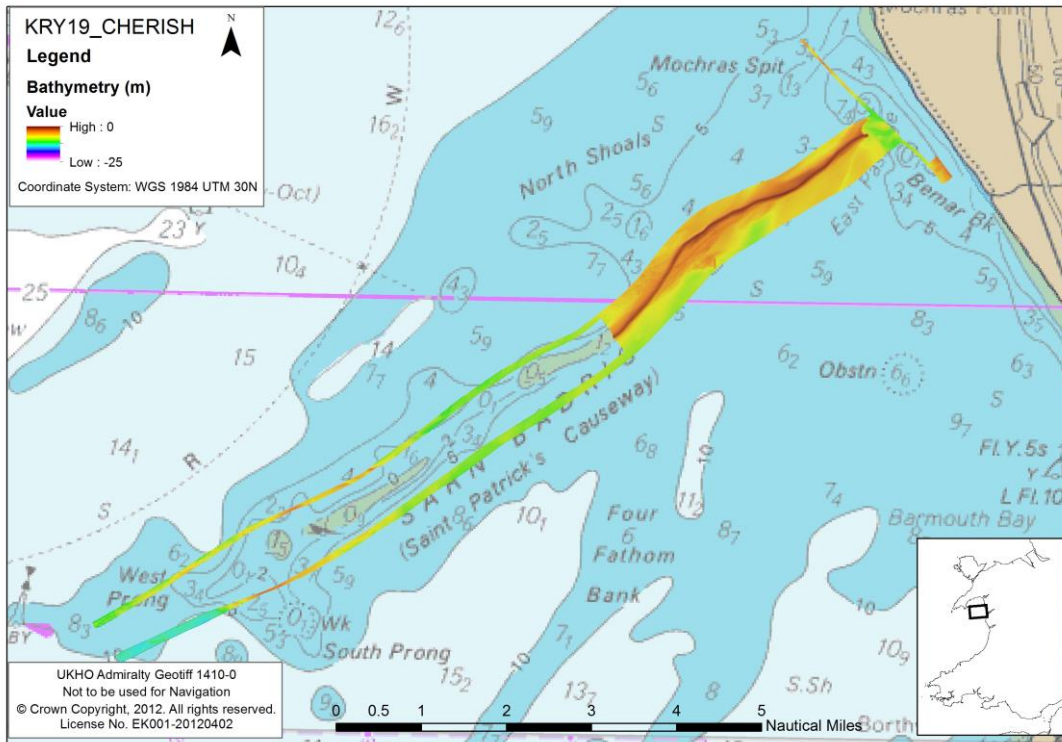


Figure 16: Bathymetry coverage for Sarn Badrig

Results indicate a narrow (~80 m), sinuous ridge along the apex of the reef. This is up to 4 m higher than surrounding seafloor and is situated at depths of 0 – 2 m. The north of the reef is shallower than the southern side.

8.1.2 St Tudwal's Islands

1.7 km² was surveyed across 76 survey lines covering 56.9 km off St Tudwal's Islands. Depths ranged from -22.6 to 1.38 m, with a mean depth of -10.2 ± 4.9 m (s.d.). The entire surrounds of the islands were surveyed to permit seamless onshore offshore maps to be created.

Shallow seafloor (-5 m) exists to the north of the islands, with deeper seafloor located to the south. There is a narrow, shallow (0 - -3m) reef extending northwards of the western island.



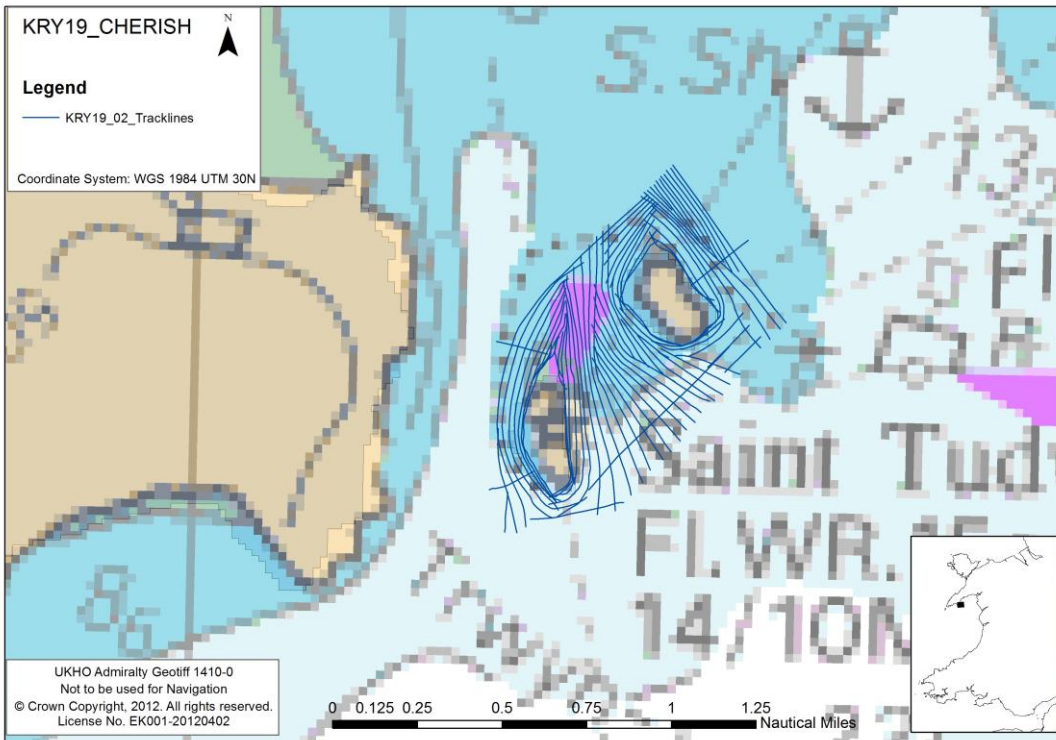


Figure 17: Vessel tracklines for St Tudwal's Islands, including crosslines

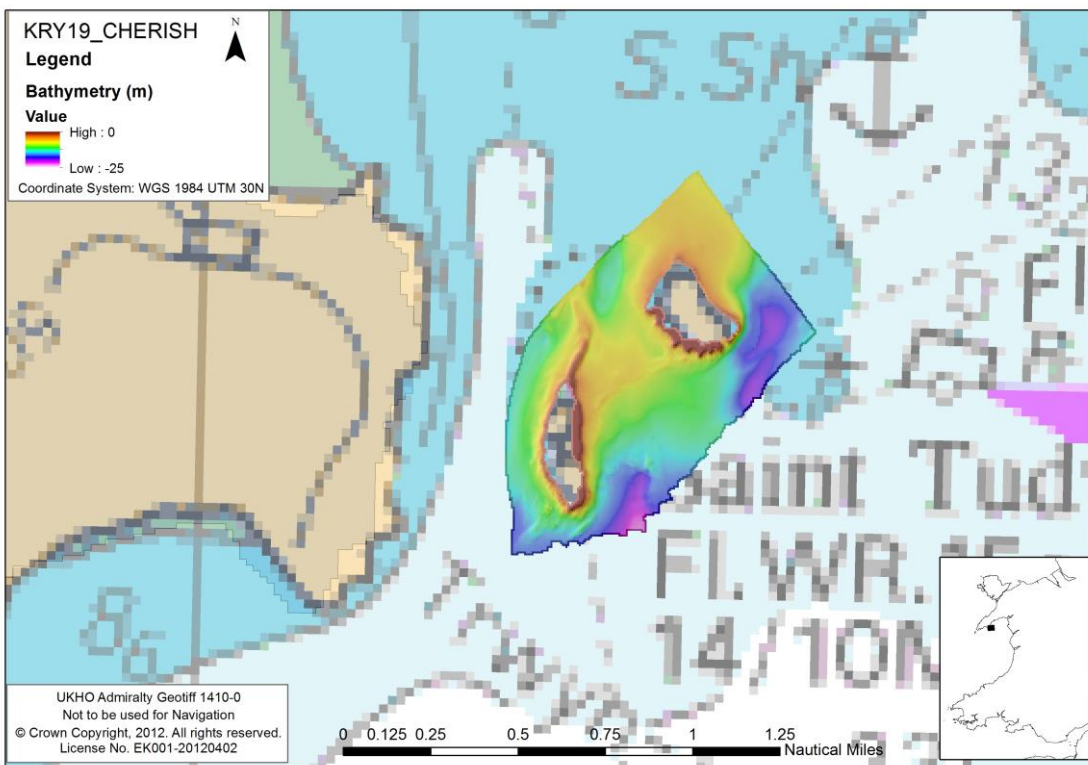


Figure 18: Bathymetry coverage for St Tudwal's Islands

8.1.3 Dinas Dinlle



1.3 km² was surveyed across 60 survey lines covering 84.8 km off Dinas Dinlle. Depths ranged from -5.39 to 0.40 m, with a mean depth of -2.61 ± 1.3 m (s.d.). The bathymetry was extended onshore as much as possible to facilitate a seamless onshore-offshore map to be created. There are no significant geomorphological features, with a generally smooth seafloor recorded.

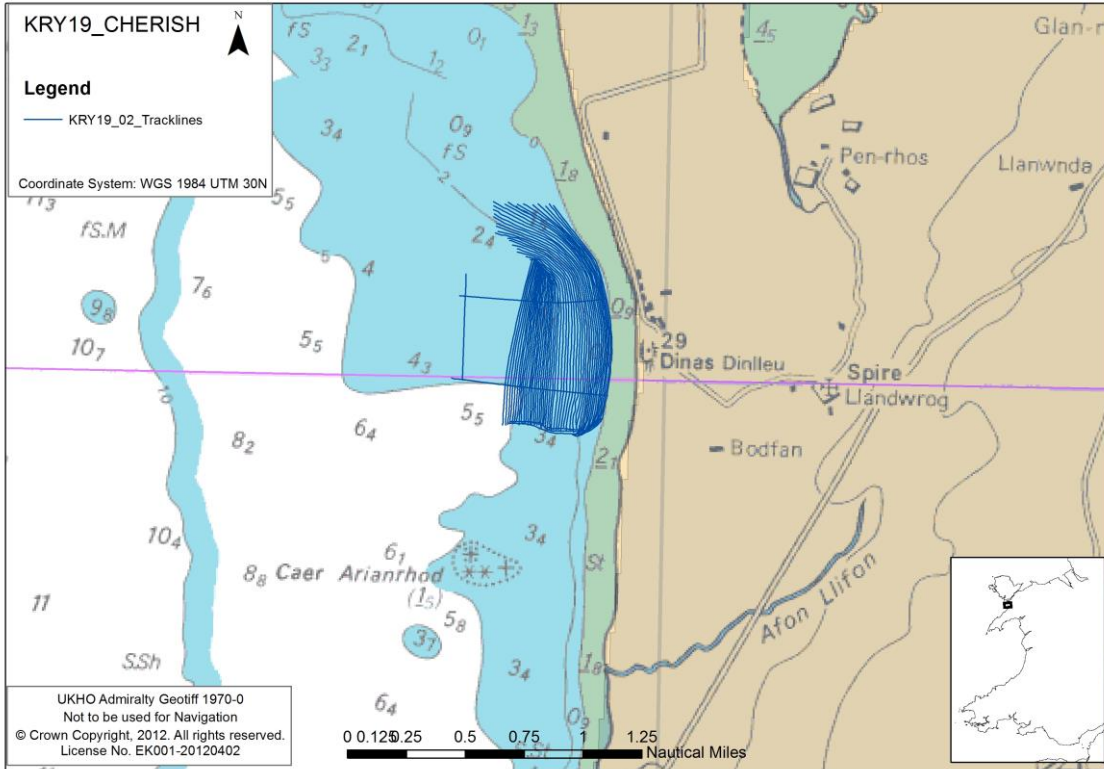


Figure 19: Vessel tracklines for Dinas Dinlle, including crosslines



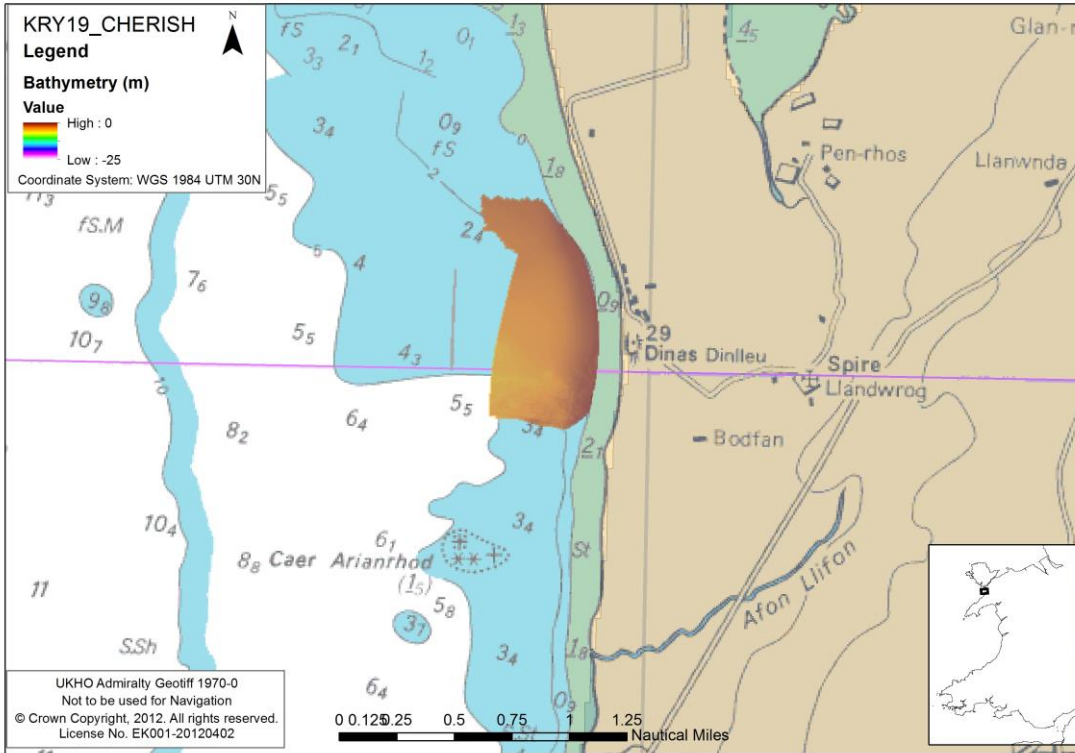


Figure 20: Bathymetry coverage for Dinas Dinlle

8.1.4 Rhosneigr

0.6 km² was surveyed across 39 survey lines covering 29.7 km off Rhosneigr. Depths ranged from -6.92 to 1.5 m, with a mean depth of -2.06 ± 1.5 m (s.d.). The bathymetry was extended onshore as much as possible to facilitate future creation of a seamless onshore-offshore map. The seabed is a mixture of rocky outcrops surrounded by soft sediment. In the northwest, rock outcrop extends out from the shore.



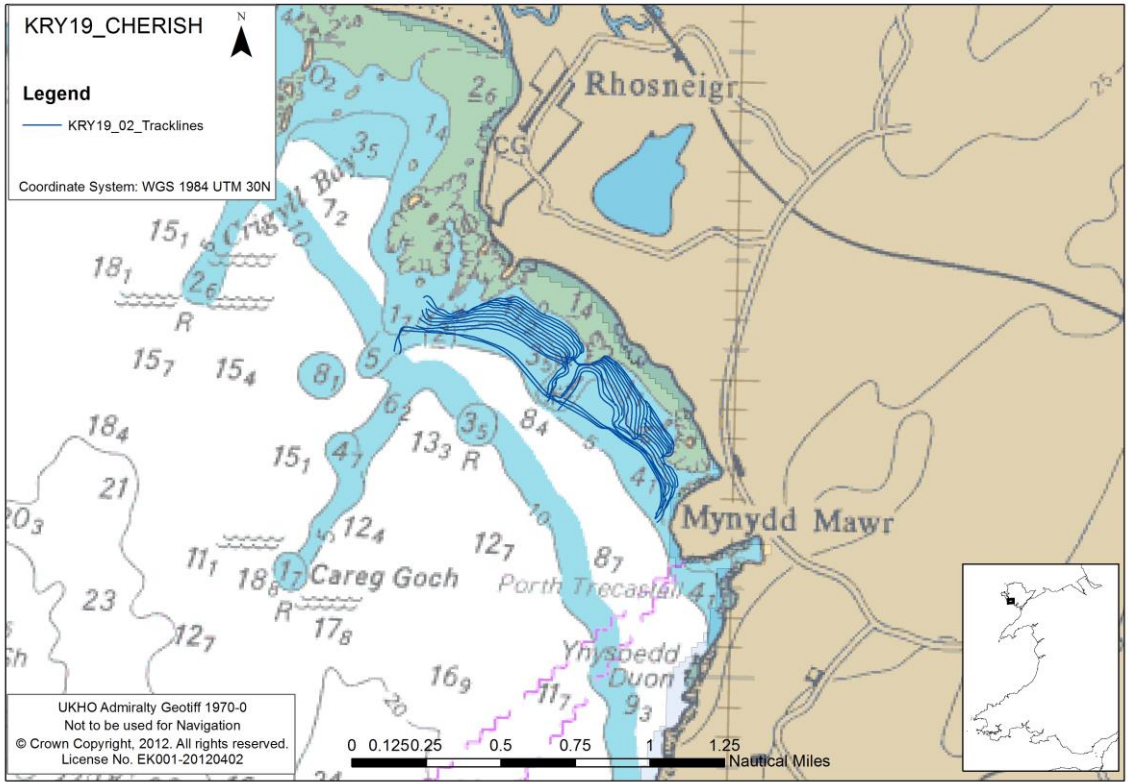


Figure 21: Vessel tracklines for Rhosneigr, including crosslines

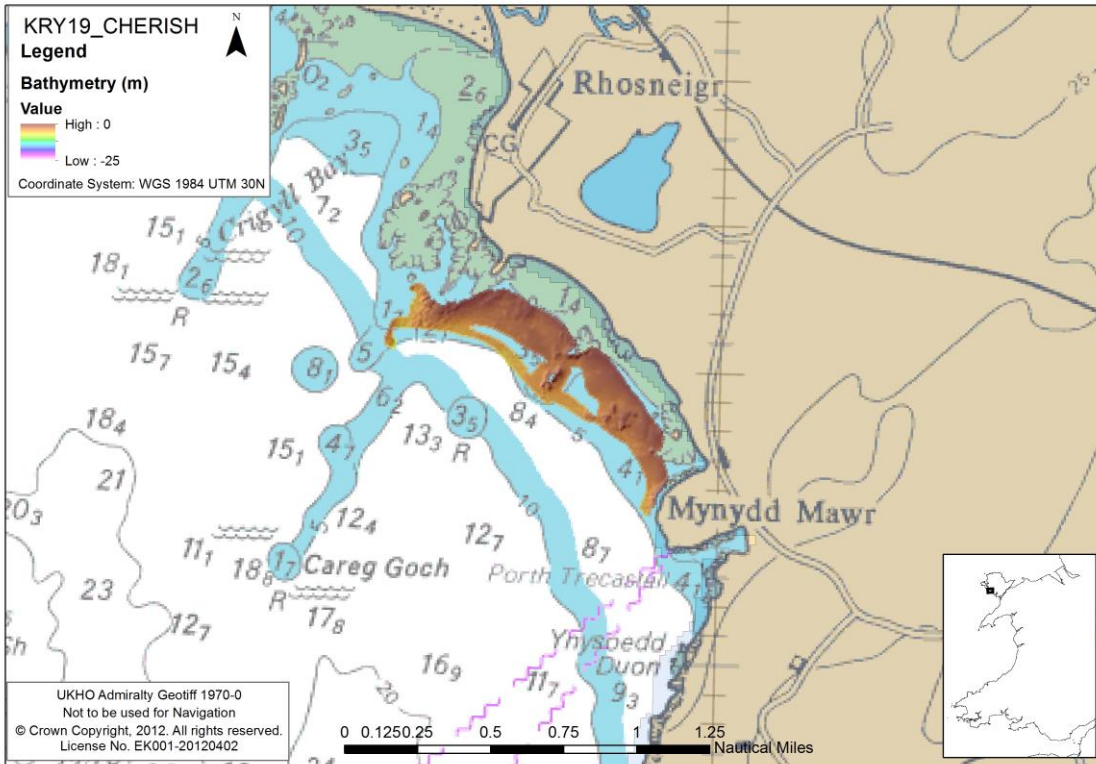


Figure 22: Bathymetry coverage for Rhosneigr



8.2 Backscatter Data

Backscatter from KRY19_02 has been compiled into the Backscatter mosaics shown in the figures below. Harder substrate (e.g. bedrock or gravel) returns a higher backscatter signal than softer substrate (e.g. muds). All locations show a diverse seabed type with both hard and soft substrates present

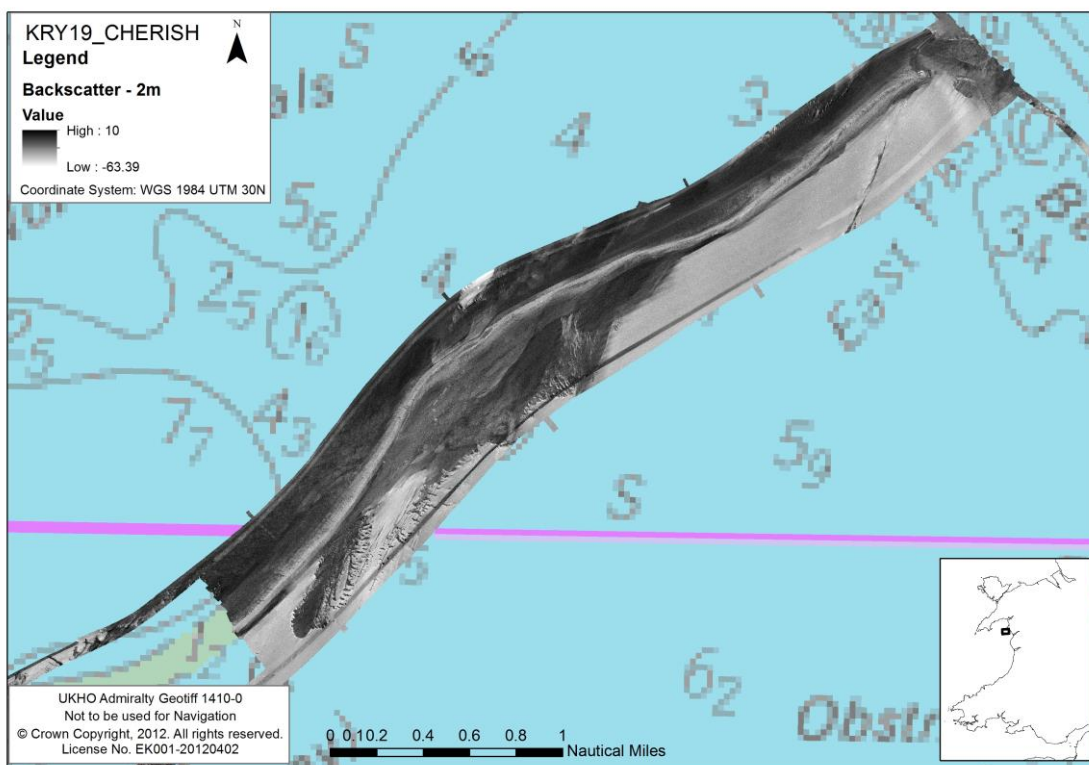


Figure 23: Backscatter coverage (2m grid) for Sarn Badrig



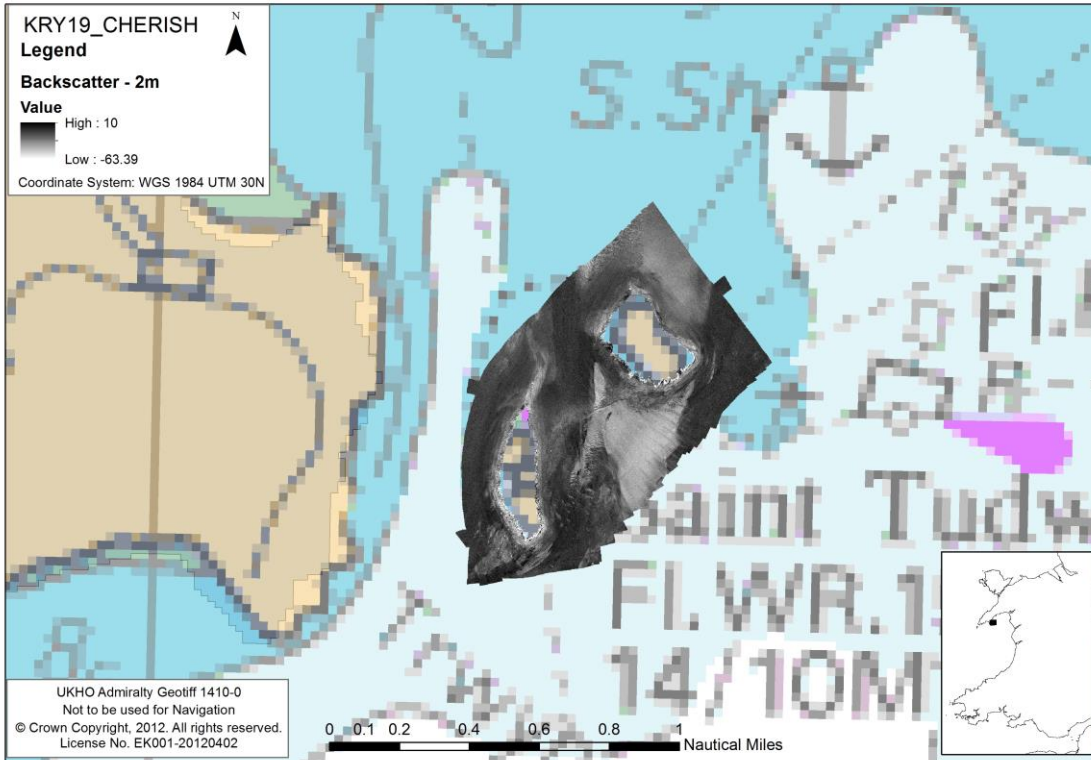


Figure 24: Backscatter coverage (2m grid) for St Tudwal's Islands

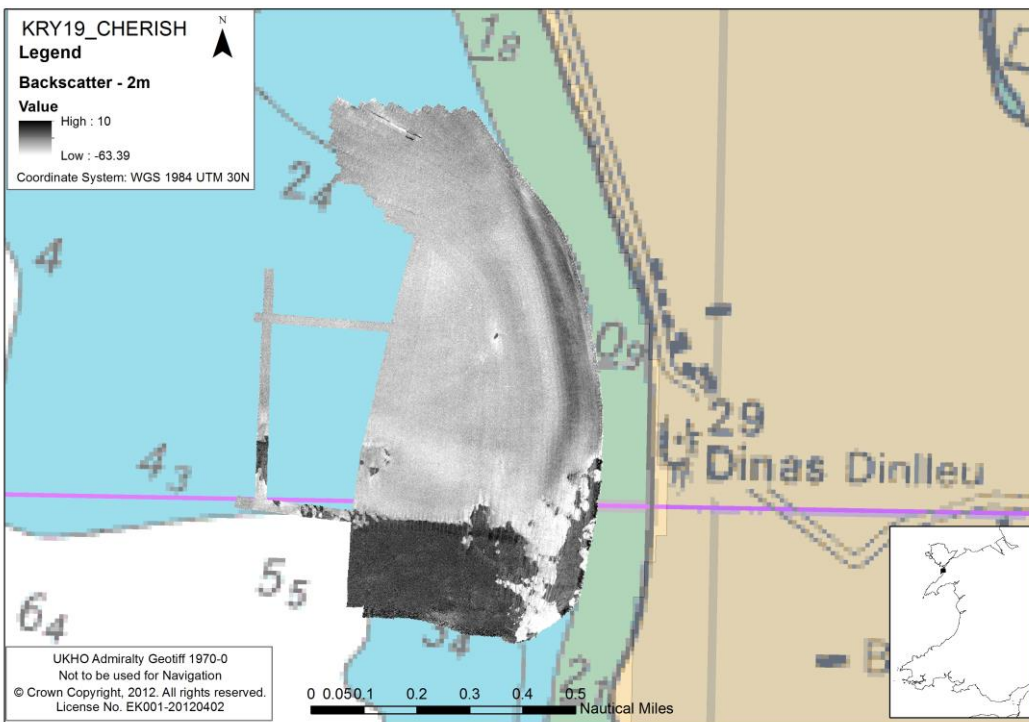


Figure 25: Backscatter coverage (2m grid) for Dinas Dinlle



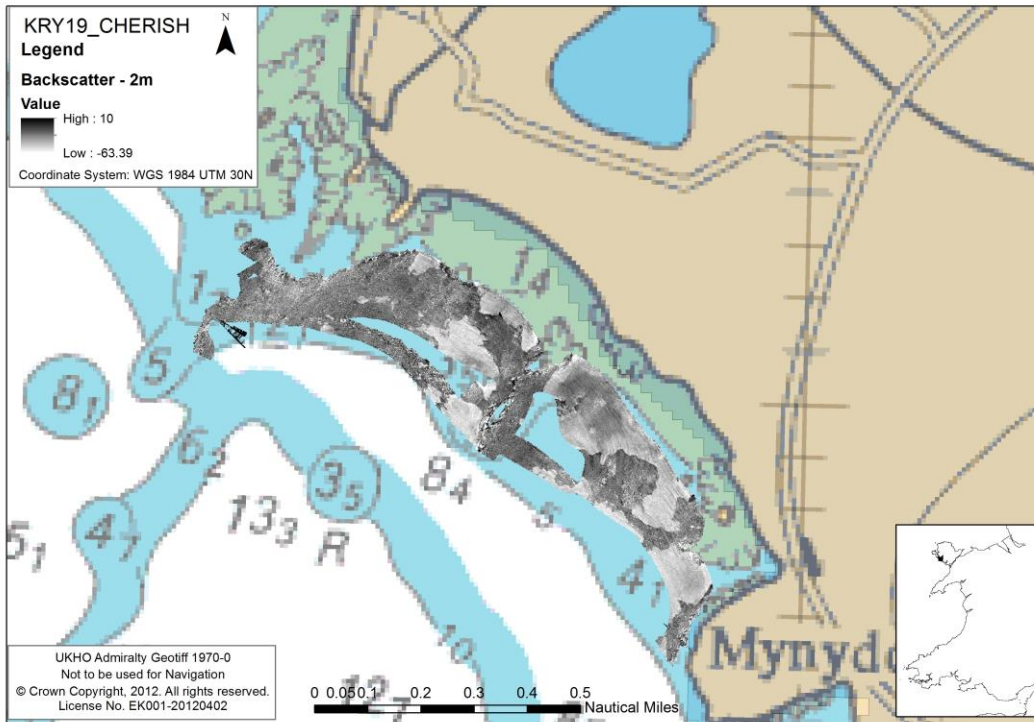


Figure 26: Backscatter coverage (2m grid) for Rhosneigr

8.3 Shallow Seismic Data

Shallow seismic data was acquired by the R.V. Keary during the CHERISH North Wales 2019 survey.

Details of the dataset acquired are provided in Section 4.3 and the locations of the various ship track-lines may be viewed in Section 8.1 of this document.

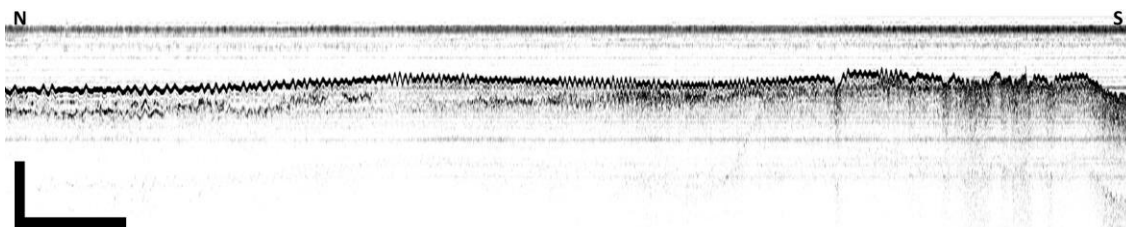


Figure 27: Example of shallow seismic data from Line 0301. Vertical scale bar 5m, horizontal scale bar 100m

8.4 Wreck Surveys

One shipwreck was surveyed (Table 25). The remains of the “Diamond” was recorded, with a clear outline of hull and debris field. A number of depressions 0.02-0.06 m in depth are located to the south and west and within 12m of the wreck.



Table 25: Wrecks surveyed in North Wales

Wreck	Northing	Easting	Result
Diamond	52.77552°	-4.18375°	Full multibeam survey completed

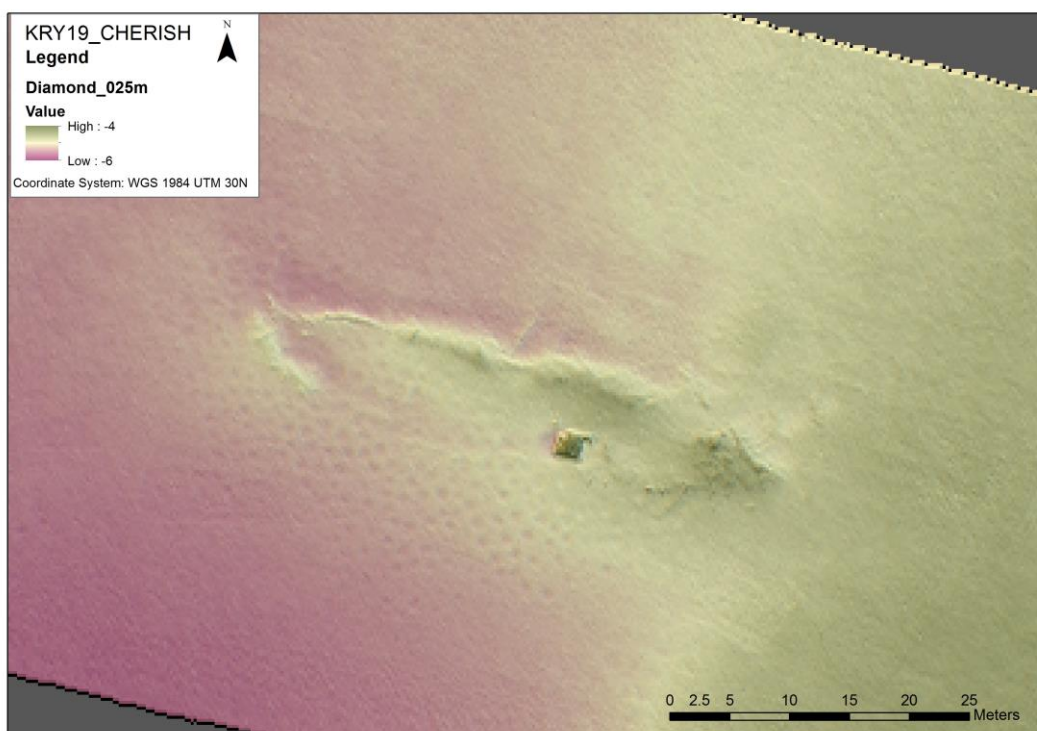


Figure 28: Locations of Wreck survey of the Diamond. See Figure 3 for location

8.5 Seabed Contacts

Multiple contacts requiring reporting to UKHO through a H102 form were made during the course of the project and this is detailed in section 8.6. All sounding data has been supplied to the UKHO.

8.6 Shoal Investigations (H102 Forms)

Two H102 forms were submitted to the UKHO arising from the CHERISH North Wales 2019 survey. These are detailed in Annex 3 with a total of 21 observations made.

H102-KRY19_02-01

Shoal feature shift from sand bank on the Sarn Badrig. Shoal feature observed rising to a depth of



0.4m in an area charted at 5.6m beside a featured bank. The sand bank has clearly shifted outside the bounds of the charted Sarn Badrig

H102-KRY19_02-02

Rock feature north of St. Tudwal's Island. Shoal feature observed rising to a depth of 0.4m in an area charted at 1.6m north of St Tudwal's Island

8.7 Marine Mammal Observations

Marine mammal observation was conducted following the JNCC guidelines for minimising the risk of injury to marine mammals from geophysical surveys (August 2017). Details on marine mammal observations can be found in Annex 3: MMO Report CHERISH North Wales 2019.

8.8 Seabed Sampling and Ground-truthing

Seabed sampling was not carried out as part of the 2019 CHERISH North Wales survey.



9 Conclusion

9.1 Conclusions and Final Remarks

All survey work was carried out to IHO S-44 Order 1a Standard.

Bathymetry datasets from 2019 CHERISH North Wales survey leg has been combined, finalised and H.102 notes delivered to UKHO for updating nautical charts and publications in offshore waters to improve safety for mariners.

Sarn Badrig, Dinas Dinlle and Rhosneigr were successfully surveyed to drying heights. The waters around St Tudwal's Islands were successfully surveyed. Bathymetry will be combined with topographical maps of headlands to provide seamless offshore-onshore maps. These maps will provide the framework for understanding the impacts of climate change to heritage in these coastal regions.

Increased cleaning of depth soundings was required in Sarn Badrig to produce a coherent seabed. A lot of noise was present, with many spurious soundings above and below seabed. It is possible the shallow nature of Sarn Badrig, in combination with strong tides and a sandy substrate caused the increased noise.

Surveyed wrecks may be re-surveyed before the completion of the CHERISH project (ending 2022) to assess the impacts of climate change on their preservation



10 References

IHO Standards for Hydrographic Surveys (S-44) 5th Edition 2008

JNCC guidelines for minimising the risk of injury to marine mammals from geophysical surveys:
August 2017

NP 40 Irish Coast Pilot Sailing Directions

UK Civil Hydrography Programme – Survey Specification 2013

UKHO Guides for UKHO notices NP100

UKHO ENC GB302049

UKHO VORF Model





Roinn Cumarsáide, Gníomhaithe
ar son na hAeráide & Comhshaoil
Department of Communications,
Climate Action & Environment



Geological Survey
Suirbhéireacht Gheolaíochta
Ireland | Éireann



CHERISH

Newid Hinsawdd a Threftadaeth yr Afodir
Climate Change and Coastal Heritage
Athrú Aeráide agus Oidhreacht Chultúrtha



Annex 1

Hydrographic Note 102 North Wales 2019





HYDROGRAPHIC NOTE

H.102
(V8.0 Oct 2014)

Date	11/11/2019	Ref. Number	H102-KRY19_02		
Name of ship or sender	Geological Survey of Ireland R.V. Keary				
IMO number if applicable	-				
Address	Beggars Bush, Haddington Road, Dublin 4, Ireland				
E-mail/Tel/Fax of sender	charise.mckeon@gsi.ie				
General Locality	Tremadoc Bay Wales				
Subject	Shoal Feature shift from sand bank on the Sarn Badrig				
Position (see <i>Instruction 2</i>)	Latitude	52.785123N		Longitude	4.152252W
	GPS	POSpac -PPK	Datum	WGS 84	Accuracy 0.1m
Admiralty Charts affected	1971-0			Edition	Unknown
Latest Weekly Edition of Notice to Mariners held	Unknown				
Replacement copy of Chart No (see <i>Instruction 3</i>)	IS NOT required				
ENCs affected					
Latest update disk applied	Week:				
Make, model and or age of ECDIS if applicable	Qinsy/Caris				
Publications affected (NP/DP number, Edition No.)	Unknown				
Date of latest supplement/update, page & Light List No. etc	Unknown				
<p>Details of anomaly / observation: Area surveyed as part of CHERIS surve19_02. Shoal feature observed rising to a depth of 0.4m in an area charted at 5.6m beside a featured bank. The sand bank has clearly shifted outside the bounds of the charted Sarn Bradirg (St. Patricks Causway)</p> <p>Data acquired by R.V. Keary: - equipped with Kongsberg EM2040D and POSmv 320 Wavemaster. All depths are reduced to VORFLAT using GPStide methods. Navigation data is reprocessed using PP-RTX and transformed to ETRS89.</p>					
Name of observer/reporter			Charise McKeon		
H.102A Submitted No			H.102B Submitted No		
Tick box if not willing to be named as source of this information <input type="checkbox"/>					

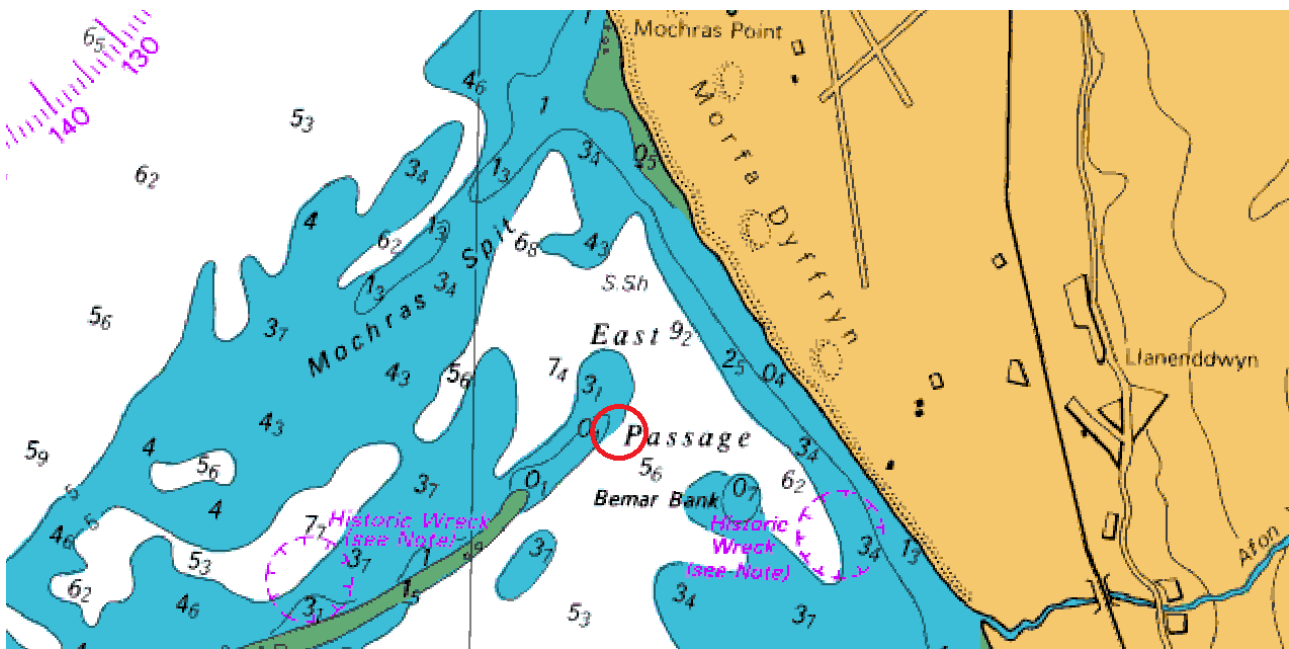


Figure 1 Overview location of shoal

Observation 01

Sand bank shift on Sarn Badrig (St. Patricks Causeway) at the NE end of the bank. Charted depth is 5.6m but shoalest depth being measured at 0.4m LAT at 52.785212N 4.152402W.



Figure 2 Zoomed image of shoal extending inside black box showing the bank moved over bounds of Sarn Badrig (St. Patricks Causeway)

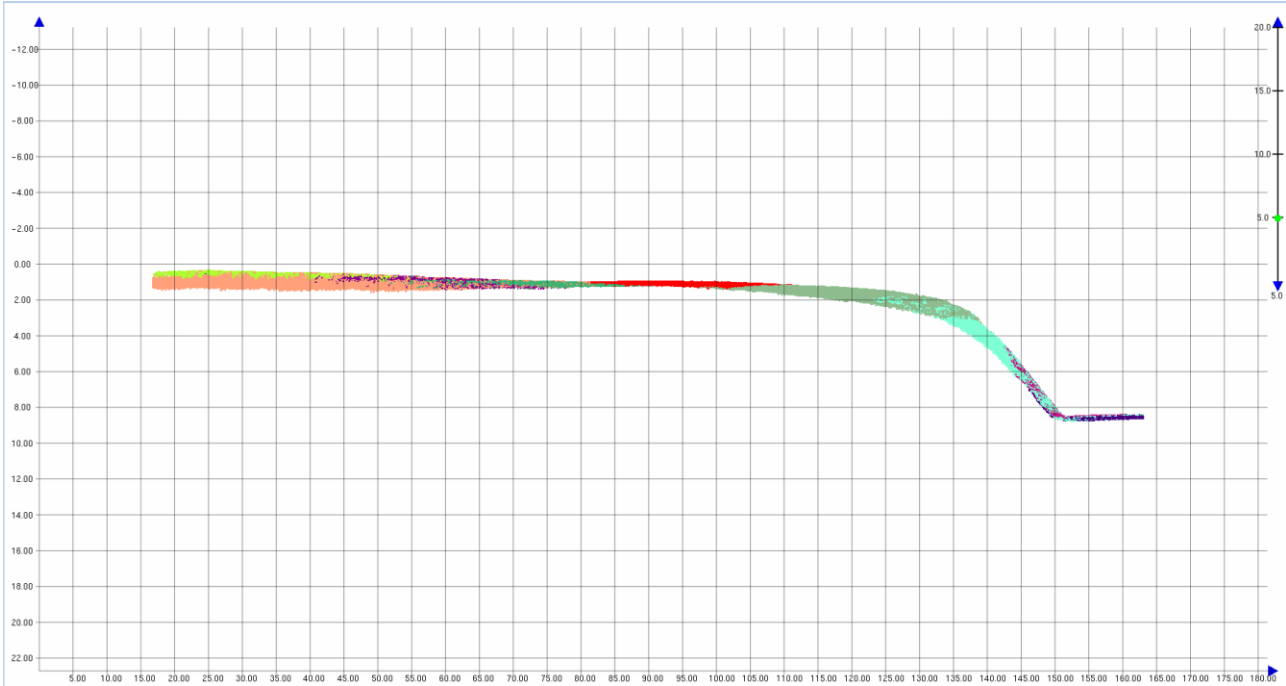


Figure 3. Subset view of shoal rising to 0.4 m LAT observed.

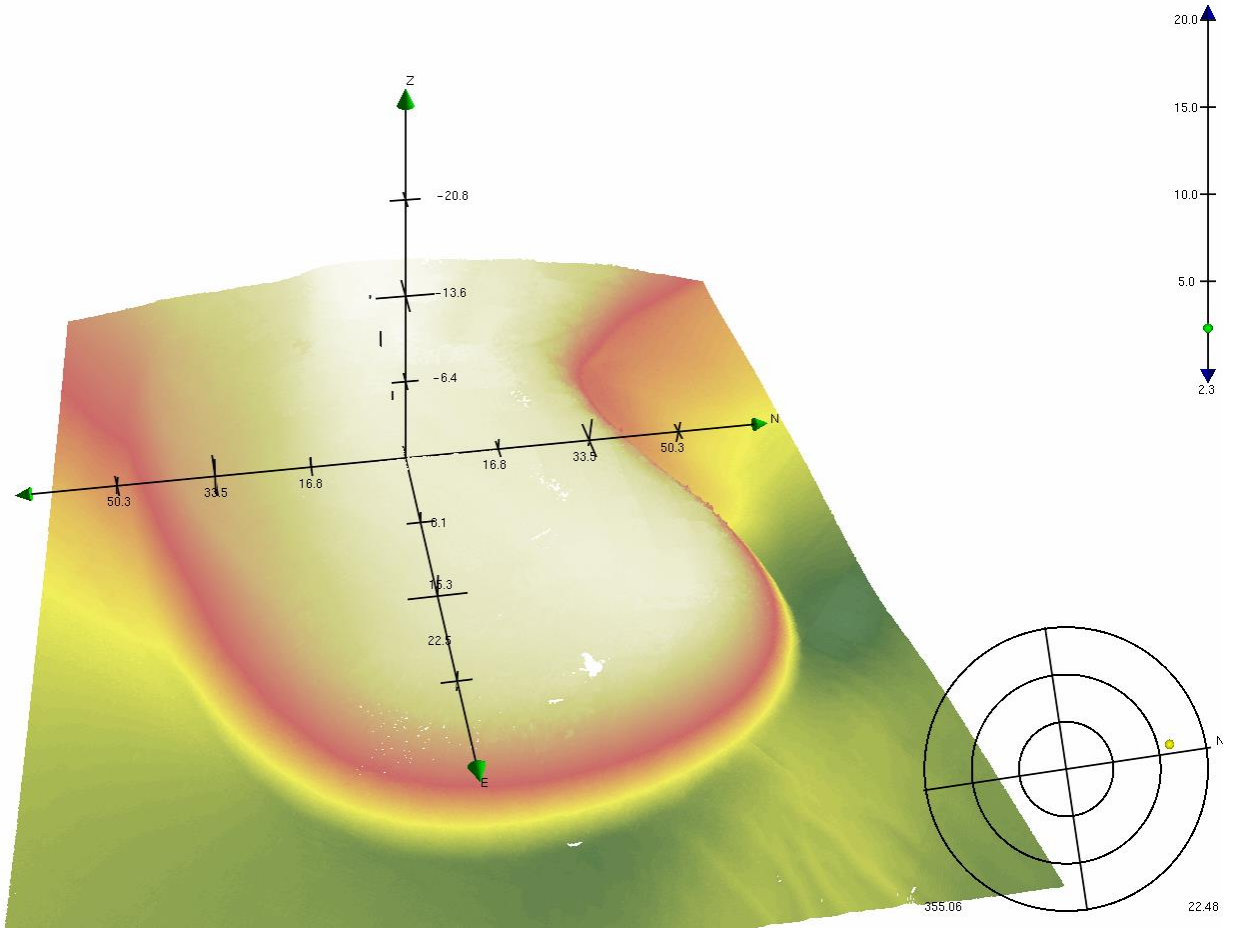


Figure 4. 3D Subset view of shoal rising to 0.4 m LAT observed.

HYDROGRAPHIC NOTE

H.102
(V8.0 Oct 2014)

Date	11/11/2019	Ref. Number	H102-KRY19_02		
Name of ship or sender	Geological Survey of Ireland R.V. Keary				
IMO number if applicable	-				
Address	Beggars Bush, Haddington Road, Dublin 4, Ireland				
E-mail/Tel/Fax of sender	charise.mckeon@gsi.ie				
General Locality	St tudwat's Island Lleyln Peninsula				
Subject	Rock feature North of St. Tudwat's Island				
Position (see <i>Instruction 2</i>)	Latitude	52.802367N		Longitude	4.471050W
	GPS	POSpac -PPK	Datum	WGS 84	Accuracy 0.1m
Admiralty Chartsaffected	1971-0			Edition	Unknown
Latest Weekly Edition of Notice to Mariners held	Unknown				
Replacement copy of Chart No (see <i>Instruction 3</i>)	IS NOT required				
ENCs affected					
Latest update disk applied	Week:				
Make, model and or age of ECDIS if applicable	Qinsy/Caris				
Publications affected (NP/DP number, Edition No.)	Unknown				
Date of latest supplement/update, page & Light List No. etc	Unknown				
<p>Details of anomaly / observation: Area surveyed as part of CHERIS surve19_02. Shoal feature observed rising to a depth of 0.4m in an area charted at 1.6m north of St. Tudwat's Island.</p> <p>Data acquired by R.V. Keary: - equipped with Kongsberg EM2040D and POSmv 320 Wavemaster. All depths are reduced to VORFLAT using GPStide methods. Navigation data is reprocessed using PP-RTX and transformed to ETRS89.</p>					
Name of observer/reporter			Charise McKeon		
H.102A Submitted No			H.102B Submitted No		
Tick box if not willing to be named as source of this information <input type="checkbox"/>					

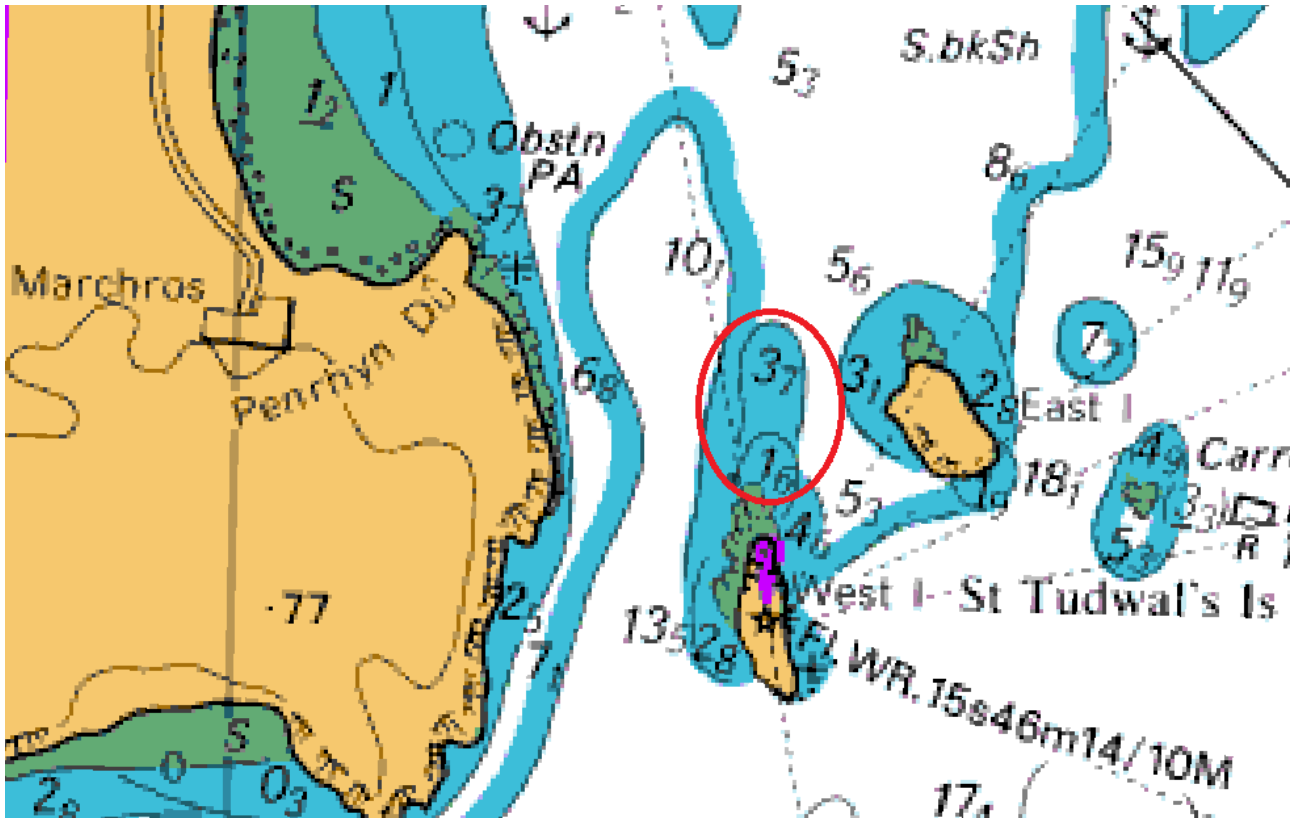


Figure 4 Overview location of shoal

Observation 01

Rock outcrop North of St. Tudwat's Island. Charted depth is 1.6m but shoalest depth being measured at 0.4m LAT at 52.802367N 4.471050W.

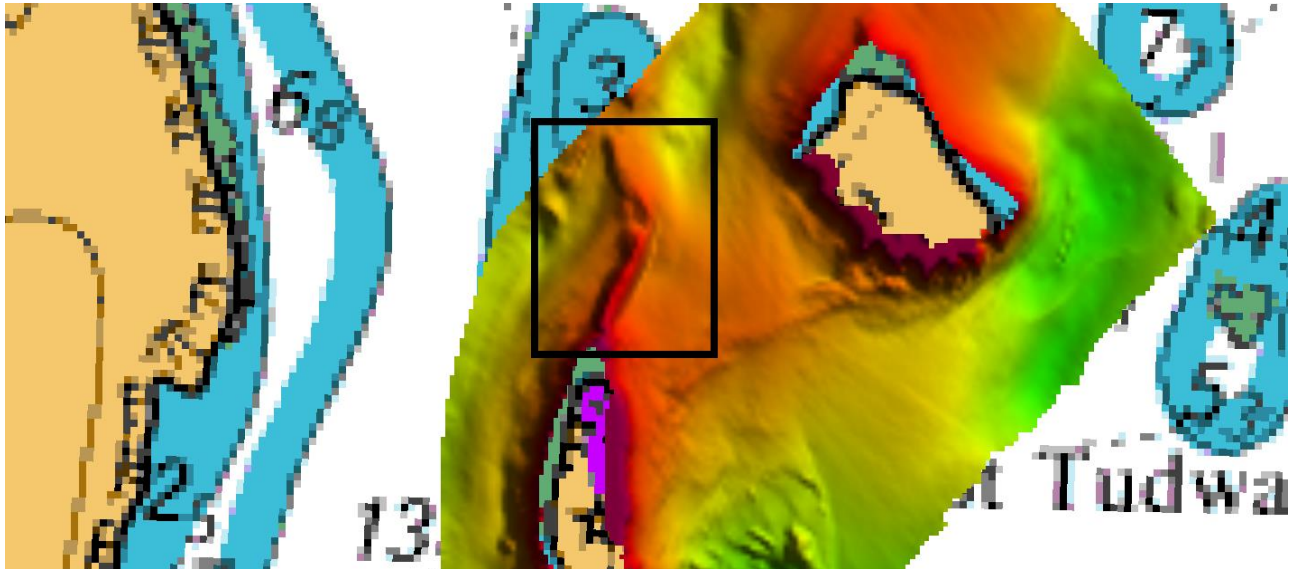


Figure 5 Zoomed image of shoal extending inside black box showing rock extent north of st. Tudwat's Island

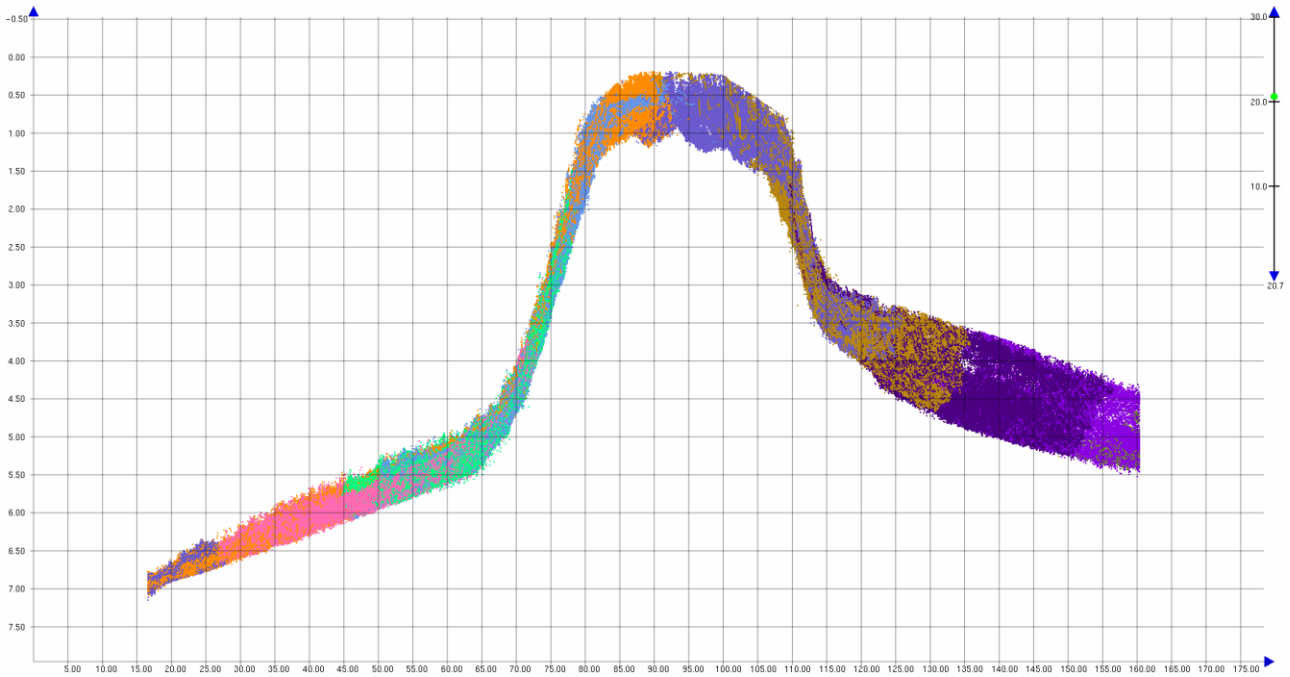


Figure 6. Width cross-section subset view of shoal rising to 0.4 m LAT observed.

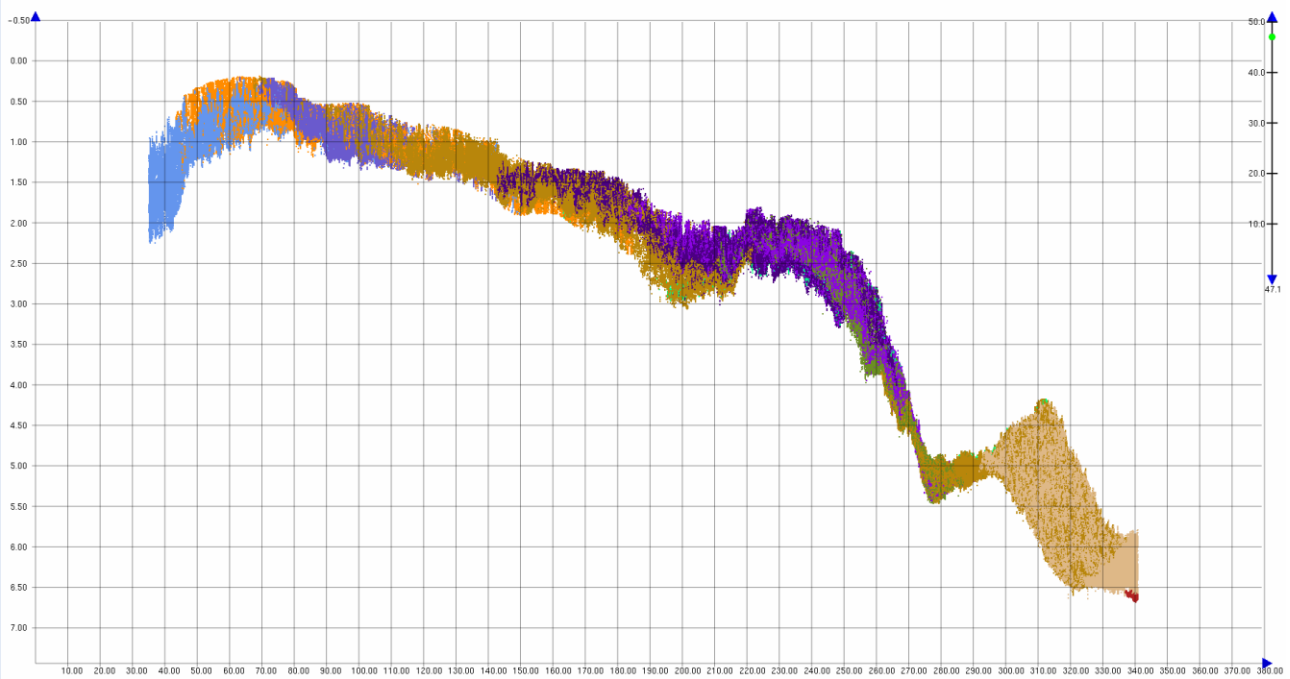


Figure 4. Length cross section subset view of shoal rising to 0.4 m LAT observed.

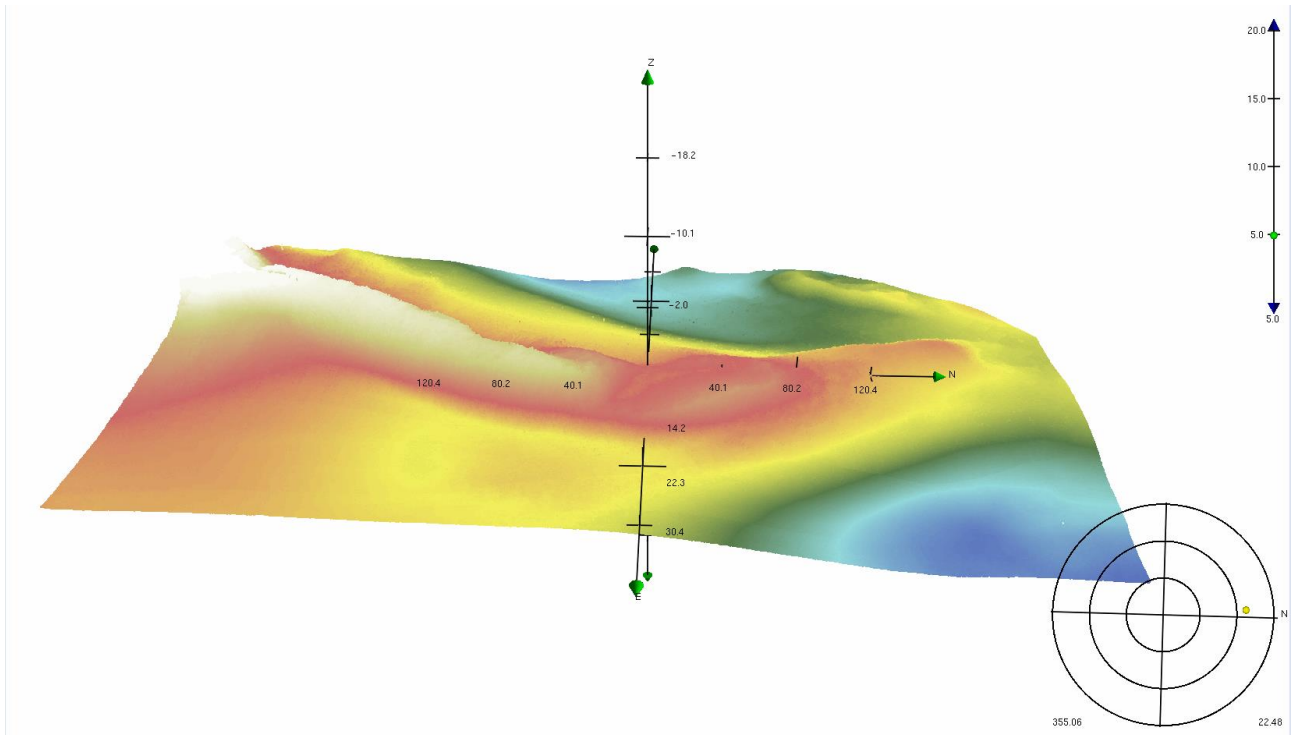


Figure 5. 3D Subset view of shoal rising to 0.4 m LAT observed.



Roinn Cumarsáide, Gníomhaithe
ar son na hAeráide & Comhshaoil
Department of Communications,
Climate Action & Environment



Geological Survey
Suirbhéireacht Gheolaíochta
Ireland | Éireann



CHERISH

Newid Hinsawdd a Threftadaeth yr Afodir
Climate Change and Coastal Heritage
Athrú Aeráide agus Oidhreacht Chultúrtha



Annex 2

Marine Mammal Observation Report – South Anglesey and North Cardigan Bay, Wales Survey 2019



Document Information

Project title: MMO Report – South Anglesey and North Cardigan Bay Survey 2019
Current Document version 1.0

Date 18/02/2020

Prepared By	Date	Comment
James Barry	18/02/20	

Reviewed By	Date	Comment
Kieran Craven	18/02/20	

Approved By	Date	Comment

Version History

Ver. No.	Ver. Date	Comment	Revised By



Executive Summary

This report details marine mammal observation work conducted on the R.V. Keary during the CHERISH seabed survey of South Anglesey and North Cardigan Bay, Wales carried out in the month of July 2019. Survey operations described in this report imply the use of vessel mounted multibeam, single beam & sub-bottom profiler acoustic equipment installed on the Irish state research vessel R.V. Keary. MMO field work and reporting were conducted with due consideration for the “*JNCC guidelines for minimising the risk of injury to marine mammals from geophysical surveys*”, documentation issued in August 2017 by the Joint Nature Conservation Committee (JNCC). Operations in Anglesey were not subject to licence conditions however due care was taken by the operations team to ensure that the guidance offered in the JNCC documentation was implemented. In a pre-season risk assessment categorizing risk to marine mammals both areas were deemed to be of low-medium risk for cetaceans.

Pre-start up watches were carried out by the designated MMO for at least half an hour prior to system start-up and generally from when the vessel crews came on duty. System start-up was performed at all times while alongside and always more than 20 minutes prior to cast-off / departure. Survey operations took place in the Anglesey area between the 2nd and the 10th July 2019. One recorded cetacean sighting was made during this time on the 3rd of July with details being provided in Appendix A: Marine Mammal Observation Forms of this report.

Date/Time	Sighting	Species	No.	Latitude	Longitude	Distance	Water Depth
03/07/2019 10.55	1	Bottlenose Dolphins	~<10	N 52° 46.917'	W 004° 19.786'	~5m	10m

All cetacean sightings occurred while the vessel was underway with systems fully operational and no operational responses were deemed necessary or taken. The pod of Bottlenose Dolphins approached the vessel during hydrographic surveying exhibiting playful behaviour and bow riding. They proceeded to remain around (5- mins)



Table of Contents

Table of Contents	iii
1. Survey Vessel / MMO Platform	1
2. Acoustic Equipment	2
3. Guideline and Licence Implementation	3
4. Soft Start Procedure	4
5. Survey Operations	4
APPENDIX A: MARINE MAMMAL RECORDING FORM – COVER PAGE	6



1. Survey Vessel / MMO Platform

The CHERISH project utilised one survey vessel, operated by GSI, in the implementation of survey work in CHERISH South Anglesey and North Cardigan Bay, Wales in 2019 - R.V. Keary.

R.V. Keary

The Irish state research vessel R.V. Keary is an aluminium catamaran designed for near shore survey work. She is ideally suited in this role due to her stable twin hull construction, shallow draft, retractable equipment pod and hydraulically operated A-Frame and winch. The R.V. Keary is typically crewed by a team of 3 individuals. Table 7 provides information on her design specifications and survey equipment on board.



Figure 1: R.V. Keary



Specification / System	Information
Length OA	15.5 m
Length (hull)	14.6 m
Beam (moulded)	5.6 m
Draught	1.9 m
Draught with pod deployed	2.4 m
Engines	2 x Cummins QSC 8.3 – 500 INT
Power output	368 kW/2600 RPM/Triple Phase
Transit Speed / Survey Speed	22 knots / 7.5 knots
Fuel	2000 lt Diesel
Generator	Cummins Onan 13.5 kva
Max passenger and crew	12 persons
Passenger Licence	P5
MBES	Kongsberg Simrad EM2040
SBES	Kongsberg Simrad EA400
Subbottom Profiler	Edgetech 3200XS Chirp
R/T SV	AML smart probe (pod mounted)
CTD/SVP	Valeport Mini SVP
Sparker	Geo-Resources Geo-Spark 200
Positioning System and IMU	POS-MV 320
DGPS	Hemisphere RTCM DGPS
Sediment Samplers	Duncan & Associates Day and Hand grabs
USBL	Sonardyne Scout
SSS	Edgetec 4200

Table 1: R.V. Keary Vessel Specifications

2. Acoustic Equipment

Acoustic Survey Equipment – R.V. Geo			
Equipment	Model	Deployment	Company
Multibeam Echo Sounder	Kongsberg Simrad EM2040	Retractable Pod	Kongsberg https://www.km.kongsberg.com/ks/web/nokbg0240.nsf/AllWeb/C75143F8AA145B48C12575E500276CA4?OpenDocument
Single Beam Echo Sounder	Kongsberg Simrad EA400	Retractable Pod	Kongsberg https://www.km.kongsberg.com/ks/web/nokbg0240.nsf/AllWeb/C75143F8AA145B48C12575E500276CA4?OpenDocument
Subbottom Profiler	Edgetech 3200XS Chirp	Retractable Pod	Edgetech https://www.edgetech.com/products/sub-bottom-profiling/

Table 2: Acoustic Equipment operated on board the R.V. Keary



3. Guideline and Licence Implementation

Prior to the commencement of the year's survey operations, a briefing was given to senior survey personnel on the nature of the guidelines for multibeam, singlebeam and sub-bottom profiler surveys in enclosed bays, inlets and estuaries. Where applicable, SAC extents were input to planning software. Licence conditions and the practical aspects of their implementation were discussed with the senior scientist on site. Copies of the DAHG Guidance for underwater sound sources (Jan 2014) and JNCC guidelines for minimising the risk of injury to marine mammals from geophysical surveys (Aug 2017) were available on board all survey platforms and licences were circulated to the Party Chief tasked with co-ordinating survey operations. The party chief ultimately took responsibility for collating all sightings and MMO related activity during survey operations while qualified crew members on each vessel acted in the role of marine mammal observer and all crew members were involved in maintaining a watch for cetaceans.



4. Soft Start Procedure

Multibeam echosounder soft starts were carried out as required. Where possible a ramp up of system power was utilised however, a ramp up of power is not possible with all multibeam / singlebeam systems, so as a recommended alternative, a soft start consists of switching power on and off during the soft start time period (20 minutes)

5. Survey Operations

Survey operations on board the INFOMAR inshore survey fleet operated by the Geological Survey Ireland are carried out during daylight hours. This fact necessitates a return to a secure berth or mooring at the end of each day's operations. Furthermore, the requirement to start up and shut-down survey equipment at the beginning and end of each work day, leads to a slightly different set of operating procedures than is used further offshore on coastal survey vessels which operate 24 hour days.

This manner of operating has the advantage of having sufficient daylight for the MMO to locate and identify marine mammals while survey systems are being operated, however it also requires that the systems are started up correctly each day whereas an offshore platform typically operates the sound source for days at a time. The requirement to re-start the system each day has been addressed by, whenever possible, starting survey systems while stationary and alongside prior to departure. This tackles the need to begin operations at the innermost point of the survey area each day, however visibility can be restricted if the vessels are in port. While moored, visibility generally is unaffected. Survey equipment on each platform is online for a minimum of 20 minutes prior to departure each day. When long transits are necessary and the equipment must be switched off and retracted, the soft start is carried out when the vessel arrives at the survey site.

CHERISH survey operations in North Wales were implemented on board the R.V. Keary between the 2nd and 10th July 2019. The vessel was based in both Victoria Dock and Pwllheli Marina and returned there each evening throughout the duration of the survey. Casual observations were maintained in the wheelhouse and back-deck by all survey crew members throughout the operation.

The official marine mammal recording forms for this survey are presented in Appendix A. It should be noted that the form titled "Marine Mammal Recording Form – Operations" is designed for seismic rather than multibeam and sub-bottom profiler surveys. Several hundred multibeam lines were acquired on this survey and it is not possible to enter the



start and end of line times for each line. It is also not necessary to enter the start and end of each line as with multibeam and sub-bottom profiler there is no reduction in power between survey lines. Data and time of start of first survey line after start up were entered and date and time of end of last survey line before power off were entered.



Chapter 2 APPENDIX A: MARINE MAMMAL RECORDING FORM – COVER PAGE

Regulatory reference number (e.g. DECC no., MMS permit no., OCS lease no., etc.)	Country Wales	Ship/ platform name R.V. Keary
Client DCCAE	Contractor CHERISH/GSI	Survey type <input checked="" type="checkbox"/> site <input type="checkbox"/> 4C <input type="checkbox"/> 2D <input type="checkbox"/> VSP <input type="checkbox"/> 3D <input type="checkbox"/> WAZ <input type="checkbox"/> 4D <input type="checkbox"/> other <input type="checkbox"/> OBC
Start date 02/07/2019	End date 10/07/2019	

Number of source vessels 1	Type of source (e.g. airguns) Multibeam	Number of airguns (only if airguns used) N/A	Source volume (cu. in.)
Source depth (metres) 0.7m	Frequency (Hz) 400kHz	Intensity (dB re. 1µPa or bar metres) 210 (MBES)	Shot point interval (seconds) Approx. 0.1 sec (MBES)
Method of soft start <input type="checkbox"/> increase number of guns <input type="checkbox"/> increase pressure (where permitted) <input type="checkbox"/> increase frequency (where permitted) <input checked="" type="checkbox"/> other			

Visual monitoring equipment used (e.g. binoculars, big eyes, etc.) Binoculars	Magnification of optical equipment (e.g. binoculars) 7 x 50	Height of eye (metres) 3m	How was distance of animals estimated? <input checked="" type="checkbox"/> by eye <input type="checkbox"/> with laser rangefinder <input type="checkbox"/> with rangefinder stick/ calipers <input type="checkbox"/> with reticle binoculars <input checked="" type="checkbox"/> by relating to object at known distance <input type="checkbox"/> other
---	---	---	--

Number of dedicated MMOs 1	Training of MMOs <input checked="" type="checkbox"/> JNCC approved MMO induction course for UK waters <input type="checkbox"/> PSO training course for the Gulf of Mexico <input checked="" type="checkbox"/> MMO training course for Irish waters <input type="checkbox"/> other <input type="checkbox"/> none
--	---

Was PAM used? <input type="checkbox"/> yes <input checked="" type="checkbox"/> no	Number of PAM operators	
Description of PAM equipment		
Range of PAM hydrophones from airguns (metres)	Bearing of PAM hydrophones from airguns (relative to direction of travel)	Depth of PAM hydrophones (metres)



MARINE MAMMAL RECORDING FORM - OPERATIONS

Regulatory reference number KRY19_02
(e.g. DECC no., MMS permit no., OCS lease no., etc.)

Anglesey/Cardigan Bay

Ship/ platform name: R.V. Keary

Complete this form every time the airguns are used, including overnight, whether for shooting a line or for testing or for any purpose.
Times should be in UTC, using the 24 hour clock.

Date	Reason for firing l = line t = test x = test followed immediately by line	Time soft start/ramp-up began	Time of full power	Time of start of line	Time of end of line	Time of reduced output (if relevant)	Time airguns/source stopped	Time pre-shooting search began	Time search ended	Time PAM began	Time PAM ended	Was it day or night in period prior to firing? d = day n = night w = dawn k = dusk	Was any mitigating action required? (yes/ no)
02/07/2019	L	1310	1330	1330	1705	N/A	1705	1240	1705	N/A	N/A	D	N
03/07/2019	L	0710	0730	0730	2015	N/A	2015	0640	2110	N/A	N/A	D	N
04/07/2019	L	0950	1010	1010	1910	N/A	1910	0800	2000	N/A	N/A	D	N

05/07/2019	L	0755	0840	0840	1840	N/A	1840	0700	1940	N/A	N/A	D	N
06/07/2019	L	0830	0850	0850	1900	N/A	1900	0750	2015	N/A	N/A	D	N
07/07/2019	L	1000	1020	1020	1915	N/A	1915	0910	2030	N/A	N/A	D	N
08/07/2019	L	1005	1025	1025	1615	N/A	1615	0920	1850	N/A	N/A	D	N
09/07/2019	L	0930	0950	0950	1615	N/A	1615	0830	1720	N/A	N/A	D	N
10/07/2019	L	0640	0700	0700	1705	N/A	1705	0555	1750	N/A	N/A	D	N

MARINE MAMMAL RECORDING FORM - EFFORT

Regulatory reference number: KRY19_02

Ship/ platform name: R.V Keary

Please record the following for all watches, even if no marine mammals are seen.

Start a new line on form if any one of these changes

Please record the following for all watches, even if no marine mammals are seen.										Start a new line on form if any one of these changes						
Date	Visual watch or PAM v = visual watch p = PAM		Time of start of watch (UTC, 24hr clock)	Time of end of watch (UTC, 24hr clock)	Start position (latitude and longitude)	Depth at start (m)	End position (latitude and longitude)	Depth at end (m)	Speed of vessel (knots)	Source activity f = full power s = soft start r = reduced power (not soft start) n = not active	Wind direction	Wind force (Beaufort scale)	Sea state g = glassy (like mirror) s = slight (no or few white caps) c = choppy (many white caps) r = rough (big waves, foam, spray) or Beaufort sea states (0 - 7+)	Swell o = low (< 2 m) m = medium (2-4 m) l = large (> 4 m)	Visibility (visual watch only) p = poor (< 1 km) m = moderate (1-5 km) g = good (> 5 km)	Sunglare (visual watch only) n = no glare w = weak glare s = strong glare v = variable

02/07/2019	V	JB	0700	1720	53° 23.431N, 006° 04.248W	4	52° 53.134N, 004° 24.373W	2	6	F	NW-NE	3	S	O	G	W
03/07/2019	V	JB	0700	2130	52° 53.134N, 004° 24.373W	2	52° 53.134N, 004° 24.373W	2	6	F	NE-NW	3-6	S-C	M	G	V
04/07/2019	V	JB	0800	2000	52° 53.134N, 004° 24.373W	2	52° 53.134N, 004° 24.373W	2	6	F	NW	2-4	G-S	O	G	V
05/07/2019	V	JB	0700	1940	52° 53.134N, 004° 24.373W	2	52° 53.134N, 004° 24.373W	2	6	F	W	1-3	G-S	O	G	V
06/07/2019	V	JB	0750	2015	52° 53.134N, 004° 24.373W	2	52° 53.134N, 004° 24.373W	2	6	F	NW	1-3	S	O	G	V
07/07/2019	V	JB	0910	2030	52° 53.134N, 004° 24.373W	2	52° 53.134N, 004° 24.373W	2	6	F	NW	3-4	S	O	G	V
08/07/2019	V	JB	0900	1850	52° 53.134N, 004° 24.373W	2	53° 07.319N, 004° 24.938W	2	6	F	NW	1-4	S	O	G	V
09/07/2019	V	JB	0830	1720	53° 07.319N, 004° 24.938W	2	53° 08.620N, 004° 16.622W	2	6	F	SW	2-4	S	O-M	M	V

10/07/2019	V	JB	0555	1720	53° 08.620N, 004° 16.622W	2	53° 08.620N, 004° 16.622W	2	6	F	SW	2-6	C	M	G	V

Cetacean Sighting Record Form: KRY19_02

Date: 03/07/2019	Time (GMT): 10:28 Duration: 5 minute	Survey Ref. No. KRY19_02	Sighting no.: 1
How did this sighting occur? (please tick) While you were keeping a continuous watch for marine mammals Spotted incidentally by you or someone else Other (please specify)			- Yes -
Ship: RV Keary Geological Survey Ireland, Beggars Bush Haddington Road Dublin inshore.infomar@gmail.com		Observer: James Barry	
Location: Cardigan Bay, Wales. Ship's position (latitude and longitude): N 52° 46.917' W 004° 19.786'		Water depth: 10 m.	
Species: Bottlenose Dolphins <i>Tursiops truncatus</i> .		Certainty of identification: <i>Probable.</i>	
Estimated Length: 2-3 m (<10 ft).		Number of adults: < 10.	
Colour: Dark Grey with white underside and falcate fin		Number of juveniles: 0	
Weather: NW winds light and variable, Swell <1m, Sea State 2, Sunny, Visibility >10 km.		Photograph or video taken: Yes. Optics Used: None.	
Sighting Description: The pod approached vessel during hydrographic surveying. They proceeded to remain around (5-mins)		Direction of travel of animals in relation to ship: Dolphin pod approached from the port side, towards the vessel.	
Behaviour: Pod of Bottlenose Dolphins, playful behaviour, bow riding.		Travel direction of animals (compass points): SSE direction.	
Activity of ship: Multibeam Surveying.	Sonar Systems pinging: (when animals first seen) Yes.	Closest distance of animals from sonar head: (Record even if not pinging) ~ 5 m.	

