CE23012 – Sub-seabed Profiling, Coral Reef surveying & Bedrock Drilling (SPeeD- The Return)

RV Celtic Explorer & Holland 1 ROV

Survey Number CE23012

Porcupine Bank – Goban Spur - SW Irish Shelf – Porcupine Seabight

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Table of Contents

Executive summary	4
Background	5
Quaternary geology of Galway Bay	5
Bedrock geology of the Porcupine Bank and Goban Spur	6
Glacial geology and seabed geomorphology of the western Celtic Sea	7
Cold-water coral habitat in the Belgica Mound Province, NE Porcupine Seabight	8
Survey objectives (and cruise track)	12
Equipment	14
RV Celtic Explorer	14
Holland 1 ROV	14
Williamson ROCS Rockdrill	15
SIMRAD EM2020 multibeam echosounder	16
Little MonSta benthic lander monitoring platforms	17
CTD with water rosette	20
Shipbased Teledyne RDI ADCP	20
iXblue Echoes Chirp sub-bottom profiler	21
Rock dredge	21
Survey log	22
Downtime and technical issues	42
ROV electrical power supply	42
ROV bad optical pass on the slip ring	43
Rock dredge failure	43
Change of ship’s crew	44
The weather	44
Summary of findings	46
Galway Bay seabed stratigraphy	46
Geology and hydrodynamics of the Porcupine Bank and Goban Spur	48
Glacial geology and seabed geomorphology of the western Celtic Sea	52
Cold-water coral reefs in the NE Porcupine Seabight	53
Appendices	55
Personnel	55
Station logs and maps	57
Master log and maps	57
Sub-bottom profiler log and maps	61
ROV dive log and maps	68
ROV multibeam echosounder log and map	89
ROV rockdrill core log and map	92
ROV coral sample log and map	95
Little MonSta lander recovery log and map	100
ROV Vibrocore log and map	101
CTD log and map	103
ADCP log and map	105

Lander deployment tests	108
USBL calibration report	110
Acknowledgements	111
Alf Wheeler and the Alf Reefs	112

Executive Summary

Due to technical issues with the ROV at the start of the survey, additional data was collected consisting of a full grid at 1 to 4 km line spacing of 3.5 kHz Chirp single beam seismics. This reveals the Quaternary stratigraphy of the entire Galway Bay down to bedrock including palaeochannels, tills and marine sediments across the entire Galway Bay.

ROV rock drilling operations from the Porcupine Bank Canyon south to King Arthur's Castle seamount on the southern tip of the Goban Spur proved challenging. However, two rock cores were collected, a quartz arenite and sparry limestone, proving that our approach was possible. A total of 14 rockdrilling ROV dives were undertaken in total. These dives groundtruthed our Bedrock Suitability Model which worked well mostly although underestimates outcrop on steep slopes and overestimate where multibeam echosounder data was noisy. However, finding sites to land the ROV to drill where these were not covered in sediment was more challenging. We did however explorer many areas not seen before collecting valuable ROV footage.

A series of sub-bottom profiler lines were run in the western Celtic Sea, south of coverage collected by the INFOMAR programme that was of limited penetration and quality. The sub-bottom profiler imaged a number of buried features included moraines from the Cork-Kerry Ice Cap mapping its southern limit.

Two Little MonSta landers were recovered from the Belgica Mounds area in a series of ridge reefs called, here, the "Alf Reefs": landers Apollo and Charlotte. These recorded ADCP current data, pH, DO, T^{o}C and salinity over 9 and 3 month respectively. In this area we also look coral samples for elemental analysis to reconstruction palaeoenvironmental conditions, vibrocores inferred as covering the Holocene and late glacial, CTD with a water sample near the seabed, and ROV video. Following this intensive contextualising data collection over the lander sites, high resolution multibeam echosounder data was collected over an extensive area (c. 22 km^2) was collected to look at the seabed morphology of the Alf Reefs and adjacent giant mounds.

The survey ended with some lander deployment tests in Galway Bay

Background

This survey is designed to address a number of objectives including the completion of some tasks that did not occur during the previous survey (CE2022013:SPeeD) due to downtime issues. The survey has been split into two legs with the first leg solely focussed on bedrock sample recovery from the SW Irish margin and the second leg covering the remaining objective: western Celtic Sea glacial limits and cold-water coral research in the Belgica Mounds area, Porcupine Seabight.

Quaternary geology of Galway Bay

Galway Bay (1150 km^2 in area) is a high energy, storm dominated marine embayment enclosed by Co. Galway in the north. where granite outcrops on shore, and Co. Clare to the south where limestones outcrop. The Aran Islands, also composed on limestone, partially enclose the western limits of the bay. Galway Bay is shallow (water depth not exceeding 80m) and can be subdivided into three geographical areas: the inner, mid and outer bays. The outer bay comprises the Aran Islands (Inis Mór, Inis Meáin and Inis Óírr) and has two approaches: the North Sound and South Sound opening towards the Atlantic Ocean. The primary inflow of Atlantic water into Galway Bay is through the South Sound, with outflow through the North Sound, creating a counter-clockwise gyre (Lei, 1995; McCullagh et al., 2020). The geology of the northern side of the bay is dominated by granite of Caledonian orogeny age, with the rest of the area (including the Aran Islands) made of Carboniferous Viséan limestone (Geological Survey of Ireland, 2007).

Mud/Muddy sand is dominant in the bay comprising ∼35% of the total area. The coarse sediments (cobbles, pebbles and coarse sand) encompasses ∼10% in the mid-bay and the north east of Aran Islands, which tend to be surrounded by sand making up to ∼25% of the surficial sediment (McCullagh et al., 2020).

The Quaternary stratigraphic model of Galway Bay was defined by Denis McCullagh in her unpublished 2019 PhD thesis based on INFOMAR pinger data (McCullagh, 2019). She notes that the INFOMAR data quality is poor in places resulting in incomplete coverage but identifies three stratigraphic units. She always provides some isopach maps for the units but this is not possible for the whole bay due to the poor quality of data with limited penetration; one third of the 800 lines were useable, and the inner Bay was not mapped. Also, the INFOMAR pinger lines were run parallel to the bathymetry (for seabed mapping) with limited lines running across buried valley. McCullagh (2019) also presents data from cores in the bay.

McCullagh (2019) interprets Unit 1 as Bedrock. Over most of the bay this is ~345-326 Ma Carboniferous limestones (Pracht et al, 2004; Gallagher et al, 2006; McNamara and Hennessy, 2010) while ~400 Ma Caledonian granites underlie the northern margin of the bay (Feely et al, 2003; Pracht et al, 2004).

Unit 2 has a chaotic internal fabric with hyperbolae and is interpreted as a diamicton (McCullagh, 2019). Galway Bay is interpreted as being fully glaciated during the last glaciation (Midlandian) with ice limits extending onto the western shelf (Peters et al., 2015). The surface of Unit 2 is incised by palaeochannels presumably formed after the ice retreated and before the sea-level rose.

Unit 3a is interpreted by McCullagh (2019) as a low sea-level marine / meltwater deposit. Post-glacial sea-level rise is poorly constrained in Galway Bay but indicated a drop in sea-level at 19 ka cal BP to a lowstand between 16 and 15 ka cal BP, followed by a sharp rise until 6 ka cal BP (Kuchar et al., 2012; Brooks et al. 2008; Bradley et al., 2011).

Unit 3b is interpreted as fully marine sediments and is exposed at the current seabed.

Bedrock geology of the Porcupine Bank and Goban Spur

Seismic studies on the western Porcupine Bank prove clues about Atlantic rifting and oceanic to continental crust transition highlighting that inherited Caledonian and Variscan crustal structures influence the geometries of the crustal domains. To the northwest, increasing volcanism supports a transition from magma-poor to magma-rich rifting along Porcupine Atlantic margin, with exhumed mantle domains present southwest of Porcupine Bank to Goban Spur (Whiting et al., 2021; Yang and Welford, 2021). The Porcupine Bank appears to lack evidence of Mesozoic subsidence and preserved sediments is explained through seismic refraction results showing little crustal thinning beneath the Bank (Masson et al., 1989). More recent surveying in the Porcupine Bank has indicated extensive areas of bedrock exposure (Strachan, 2021). Bedrock outcrop is mainly observed in canyon head of Porcupine Bank Canyon, on small escarpment creating bedrock cliffs, along the steeply sloping centre margin or along moderate to steeply sloping seafloor (Strachan, 2021).

The Goban Spur is located south of the Porcupine Seabight and characterised by a steep (up to 40˚) escarpment (beginning at -1800 m) to the Porcupine Abyssal Plain (<-5000 m) (de Graciansky et al., 1985; Masson et al., 1989; Naylor et al., 2002; Dorschel et al*.,* 2010). The Goban Spur was affected by the Variscan orogeny and subsequent rifting phases that overprinted peri-Gondwanan basement (Kimbell et al., 2010; Yang et al., 2020). It is defined by complex structures affected by faults that appear geomorphologically as highs, lows, and escarpments. Goban Spur reveal is a syn rift geological sequence with faulting and subsidence caused by crustal thinning during Early Cretaceous rifting event (Masson et al., 1989). Thinning on continental crust (Early Cretaceous-Middle Albian) and widening of adjacent oceanic domain (Albian-Campanian) created tensional movements following Caledonian trends. Tops of tilted fault blocks remained close to sea level during rifting. During last stage of rifting (Early Albian) the margin rapidly subsided. The whole Goban Spur margin was affected by Eocene intraplate deformation (Sibuet et al,. 1985).

In the early 1970’s the IFREMER *Cyaporc* submersible cruise undertook 5 submersible traverses and 4 dredge hauls on the western slopes of Porcupine Bank and Goban Spur. Sampling and observation revealed a metamorphic basement overlain by a sequence of

Upper Palaeozoic siltstones and sandstones. The oldest rocks on the Goban Spur are weakly metamorphosed sandstones from the Late Palaeozoic. These are overlain with a thick sequence of shallow water limestones deposited during the late Early Cretaceous rifting event. Granite intrusions are found along the southern flank of the Goban Spur (Pautot et al., 1976). The Palaeozoic sequence of the Goban spur closely resembles that of onshore sequences in southwest England. Whereas the Porcupine Bank sequence is comparable to the Hercynian foreland seen in Ireland.

Coarse geological maps of the margin are available on the EMODnet website (https://emodnet.ec.europa.eu/geoviewer/) based on INFOMAR surveying and groundtruthing (O'Toole & Monteys et al., 2010).

Glacial geology and seabed geomorphology of the western Celtic Sea

The INFOMAR survey has created a high resolution bathymetric map of most of Irish shelf seabed which reveals many morphological and geomorphological features. For instance, off the south coast of Ireland (Celtic Sea), the morphological expression at the seabed of partially filled palaeochannel formed by rivers, and ice front drainage have been mapped by Giglio et al. (2021) and sediment wave fields by Summer et al. (2021). A complete geomorphological map of the entire Irish Shelf has recently been published by Arosio et al. (submitted) using semi-automated approaches (see also Arosio et al, 2023 for approaches using AI). These maps reveal many interesting features related to the glacial history and seabed development on the Irish shelf.

The Cork-Kerry Ice Cap was a localised ice cap, that covered the Cork-Kerry mountains beyond the limit of the Irish Ice Sheet (Warren & Ashley, 1994; Ballantyne et al. 2011) and had an independent advance and retreat history. However, limited evidence is published about the southern ice limit offshore of the Cork-Kerry Ice Cap (e.g. see Ó Cofaigh & Evan, 2007) prior to the confirmation of moraines, drumlins, meltwater channels and grounding zone wedge by Giglio et al (2022). The drumlins investigated in this study (inner shelf, offshore County Cork) are oriented SSW denoting south-westerly ice flow at the time of their formation. Recently, the classification of seabed features in the Irish shelf using semi-automated approaches using high-resolution bathymetry data (Arosio et al. 2023) helped to delineate morphological features suggestive of terminal moraines further south of the previously studied regions. This subtle ridge-like feature is in alignment with the moraines confirmed by Plets et al. (2015) and Giglio et al. (2022). Since the offshore extent of the CKIC has not yet been delineated with certainty, this survey using single channel Chirp seismic profiles was planned across these ridge-like features will help to validate the presence of the buried recessional moraines and/or Grounding zone wedge.

Cold-water coral habitat in the Belgica Mound Province, NE Porcupine Seabight

Ireland is well known for its cold-water coral with a number of well studies cold-water coral sites (Hennige et al., in press). Despite a variety of species including soft corals (Morrissey et al., 2023), the framework forming corals are of particular interest as they provide structural habitats and reefs. Ireland is particularly famous for its giant carbonate mounds (Wheeler et al. 2007) that have been growing episodically for 2.6 Ma (Thierens et al., 2010).

Despite the occurrence of giant carbonate mounds in the Belgica Mound Province, ROV observations and seabed mapping have identified smaller, c. 50m diameter, Moira Mounds (Wheeler et al., 2011) which have been the focus of several studies (e.g. Fentimen et al., 2018, 2020; Boolukos et al., 2019; Lim et al., 2020; De Oliviera et al., 2022).

Monitoring environmental controls on cold-water coral reefs in a dynamic changing ocean is critical to understanding the fate and management priorities for these important habitats as cold-water corals are considered ecosystem engineers that form the base for biodiversity hotspots (Roberts et al., 2006). A recent study from the area shows a decline in coral cover in the Moira Mounds across a 4 year span (Boolukos et al., 2019) although the environmental drivers for this are unclear. Investigations of temperature, current speeds and direction and supply of suspended particulate matter can provide crucial insights of why these organisms may be in a state of change. On this survey we recover two Little MonSta landers that have been monitoring a recently discovered area of cold-water coral reef growth and will help understand forcing factors.

Multibeam mapping this area of ridge-reefs will allow a morphometric evaluation of this reef type to be integrated with quantified existing video data (O'Reilly et al, 2021). We anticipate this data will provide evidence to challenge existing reef development models (Squires, 1964; Roberts et al., 2006) as coral ridge types reefs are not well documented, especially in the Porcupine Seabight were there has been a focus on mounds.

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Survey Objectives (and cruise track)

Several objectives were planned for this survey and are listed below in the order they were to be addressed. Tasks to fulfil the objectives are also listed:

Objective 1: to identify and sample rock types outcropping on the Irish continental margin towards the development of a geological map and stratigraphic model for Ireland's deep-water territories

Task 1- Collect rock cores from bedrock outcrops on the Irish southern continental margin: identified bedrock outcrops from the Sea Rover video survey and probable outcrops from advanced GIS modelling were targeted. Rock cores were collected using an ROV rockdrill and will be subsequently analysed petrographically, geotechnically and dated. Identified rock units will also be related to acquired industry seismics data from the margins

Objective 2: to map in high resolution an area of cold-water coral (CWC) ridge-reefs, giant mounds and Moira Mounds to better understand CWC reef development models and biogeoenvironmental interactions

Task 2 – undertake *ROV MBES survey in the Belgica Mounds SAC*: high resolution multibeam echosounder data was collected by ROV at 150m above seabed with 450m swathe providing morphometric data relatable to video-based coral distribution and inferred sedimentology.

Objective 3: to recover long-term deployments of Little MonSta lander platforms from the Beligica Mounds SAC (Porcupine Seabight) characterising environmental controls on cold-water coral reefs

Task 3 – *Lander retrieval*: Two Little MonSta landers were retrieved from in the Belgica Mound Province following an annual deployment (Wheeler et al., 2022) and additional ROV video, coral samples, vibrocores and CTDs also.

*Objective 4:*to collect geological (seabed and sub-seabed) data for the western Celtic Sea to need determine geological processes

Task 4 – Geological appraisal of SW Irish shelf: CHIRP sub-bottom profiler data was collected for verification of geomorphological feature, stratigraphic and buried feature studies related to SW Irish ice sheet dynamics and limits.

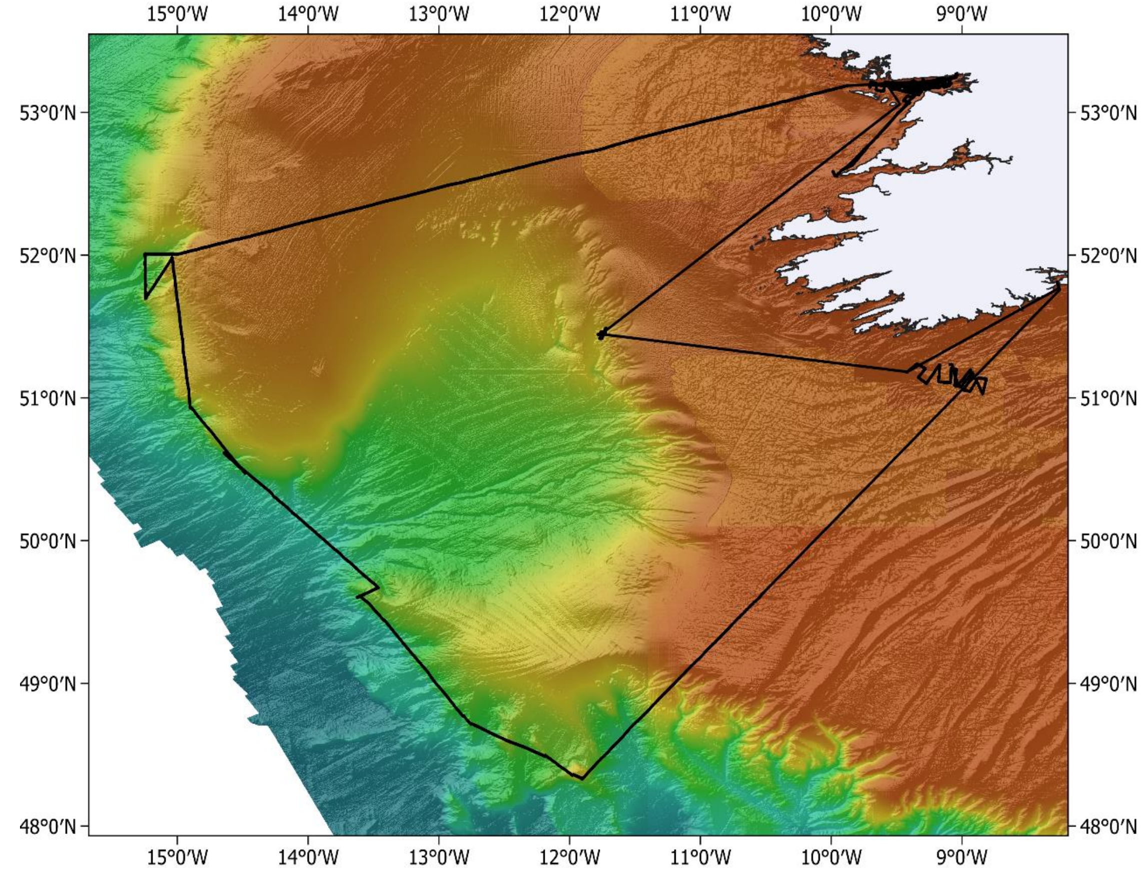


Figure 1. CE22013 SPeeD - The Return survey shiptrack: Galway to Porcupine Bank to Goban Spur to Cork to the western Celtic Sea to NE Porcupine Seabight to Galway

Equipment

RV Celtic Explorer

The RV Celtic Explorer is a 65.5 m multi-purpose research vessel. The vessel has wet, dry and chemical laboratories, which are permanently fitted with standard scientific equipment, a fume hood and can accommodate 20-22 scientists along with 13-15 crew who are highly-skilled with the handling and deployment of scientific equipment. It has a maximum endurance of 35 days. The RV Celtic Explorer is equipped with two Trimble 300-D GPS' and has Dynamic Positioning. The aft deck has a 25 tonne "A-frame" with a 4 m outward and inward reach in addition to a 3 m, 10 tonne starboard T-frame. The ship also comprises of a midship, forward and aft crane as well as a 6 tonne CTD winch. The CTD forms part of the vessel's equipment pool.

Figure 2. RV Celtic Explorer (courtesy of Hugo Ferreira)

Holland 1 ROV

The Holland 1 3000m depth ROV (remote operated vehicle) is a platform for capturing real-time underwater video footage, data and user-controlled samples. It has 100 hp engine with a maximum speed of 3 knots. The Holland 1 has a HDTV camera, low resolution cameras and a HD digital stills with laser rangers which are well illuminated providing pan-and-tilt forward views, below and aft. It is also fitted with a CTD and 2 robotic arms for sampling (aT4 7-function arm and an Orion 5-function arm). Collected samples are stored in bio-boxes (divided into 8 compartments). An EM2040 multi-beam echo sounder was mounted on the vehicle for high resolution bathymetry imagery & precision mapping of the seabed. The EM2040 operates at 200 - 400 kHz and is effective to 6000m. Underwater navigation is done via USBL position smoothed by an integrated inertial navigation and Doppler system.

Figure 3. Holland 1 Remotely Operated Vehicle

Williamson Rockdrill

A Williamson & Associates Remotely Operated Core Sampler (ROCS) ROV rock drill (rented from the Norwegian University of Science & Technology, Trondheim) was attached to the ROV. The ROCS is a compact, 4000m depth rated, subsea core drill designed to be mounted to and powered by a work class ROV. It is capable of taking single core samples 70 to 100mm in diameter up to 1000mm in length. It weights 300kg with a maximum RPM of 1000 with a core breaking force of 4500 kg. It is hydraulically powered and isolated from the main ROV hydraulic system.

Figure 4. Holland 1 Remotely Operated Vehicle with the Williamson ROV rockdrill attached at the front

SIMRAD EM2020 multibeam echosounder

An SIMRAD EM2040 multi-beam echo sounder was mounted on the Holland 1 ROV for high resolution bathymetry mapping of the seabed. The EM2040 operates at 200 - 400 kHz and is effective to 6000m. Underwater navigation is done via USBL position with an integrated inertial navigation and Doppler system. SIS was used as a top-end acquisition software.

Figure 5. Holland 1 Remotely Operated Vehicle with the EM2020 multibeam echosounder head install on the front

Little Monsta benthic lander monitoring platforms

Two “Little MonSta” benthic lander monitoring platforms, referred to as landers, were recovered from a 1 year deployment on the seabed during this survey. Each Little MonSta is equipped with an Acoustic Doppler Current Profiler (ADCP), Sediment Trap and Multi-sensor CTD package.

- The **ADCP** is a 1 Hz ***Nortek Aquadopp***, depth-rated to 3000 m water depth and powered by a battery pack that can continually measure data from 0-25 m from the transducer for up to six months. The ADCP is mounted vertically, pointed upwards, near the top of the Little MonSta.

- The sediment trap is a ***Technicap* sediment trap**, depth-rated to 6000 m water depth. It is made up of a streamline (teardrop-shaped) carbon fibre housing for minimal disturbance to the local hydrodynamic regime. The housing has a funnel which allows particles (e.g. sediment, POM, and microplastics) to settle into the trap. The sediment is stored within 24 x 500 ml bottles, which open at defined intervals to trap particulates during each period. The titanium motor is battery operated and can continuously record for up to 3 months. The motor controls the rotation of the bottle carousel.
- The **IDRONAUT *CTD multi-sensor*** consists of conductivity, temperature, pressure, pH, dissolved oxygen, turbidity and reference sensors.
  - The ***pressure sensor*** is an annually calibrated strain gauge with an accuracy of 0.05%FS and response time of 50ms.
  - The ***temperature sensor*** has a platinum resistance thermometer fitted to a stainless steel/titanium housing. This sensor can withstand 700bar and has a response time of 50ms.
  - A thermic insulated cylindrical plastic body houses the ***conductivity sensor cell*** used as a proxy for salinity. The sensor is a flow-through self-flushed cell consisting of seven platinum ring electrodes. Two adjacent pairs of rings sense the relative drop in voltage due to electrical conductivity of the measured water. Electrical interference from outside the measuring cell is shielded from the outermost pair of rings. Response time is 50ms per 1m/s waterflow.
  - The ***dissolved oxygen sensor*** contains a fluorescent dye that is excited by a certain wavelength. Luminescence response depends on amount of oxygen molecules present. This excitation of light is transmitted by a polymer fibre, simultaneously transmitting the fluorescence response of the sensor to the measurement device. The oxygen sensitive dye is immobilized in a polymer matrix. The sensor if stable over long deployment period. REDFLASH technology is excitable by red light and show oxygen-dependent luminescence in the NIR. Luminescence decreases with increasing of oxygen in the NIR. Excellent luminescence brightness of REFLASH indicator allows sensor matrix to be thin, leading to fast response times for oxygen sensors. A blue measuring membrane cap is fitted inside the titanium support to prevent unwanted removal or accidental loss. It is made of blue plastic to shield external light. A black sensor spot on the bottom of the cap allows for oxygen measurement.
  - The ***IDRONAUT reference sensor*** is in contact with the unknown sample by means of a small hole in the glass tip. The reference sensor is a silver/silver chloride cell in a saturated potassium chloride solid gel and the sensor head is made of titanium. It is developed for long-term monitoring where the internal cell is 0.7 mol NaCl. The glass body of the sensor is fitted with a plastic hydrating cap filled with the IDRONAUT reference sensor storage solution based on 3-mol KCl (or NaCl). This cap is to be removed before measurements.

- The ***pH sensor*** has a titanium head, a glass body, and a pH sensitive glass tip, which can withstand max pressures of 700 bar. When inactive, the glass tip must be fitted with a white plastic hydrating cap filled with the pH 7 Buffer Solution, or clean water. This cap is to be removed before measurements. The pH sensor measurement range is 1-13pH, with an accuracy of 0.01pH, a response time of 3s, and resolution of 0.001pH.
- A **turbidity meter** is fitted externally for the main IDRONAUT pressure vessel and is place at the top of the Little MonSta next to the opening of the sediment trap. It measures water turbidity with a range of 15cm from the sensor head.

- *Figure 6. Little MonSta lander "Charlotte" ready for deployment on the front of the Holland 1 ROV*

CTD with water bottle rosette

A Sea Bird Electronics SBE 911 plus CTD was used to calibrate ADCP backscatter from the Little MonSta landers by sampling water for determine the concentration suspended material in the water column and to calculate sound velocity profiles (SVPs) to help navigate the multibeam echosounder ray paths and USBL beacons. The CTD was equipped with the following: SBE 35 Digital Thermometer, a SBE44plus conductivity sensor, a Digiquartz pressure sensor, a SBE 43 dissolved oxygen sensor, altimeter, fluorometer and a nitrogen saturation sensor. A series of 6 water bottle are attached to a rosette and can be fired by live feed in real-time from the deck unit.

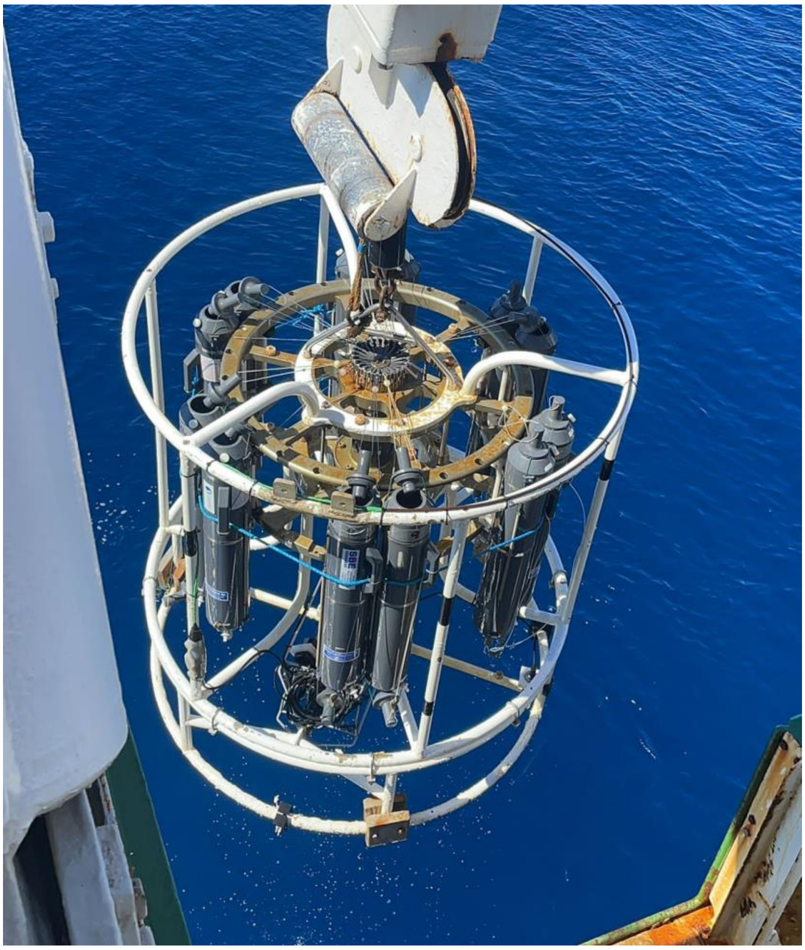


Figure 7. Sea Bird Electronics SBE 911 plus CTD

Shipbased Teledyne RDI ADCP

The RV Celtic Explorer is equipped with a hull mounted 75 kHz Teledyne RDI Ocean Surveyor Acoustic Doppler Profiler (ADCP) Model 71A-1022-00. The system can profile current speeds down to >750m with a velocity accuracy of +/- 1.0% of measured velocity +/- 0.5 cm/s. It has a velocity range of -5 to +9 m/s measured with a beam angle of 30°. The ADCP is triggered and data acquired using Teledyne RDI VmDas software version 1.50.19.

iXblue Echoes Chirp sub-bottom profiler

The RV Celtic Explorer is equipped with a hull-mounted iXblue Echoes 3500 T7 sub-bottom profiler consisting of 7 transducers to provide quality data from shallow to deep sea environments (to 6000m). The system emitted a Chirp spectrum coverage of 1.7 to 6kHz. Mean acoustic level 208 dB (ref 1µPa@1m) @ 4 kVA. The system is controlled and data visualised through an iXblue Delph Geo Acquisition system.

Rock dredge

The rock dredge consist of a robust circular iron ring with a iron chain net with a heavy duty nylon net inside. When towed on the seabed, addition all weighed down by a heavy tow chain, the ring cuts into the seabed and cobbles and rocks are retained in the next with finer gravels, sand and muds passing through. The dredge has a weak-link shackle at the tow end which fails, reverts in the orientation of the dredge into a passive mode, if obstacles hit are too resistant. The tow chain is connected to a 20 tonne Dynex cable and is towed through the A-frame.

Figure 8. Rock dredge

Survey Log

Note: all times are in UTC (-1hr Shiptime)

25th August 2023: Galway Harbour

ROV mobilisation starts at **08.00 UTC**. Science party starts to arrive.

26th August 2023: Galway Harbour

ROV mobilisation continues with ROV lifted on deck in the morning. Full science company arrived by **11.00**. In the evening electric power supply and communications to the ROV is found to be faulty (see Downtime and Technical Issues).

27th August 2023: Galway Harbour to Galway Bay

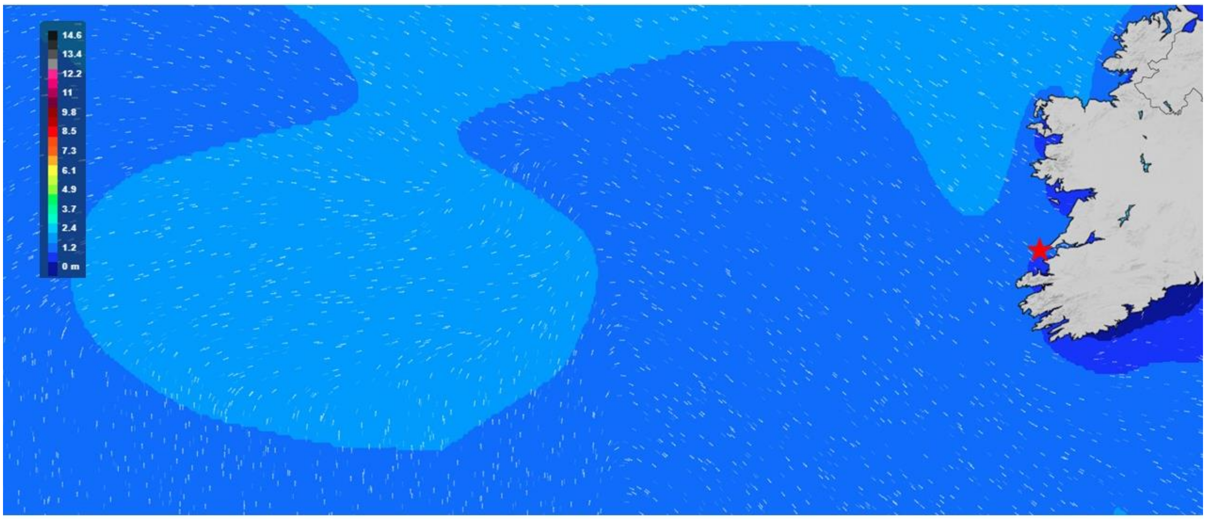
Electric power fault to the ROV is isolated to the winch - umbilical by lunchtime, tests continue. At **12.10** RV Celtic Explorer leaves Galway Dock and stays south of Mutton Island from **12.44** while work on the ROV continues. Marine mammal observations (MMO) were started at **12.55**. At **13.42** a soft start of the sub-bottom profiler commenced for training only. The survey line (not logged) run up Galway Bay to test sub-bottom profiler at **15.00**. *15.00 Wind NW Force 5.* Sub-bottom profile test line (not logged) finished at **17.21**. *17.21 Wind NW Force 4, good visibility, calm seas. 21.04 Wind NWN Force 3*. Started to transit to Loop Head at **22.48**.

Swell height 12.00am 27th August 2023

28th August 2023: Galway Bay to Loop Head to Galway Bay

03.00 Wind WNW Force 4, good visibility, slight sea. 07.00 Wind WNW Force 4, good visibility, slight sea. We arrived at Loop Head at **07.31** and transited to start of first dredge site on the bedrock exposures of the Ross Sandstone Fm. Dredging commenced at **09.31** ending at **09.47**.

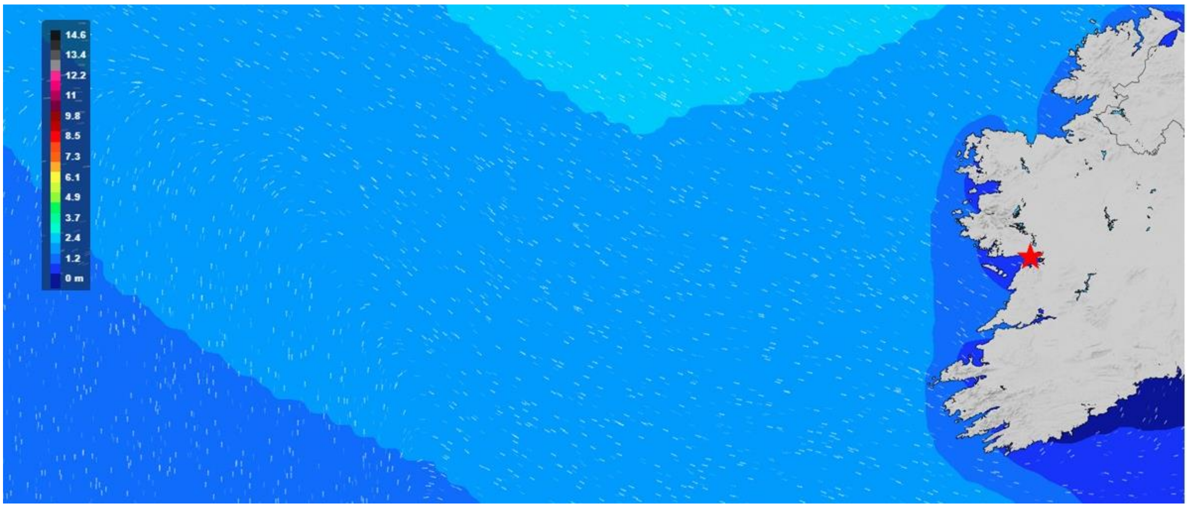
No sample was recovered and the dredge failed (see Downtime and Technical Issues) so there is no station number. Marine Mammal Survey (MMO) were initiated at 11.00. Dolphins were observed at 11.29 so the MMO survey was restarted. By 12.05 the survey was finished with no dolphins observed. A slow start of sub-bottom profiler started at 12.07. Sub-bottom profiler line (**St1_SB01**) commenced at **12.37** with EOL at **12.57.** The ship was then put onto DP facing into the waves to make it as smooth as possible for the ROV crew who are re-terminating the ROV umbilical. *15.00 Wind WSW Force 3-4*. At **15.35** we set sail for Galway Bay. *17.00 Wind SW Force 4, good visibility, slight sea*. *19.00 Wind NW Force 2, good visibility, slight sea*. We arrived just outside the South Sound (Outer Galway Bay) and started the MMO survey at **19.27**. *19.58, Wind S, Force 3.* At **20.11**, we started sub-bottom profiling in Galway Bay (**St2_SB02**) with a series of lines crossing the South Sound connected by transect lines joining the northern and south. EOL as at the edge of the channel. By the end of the day we had completed 8 lines covering the South Sound with c.4km line spacing (**St2_SB1-8**). *23.55 Wind SSE, Force 3*.



Swell height 09.00 am 28th August 2023

29th August 2023: Galway Bay

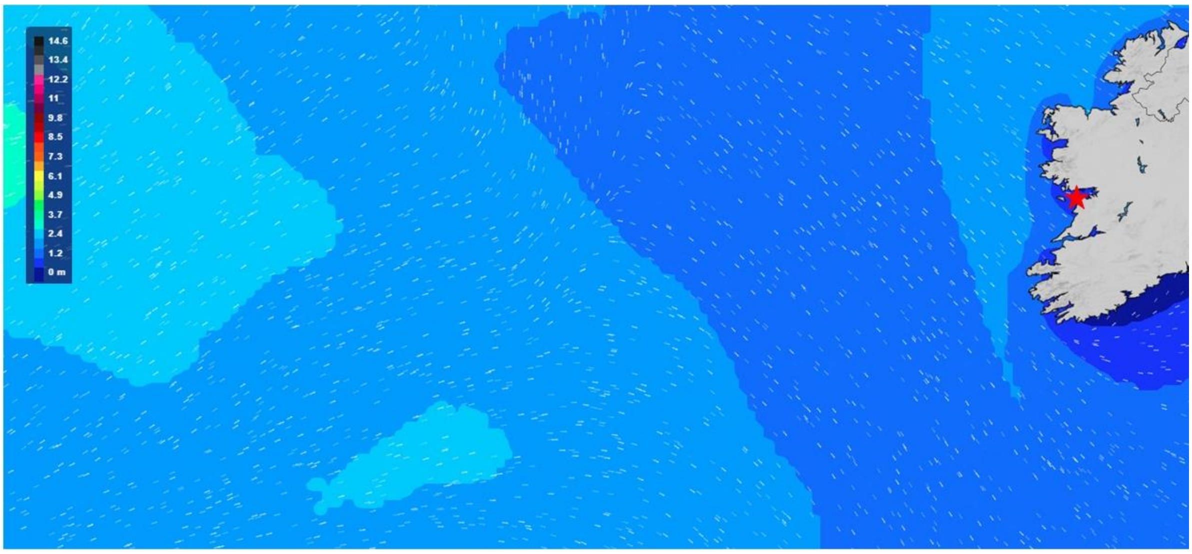
Sub-bottom profiling continued with lines across the enter bay working east (**St2_SB09-20**). *03.00 Wind SE, light airs*. *05.00 Wind WNW, Force 3, good visibility, calm.* By **06.25** we reached the Margaretta Buoy (**St2_SB20 EOL**) where a narrow channel heads to Galway Harbour. Here we run a line up the channel (**St2_SB21**) to south of Mutton Island finishing at **07.05**. *07.00 Wind W, Force 5, good visibility, calm seas.* We stayed on station while A/B Peter Joyce was transferred to land in the small boat. The small boat was back on-board and secured and the vessel manoeuvred to the next line which is a parallel line back down the channel. Sub-bottom profiling resumed at **08.45** (**St2_SB22**). This line was broken half way to put in two cross-lines (**St2_SB23, 25 & 27**) connected by transfer lines (**St2_SB24 & 26**) between **09.08** and **10.01**. The second parallel line down the channel was picked up again with a new line(**St2_SB28**) ending at **10.28**. *10.29 Wind WNW, Force 4.* Once past the Margaretta Buoy, we continued the line out into the bay (**St2_SB29**) ending at **11.08** and then started to increase the density of lines by running north-south (and south-north) between the existing lines (**St2_SB30 - 32**) between **11.11** and **12.38** and working easterly into the south-eastern part of the bay south of Tawin Island (**St2_SB33 - 36**) between **12.39** and **13.32**. *15.00 Wind WNW, Force 4.* A large cross line was then run from the south-eastern part of the bay west to the southern shore in the middle bay (**St2_SB37**) ending at **15.20**, with an infill line running north (**St2_SB38**) followed by a short line back to the middle of the bay (**St2_SB39**) ending at **17.11**. *17.16 Wind NW, Force 5.* The vessel then headed back to Galway to collect the replacement A/B Frank Kenny. The small boat was lowered **18.35** and recovered with Frank at **19.05**. Transit commenced at **19.18** to pick up the sub-bottom lines. A cross line through North Sound (**St2_SB40**) commenced at **20.41** finishing at **23.22**. *22.55 Wind NW, Force 4.* A series of north - south transects across the North Sound head back east were run with connecting lines at the northern and southern margins of the Sound starting at 23.35 (**St2_SB41**).



Swell height 09.00 am 29th August 2023

30th August 2023: Galway Bay

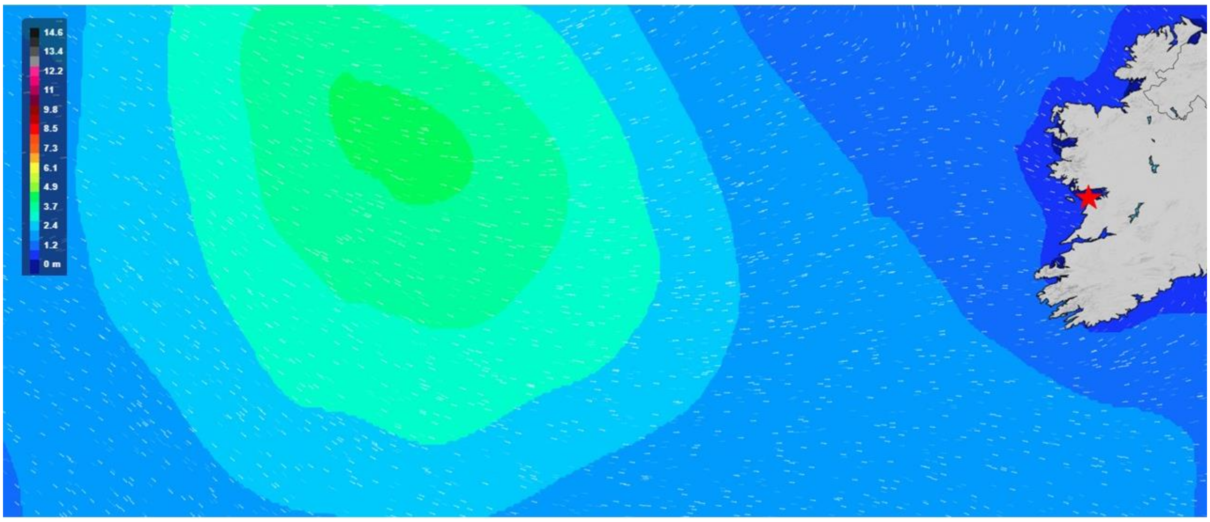
The north - south transects across the North Sound heading back east were run with connecting lines at the northern and southern margins of the Sound (**St2_SB41 to 51**) finishing at **06.14**. *03.00 Wind NW, Force 4. 05.00 Wind NW, Force 5, good visibility, calm seas.* A series of cross lines (with no connecting lines) were then run infilling the upper South Sound starting at **06.17** (**St2_SB52**). *07.00 Wind light airs, good visibility, calm seas. 10.52 Wind SW, Force 2.* **St2_SB56** finished at **12.00** and the vessel started the transit to Galway Dock. At **15.20**, the vessel was alongside in Galway Dock and the gravity corer, Shipek and Day grabs were craned onboard. Vessel cleared the lock gates at **15.55** and transited to the ROV wet test site in the North Sound arriving at **19.00**. *19.00 Wind SE, Force 5, good visibility, sheltered sea*. *21.24 Wind SE, Force 5.* The ROV wet test was performed at **22.21** but was unsuccessful due to failed ROV communications telemetry. The ROV was recovered at **22.42**. Sub-bottom profiling then resumed filling in final cross lines with **St2_SB57** starting at 23.33. *23.56 Wind SE, Force 6*.



Swell height 09.00 am 30th August 2023

31st August 2023: Galway Bay to west of the Arran Isles

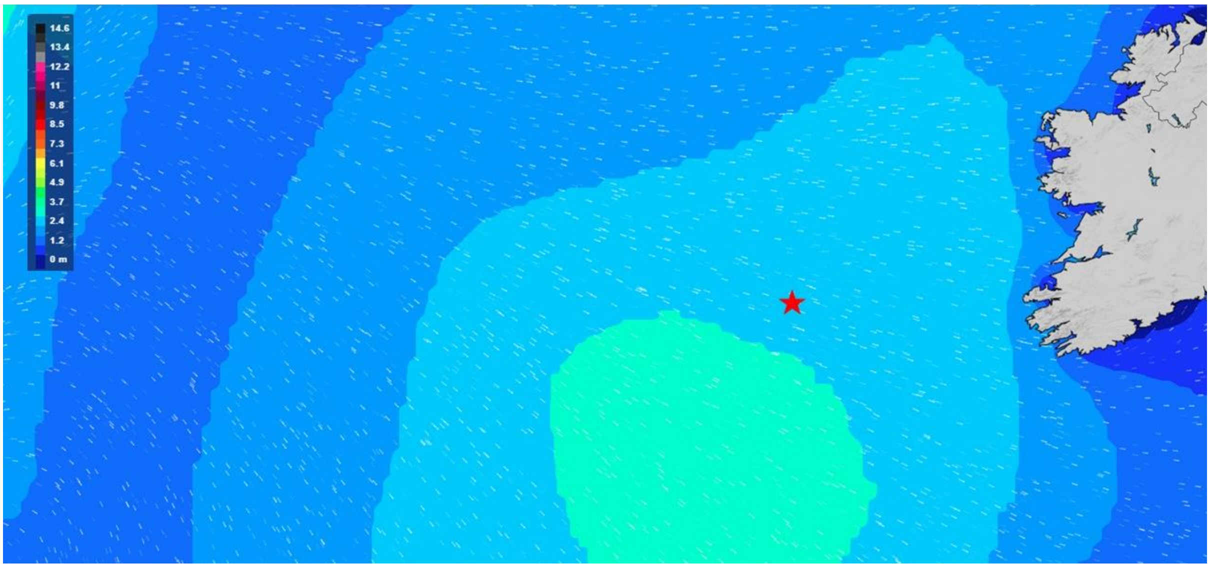
03.00 Wind SE Force 6. The final sub-bottom profiler line was finished at **04.53** (**St2_SB57**). *05.00 Wind S, Force 5/6, moderate visibility.* The vessel then returned to the wet test station awaiting the wet test redeployment of the ROV at **07.00.** *07.00 Wind W, Force 4, good visibility, slight sea. 09.59 Wind SE, Force 5.* A Shipek and Day Grab sample were taken for student training, these were not recorded and no station number allocated: the sediment was a silty, fine sand, moderately sorted. The ROV was off deck and the 2nd wet test started at **10.14** and recovered at **10.50**. At **10.58**, a third wet test was performed after minor adjustments to the ROV. *Wind WSW, Force 3*. The ROV was recovered at **11.21** after a successful wet test and we commenced the transit to the first drill site on the edge of the Porcupine Bank Canyon at 8 knots slowed by a headwind. *15.00 Wind SW, Force 5, good visibility, slight sea. 17.00 Wind SW, Force 5, good visibility, slight sea. 19.00 Wind SW, Force 5, good visibility, slight sea. 22.52 Wind SW, Force 5. 22.52 Wind W, Force 5.*



Swell height 09.00 am 31st August 2023

1st September 2023: Western shelf to Porcupine Bank Canyon

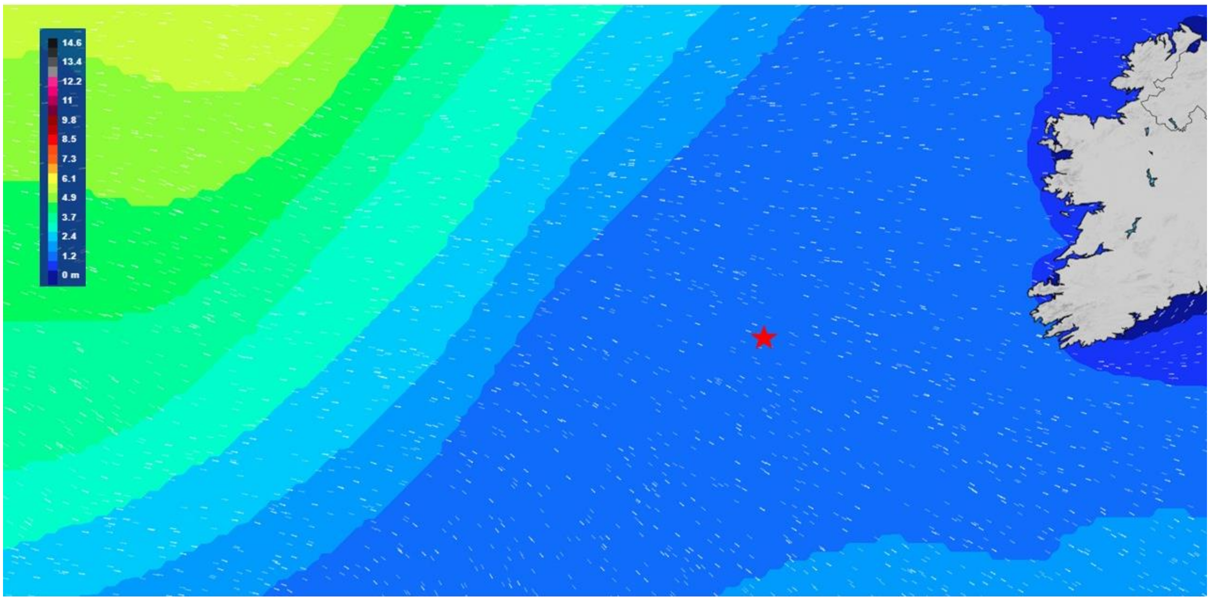
At midnight we continued our transit to the Porcupine Bank Canyon at 8 knots slowed by a lazy head-on swell although the headwind had dropped. *03.00 Wind W, Force 3. 05.00 Wind light airs, Force 5, good visibility, moderate sea. 07.00 Wind N, Force 2, good visibility, moderate sea*. The ADCP was turned on as we started to run west down the Porcupine Bank (**St 03_ADCP**) and continued to the ROV dive station. *09.42 Wind NW, Force 3*. *10.54 Wind N, Force 4*. We arrived on station at **13.10**. The ADCP was stopped at **13.23** and the decision was taken to launch the ROV. The ROV was off deck and in water at **14.34** (**St 04_ROV1**). *15.00 Wind N, Force 2*. Dive 1 went to 950m water depth, the ROV encountered strong currents at 650m and was too buoyant. As a result it had a problem keeping position without overheating (through overuse of the thrusters) and loosing too much hydraulic fluid. This was because, although the drill rig was heavy, there was too much buoyance and also a lot of drag. Eventually the ROV was moved to the drill site by towing with vessel moves. The drill site coordinates were wrong due to an input error on a previous survey from a data point where no sample was taken so with a lower QR value. Rock was found on a steep escarpment but no landing site was available. *17.00 Wind N, Force 3, good visibility, slight sea.* Dive was aborted due to rugged terrain and the ROV was on deck at **18.31**. *19.00 Wind NW, Force 2/3, good visibility, slight sea*. *20.06 Wind NNW, Force 4.* With extra weight added, the ROV was off deck at **20.37** for **St 05_ROV2**. The ROV was on bottom at **22.25** at 2142m but the seabed on the northern side of the canyon is covered in heavily bioturbated fluffy mud with weak current and the possibility of finding exposed bedrock was very low. *22.54 Wind NW, Force 4.*



Swell height 09.00 am 1st September 2023

2nd September 2023: Western shelf to Porcupine Bank Canyon to Porcupine Bank

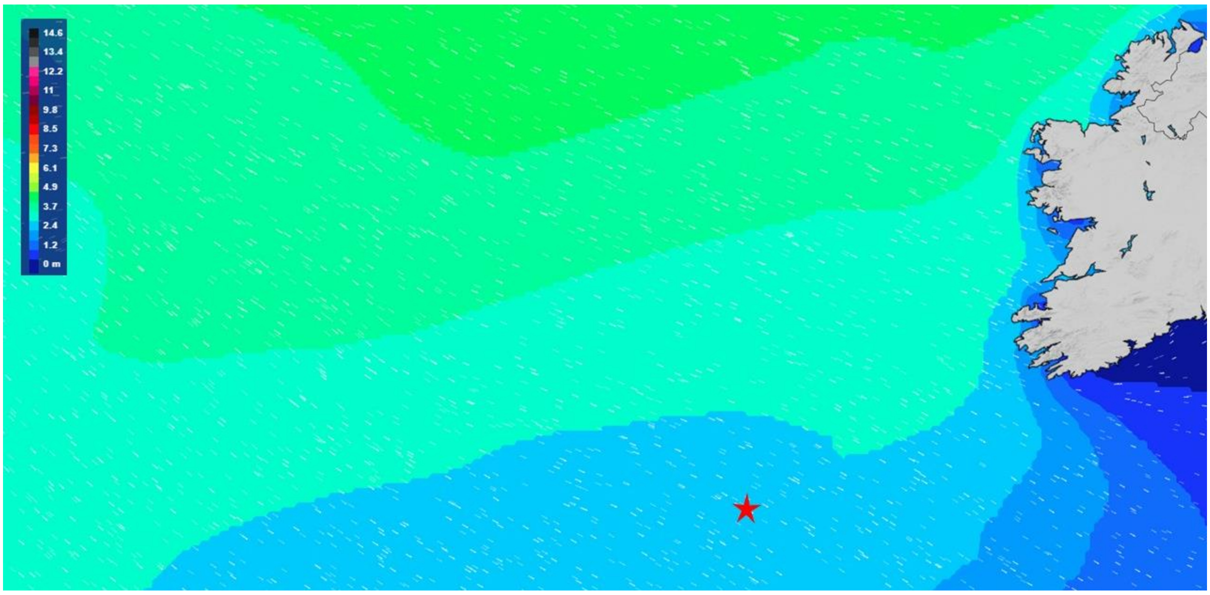
The site was abandoned with no drilling and the ROV was recovered to deck at **00.13**. It is assumed that the Bedrock Suitability Model showed the probability of bedrock here due to poor MBES data generating a spurious BPI and/or rugosity value. An ADCP line (**St 06_ADCP**) was then run across the canyon mouth from north to south between **00.15** and **02.20**. The was ROV off deck at **02.29** to dive to 1650m at **St 07_ROV3**. *03.00 Wind W, Force 23.* The seabed had plenty of rock rubble and the ROV moved easterly upslope to a slab of bedrock with some cobbles on top. The ROV settle down and drilling commenced at **04.21**. *05.00 Wind W, Force 2, good visibility, moderate sea. 07.00 Wind W, Force 3, good visibility, moderate sea.* Drilling was very slow and finished at **07.15** with limited penetration (c.15 cm). On retrieval the rock core was left in the seabed and did not snap off. The ROV was recovered of the bottom at **07.25**. ROV on deck at **08.23**, the core barrel was empty but it was clear the drill head had got warm. We started transit to next dive site at **08.53** and the ADCP turned on at **08.57** (**St 08_ADCP**). *08.55 Wind S, Force 3*. **St 08_ADCP** ended at **10.52**. *10.53 Wind SSW, Force 4*. We arrived on station at **10.55** and the ROV was off deck at **11.20** and on bottom at **12.18** (**St 09_ROV4**). The focus of this dive was to core the conglomerate observed in this area on the *ILV Granuaile* survey RH17002 (2017) and attempted in ROV Dive 1 (Station 4). The conglomerate was not visible on arrival to the seabed and a search was conducted downslope, the moving laterally to the north, then upslope and laterally back to the landing location. Near the landing location the conglomerate was observed with a rusty oxide covering. It was not possible to land. We then proceeded south and found the conglomerate again exposed in a short ledge 0.5m tall and above it on a 40° slope. Again, unfortunately no landing site was possible. As the swell was due to arrive rapidly at 17.00, it was decided that there was no more time to search and drill before recovery was essential. It was then decided to recover the ROV off the bottom at **12.49** and it was on deck at **14.36**. A significant transit south to the next proposed dive site on the SW Porcupine Bank (weather permitting see below for actual) was undertaken which would move us away from the incoming weather. *15.00 Wind SW Force 4*. The ADCP was run during the transit (**St 10_ADCP**) starting at **15.09.** *17.00 Wind SSW Force 5, good visibility, slight sea*. *19.00 Wind SSW, Force 4, good visibility, slight sea.* The ADCP was stopped at **21.51**. We arrived at the next dive site at **21.51** after finishing the transit. The ROV was off-deck at **22.13** for **St 11_ROV5** on the SW Porcupine Bank. *22.53 Wind SSW, Force 5.*



Swell height 09.00 am 2nd September 2023

3rd September 2023: Porcupine Bank

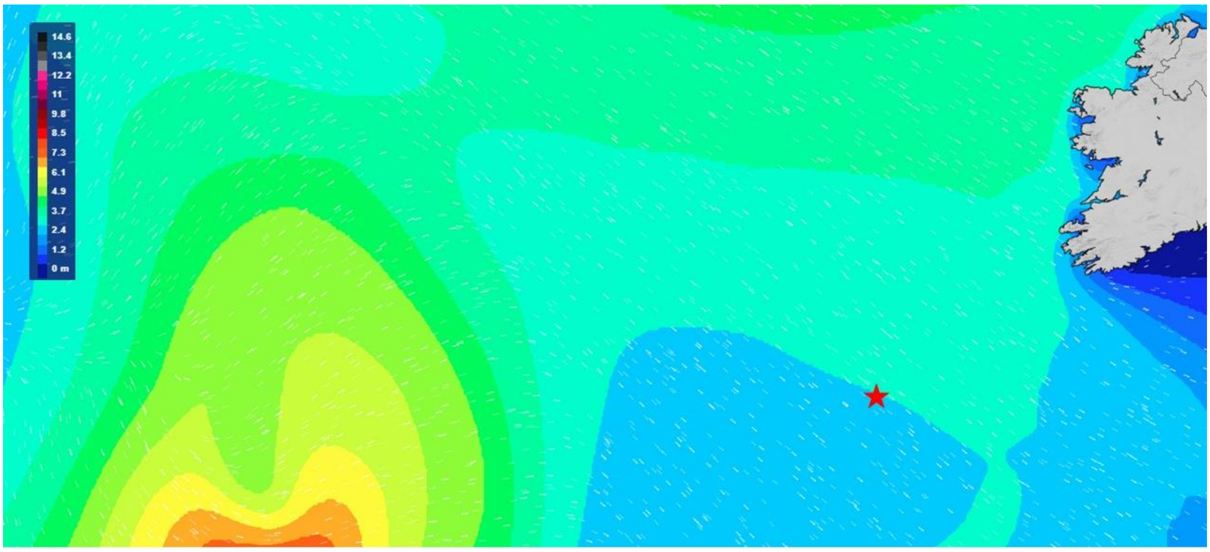
The ROV reached the bottom at **00.17** and landed on a muddy plateau (**St 11_ROV5**). It proceeded north and encountered a steep craggy rock face, rocks "looked" to be hard gneissic type rocks (rounded with no planar structures) but very hard to say as covered in black oxides. The ROV proceeded to climb the slope looking for a landing site with some attempts. *03.00 Wind SSW, Force 5.* Drilling commenced at **01.16** and proceeded well with good progress on the penetration. However, he drill was undertaken at an angle. Unfortunately, the ROV shifted, the rock split and the drill released the corer at **01.36**. The core barrel was recovered but the drill site had to be abandoned. No rock was recovered in the barrel. The ROV continued to travel upslope with the hope of finding a new landing site but it was too craggy and eventually the dive was abandoned. ROV arrived back on deck at **04.57**. *05.00 Wind SSW, Force 4, good visibility, slight sea. 07.00 Wind SSW, Force 4, good visibility, slight sea.* Transit commenced to the next dive site on the southern tip of the Porcupine Bank arriving on station at **08.36**. *08.36 Wind S, Force 4, good visibility, slight sea.* The ROV was off the deck at **09.03** and on the bottom at **11.05** at 2950m (**St 13_ROV6**). *11.07 Wind S, Force 3.* The ROV eventually found a crested top with some boulders at **1218**. This was 100m deeper than anticipated, currents were strong to the NW. The ROV proceeded to the north and encountered bedrock. It was very steep with nowhere to land and there was a lot of sediment covering the slopes also. Proceeding upslope, more sediment was encountered on steep slopes but bedrock was not found. We proceeded up slope to 2580 m onto a spur but no further sight or even hint of bedrock. The dive was abandoned at **12.45** and the ROV was off the bottom at **12.45** and recovered to deck at **14.21**. A transit commenced north at **14.26**. The ADCP was started at **15.27** (**St 14_ADCP**) and ended at **15.34**. The ROV was off deck at **15.46** but the dive was aborted due to a camera failure in a water. The ROV was back on deck at **16.05** and back in the water at **16.48** once the fault was fixed. *19.00 Wind SSE Force 2, good visibility, moderate swell.* By **19.29,** the ROV had reached 1630m and was encountering very strong north-westerly contour currents which was preventing the ROV from descending without streaming away. After various attempts to get down it was decided that the currents were simply too strong and the dive was abandoned. The ROV was recovered to deck at **20.28** and a transit started to the Pastouret Spit on the NW Goban Spur at **20.36**. *20.36 Wind SE Force 3. 22.57 Wind ESE Force 5.* The ADCP was run on the transit (**St 14_ADCP**) starting at **23.00**.



Swell height 12.00 am 3rd September 2023. Note the swell period is long (lazy) so quite workable

4th September 2023: Porcupine Bank to Goban Spur

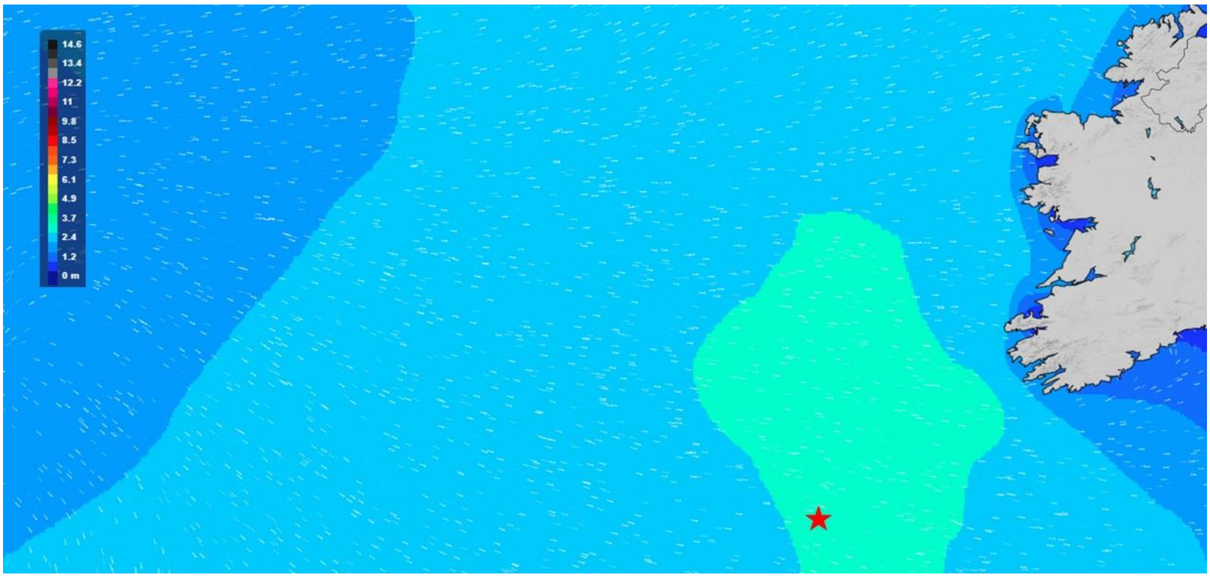
03.00 Wind ENE Force 3. The ADCP (**St 14_ADCP**) was turned off at **04.19** and we arrived on the south flank of the Pastouret Spit (NW Goban Spur) at **04.40**. The ROV was off deck at **04.48** (**St 16_ROV7**). *05.50 Wind ENE Force 4, good visibility, slight sea.* And the ROV was on the bottom at **06.00**. The seabed was muddy and we proceed along slope to the NW finding occasional dropstones. After 200m we crossed the track of a previous air gun sesimic line that showed outcrop but at the seabed this was covered by sediment. After 1 km the line finish and we turned 90^o to the SW travelling up the slope of the Pastouret Spit. Again no bedrock was seen. At 2050m water depth we again turned 90^o to the SE and contoured along the slope. No bedrock was observed just mud and dropstones. After 500m we crossed the seismic line and recovered the ROV. *07.00 Wind E, Force 5 good visibility, slight sea.* The ROV was off bottom at **08.35** and on deck **09.52**. A transit was started at **09.55** towards the SW to the Pendragon Escarpment. *10.55 Wind NE, Force 4. .*At **11.16,** a short sub-bottom Chirp line (**St17_SB1**) was run down the Pendragon Escarpment to see if we could resolve a sediment cover over bedrock. The water depth was 2750m and the data was poor quality (probably more to do with the slope) and it was not possible to resolve more than the seabed. The ROV went off the deck at **11.30** for **St 18_ROV8** at hit the bottom at **13.52**. The bottom was muddy and we proceeded NE toward the steep rise. When we got there, we were presented with a near vertical rock cliff for a few metres high. We traversed the base of this cliff for 50m northerly looking for a landing place, then rose up 5m and traversed back 50m southerly. No landing places were visible. We then rose a further 10m and repeated the lateral searchers progressively stepping up the face ever 50m lateral traverse. After the basal 10-15m the cliff became a steep (70^o) face of sediment. Eventually after climbing for 300m we abandoned trying to find a ledge and recovered to deck. It is clear that with most of these sites we find bedrock exposed at the base but any ledges that may have existed are covered in steep sediment and are not “landable”. *15.00 Wind NE, Force 6.* The ROV was recovered to deck at **17.08**. *17.10 Wind E, Force 5/6, moderate visibility, moderate sea.* And strapped down and a transect taken to the south ending at **19.00**. *19.00 Wind E, Force 5 good/moderate visibility, moderate sea.* We stayed on station for 1 hour waiting for the swell to fall and then put the ROV in the water for **St 19_ROV9** at **20.10** and it was on the bottom at **21.57**. After landing on the botto,m it was initially muddy but we actually landed right on the lip of steep rocky outcrop. We drifted back a few metres and discovered this cliff so we proceeded to keep going back and surveyed the slope through vertical and lateral moves. It was rocky, near vertical and it was not possible to land. We therefore decided to climb up but encountered very steep sediment walls that were partially lithified. We decided to rise up the slope a few 100 metres Occasionally we found bedrock exposures but there were not flat areas to land the ROV. We therefore decided to go all the way to the top and see if there was bedrock at the ridge as we found bedrock periodically up. On reaching the ridge we found that currents crossing the ridge had prevented thick accumulations of sediment and a small flat area of bedrock was exposure next to an area of lithified stoney hardground. The ROV landed at an angle of 12^{o} and was stable. *22.52 Wind E, Force.* Drilling commenced at **23.45** at a water depth 2440 mwd.



Swell height 09.00 am 4th September 2023.

5th September 2023: Goban Spur.
03.00 Wind E, Force 5. After 3 hours of drilling (**03.02**) on **St 19_ROV9**, a core was recovered (**St 19_R1**). The ROV was recovered and returned to deck at **05.00**. *05.00 Wind E, Force 3 good visibility, slight sea.* The vessel then commenced a transit to the next site and the ADCP line (**St 20_ADCP**) was run from **05.04** to **10.40** southerly along the Pendragon Escarpment. *07.00 Wind E, Force 4, poor visibility, moderate sea. 08.52 Wind E, Force 5.* The vessel arrived on station at **10.30.** *10.30 Wind ENE, Force 5.* The ROV was deployed after lunch/shift change leaving the deck at **11.04** and commenced dive **St 21_ROV10**. The ROV was on the bottom at **12.49** and the seabed was a steep muddy cliff. We proceeded to climb the cliff to the NE which was muddy all the way to the top. The top of the ridge was broad and the currents were not particularly strong. We proceeded up slope to the NW but did not encounter bedrock or any indication of bedrock. The ROV dive was aborted and the ROV was back on deck at **14.15**.

Repairs were done to the pan-and-tilt camera that was flickering during the last dive as well as the pan-and-tilt controls misfiring slightly. *15.00 Wind SE, Force 6.* A short transit was taken at **16.13** to the next station arriving on station at **16.56**. *16.55 Wind SE, Force 6/7, good visibility, moderate sea.* The ROV deployed at **17.00** and descended 1600m before it developed a problem with the telemetry and communication to the cameras and motor were lost. If was a dead-sub recovery being on deck at **19.11** (see Downtime and technical issues). *19.00 Wind SE, Force 7, good visibility, moderate sea.* The issue was isolated to a poor optical pass on a slip ring in the winch and it was decided to carry on at present with the known issue. The ROV was redeployed at **22.39** for dive **St 22_ROV11**. ***Please note the overlay nav on the video files is wrong).*** *22.52 Wind SSE, Force 5.* On reaching he bottom at **23.57**, the seabed was found to be muddy and a search around did not reveal and outcrops. The ongoing telemetry issue proved to be manageable.

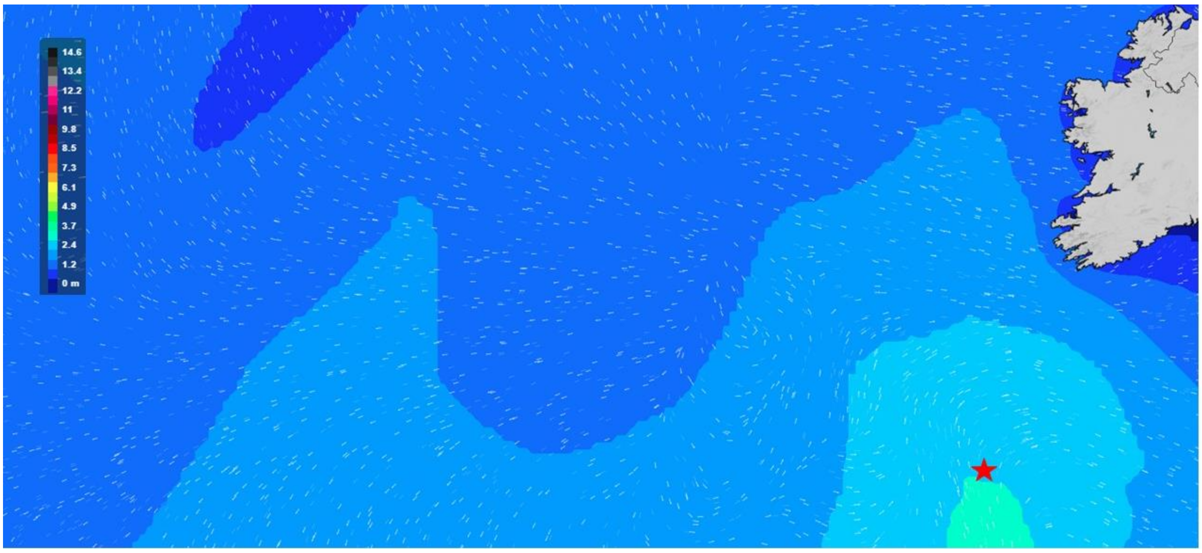


Swell height 09.00 am 5th September 2023.

6th September 2023: Goban Spur.

The ROV dive **St 22_ROV11** was abandoned at **01.10** and the ROV was recovered to deck. On the way up, the top buoyancy float over the drilling rig on the ROV broke loose but remained tethered to the ROV. It was hitting the ROV and there was concern about damage. The ROV was recovered to deck at **02.21**. *03.00 Wind SE, Force 7.* Transit to the next site commenced at **02.27.** *03.00 Wind SE, Force 7. 05.00 Wind SE, Force 6, good visibility, moderate sea.* Arriving on station at **06.20**. Repairs to the ROV were undertaken during transit and no damage to the ROV. At arrival on station it was a little rough and it was decided to launch after breakfast. *07.02 Wind SE, Force 6/7, good visibility, high seas.* At **08.50** it was decided that the sea was still too rough to launch. The ROV was eventually off the deck at **09.56** (**St 23_ROV12**). ***Please note the overlay nav on the video files is wrong).*** *10.58 Wind SE, Force 6.* The ROV reached the seabed at **10.59** and it was very muddy. Initially we headed NE to reach the edge of the slope which was gently dipping. We then headed north and the seabed continued to be muddy. Eventually the seabed began to rise steeply but remained muddy. A scan for outcrop was made with the sonar, none was found and we came off the bottom at

12.29 and recovered to deck by **13.33.** Some repairs were done to the umbilical and transit started at **13.59**. *15.00 Wind SE, Force 7.* The ROV was back in the water at **15.50** and on the bottom at **16.35** (**St 24_ROV13**). ***Please note the overlay nav on the video files is wrong).*** The bottom was hard, semi-lithified mud that had been current swept with some gravel. We headed NE upslope and encountered and metalliferous hardground that had been undercut. The ground became more gravelly in places, plenty of dropstones with corals and sponges as well as several Orange Roughy. We proceeded upslope until we reached the top of the seamount but did not, despite encouraging signs, encounter any bedrock exposures. On the top it was a little more muddy but still evidence of strong currents. *17.00 Wind SE, Force 5, good visibility, moderate seas.* The ROV was recovered off the bottom and was on deck at **18.38**. We transited to next station further east along the flank of the seamount ending at **19.15**. *19.20 Wind SE, Force 6, moderate visibility, slight seas* The ROV was off deck at **19.23** for **St 25_ROV14**, ***Please note the overlay nav on the video files is wrong)*** and the bottom at **20.19**. The seabed on arrive was a rippled sand with dropstones, we continued NE following the best Bedrock Suitability Model climbing laterally upslope but the rippled sand continued with no indication that bedrock would appear. *21.30 Wind SE, Force 6.* After a while we changed approach and decided to target the deep, steeper slope and did a "blue water hop" with the ROV due south for 850m. On reaching the seabed it was rocky and very steep. We proceeded to climb the slope looking for a landing place but none were available. The rock "looked" like basalts based on how it was weathering, internal structuring and also loose broken blocks showing fresh faces one of which appeared to show amygdales (?). We headed up to the break of slope where it was flattered but bedrock outcrops were still occasionally visible. *22.54 Wind SE, Force 6.*



Swell height 09.00 am 6th September 2023.

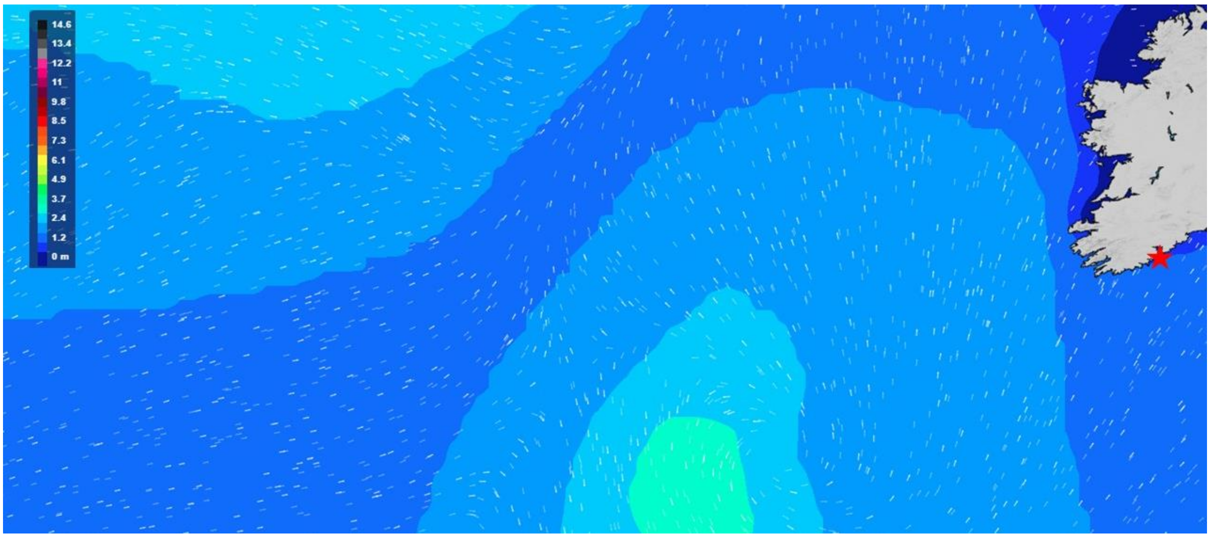
7th September 2023: Goban Spur to Celtic Sea.

We continued the ROV dive (**St 25_ROV14**) ***Please note the overlay nav on the video files is wrong)*** exploring this depth range at about 1550-1590m finding occasional small outcrops and attempting to land but it was not possible to land adequately to drill. Eventually we did land securely and a drill core (**St 25_R2**) was taken at **01.28**. Drilling continued until **03.27** after which the ROV was recovered to the deck at **04.36**. A transit for Cork Harbourwas taken to swap out the ROV rockdrill and some scientist, the transit commenced at **04.37** at 9.5-10 knots. *05.00 Wind SE, Force 7, good visibility, moderate seas. 07.00 Wind SE, Force 6, good visibility, moderate seas. 09.09 Wind SE, Force 6. 10.57 Wind SE, Force 6. 15.00 Wind SE, Force 5. 19.00 Wind SE, Force 4, good visibility, slight sea. 21.01 Wind SE, Force 3, good visibility, slight sea. 22.52 Wind ESE, Force 4.*

Swell height 09.00 am 7th September 2023.

8th September 2023: Celtic Sea to Cork to western Celtic Sea

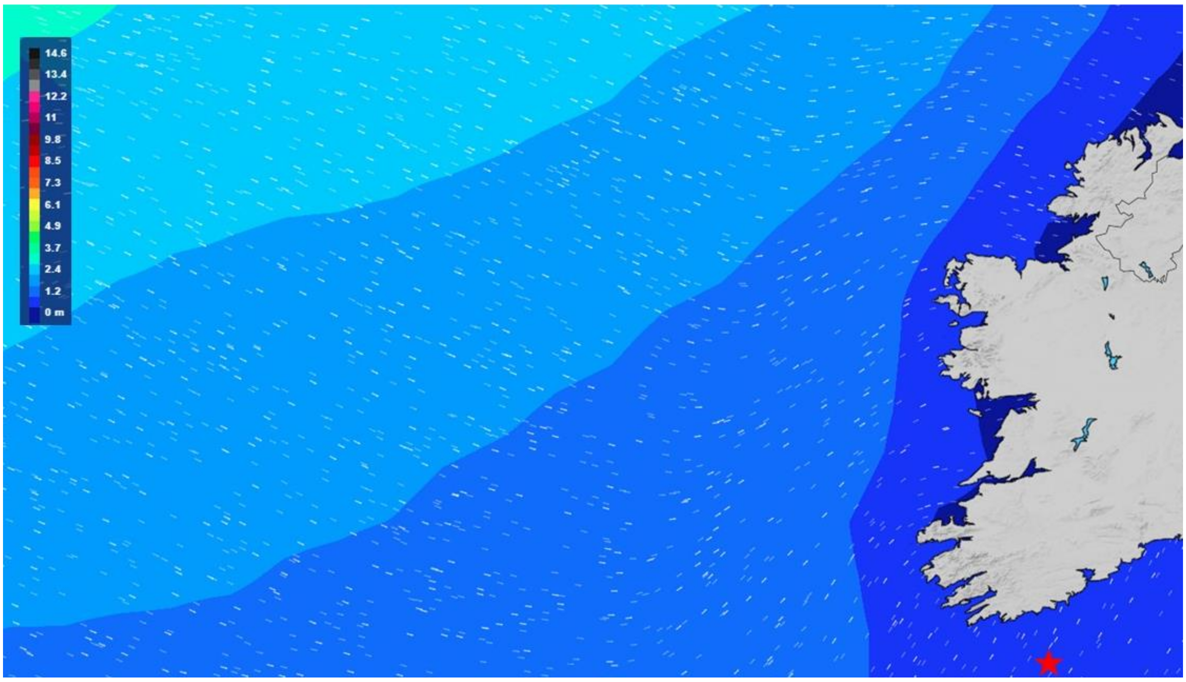
03.00 Wind ESE, Force 2. 05.00 Wind light airs, poor visibility, calm sea. We arrive at Roche's Point at **06.30** and proceed up the Harbour. *07.00 Wind light airs, poor visibility, fog.* We were along side in Cork Harbour at **09.00**, the rock drill was taken off and some of the scientist team swapped out. We set sail at **12.34** from Port of Cork. **START OF LEG 2**. The drop keel was lowered at **15.03** and the transit resumed at **15.20**. *17.00 Wind S, Force 2, poor visibility, fog, moderate sea.* We arrived on station and started the Sub-bottom profiler line **St26_SB_01** at **17.52**. The line was run from ENE to WSW at 4.5 knots. This line gave poor penetration so to get to a more interesting part of the line we speed up after a while logging to 10 kts and kept recording. *19.00 Wind S, Force 2, poor visibility, fog, moderate sea.* At **19.47** we started logging a second line (**St26_SB_02**) as a continuation but again at 4.5 kts. This new line looks better but has a heavy heave artefact that will require post processing. Until we solved this problem, we stopped acquiring **St26_SB_02** EOL at **20.29**. **St26_SB_03** started at **20.46** on the same heading. *20.50 Wind S, Force 2, poor visibility, fog.* At **21.55** we took a series of 90° turns to port to see if the heading affected the heave artefact on the sub-bottom. At **22.07** we resumed the line. New SOL at **St26_SB_04** at **22.11**. *22.30 Wind SE, Force 3.*



Swell height 09.00 am 8th September 2023.

9th September 2023: western Celtic Sea

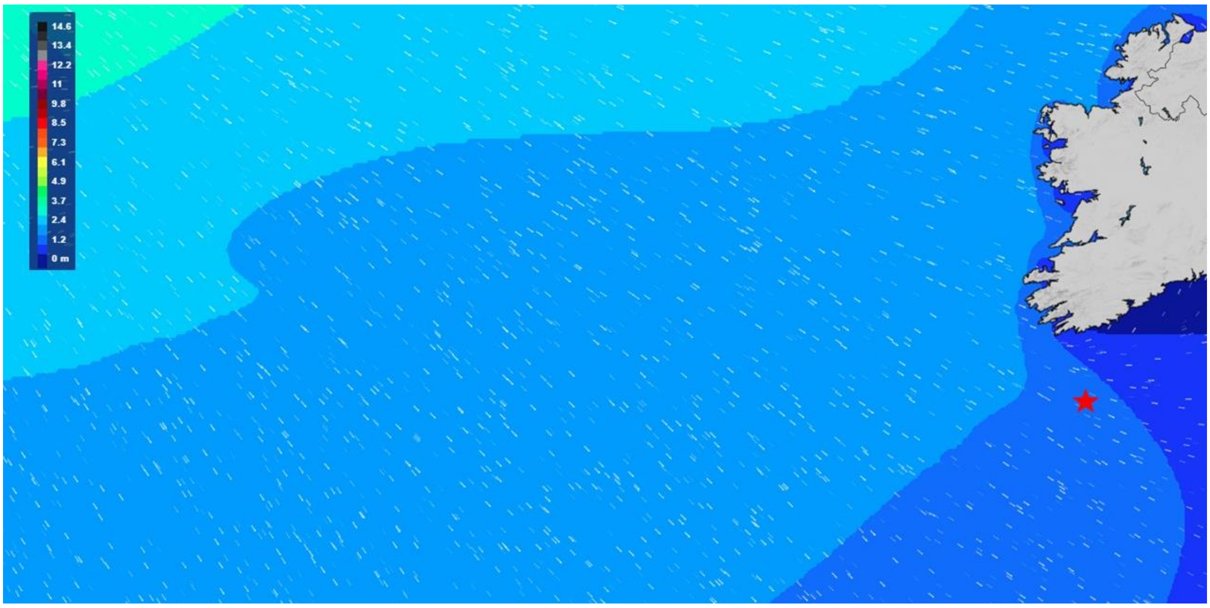
EOL was **St26_SB_04** reached at **00.13**. A short NNW line (**St26_SB_05**) was started at **00.20** and finished at **00.57**. A ENE line (**St26_SB_06**) was started at **01.01** and finished at **02.29**. A Short SE line (**St26_SB_07**) was started at **02.33** and finished at **02.44**. *03.00 Wind SE, Force 2, poor visibility, fog, slight sea.* A SWS line (**St26_SB_08**) was started at **02.46** and finished at **03.57**. A Short ESE line (**St26_SB_09**) was started at **04.00** and finished at **04.33**. A NNE line (**St26_SB_010**) was started at **04.36** and finished at **05.54**. This line was really good with the lines generally showing buried channels and moraine ridges rising to the seabed. A Short ENE line (**St26_SB_11**) was started at **05.56** and finished at **06.14**. A SWS line (**St26_SB_12**)was started at **06.17** and finished at **07.36**. *07.00 Wind SE, Force 2, poor visibility, fog, moderate sea.* A short easterly transect was taken and not logged. A new N line (**St26_SB_13**) was started at **07.46** and ended at **09.09.** A short connecting line **St26_SB_14** was started at **09.12** running E-W ending at **09.20**. Line **St26_SB_15** was starting at **09.22** running to the south**.** *09.33 Wind ESE, Force 2, poor visibility, fog. 10.53 Wind SE, Force 2, poor visibility, fog. 10.53 Wind SE, Force 2, poor visibility, fog.* Line **St26_SB_15** ended at **11.05**. Long NE bearing line **St26_SB_16** was started at **11.16** and ended at **12.40**. A new line **St26_SB_17** was started at **12.46** running SE and ending at **13.07**. A new line **St26_SB_18** started at **13.10** running SSW and ended at **14.01**. A new line **St26_SB_19** was started at **14.22** running E and ended at **14.38**. A new line **St26_SB_20** was started at **14.40** running NNE and ended at **15.51**. *15.00 Wind E, Force 2.* A shorter line **St26_SB_21** was started at **15.53** running E and ended at **16.21** before turning S onto **St26_SB_22** which started at **16.27** and ended at **17.46**. This concluded the eastward continuation of N-S lines with connections. The next line ran back NW **St26_SB_23** starting at **16.50** and ending at **19.59**. *20.02 Wind NE, Force 6.* Line **St26_SB_24** started at **20.02** running SW between St26_SB_16 and St26_SB_18, an ended at **21.33**. A shot connecting line, **St26_SB_25**, was started at **21.35** running to the W and ended at **22.00.** The next line **St26_SB_26** ran N starting at **22.01** and ended at **23.34** crossing St26_SB_15. *22.51 Wind N, Force 2.* A short connecting line was run to the west, **St26_SB_27**, crossing line St26_SB_15 again, this started at **23.37** and ended at **23.56.**



Swell height 09.00 am 9th September 2023.

10th September 2023: western Celtic Sea to NE Porcupine Seabight

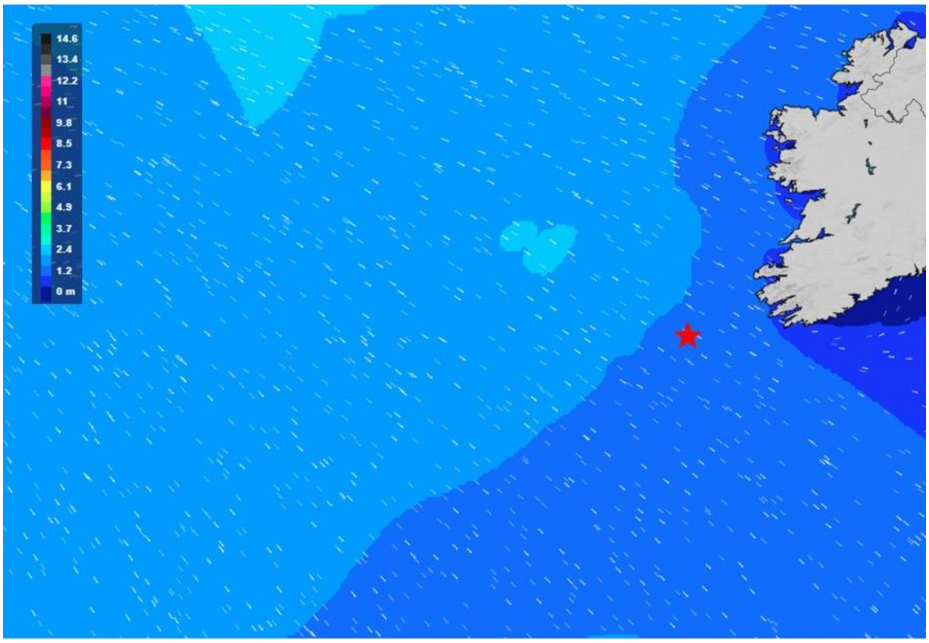
A sub-bottom profiler line **St26_SB_28** was started **00.00** and ended at **01.14** running S. Again, a short connecting line (**St26_SB_29**) was run to the W that started at 01.18 and ended at 02.01. This was followed by line **St26_SB_30** running N that started at **02.03** and ended at **03.38**. *03.00 Wind N, Force 2.* This line crosses St26_SB_10 near the end. Line **St26_SB_31** runs SW and crosses St26_SB_09 near the end and started at **03.41** and ended at **05.31**. *05.00 Wind N, Force 3.* Line **St26_SB_32** started at **05.3,** runs NW and ended at **06.18**. Line **St26_SB_33** started at **06.21**, runs NE and ended at **07.13**. This line crosses St26_SB_04 at the start. *07.00 Wind NE, Force 2.* The next line ran NW (**St26_SB_34**) and started at **07.16** and ended at **07.57** and crosses St26_SB_06 before reach the next line. The next line **St26_SB_35** started at **07.59** and ended at **08.59**. *07.58 Wind SW, Force 3.* A transit to the NE Porcupine Seabight commenced at **09.00** at 9.5 kts. *09.00 Wind NW, Force 3. 10.53 Wind NNW, Force 3. 15.00 Wind NW, Force 2. 17.00 Wind NW, Force 2, good visibility, slight sea.* At 17.55 the ADCP was turned on (**St34_ADCP**) and continued to log for the whole survey. Note the night shift turned this on and did nto originally log it hence the station number is 33 as we caught it retrospectively. We arrived on station at **18.30** in the **" Belgica Mounds Province, NE Porcupine Seabight** over an area of ridge reefs referred to here as the Alf Reefs. A CTD was deployed in the water at **18.50** (**St27_CTD_1)**. It stopped near bottom at 910m water depth (9m off bottom) at **19.07**. *19.00 Wind W, Force 2, good visibility, slight sea.* An acoustic release was tested and 2 water bottles were fired (bottles 1 & 2). The CTD was raised 5 m to 905m water depth (14m off bottom) and 2 more water bottles were fired (bottles 3 & 4). The CTD raised a further 10 m to 900m water depth (19m off bottom) and 2 more water bottles were fired (bottles 5 & 6). The CTD was recovered to deck at **19.27**. *19.00 Wind W, Force 2, good visibility, slight sea.* The ROV was deployed being off deck (**St 28_ROV15**) at **19.41** to recover a lander and take coral samples. The ROV was on the bottom at **20.17** near to the landers where there were a series of several metre tall coral ridges and troughs (the Alf Reefs). On arrival, there was no lander and no response from the homer beacon. The ROV then commenced a search initially heading NE picking up the first response from the homer beacon (43m distant) at **20.29**. Responses from the homer beacon were intermittent and often contradictory. The lander was boxed in by a search and eventually a visual sighting was made at **21.12**. The lander (Apollo) was in a trough between ridges and had fallen over. The position was 34.4m away from where deployment was supposed to be on a bearing of 305°. This offset is probably due to a faulty heading inaccuracy on the USBL system which seems to be a recurring issue. A waypoint was plotted and a search for the second lander (Charlotte – with no beacon) commenced using a box search to the west. Charlotte was found at **21.48** in a consistent location given the USBL offset error. A waypoint was loaded. The station (**St 28_ROV15**) now focussed on collection coral samples. *Lophelia* and *Madrepora* corals were collected from both the Charlotte (at **21.52**) and Apollo lander sites (at **22.55**). Once completed, Charlotte was recovered to deck by the ROV. *23.51 Wind WSW, Force 3.*



Swell height 09.00 am 10th September 2023.

11th September 2023: NE Porcupine Seabight

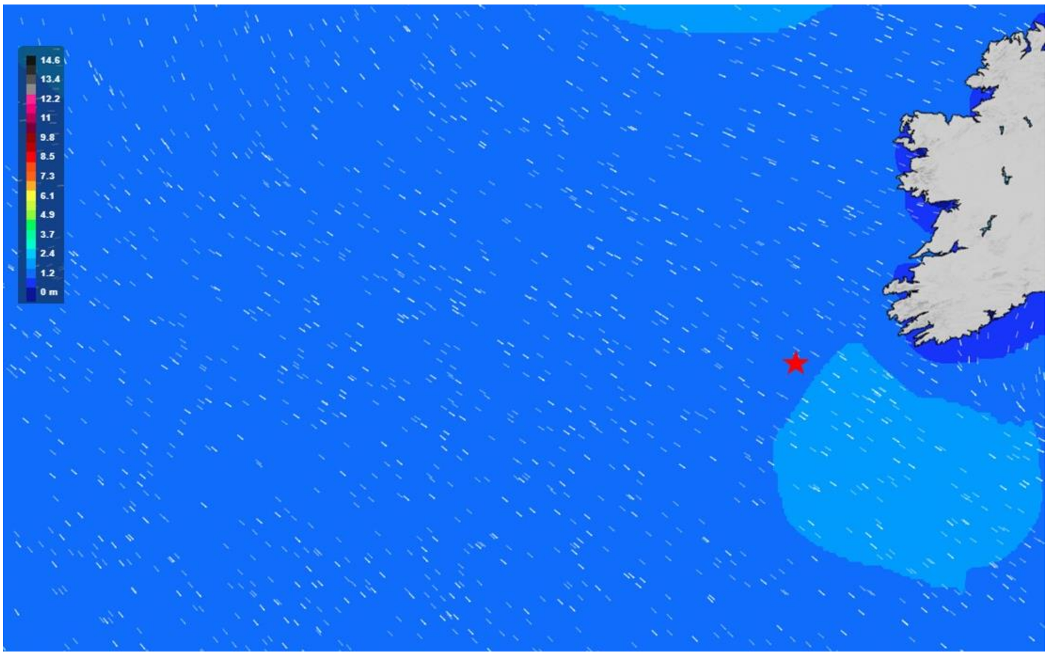
Charlotte was recovered from station **St 28_ROV15** and was on deck at **00.50**. Coral samples were sorted, documented and dried in the oven. The ROV was back in the water at **01.04** for **St 28_ROV16**. The ROV was on the bottom at **01.37** next to the Apollo lander. Apollo was picked up and recovered to deck at **02.43**. *03.00 Wind W, Force 3, slight sea* We then started a calibration test of the USBL beacon at 915m water depth prior to use with ROV multibeam echosounder mapping. A USBL beacon was free fallen from the vessel at **04.10** and the vessel was spin-up over the beacon, near the beacon and was moved away on a heading. After these quick test it was confirmed that the pitch and roll reading were accurate but the heading reading was sub-standard. A full calibration was then initiated with the vessel spinning to the west, north, east and south of the USBL position. *07.00 Wind W, Force 5, good visibility, slight sea.* By **08.40** the ROV was mobbed for vibrocoring. *10.58 Wind NNW, Force 6.* The USBL calibration was completed at **11.38.** Following the calibration, the heading reading fell back within acceptable limits and the location of the beacon on the seabed at 915m water depth was accurate to 2m rather and 6m (see Appendix USBL Calibration Report). The USBL beacon was released off the bottom at **11.40** and on the surface at **11.55**. Strong winds (25 m/s) hampering recovery but the USBL beacon was on deck at **12.16**. The vessel now headed back on the Apollo former landing site to commence vibrocoring. We were back on station at **13.30** but the wind was too strong (27 m/s) and the ROV deployment was delayed until the wind dropped. We therefore transited to deep water to get a fresh SVP profile that is longer than the MBES surveying depth. We arrived at the CTD station at **13.11**. The CTD was deployed but reading were not good so it was recovered back to deck to flush with freshwater. The CTD (**St 29_CTD1)** was redeployed at **13.30** reaching 1050m water depth at **13.45**. It was recovered to deck at **14.00**. We then transited back to the Apollo former landing site and ended the transit at **14.30**. At **15.04**, the swell and wind had subsided enough to allow the ROV to dive on **St 30_ROV 17**. The ROV was in the water at **15.08** equipped with vibrocores to sample the Apollo and Charlotte sites. *15.00 Wind NW, Force 5.* The ROV reached the bottom at **16.02** near to the Apollo site. As the USBL has been calibrated we are not sure it is the exact Apollo site but it is near. Vibrocoring commenced at **16.05** at 916m water depth. A few minutes into coring operation the shackle connecting the recovery rope to the vibromotor broke loose. We continued coring by lifting the motor with the T4 robot arm. This proved effective but we then damaged the posts supporting the arm. Core penetration was successful at c.2m and the core was stowed (**St31_VC1**). The motor posts were then held by the T4 and Orion arms and the ROV recovered to deck at **17.14**. The core barrel was damaged in the robot jaws and the liner was hard to remove resulting in a c.110c disturbed core. The vibrocorer rig was fixed and the ROV dived again at **18.07** (**St 31_ROV 18**). We reached the bottom at 916m at **18.45** and four vibrocores were taken, two at Apollo (**St31_VC2 & 3**) in the trough and two at Charlotte (**St31_VC4 & 5**) on the ridge. *19.12 Wind NNW, Force 4, good visibility, moderate sea.* The ROV was recovered to deck at **20.56**. The ROV vibrocorer demobbed and the EM2020 MBES mobbed. *23.55 Wind NNW, Force 5.*



Swell height 09.00 am 11th September 2023.

12th September 2023: NE Porcupine Seabight

03.00 Wind N, Force 4, good visibility, moderate sea. 05.00 Wind NW, Force 4, good visibility, slight sea. The ROV was deployed in multibeam echosounder mode at **05.30** (**St 32_ROV19**). *07.00 Wind N, Force 3, good visibility, slight sea.* Following the ROV deployment, initial problems were encountered loading information into the top-end SIS software. It was not possible to load the sound velocity profile (from St 29_CTD1) although this can be managed in post-processing. The helmsman display worked well but importing lines and the base map for the display was also a problem, line input was however managed manual. At **06.12** the patch test was initiated with a number of lines acquired for roll correction (**St32_MBES1** & **St32_MBES4**), heading (**St32_MBES2-3**), pitch (**St32_MBES5-6**) and time delay (**St32_MBES7**) and finished at **10.19**. The ROV stayed in the water and started the next station (**St 33_ROV 20**) which is the MBES survey. At **10.36** the first survey line was picked up and run to the NE (**St33_MBES1**). *10.59 Wind N, Force 4*. *15.00 Wind N, Force 3, good visibility, slight sea.* Some difficulties were encountered on the line with a period of water turbulence making the ROV rise and fall 30m at **15.40** and again at **15.50**. *17.00 Wind NNW, Force 3, good visibility, slight sea.* **St33_MBES1** finished at **18.37** and the software GUI restarted**.** *19.00 Wind N, Force 2, good visibility, slight sea.* At **19.15** a new line was started (**St33_MBES2**) running SW. mid-line, a fly height error occurred as the altitude reading froze resulting in a narrow swathe (due to bottom lock loss) and a hole generated. *21.52 Wind N, Force 2. 22.47 Wind SW, Force 2.*

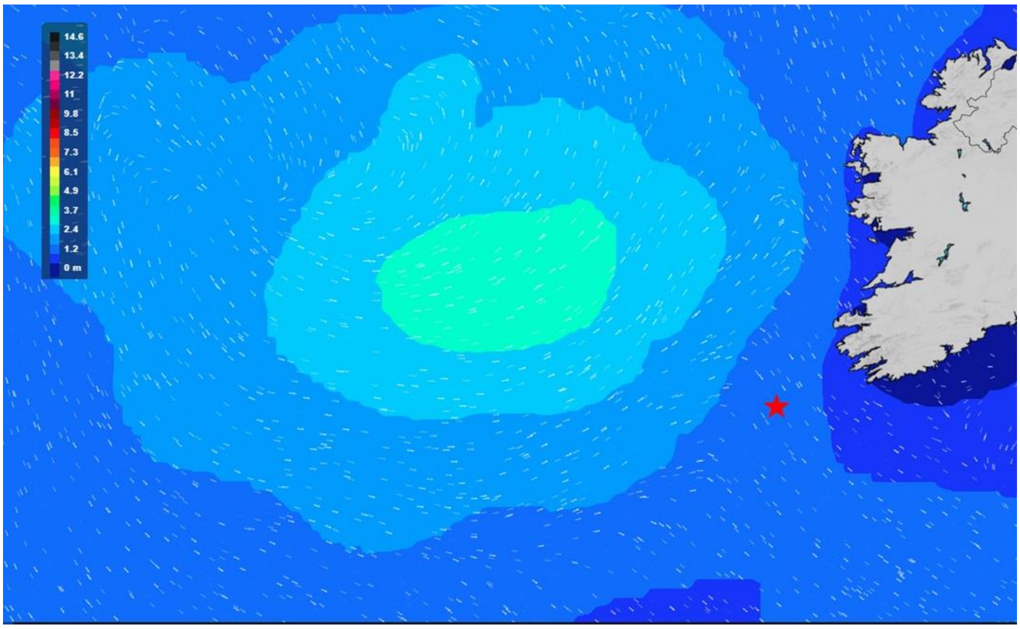


Swell height 09.00 am 12th September 2023.

13th September 2023: NE Porcupine Seabight

03.00 Wind S, Force 2, calm sea. Line **St33_MBES2** was finished at **03.24** and a short line **St33_MBES3** started at **03.55** and finishing at **03.58.** Line **St33_MBES4** was started at **04.07** running NE**.** *05.00 Wind S, Force 5, good visibility, slight sea. 07.00 Wind S, Force 6/7, good visibility, moderate sea***. 08.30** the wind was up to 30 kts, ahead of the prediction. *09.18 Wind*

SSW, Gale Force 8. Line **St33_MBES4** was terminated at **09.18** and ROV was recovered off bottom as the wind hit 35 kts and rising with the surface vessel struggling to hold station on DP. At **09.51** the ROV was out of the water and the weather downtime commenced (see Downtime and Technical Issues), the vessel was taken out of DP and hoved to. *11.05 Wind SSW, Force 8*. At **12.00** the wind was 38 kts. At **12.50** the wind was 37kts. At **14.30** the wind had dropped to 25 kts but the swell was still high and the DP was struggling. At **14.46,** we moved the vessel to the next CTD station and new ROV dive position to see how she settled down. *15.00 Wind W, Force 6, poor visibility, large sea and swell.* The CTD (**St34_CTD1**) was deployed at **15.44** to 955m for an SVP and was back on deck at **17.23**. *17.00 Wind W, Force 5/6, good visibility, rough sea.* The ROV was off deck and in the water at **18.12** for **St 33_ROV 21** to continue the MBES survey which started at **19.03** with a cross line (**St33_MBES5**) from W to E and ended at **21.54.** *19.00 Wind W, Force 4/5, good visibility, moderate sea.* At **22.50** we commenced line **St33_MBES6** running northwards. *22.52 Wind W, Force 5.*



Swell height 09.00 am 13th September 2023.

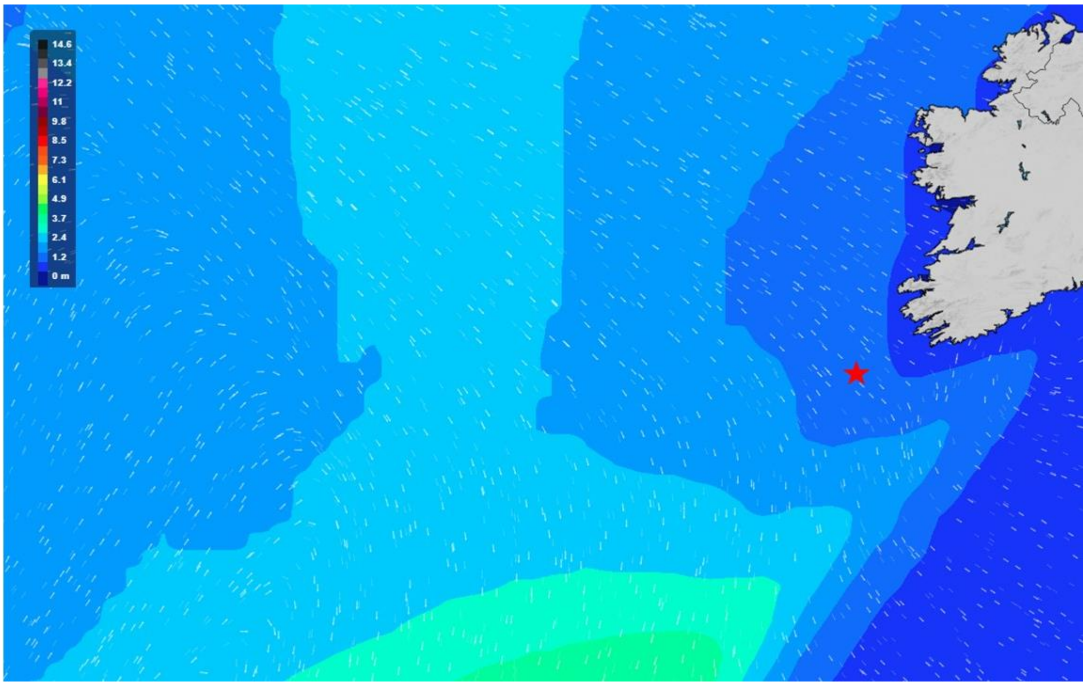
14th September 2023: NE Porcupine Seabight

A MBES cross line **St33_MBES6** on dive **St 33_ROV 21** was completed at **02.14**. A cross line **St33_MBES7** running east to west then commenced at **02.38** and ended at **04.18**. *03.00 Wind W, Force 3, good visibility.* When moving to the next line, a hydraulic failure on the ROV occurred and it was recovered on deck by **05.10**. *05.10 Wind N, Force 2/3, good visibility, slight sea.* After repairs, the ROV was off the deck at **06.38** (**St 33_ROV 22)** and commenced line **St33_MBES8** at **07.08** running to the south until it joined up with the end of **St33_MBES4** at 10.12. The ROV was side stepped to west to pick up a new line **St33_MBES9** heading south that started at **10.29** and ended at **14.30.** *10.54 Wind N, Force 3.* Line **St33_MBES10** started at **14.30** as a continuation south and ended at **16.17.** *15.00 Wind E, Force 3, good visibility, moderate swell. 17.00 Wind N, Force 3/4, good visibility, slight sea.* Line **St33_MBES11** started at **17.11** heading north and ended at **19.26.** Line **St33_MBES12** started at **19.27** as a continuation with a subtle bearing shift heading north and ended at **21.59.** *19.00 Wind N,* *Force 5, good visibility, slight sea.* At **22.32** at new southerly line **St33_MBES13** was picked up defining the western limit of the coverage. *22.51 Wind N, Force 4.*

Swell height 09.00 am 14th September 2023.

15th September 2023: NE Porcupine Seabight to western shelf

Line **St33_MBES13** ended at **01.29** and was followed by line **St33_MBES14** heading on a slihtly different bearing that started at **01.31**. This line ended at **02.23** and was followed again by a new line at a slightly different bearing (**St33_MBES15**) starting at **02.23** but was incredibly short ending at **02.24**. A fresh attempt was made with a new line at **St33_MBES16** at **02.25** that ended at **03.25**. *03.00 Wind N, Force 4, good visibility, slight sea.* Line **St33_MBES17** was a cross line running east to west and started at **03.54** and finished at **06.50**. *05.00 Wind NNW, Force 6, good visibility, moderate sea* The wind was blowing 20 kts at **05.30**. Despite conditions a new line (**St33_MBES18**) running to the nort was started at **07.18** but it was clear it would not be completed. *07.00 Wind N, Force 6/7, good visibility, moderate sea.* By **07.30** it was 28kt and up to 30 kts by **08.00**. At **08.25** the vessel was holding its heading but the weather would end the line soon. Given transit consideration into the wind and the fact we would not make half of this line before we had to go, it was decided to end the survey line (**St33_MBES18**) a bit early at **08.26** to give us more time in Galway Bay rather than risk more in transit. *07.38 Wind N, Force 8.* The ROV was on deck at **09.03** and transit to Galway Bay started at **09.20**. *09.10 Wind N, Force 7.*



Swell height 09.00 am 15th September 2023.

16th September 2023: Western shelf to Galway Bay

We arrived in the North Sound of Galway Bay at **03.30** to commence test deployment of the landers from the CTD winch to see how they land if slipped from the winch rather than deployed by the ROV as test trails for further deployments (no station recorded as not part of the science programme). Tests were carried out for a: 1m drop off bottom (**04.27**), 3m drop off bottom (**05.32**), and 5m drop off bottom (**06.19**). Tests worked well (see Appendix: Lander deployment tests) with the lander landing straight, some evidence of the legs fastening weakening due to impact. At **07.33** the ROV and Apollo lander was back in the water and the lander was lowered but a hydraulic failure occurred on the ROV and it was recovered at **07.46**. The ROV and lander were back in the water at **08.24** and the lander was dropped from a 10m height (**08.50**). On landing it fell over as with the speed of decent also increased the drag under the lander causing it to fall at an angle. The survey was then completed and we docked in Galway ay 19.00 with the demob continuing into the next day.

Downtime and Technical Issues

ROV electrical power supply

During mobilisation on **26th August** is was not possible to start the ROV motor on the ship's electrical power to the ROV.

On the **27th August**, a short spare umbilical was connected and the power supply fault was isolated to the winch-umbilical. We left Galway Dock on schedule at high tide (**12.13**) and stayed in the bay while fault isolation and fixing continued incurring downtime. By **16.00** on 27th August the fault was isolated to the umbilical but when mega-tested it showed no fault although it could not transmit power adequately to start the motor (this was at the time a mystery). The transformer in the ROV shack which was capable of delivering supply with the short umbilical was tested at **19.00** to see if it could deliver down the longer umbilical. Test appeared positive. All details were sent to SMD at **20.00** and we stayed near shore to see if their reply required shore assistance.

On **28th August**, SMD did not reply as it was a Bank Holiday in the UK. At **12.30**, the decision was made to cut 25m off the wet end of the umbilical and re-terminate. After termination the motor started fine 2 times but then failed on three subsequent times. Before further cuts of the cable were completed it was decided to wait for a reply from SMD.

Figure 9. ROV crew re-terminating the umbilical

On **29th August**, the ROV crew replaced all the connections from the ROV, through the winch, to the transformer and then into the ROV shack. The ROV motor started successfully 2 times but then failed 3 times again. Ten positive starts are required to ensure that the risk of motor failure on the seabed is negligible. At **15.00** SMD (ROV manufactures) made contact and gave advise consisting of the actions already undertaken.

On **30th August**, SMD advised that it might be a software issue that was causing the motor to cut out. The ROV crew then set about rewriting the code to see if this produced ten positive starts in a row. In the meantime, new equipment was ordered for shore for an alternative science plan (Shipek grab, Day grab and gravity corer) which was mobilised with a quick port call in the afternoon. At **13.46**, the ROV passed the deck test and was now fully functional. Repotting of the umbilical then commenced. An ROV test was performed at **22.21** but was unsuccessful due to difficulties with the telemetry/ communications to the ROV. ROV recovered to deck at **22.42**.

On the **31st August**, further repairs were done to the ROV comms and it was wet tested again: launched at **10.14** and recovered at **10.50**. Still a few issues what were resolved in the second wet test: launched at **10.58** and recovered at **11.21**. Transit to Porcupine Bank.

Downtime = 3 days 15 hours

ROV bad optical pass in the slip ring

On the **5th September** (dive 11 first attempt) a telemetry problem occurred with the ROV at 1600m resulting in the loss of communication with the ROV (multiple camera and several motor fails). The HD camera had developed an intermittent fault on the previous dive (**St 21_Dive 10**) and this had developed further. The ROV was recovered to deck at **19.11** and the cable was inspected. It was discovered at **20.45** that there was a bad optical pass in the slip ring. Fixing this is not easy and will take c.1.5 day and some shelter. It was decided to carry on with this known fault avoiding the bad pass when stopping the winch. This will result in intermittent HD communication loss. As a temporary fix, the poor fibre optic cable was swopped out. The ROV was back on the water at **22.39**. Please note the overlay nav on the video files (**St 22_Dive 11** to **St 25_Dive 14**) is wrong after this fault as we had to spilt out one fibre optic cable into two.

Downtime = 5 hours 39 minutes

Rock dredge failure

The rock dredge was deployed off Loop Head on **28th August** on a flat area of bedrock with the intension of collected cobbles off the seabed so that we can confirm (or not) the bedrock as belonging to the Ross Sandstone Formation. We towed at 1 knot into the wind (east to west) in 50m of water with 250m dynex cable out over c. 400m of seabed. The cable showed tension at the start especially and then throughout the tow episodically. On the retrieval of the rock dredge, there was no sample recovery as the excessive tension on the rock dredge had broken the sacrificial coupling causing the rock dredge to flip backwards into a non-sample recovery position with less resistance on the cable (safe mode). The sacrificial coupling ensures that it goes before the cable breaks. However, in safe mode the dredge was still getting snagged on rock (presumably) with the corresponding force opening the shackle. This was done by stripping the thread of screw closure and then bending open the shackle (see photo). Fortunately and luckily the rock dredge did not hop off the shackle and was recovered. It was decided that further plans to tow the rock dredge across rock to break-off samples be abandoned.

No downtime.

Figure 10. Damaged shackle attaching the dredge to the cable. Closed up shows the shredded threads of the screw

Change of ship's crew

On the morning of the **29th August**, A/B Peter Joyce needed to leave the vessel for personal reasons. We happened to be at Mutton Island at **07.30**. The A/B was transferred to shore by the small boat which was deployed at **07.50**. The small boat was recovered at **08.15** we resumed the survey. At **17.11**, survey was stopped and we headed to Galway to pick up the new AB Frank Kenny who was recovered from shore by small boat by **19.05**. A/B Peter Joyce was swapped back onto the vessel in Cork.

Downtime = 2 hrs 40 minutes (but coinciding with ROV downtime)

The weather

On the whole during Leg 1 the weather was kind to us. From **25th - 31st August** the wind and swell were low. A series of weather systems then came in to the north and south of us giving significant swell but with a long period so deployments were unaffected and wind speed remained at or below 20 kts. On the 4th September the sea picked up again with a shorter wave period and wind speeds again reached 20 kts. The sea was marginal for launch and recovery but we persisted. On the morning of **6th August** wind speed reached 30 kts temporarily and the sea remained confused with an occasional large roller. It became too rough to launch at **06.30** and a decision not to launch was taken with the sea state checked every 15 mins. ROV in at **09.56.**

The start of Leg 2 had very calm seas with fog but the wind picked up on 11th August. On **11th August** the sea was too rough to deploy the ROV at **12.16.** ROV eventually deployed at **15.08**. During the downtime we took an additional SVP just for a fresher deeper recording.

On the **13th September** the wind rose to 35 kts at **09.51** and the vessel was struggling in DP. The ROV was recovered and the wind continued to rise to 38 kts by **12.00** only falling back to 25 kt at **14.30**. By this stage the sea has also rose and it was too rough to put the ROV in. At **15.44** we took a CTD for an SVP and eventually redeployed the ROV at **18.12** to continue the MBES survey.

On **15th September** the wind was blowing 20 kts at **05.30**, by **07.30** it was 28kt and up to 30 kts by **08.00**. At **08.30** the vessel was holding its heading but the weather would end the line soon. We had hoped to end the line at **11.30** to complete the coverage but that was highly unlikely. Given transit considerations into the wind and the possibility of decreasing the transit speed the later we left, it was decided to end the survey line to give more time in Galway Bay to see if we could configure the landers for freefall in fair seas.

Downtime = 14 hrs and 38 minutes

Summary of Findings

Galway Bay seabed stratigraphy

Although bathymetric and backscatter data acquired by the INFOMAR projects provides a comprehensive coverage and characteristics of the seabed, the sub-seabed nature of the Galway Basin is relatively less known, more particularly the depth to the bedrock. The SEG-Y sub-bottom profiler files available for free download in the INFOMAR helps to resolve the sub seabed reflectors of the top-unit, however, the depth to the bedrock cannot be entirely delineated in these sections. To better understand the depth to the bedrock, this study acquired 40 Chirp sub-bottom profiler sections (SBP). The SBP survey in Galway Bay was not in the original scope of work but was only carried out to both QC the SBP system onboard and collect opportunistic data while waiting for the technical issues to be resolved with the ROV. The SBP survey lines are widely spaced but lines are strategically planned to give a better picture of the depth to bedrock and overlying sediments stratigraphy and character.

The maximum acoustic penetration was down to 40m (until the top of the bedrock) with penetration varying from the inner to outer bay. Three main acoustic units were clearly distinguished in the mid-bay region. The high impedance reflector is the bedrock which is overlain by a medium transparent unit with few hyperbolic reflections interpreted as glacial till following Clarke (2014) and McCullagh (2019). It is shows evidence of glacio-fluvially cut channels into the bedrock (Figure Q). The top unit is acoustically transparent and is interpreted as post glacial marine sediments (Figure Q).

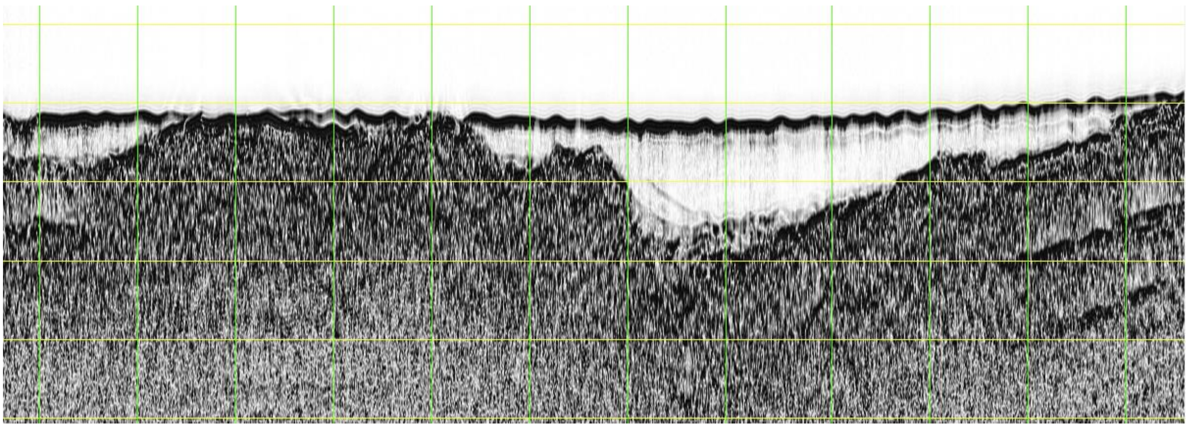


Figure 11. Sub-bottom profiler line from the South Sound (Line 2) showing dipping bedrock (probably limestone) with hollows partially filled by the lower unit (fluvio-glacial) overlain by upper unit. Vertical scale is 10m

Some further examples of sub-bottom profiler lines are shown below from across the Bay below:

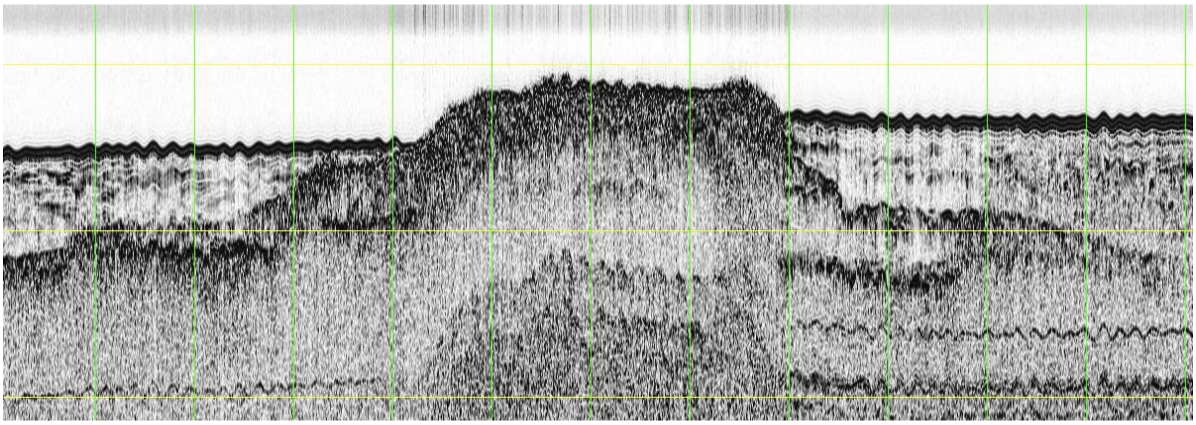


Figure 12. Sub-bottom profiler line from the Inner Bay (Line 32) showing bedrock rising above the seabed surround by the lower unit (fluvio-glacial) with a thin veneer of upper unit (Holocene marine sediment)

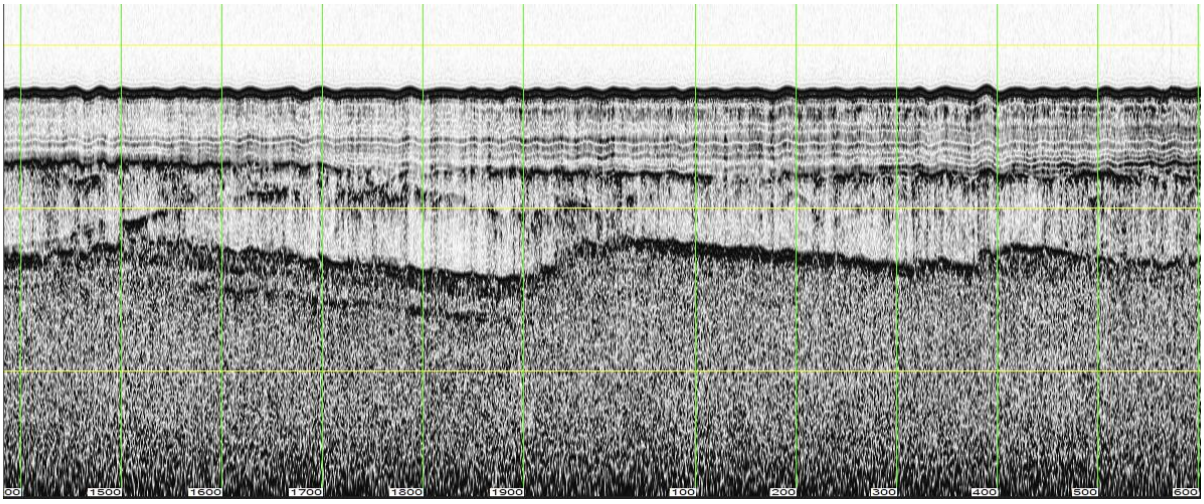


Figure 13. Sub-bottom profiler line from the Mid Bay (Line 7) showing dipping bedrock with clifflets overlain by the lower unit (fluvio-glacial) with parabolic reflectors from boulds and some internal structures. This is overlain by a thick upper unit (Holocene marine sediment) which is more stratified at the base.

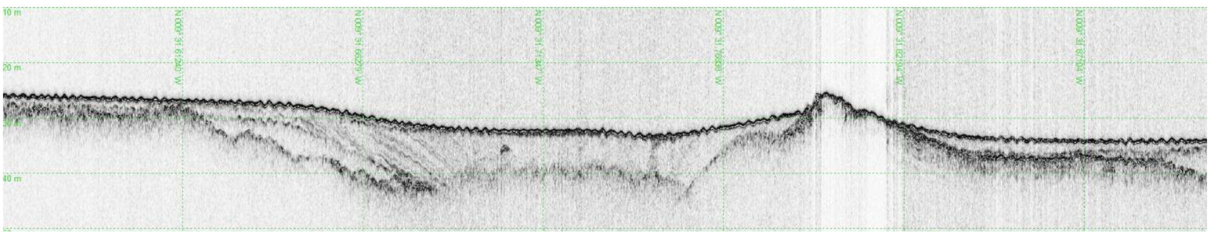


Figure 14. Sub-bottom profiler line from the North Sound (Line 47) showing more rounded bedrock (probably granite) overland by a migrated channel fill and think upper unit

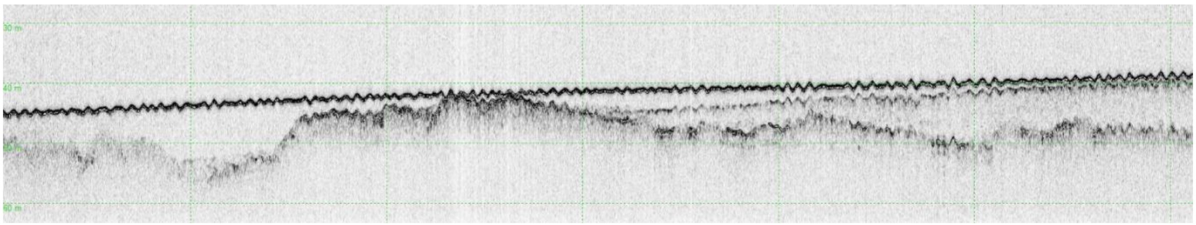


Figure 15. Sub-bottom profiler line from the North Sound (Line 43) showing bedrock overlain by the lower unit (right-side) and the upper unit overlying all.

References:

Clarke, C. (2014). An interpretation of the single channel high frequency seismic reflection datasets of Galway Bay, Ireland (Unpublished Masters thesis). National University of Ireland, Galway.

McCullagh, D. (2019). *A palaeoenvironmental reconstruction of Galway Bay, Western Ireland, from the last glacial maximum to present day* . (Unpublished Doctoral thesis). Ulster University, Coleraine, Northern Ireland

Geology and hydrodynamics of the Porcupine Bank and Goban Spur

Collecting rock drill core remotely with the ROV proved difficult. Exposures of bedrock tend to be on steep terrain that is hard to land on and the rock-drilling under the best of circumstances is temperamental. To recover rock from rock drill cores three key criteria need to be addressed:

1. Bedrock has to be exposed on the seabed: to identify sites we used our Bedrock Suitability Model (Recouvreur et al., submitted) which mostly worked well in predicting where bedrock occurred. It underestimated bedrock on steep slopes due to the lack of observations taken on steep slopes and it also overestimated bedrock in deep-water and areas of poor bathymetry. Nevertheless, the model proved extremely useful.

2. We have to be able to land the ROV: Located bedrock exposures need to be flat and horizontal and big enough to land the ROV on. This is not easy a most bedrock exposures occur on step craggy slopes where landing sites are rare. In cases where these locations were explored, in many cases, it was found that any ledges were coved by sediment and not exposed. It was therefore necessary ti identify places where sediments were absent due to high currents allowing the bedrock to be exposed. The first core was taken from such a place being on top of a ridge between two step escarpments where the currents kept the ridge clear of sediments

3. The drilling rig has to drill: to do this the ROV has not be perfectly stationary but it only has limited power to hold its position with thrusters down and supply power to the drill rig. The drill rig by its very nature (fast rotation and pressure) is power hungry and it was important not to overheat the hydraulics casing a loss in pressure. Furthermore, drill rigs are fickle and temperamental and not all drilling attempts result in core retrieval

The difficulties of drilling resulted in no rock samples being collected from the Porcupine Bank. In the Porcupine Bank Canyon, three sites were attempted with the first site attempted twice. This site (Station 4 and 9) was a conglomerate site but although bedrock was found it was not possible to land and drill. Station 5 was on the northern flank of the canyon and proved very muddy on the bottom and bedrock was not spotted. This was despite the Bedrock Suitability Model showing good probability, but this was probably due to poor quality multibeam echosounder input data. At Station 7 bedrock was found and drilling commenced but penetration proved hard for unknown reasons and no core was covered.

Further south along the Porcupine Bank at Station 11, bedrock was found, the ROV landed and drilled commenced with good penetration but ROV shifted and the drill core was left in the hole. Om the SW Porcupine Bank, bedrock was encountered (station 13) with a lot of sediment so a landing site could not be found. A further attempt was made at another site but strong current mid-water prohibited the ROV from reaching the bottom.

Acoustic Doppler Profiler Data was collected to measure current speeds down to 800m in order to add to a dataset of benthic current speeds influenced by internal waves. This data was not processed on-board but strong current were felt when the ROV was diving at various locations. Strong currents were frequently experience from 1600 m to 2500m water depth.

Recovering rock cores on the Goban Spur continued to be a challenge with bedrock frequently encountered at the base of slopes but proving “un-landable” with any potential ledges covered in sediment. Two sites on ridges and spurs on steep slopes were landed and drilling attempted. At **St11_ROV5**, the ROV shifted and although drilling had commenced the core was lost as the ROV dropped he barrel. At **St19_ROV9** a successful core was retrieved (**St19_R1**). Based on this we targeted similar sites on ridges between two gullies but these were all muddy. On King Arthur’s Castle seamount we took two dives. **St24_ROV13** revealed step cliffs with rock but not landing sites followed by a sediment covered seamount summit. On the final dive, **St25_ROV14**, we encountered steep bedrock outcrops (looked like ?basalt) with flatter terrain covered by rippled sand. On the break of slope between the two we successful recovered bedrock (**St25_R2**).

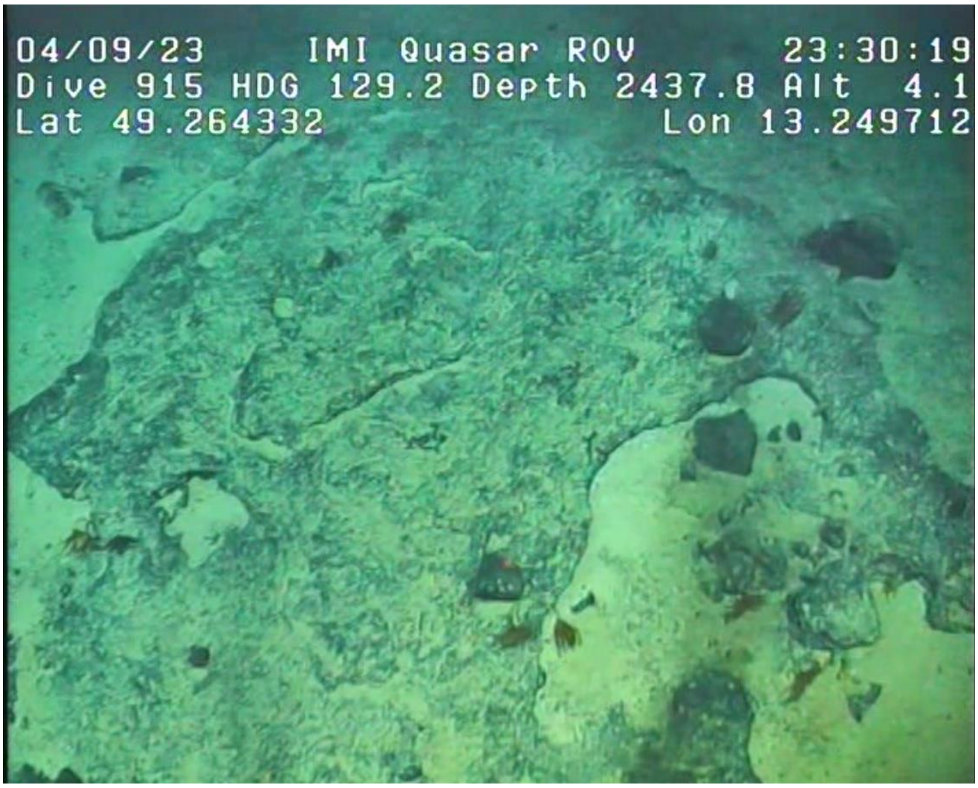


Figure 16. (top) Bedrock exposure on the Goban Spur at St19_ROV9 that was successfully drilled, and (bottom) retrieved rock core St19_R1.

Figure 17. (top) Bedrock exposure on the King Arthur's Castle Seamount at St25_ROV14 that was successfully drilled, and (bottom) retrieved rock core St25_R2.

Of the number ROV rock drill dives attempted (14 dives), bedrock was found on 10 of them (success rate of 71%) but only 4 resulted in landing (40% success rate). Of these 4, only 2 site was successful (an 50% success rate or 14% overall)

References
Recouvreur, A., Wheeler, A.J., Strachen, R., Meere, P.A., Unitt, R.P. & Lim, A. (submitted). Large scale bedrock outcrop mapping on the NE Atlantic continental margin. *Geomorphology*.

Glacial geology and seabed geomorphology of the western Celtic Sea

Seventeen (17) chirp lines were collected across the ridge-like features on the seabed of the western Celtic Sea offshore County Cork. The sub-seabed penetration is limited, varying between 5 to 20m, with no penetration was achieved in most parts of one survey line. The line segments with penetration shows a wavy 1st reflector buried at depths varying between 5 to 15m. The top sedimentary unit is acoustically transparent and is interpreted as Holocene sediments. The wavy high acoustic impedance reflector outcrops the seafloor and corresponds to the area which shows arcuated morphology in bathymetry. Survey lines were also run across the flat seabed between the two ridge-like features. These lines also show similar buried reflectors along the trend of the ridges. We believe these buried features correspond to moraine successions and hence interpreted as recessional moraines. The exposed subtle bathymetric highs are highly reflective with no penetration. This corresponds with the signature of morainal features preserved on the seabed most likely composed of coarser material than the surrounding seabed (e.g. Stewart and Bradwell, 2014), with the troughs accumulating the finer material. Since the acoustic signature of our data corroborates with the grounding zone wedge impressions left by a retreating icesheet, we propose a comprehensive ground truthing and high-resolution seismic survey for future work.

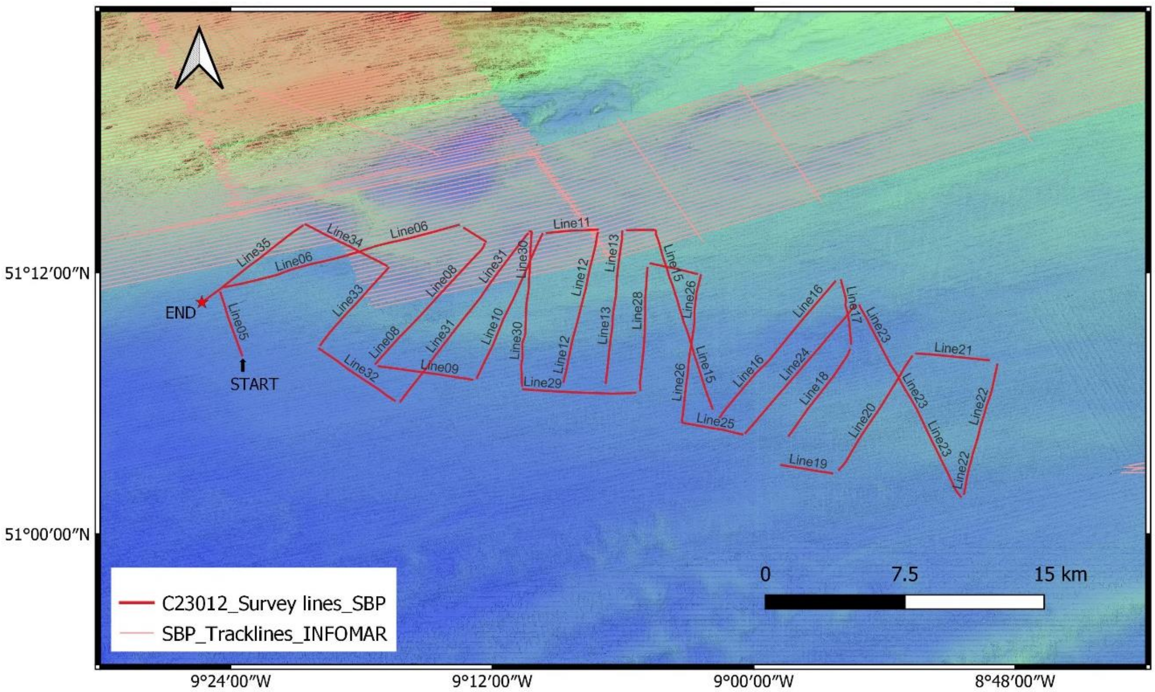


Figure 18: The sub-bottom profiler survey lines in Celtic Sea.

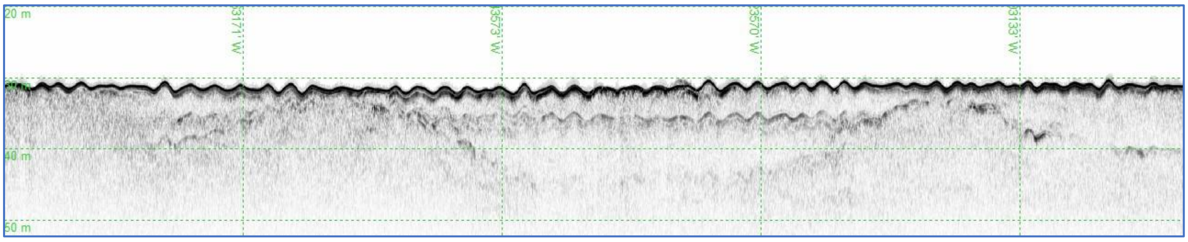


Figure 19 The sub-bottom profiler section showing a thin transparent 1st acoustic reflector and an U-shaped 2nd reflector characteristic of a recessional moraine.

References:

Stewart, H., Bradwell, T., 2014. The use of Multibeam Backscatter Intensity Data as a Tool for Mapping Glacial Deposits in the Central North Sea, UK Geophysical Research Abstracts 16, EGU2014-Abstract Number 16616.

Cold-water coral reefs in the NE Porcupine Seabight

Two Little MonSta lander were recovered from an area of ridge reefs, here called the Alf Reefs (after the late Alfred Wheeler – see end of report). Both of the landers had fallen over but an assessment of the data showed that they have been monitoring current, dissolved oxygen, pH, temperature and salinity on the top and at the base of the of the ridge reefs for 9 and 3 months. To complement this data set we collected corals (*Lophelia pertusa* and *Madrepora oculata*) with will be analysed for elemental changes across growth ring to look for change seabed conditions. This will allow an extension of the Little MonSta time series data and which will also calibrate the elemental record. In addition, we also took 4 successful cores, again from on top and at the bottom one of the ridges and close to the Apollo and Charlotte sites. These will be useful in telling longer term environmental changes over millennia and also confirmed that the ridges are not just coral colonised but have been growing for some time with sub-fossil corals in the core over 50 cm down. When the cores are opened this observation will become clearer. There is also the possibility of doing elemental analysis on the sub-fossil material.

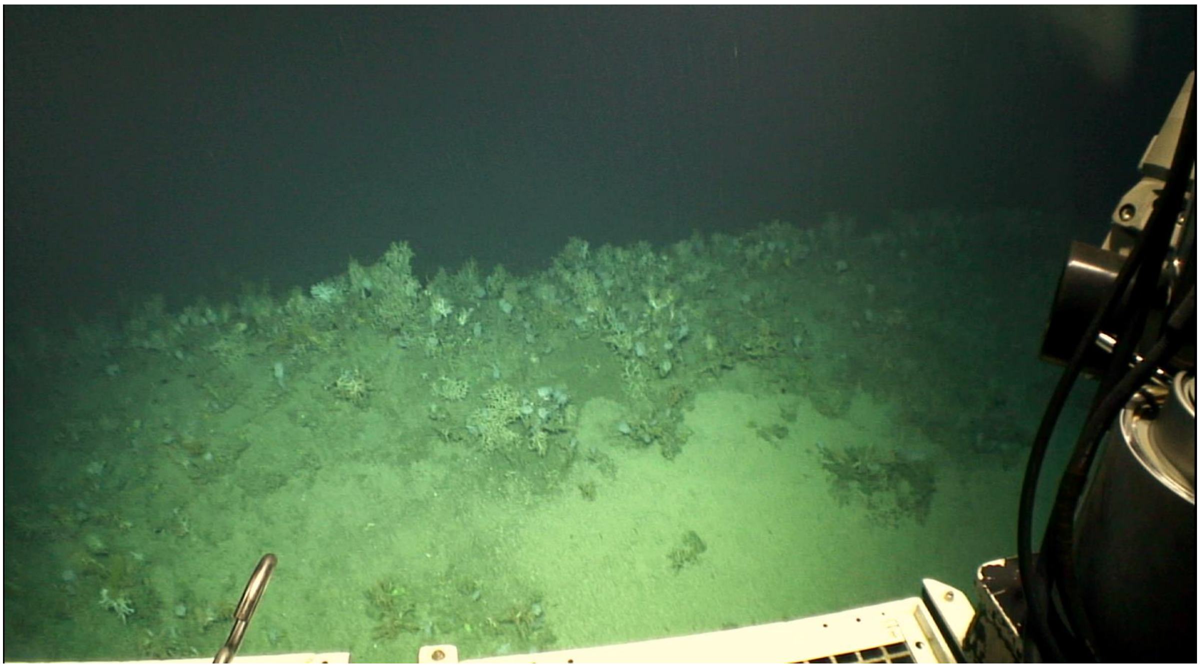


Figure 20. Still from Dive 15 showing the ridged crest of one of the coral reefs in The Alf Reefs with sand near the summit

Figure 21. Still from Dive 15 showing coral and sponge habitat in the Alf Reefs

To finish the data set a significant area (c. 22km^2) was mapped with an ROV multibeam echosounder flying at a height of 150m for c. 45km. This will significantly improve on the resolution of existing hull-mounted multibeam echosounder bathymetric maps that have a resolution of 25m / pixel. The morphology of the Alf Reefs will be revealed as well as coral growth morphology on the giant mounds (including Therese and Galway Mounds) and intervening sediment waves. Existing ROV video (including through the Alf Reefs) will groundtruth this coverage.

Appendices

Personnel

Scientific Party

Prof Andy Wheeler	Chief Scientist	Leg 1 & 2: Cruise management, reporting	UCC
Dr Audrey Recouvreur	Co-Chief Scientist	Leg 1: Lead night operations / co-chief / Geologist	UCC
Dr Hugo Ferreira	Scientist	Leg 1: Scientific party / Marine technology	INESCTEC
Rebecca Dudley	Scientist	Leg 1: Scientific party / MMO	IWDG
Brian Huxley	Scientist	Leg 1: Scientific party / Biologist	UCC
Reece Mills	Scientist	Leg 1: Scientific party / Biologist	QUB
Susanth Sundaran	Scientist	Leg 1 & 2: Scientific party / Geophysicist	UCC
Jessica Harty	Scientist	Leg 1: Scientific party / Geologist	Freelance
Felix Butschek	Scientist	Lead night-operations Leg 2 / Oceanographer	UCC
Gervaise Barre	Scientist	Leg 2: Scientific party / Biologist	Portugal
Luca Caminiti	Scientist	Leg 2: Scientific party / Biologist / MMO	Freelance
Jennifer Cocking	Scientist	Leg 2: Scientific party / Robotics	Freelance

Holland 1 ROV Technical crew

Paddy O'Driscoll	ROV superintendent
Karl Bredendieck	ROV pilot
Colin Ferguson	ROV pilot
Rob Carpenter	ROV pilot
George Findlay (Dode)	ROV pilot
Mark Duffy	ROV pilot

Officers and Crew of the RV Celtic Explorer

Denis Rowan	Master
John Sammon	Chief engineer
John O'Regan	C/O & Security Officer
Paddy Kenny	2/O & Safety Officer
Fintan Keating	2^{nd} Engineer
Gerard O'Connell	ETO
Tom Gilmartin	Bosun
Martin Powell	Bosun's Mate
Tommy Grealy	AB Deckhand
Peter Joyce*	AB Deckhand
Frank Kenny*	AB Deckhand
Nigel Dowd	AB Deckhand
Eoin Colfer	AB Deckhand
Jimmy Moran	Cook
Tony Hill	Assistant cook
Lukasz Pawlikowski	Technician

* Peter Joyce left vessel from 29^{th} August to 8^{th} September and covered by Frank Kenny.

Figure 22: CE23012_SPeeD - The Return scientific party Leg 1 & 2

Left to Right: Becky Dudley (1), Luca Caminiti (2), Reece Mills (1), Susantha Sundaran (1,2), Brain Huxley (1), Audrey Recouvreur (1), Felix Butschek (2), Andy Wheeler (1,2), Jenn Cocking (2), Gervaise Barre (2), Jess Harty (1,2), Hugo Ferreira (1)

Station Logs and Maps

Master Log and Map (all time UTC)

Master Log				dd	dd		ROV				Tick appropriate										
Station Number	Dive / Profile #	Date	Time (UTC)	Lat	Long	Depth (m)	off deck	on seabed	off seabed	on deck	Rock drill	Rock dredge	ROV Video	Lander	CTD	ROV MBES	ADCP	Vibrocore	Multibeam	Subbottom	Note
6	EOL	02/09/2023	02:20	51°41.52	-15°14.38												x				
7	3	02/09/2023	02:24	51°41.86	-15°14.66	1650	02:29	03:39		08:23	x		x								
8	SOL	02/09/2023	08:57	51°42.26	-15°.14.20												x				Transit #019
8	EOL	02/09/2023	10:52	51°58.46	-15°02.24												x				
9	4	02/09/2023	11:20	51°58.83	-15°02.35	827	11:20	12:18-13:49		14:36	x		x								
10	SOL	02/09/2023	15:09	51°58.55	-15°02.34												x				Transit 5 down PORC BANK #020
10	EOL	02/09/2023	21:51	50°55.72	-14°54.06												x				
11	5	02/09/2023	22:16	50°55.75	-14°54.02	2622	22:16	00:17		04:57	x		x								
12	SOL	03/09/2023	05:46	50°50.48	-14°48.49												x				Transit from ST-11 to ST-13 #021
12	EOL	03/09/2023	09:15	50°29.58	-14°30.10												x				
13	6	03/09/2023	09:02	50°28.29	-14°29.00	2850	09:03	11:05		14:21	x		x								
14	SOL	03/09/2023	14:29	50°28.96	-14°29.40												x				Transit from ST-13 to ST-14 (SBP tests)
14	EOL	03/09/2023	15:34	50°36.82	-14°38.64												x				
15	SOL	03/09/2023	23:00	50°19.15	-14°16.26												x				Transit to Goban Spur #022
15	EOL	04/09/2023	04:19	49°40.36	-13°27.89												x				
16	7	04/09/2023	04:48	49°40.14	-13°27.80	2165	04:48	06:00		09:52	x		x								
17	SOL	04/09/2023	11:16	49°36.43	-13°36.70	2758														x	Goban Spur, Pendragon Escarpment
17	EOL	04/09/2023	11:28																	x	
18	8	04/09/2023	11:30	49°36.45	-13°36.61	2750	13:52	13:52		17:08	x		x								slope? Aborted
19	9	04/09/2023	20:10	49°26.60	-13°25.50	2698	20:10	21:57	23:45_drill	04:55	x		x								0.8 m long sample recovered (ST19_D9_S1)
20	SOL	05/09/2023	05:04	49°26.43	-13°24.93												x				Transit from ST-19 to ST-21 #025
20	EOL	05/09/2023	10:40	48°46.04	-12°48.79												x				
21	10	05/09/2023	11:04	48° 46.03	-12°48.19	2680	11:04	12:49			x		x								
22	11	05/09/2023	17:00	48° 42.70	-12°45.33		17:00			19:24	x		x								Aborted (didn't touch bottom)
22	11 (2nd	05/09/2023	22:41	48° 42.72	-12°45.29	2435	22:41	23:57		03:21	x		x								Mud
23	12	06/09/2023	09:56	48° 29.19	-12°11.16	1941	09:57	10:59	12:28	13:33	x		x								
24	13	06/09/2023	15:50	48° 21.28	-11°38.75	1264	15:50	16:35		18:38	x		x								
25	14	06/09/2023	19:28	48° 20.05	-11°54.36	1523	19:29	20:19		04:36	x		x								Drill + sample

All Leg 1 stations

Master Log sheet				dd	dd		ROV												
Station Number	Dive / Profile #	Date	Time (UTC)	Lat	Long	Depth (m)	off deck	on seabed	off seabed	on deck	ROV Video	Lander	CTD	ROV MBES	ADCP	Vibrocore	ROV MBES	Subbottom	Note
26	SOL1	08-09-2023	19:47	51.2886	46.9333	91.20									x			x	Western Celtic Sea
	EOL35	10-09-2023	8:59	51.1775	8.5781	102							x		x			x	Western Celtic Sea
27	1	10-09-2023	18.50	51.4598	-11.7335	919					x	x			x				Porcupine Seabight: bottles 1+2 (9m off bottom), 3+4 (14m), 5+6 (19m)
28	15	10-09-2023	9.50	51.4598	-11.024	916	19.41	20.17	23.52	0.5	x	x			x				Charlotte recovery and coral samples
28	16	11-09-2023	0.57	51.4598	-11.024	920	1.04	1.37		2.43	x				x				Apollo recovery
29		11-09-2023	13:30	51.4595	-11.7615	960							x		x				SVP
30	17	11-09-2023	15:08	51.4602	-11.734	916	16:02				x				x	X			1 vibrocore at Apollo, stopped due to rig malfunction
31	18	11-09-2023	18:07	51.4603	-11.7335	916	18:45				x				x	X			x4 vibrocores
32	19	12-09-2023	05:30	51.4168	-11.6947	959	06:12							x	x		X		MBES patch test 50m from bottom
33	20	12-09-2023	10:36	51.4145	-11.7608	950	18:37	9.48						x	x		X		MBES mosaic, recovered due to 35kh wind
33	21	13-09-2023	18:12	51.4597	-11.7615	959	19:03							x	x		X		Continuing MBES mosaic
33	21	14-09-2023	04:44	51.4878	-11.7297	909		05:10						x	x				Dead sub, hydraulic failure @760m
33	22	14-09-2023	06:38	51.488	-11.7295	909	07:05							x	x				
34		10-09-2023	15:45	51.4595	-11.7615	960							x		x				SVP. Down to 5m above bottom

All Leg 2 stations

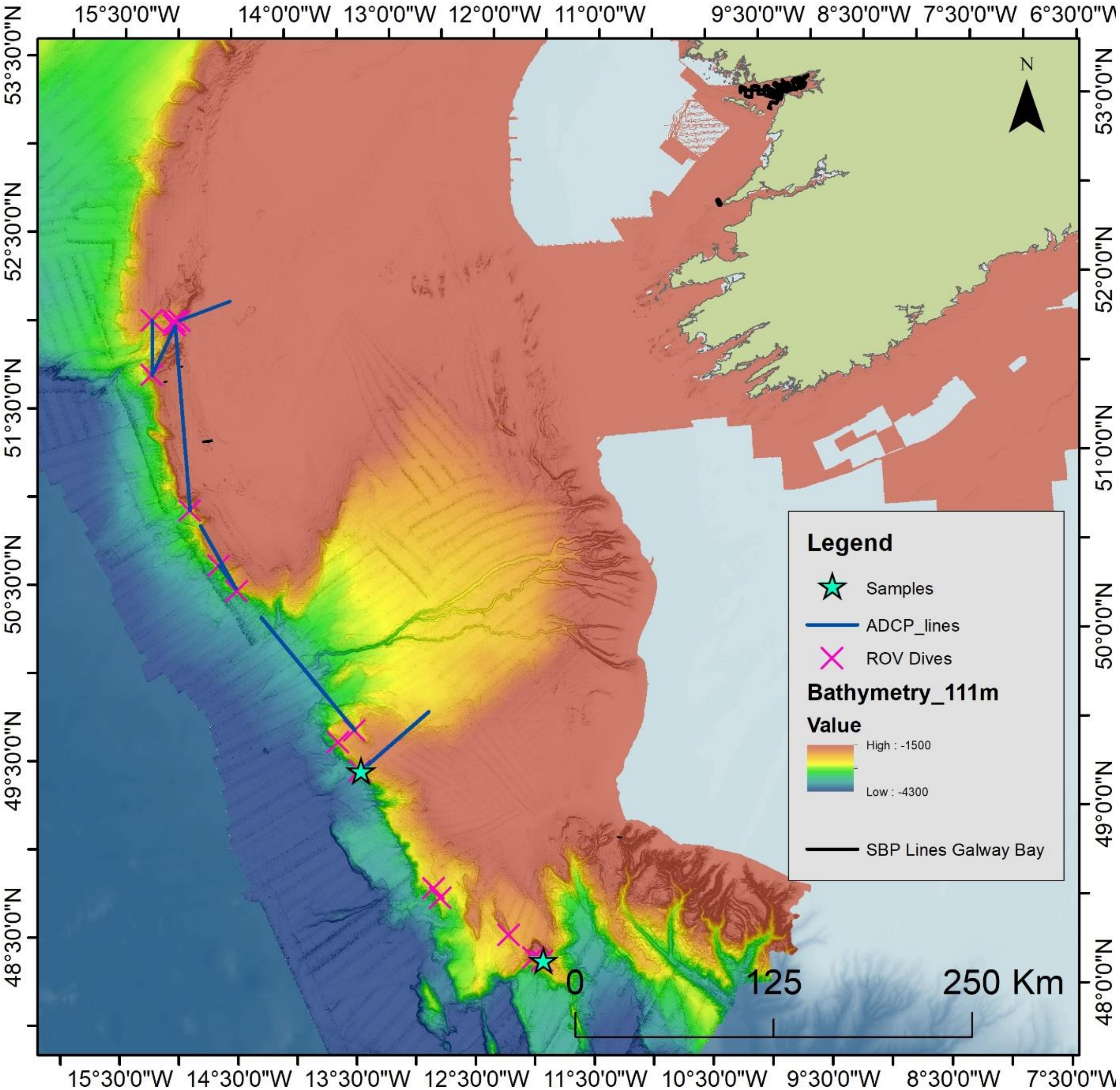


Figure 23. Map of all location (Leg 1)

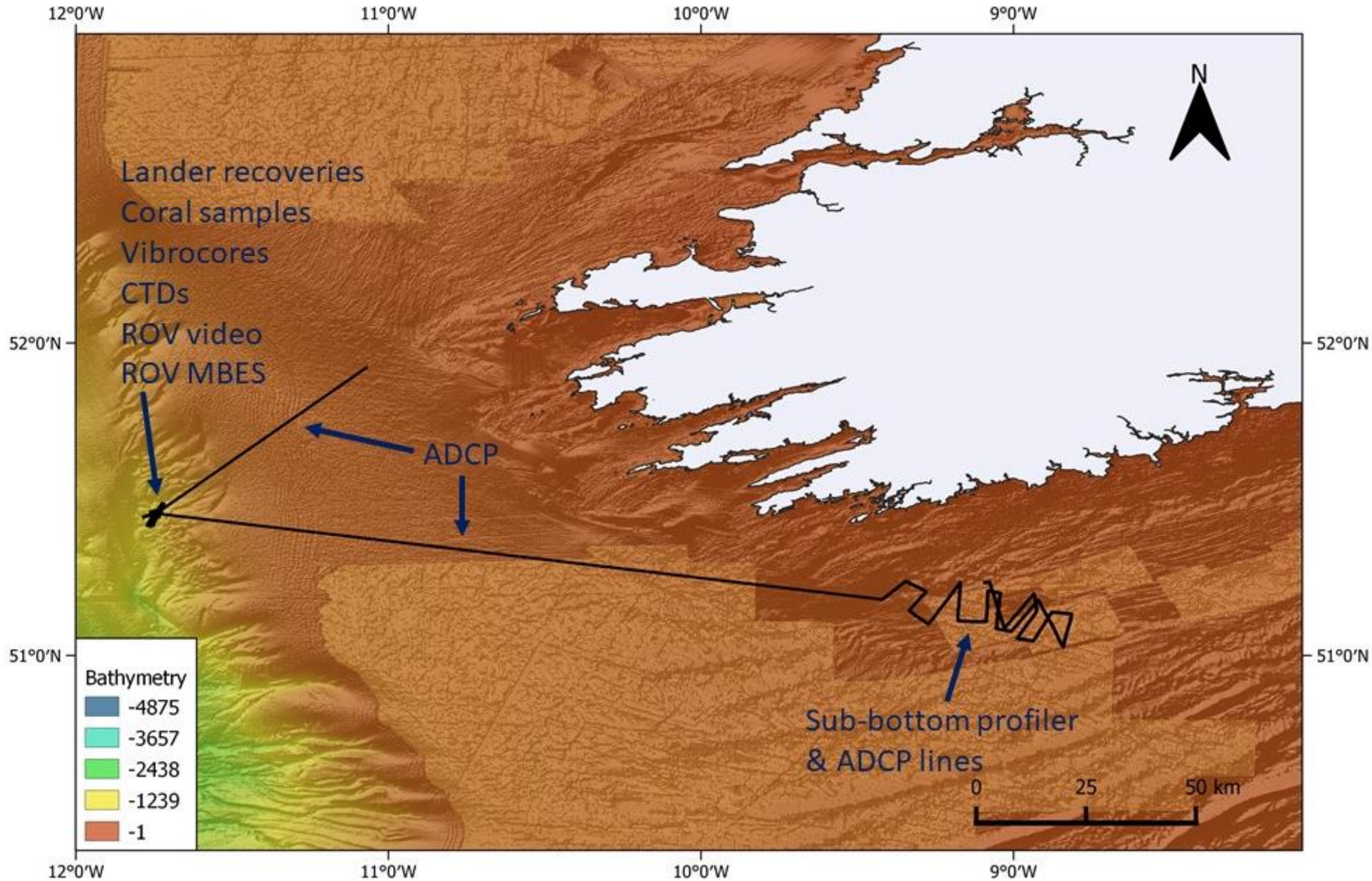


Figure 24: Map of all location (Leg 2)

Sub-bottom Profile Log and Maps

(all time UTC)

Subbottom profiler Log			Time (UTC)		SOL				EOL						
Station Number	Profile #	Date	SOL	EOL	Lat Degº	Lat decimal Min'	Long Degº	Long decimal Min'	Lat Degº	Lat decimal Min'	Long Degº	Long decimal Min'	Depth (m)		Comments
1	#T1	28/08/2023	12:28:00	x	52	35.12	-9	59.18	x	x	x	x	73	x	Test
1	#1	28/08/2023	12:37:00	12:57:00	52	34.72	-9	58.92	52	33.50	-9	58.20	65	x	SBP line1 **Loop Head**
2	#1	28/08/2023	20:11:00	20:33:00	53	4.23	-9	25.65	53	4.91	-9	26.87	44.5	x	**Galway Bay** Channel
2	#2	28/08/2023	20:38:00	21:06:00	53	5.05	-9	26.77	53	6.78	-9	25.22	35.5	37.7	Channel / inhill!
2	#3	28/08/2023	21:10:00	21:32:00	53	6.78	-9	24.92	53	6.25	-9	22.53	38	36.4	
2	#4	28/08/2023	21:35:00	22:00:00	53	6.28	-9	22.23	53	7.78	-9	20.82	36.4	32.7	
2	#5	28/08/2023	22:05:00	22:34:00	53	7.92	-9	20.83	53	8.78	-9	23.38	33	37	
2	#6	28/08/2023	22:40:00	?	53	9.10	-9	23.13	x	x	x	x	35.7	x	System Restarted!
2	#6 cont	28/08/2023	22:52:00	23:02:00	53	9.90	-9	22.43	53	10.47	-9	21.82	34	33	Restarted line
2	#7	28/08/2023	23:06:00	23:30:00	53	10.60	-9	21.52	53	9.88	-9	19.23	32.7	31.4	
2	#8	28/08/2023	23:32:00	23:56:00	53	9.82	-9	16.93	53	10.28	-9	16.45	30.7	28.4	
2	#9	29/08/2023	00:00:00	00:37:00	53	10.48	-9	16.62	53	12.38	-9	18.03	28.9	26.3	
2	#10	29/08/2023	00:41:00	01:12:00	53	12.53	-9	18.73	53	12.95	-9	15.50	25.7	22.6	
2	#11	29/08/2023	01:21:00	01:55:00	53	12.83	-9	14.83	53	10.65	-9	12.88	22.5	23.4	
2	#12	29/08/2023	02:04:00	02:31:00	53	10.60	-9	12.77	53	10.25	-9	10.63	23.4	18.6	
2	#13	29/08/2023	02:32:00	03:22:00	53	10.30	-9	10.23	53	13.33	-9	12.25	18.6	20	
2	#14	29/08/2023	03:23:00	03:38:00	53	13.45	-9	12.05	53	14.13	-9	10.62	19.7	16.1	
2	#15	29/08/2023	03:42:00	04:33:00	53	14.02	-9	10.48	53	10.53	-9	18.22	16.6	17.4	
2	#16	29/08/2023	04:37:00	04:49:00	53	10.57	-9	7.93	53	10.95	-9	6.65	17.5	16.2	
2	#17	29/08/2023	04:52:00	05:42:00	53	11.12	-9	6.75	53	14.28	-9	8.70	14.2	12.2	
2	#18	29/08/2023	05:47:00	06:05:00	53	14.27	-9	8.48	53	13.80	-9	6.68	11.9	12.3	
2	#19	29/08/2023	06:06:00	06:15:00	53	13.75	-9	6.62	53	13.25	-9	5.87	12.3	12.9	
2	#20	29/08/2023	06:18:00	06:25:00	53	13.75	-9	6.62	53	13.25	-9	5.87	12.3	12.9	
2	#21	29/08/2023	06:28:00	07:05:00	53	13.63	-9	6.43	53	14.78	-9	3.10	12.5	7.9	
2	#22	29/08/2023	08:45:00	09:06:00	53	14.92	-9	3.33	53	14.23	-9	5.08	6.8	7.6	
2	#23	29/08/2023	09:08:00	09:12:00	53	14.30	-9	5.12	53	14.43	-9	5.27	7.4	7.7	
2	#24	29/08/2023	09:14:00	09:20:00	53	14.43	-9	5.35	53	14.30	-9	5.70	7.8	8.2	
2	#25	29/08/2023	09:39:00	09:46:00	53	14.30	-9	5.68	53	13.68	-9	5.23	8.1	8.3	
2	#26	29/08/2023	09:48:00	09:52:00	53	13.83	-9	5.10	53	13.93	-9	4.80	8.2	7.7	
2	#27	29/08/2023	09:53:00	10:01:00	53	13.98	-9	4.82	53	14.33	-9	5.18	7.7	7.6	
2	#28	29/08/2023	10:10:00	10:28:00	53	14.33	-9	4.78	53	13.70	-9	6.52	7.1	10.8	
2	#29	29/08/2023	10:29:00	11:08:00	53	13.70	-9	6.57	53	12.83	-9	10.65	10.9	9.1	
2	#30	29/08/2023	11:11:00	11:26:00	53	12.97	-9	10.80	53	13.83	-9	11.47	9.1	15.5	
2	#31	29/08/2023	11:28:00	11:45:00	53	13.87	-9	11.38	53	14.07	-9	9.58	15.5	12.7	
2	#32	29/08/2023	11:47:00	12:38:00	53	13.98	-9	9.52	53	10.73	-9	7.33	12.7	17.1	

Subbottom profiler Log			Time (UTC)		SOL				EOL						
Station Number	Profile #	Date	SOL	EOL	Lat Degº	Lat decimal Min'	Long Degº	Long decimal Min'	Lat Degº	Lat decimal Min'	Long Degº	Long decimal Min'	Depth (m)		Comments
2	#33	29/08/2023	12:39:00	12:54:00	53	10.73	-9	7.28	53	11.20	-9	5.70	17.1	13	
2	#34	29/08/2023	12:57:00	13:15:00	53	11.30	-9	5.65	53	11.18	-9	6.12	13.2	12.9	
2	#35	29/08/2023	13:17:00	13:23:00	53	12.43	-9	5.90	53	12.57	-9	5.32	12.6	11.3	
2	#36	29/08/2023	13:25:00	13:32:00	53	12.50	-9	5.23	53	12.08	-9	4.90	11.2	14.9	
2	#37	29/08/2023	13:34:00	15:02:00	53	12.02	-9	4.95	53	9.75	-9	16.50	14.9	29.2	
2	#38	29/08/2023	15:31:00	16:36:00	53	9.88	-9	17.38	53	13.08	-9	22.72	30.6	27	
2	#39	29/08/2023	16:39:00	17:11:00	53	12.97	-9	22.78	53	10.62	-9	23.07	27.3	34.3	
2	#40	29/08/2023	20:41:00	23:22:00	53	10.67	-9	23.42	53	11.52	-9	42.05	30.8	50.6	Towards North Channel (Crossline)
2	#41	29/08/2023	23:35:00	00:09:00	53	10.72	-9	42.05	53	12.63	-9	41.35	31.2	32.5	
2	#42	30/08/2023	00:09:00	00:31:00	53	12.62	-9	41.20	53	12.12	-9	39.13	31.5	43.5	
2	#43	30/08/2023	00:33:00	01:10:00	53	12.02	-9	39.05	53	9.47	-9	39.37	47.7	40	
2	#44	30/08/2023	01:12:00	01:40:00	53	9.40	-9	39.22	53	8.80	-9	36.13	39.1	35.6	
2	#45	30/08/2023	01:45:00	02:42:00	53	8.92	-9	35.83	53	12.62	-9	35.28	35.7	33.8	
2	#46	30/08/2023	02:47:00	03:12:00	53	12.65	-9	34.82	53	12.52	-9	31.97	33.4	31.5	
2	#47	30/08/2023	03:19:00	03:59:00	53	12.38	-9	31.55	53	9.75	-9	32.17	33.8	37.9	
2	#48	30/08/2023	04:02:00	04:26:00	53	9.73	-9	32.00	53	9.55	-9	28.62	29	28.9	
2	#49	30/08/2023	04:28:00	05:07:00	53	9.63	-9	28.58	53	12.17	-9	28.32	35	34	
2	#50	30/08/2023	05:12:00	05:34:00	53	12.37	-9	28.13	53	12.22	-9	25.88	31.5	32	
2	#51	30/08/2023	05:35:00	06:14:00	53	12.13	-9	25.92	53	9.47	-9	26.18	32.5	31	
2	#52	30/08/2023	06:17:00	07:21:00	53	9.42	-9	26.02	53	7.37	-9	19.53	31.2	25.3	
2	#53	30/08/2023	07:30:00	08:30:00	53	7.75	-9	19.38	53	9.68	-9	25.87	27.2	31.3	
2	#54	30/08/2023	08:40:00	09:42:00	53	10.20	-9	25.42	53	8.18	-9	18.92	31.1	23.8	
2	#55	30/08/2023	09:49:00	10:49:00	53	8.73	-9	18.63	53	10.55	-9	24.87	25	31.1	
2	#56	30/08/2023	10:56:00	11:59:00	53	11.18	-9	24.68	53	9.13	-9	18.58	32	28.2	After ROV wet test
2	#57	30/08/2023	23:33:00	00:35:00	53	9.22	-9	28.22	53	7.72	-9	21.73	26.2	36.2	
2	#58	31/08/2023	00:43:00	01:14:00	53	8.07	-9	21.07	53	10.03	-9	19.00	36	31.7	
2	#59	31/08/2023	01:21:00	02:13:00	53	10.28	-9	18.80	53	12.75	-9	23.18	31.8	27.2	
2	#60	31/08/2023	02:25:00	03:33:00	53	13.32	-9	22.13	53	10.05	-9	16.80	27	30.7	
2	#61	31/08/2023	03:38:00	03:48:00	53	11.07	-9	16.28	53	10.22	-9	15.07	30.1	28.2	
2	#62	31/08/2023	03:54:00	04:52:00	53	10.45	-9	15.12	53	13.82	-9	18.02	28.2	23.2	
17	#1	04/09/2023	11:16:00	11:28:00	49	36.43	-13	36.70	49	36.45	-13	36.62	2758	1515.563	Goban Spur Pendragon Escarpment
26	1	08/09/2023	17:52:00	19:12:00	51	19.85	-8	37.32	51	17.32	-8	46.13	91.2		speed increased to 10 knots, no penetration
26	2	08/09/2023	19:47:00	20:27:00	51	15.25	-8	54.88	51	14.18	-8	58.93	98.4		**Western Celtic Sea**
26	3	08/09/2023	20:46:00	21:49:00	51	13.80	-9	0.42	51	11.90	-9	7.98	99.7		heave issue not resolving >changing heading for check
26	4	08/09/2023	22:10:00	00:13:00	51	11.88	-9	7.78	51	7.93	-9	22.65	103		latency 2ms
26	5	09/09/2023	00:20:00	00:57:00	51	8.22	-9	23.50	51	11.12	-9	24.98	0		latency 1.5 ms
26	6	09/09/2023	01:01:00	02:29:00	51	11.33	-9	24.28	51	14.18	-9	13.48	100		
26	7	09/09/2023	02:33:00	02:44:00	51	14.02	-9	13.22	51	13.40	-9	12.47	101		power 45%
26	8	09/09/2023	02:46:00	03:57:00	51	13.30	-9	12.35	51	7.77	-9	17.27	102		power40%
26	9	09/09/2023	04:00:00	04:33:00	51	7.68	-9	17.15	51	7.07	-9	12.37	103		

Subbottom profiler Log			Time (UTC)		SOL				EOL					
Station Number	Profile #	Date	SOL	EOL	Lat Degº	Lat decimal Min'	Long Degº	Long decimal Min'	Lat Degº	Lat decimal Min'	Long Degº	Long decimal Min'	Depth (m)	Comments
26	10	09/09/2023	04:36:00	05:54:00	51	7.18	-9	12.68	51	13.78	-9	9.88	103	Western Celtic Sea
26	11	09/09/2023	05:56:00	06:14:00	51	13.82	-9	9.45	51	13.97	-9	7.67	103	
26	12	09/09/2023	06:17:00	07:36:00	51	13.80	-9	7.15	51	7.02	-9	8.12	109	
26	13	09/09/2023	07:48:00	09:09:00	51	6.23	-9	6.78	51	13.92	-9	5.72	109	
26	14	09/09/2023	09:12:00	09:20:00	51	13.95	-9	5.43	51	13.93	-9	4.93	99.6	
26	15	09/09/2023	09:22:00	11:05:00	51	13.87	-9	4.47	51	5.68	-9	1.48	99.2	
26	16	09/09/2023	11:16:00	12:40:00	51	5.45	-9	1.47	51	11.58	-8	56.87	111	
26	17	09/09/2023	12:46:00	13:07:00	51	11.62	-8	55.97	51	8.75	-8	55.23	104.5	
26	18	09/09/2023	13:10:00	14:01:00	51	8.42	-8	55.62	51	4.52	-8	58.52	111.2	
26	19	09/09/2023	14:22:00	14:38:00	51	3.15	-8	58.65	51	2.77	-8	56.37	109	
26	20	09/09/2023	14:40:00	15:51:00	51	2.77	-8	56.35	51	8.17	-8	52.35	106	
26	21	09/09/2023	15:53:00	16:21:00	51	8.27	-8	52.42	51	7.97	-8	49.70	106	
26	22	09/09/2023	16:27:00	17:46:00	51	7.75	-8	48.82	31	1.82	-8	50.15	108	
26	23	09/09/2023	16:50:00	19:59:00	51	1.72	-8	50.50	51	10.52	-8	55.35	109	Dropped SOG to 2.2 knt to avoid trawler
26	24	09/09/2023	20:02:00	21:33:00	51	10.48	-8	55.35	51	4.60	-9	0.15	104	
26	25	09/09/2023	21:35:00	22:00:00	51	4.55	-9	0.47	51	5.13	-9	3.43	111	
26	26	09/09/2023	22:01:00	22:34:00	51	5.15	-9	3.28	51	11.88	-9	2.28	102	
26	27	09/09/2023	23:37:00	23:56:00	51	11.95	-9	2.67	51	12.42	-9	4.42	101	
26	28	10/09/2023	00:00:00	01:14:00	51	12.20	-9	4.87	51	6.58	-9	5.77	111	
26	29	10/09/2023	01:18:00	02:01:00	51	6.47	-9	5.45	51	6.65	-9	10.25	110	
26	30	10/09/2023	02:03:00	03:38:00	51	6.80	-9	10.62	51	13.88	-9	10.60	104	
26	31	10/09/2023	03:41:00	05:31:00	51	13.77	-9	10.37	51	6.07	-9	16.27	111	
26	32	10/09/2023	05:35:00	06:18:00	51	6.12	-9	16.48	51	8.52	-9	19.22	109	
26	33	10/09/2023	06:21:00	07:13:00	51	8.68	-9	19.87	51	12.22	-9	16.95	104	
26	34	10/09/2023	07:16:00	07:57:00	51	12.32	-9	16.87	51	14.20	-9	20.75	103	
26	35	10/09/2023	07:59:00	08:59:00	51	14.13	-9	20.75	51	10.65	-9	25.62	102	

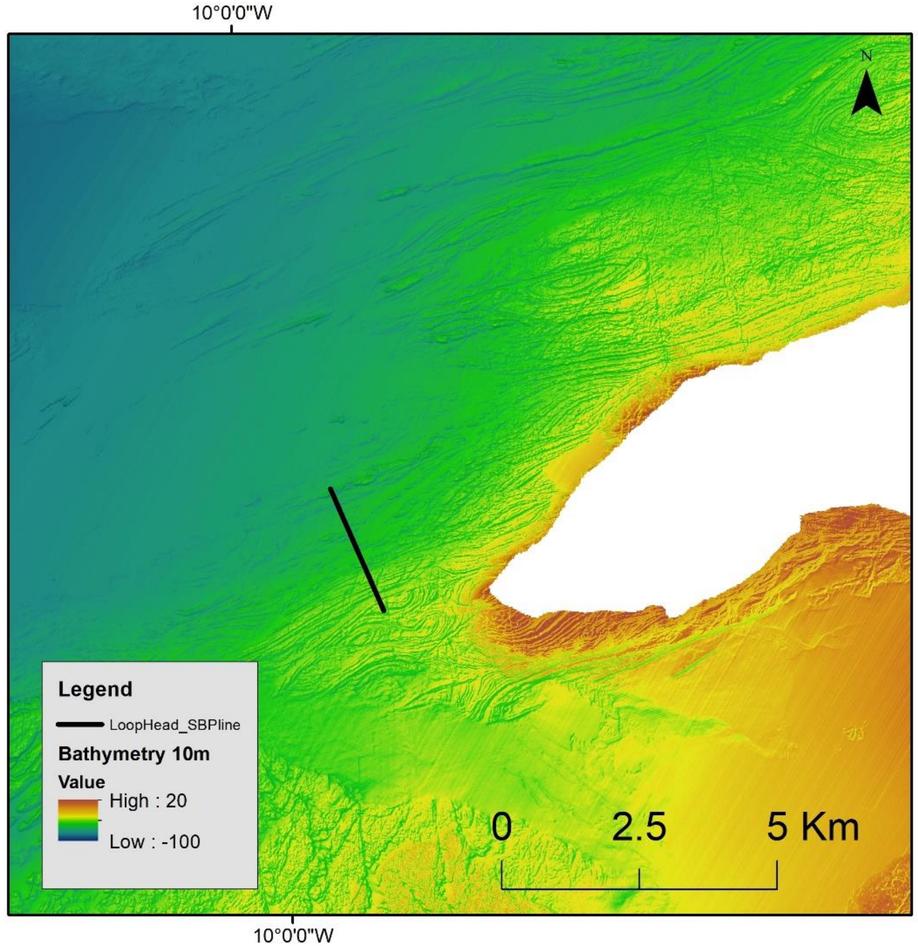


Figure 25: Station 1. Loop Head

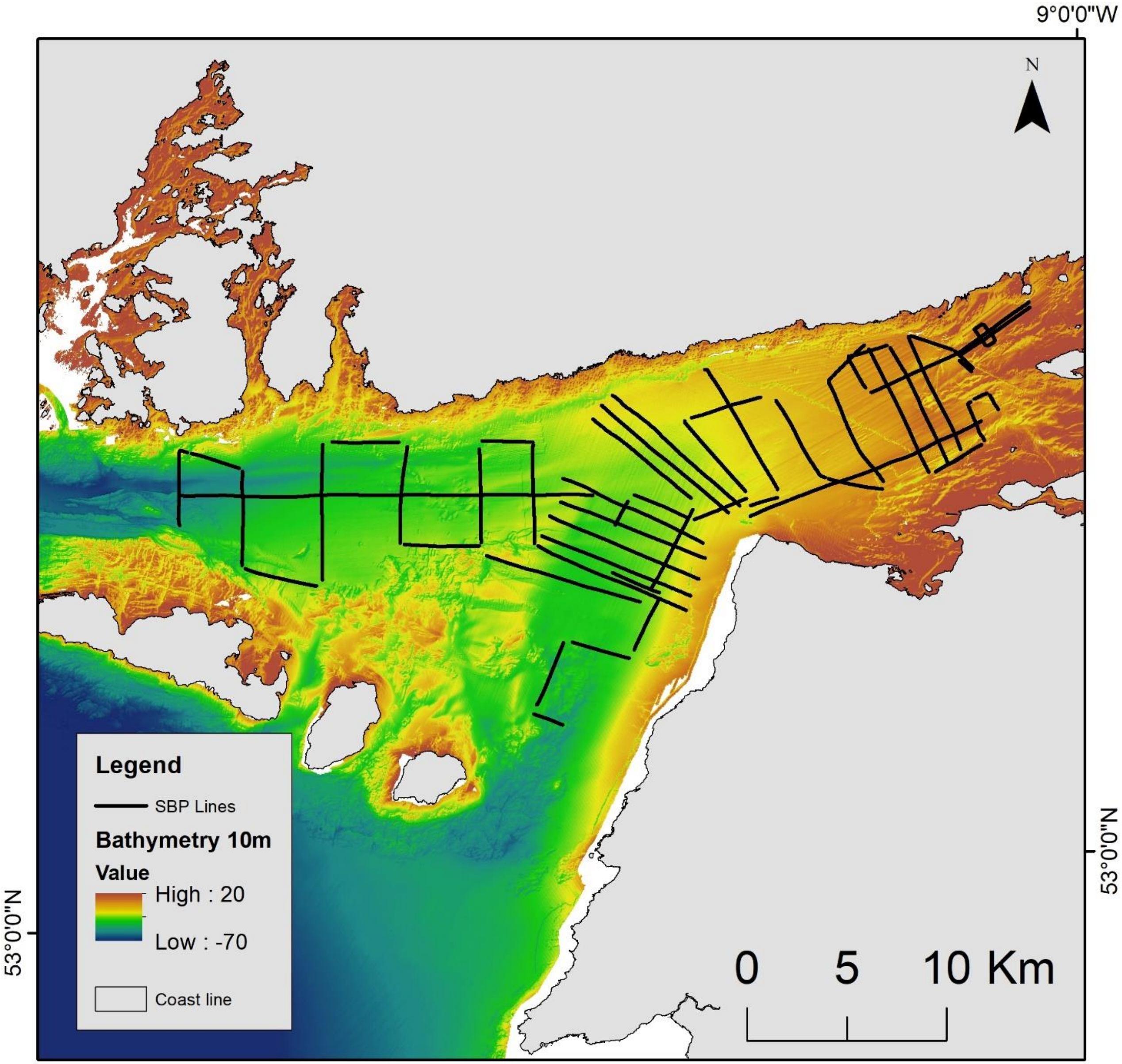


Figure 26: Station 2: Galway Bay

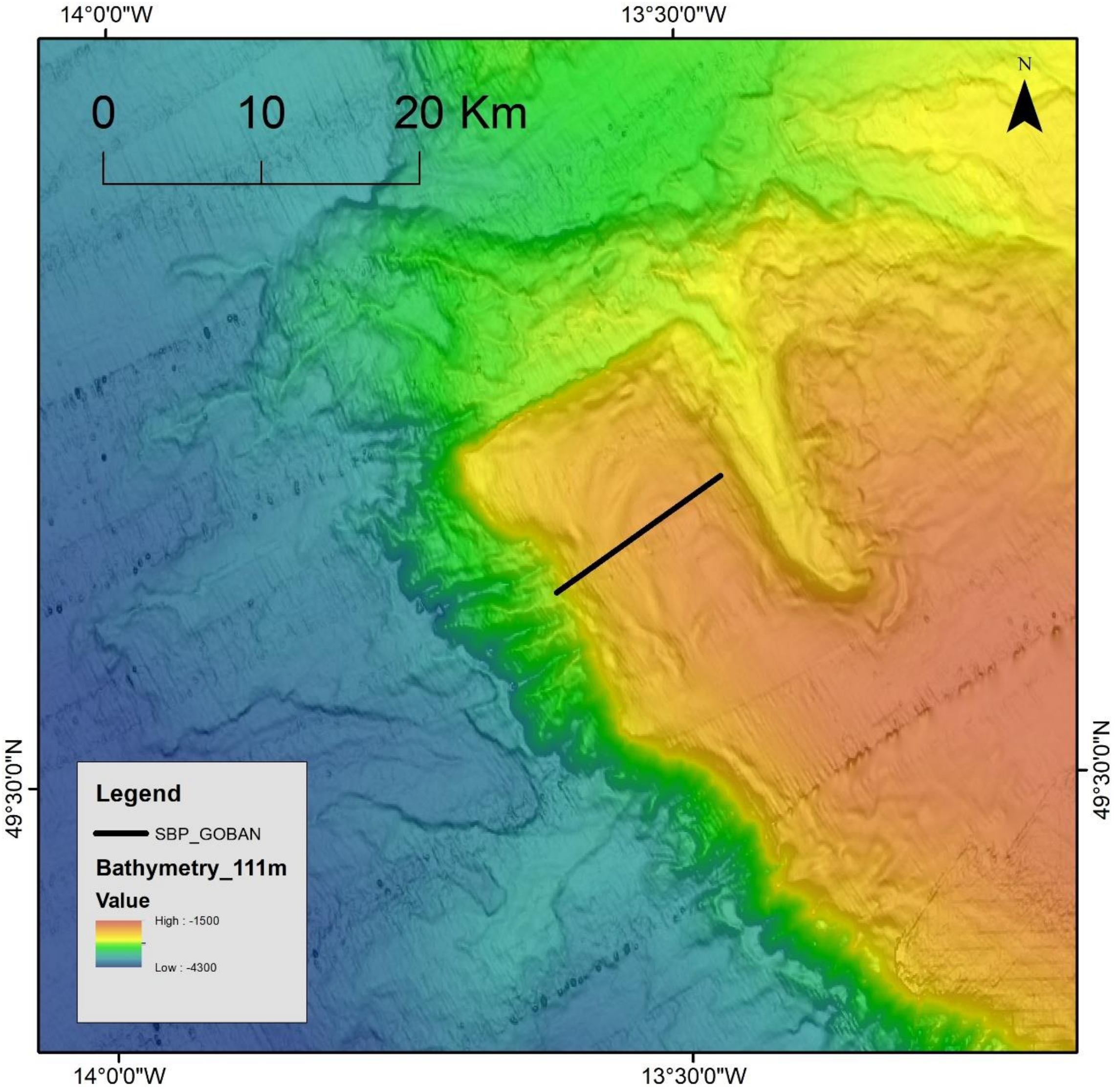


Figure 27: Station 2: Northern Goban Spur (Pastouret Spit to Pendragon Escarpment)

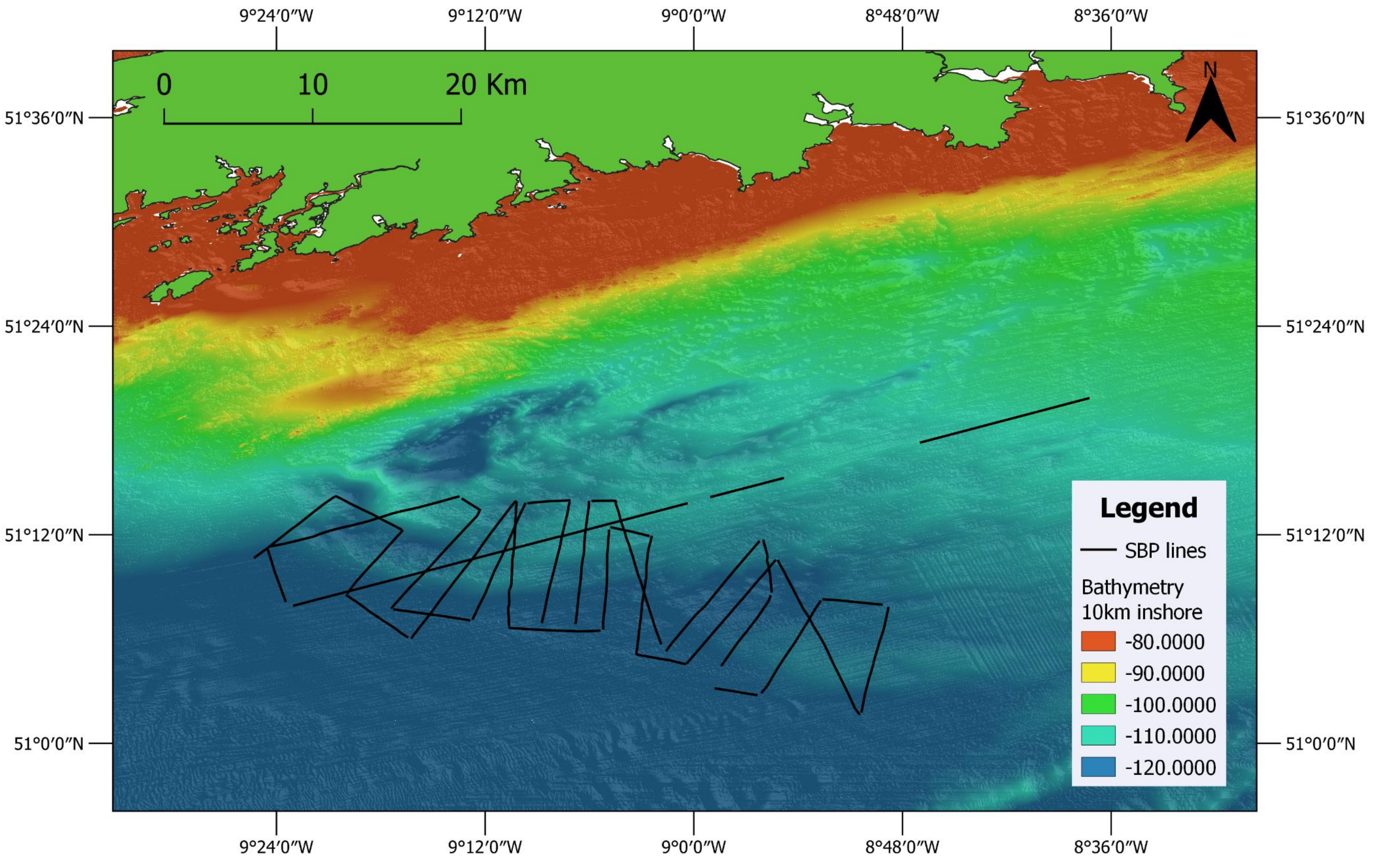


Figure 28: Station 26: Western Celtic Sea

ROV Dive Log and Maps (all time UTC)

		Time (UTC)	dm	dm		time	time	time	time	time	dd	dd	dd	dd	y/n	Name	
Dive #	Date		Lat	Long	Depth (m)	ROV IN	ROV ON BOTTOM	ROV ON DECK	Drill start	Drill stop	ROV on bottom Lat	ROV on bottom Long	Outcrop Lat	Outcrop Long	Rock recovery	Sample	Comments
1	01/09/2023	13:30:00	52°00.39	14°59.70	950	13:33	On bottom but no drill	18:31:00									
2	01/09/2023	20:40:00	52°00.46	15°14.80	2142	20:43	22:25:00	00:13:00			52°0.44670'	15°14.89987'					Off seabed 22:45
3	02/09/2023	02:24:00	51°41.86	15°14.66	1650	02:29	03:39:00	08:23:00	04:21:00	07:15:00	51.418437	15.145056°	51.41843°	15.145026°			Rock, 04:53 drill stop spinning (empty)
4	02/09/2023	11:20:00	51°58.83	15°02.35	827	11:20	12:18:00 - 13:49:00	14:36:00									13:42 rock seen but could not land
5	02/09/2023	22:16:00	50°55.75	14°54.02	2622	22:16	00:17:23 - 00:40:50				50.558426°	14.5396°					Rock 00:13
							00:57:48 - 01:03:05 - 01:09:00		01:16:00	01:36:00	50.5591715°	14.538796°					Outcrop drill test
							01:36:00 - 02:16:00				50.5591715°	14.538796°					problem with drill
							03:43:00	04:57:00									End of search
6	03/09/2023	09:02:00	50°28.296	14°29.009	2850	09:03	11:05:00	14:21:00									
7	04/09/2023	04:47:00	49°40.14	13°27.80	2165	04:48	06:00:00 - 07:03:00	09:52:00									
8	04/09/2023	11:30:00	49°36.45	13°36.61	2750	11:31	13:52	17:08			49.365°	13.365°	49.365°	13.364°			slope? Aborted
9	04/09/2023	20:10	49°26.60	13°25.50	3 (drill at 2	20:10	21:57 (landing for drill at 23:33:00)	04:55	23:45	03:02	49.264290°	13.249701°	49.264309°	13.249774°	y	St19_R1	0.8 m long sample recovered (ST19_D9_S1)
10	05/09/2023	11:04	48° 46.03	12°48.19	2680	11:04	12:49	14:15			48.460258°	12.48804°					
11	05/09/2023	22:41	48° 42.72	12°45.29	2435	22:41	23:57	02:21									Mud
12	06/09/2023	09:56	48° 29.19	12°11.16	1941	09:57	10:59 - 12:28	13:33			48.2919°	12.1115°					
13	06/09/2023	15:50	48° 21.28	11°38.75	1264	15:50	16:35	18:38			48.214138°	11.589944°					Video overlay - issues lat long - don't trust
14	06/09/2023	19:28	48° 20.05	11°54.36	1523	19:29	20:19	04:36	01:28	03:27			48.333°	11.8991°	Y - drill	St25_R2	Use raw USBL coordinates (video overlay don't trust)
OF	LEG 2																
15	10-Sep	19:41:00	51.45983	-11.024	916	19.41	20.17	0.50 11/09			51.45983	-11.024				y	
											51.46025167	-11.73348333					Apollo 34.4 m bearing 304 away for location
											51.460405	-11.7338					Charlotte 917m
											51.46043333	-11.73373667					Coral samples left drawer Charlotte
											51.460405	-11.7338					Coral samples right drawer Apollo
																	ROV off bottom 23.52
16	11-Sep	00:57:36	51.45983	-11.024	920	1.04	1.37	2.43			51.460195	-11.73357167					Apollo recovered
17	11-Sep	15:08	51.46017	-11.734	916	15:08	16:02				51.46025	-11.73347167					1 vibrocore at Apollo, stopped due to rig malfunction
18	11-Sep	18:07	51.46025	-11.7335	916	18:07	18:45				51.46028167	-11.73346833					x4 vibrocores
19	12-Sep	05:30	51.4168	-11.6947	959	05:30	06:12										MBES patch test 50m from bottom
20	12-Sep	10:36	51.4145	-11.7608	950		18:37	9.48									MBES mosaic, recovered due to 35kh wind
21	13-Sep	18:12	51.45967	-11.7615	959	18:12	19:03				51.45977833	-11.76197333					Continuing MBES mosaic
21	14-Sep	04:44	51.48783	-11.7297	909	04:44		05:10			51.48770167	-11.7304					Dead sub, hydraulic failure @760m
22	14-Sep	06:38	51.488	-11.7295	909	06:38	07:05	6.38			51.4227	-11.749	EOL				Finalising MBES survey

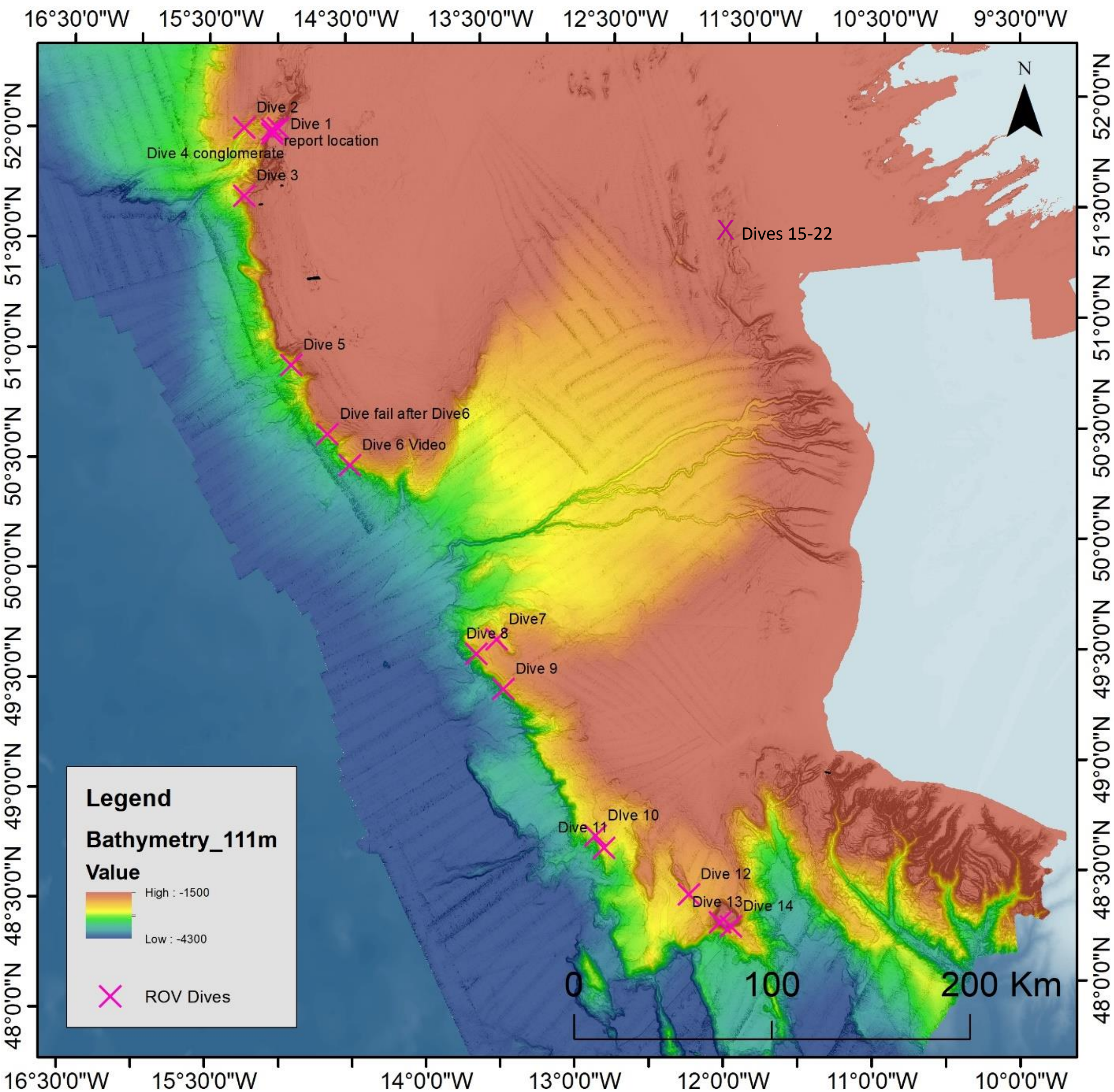


Figure 29. ROV dive locations (Leg 1)

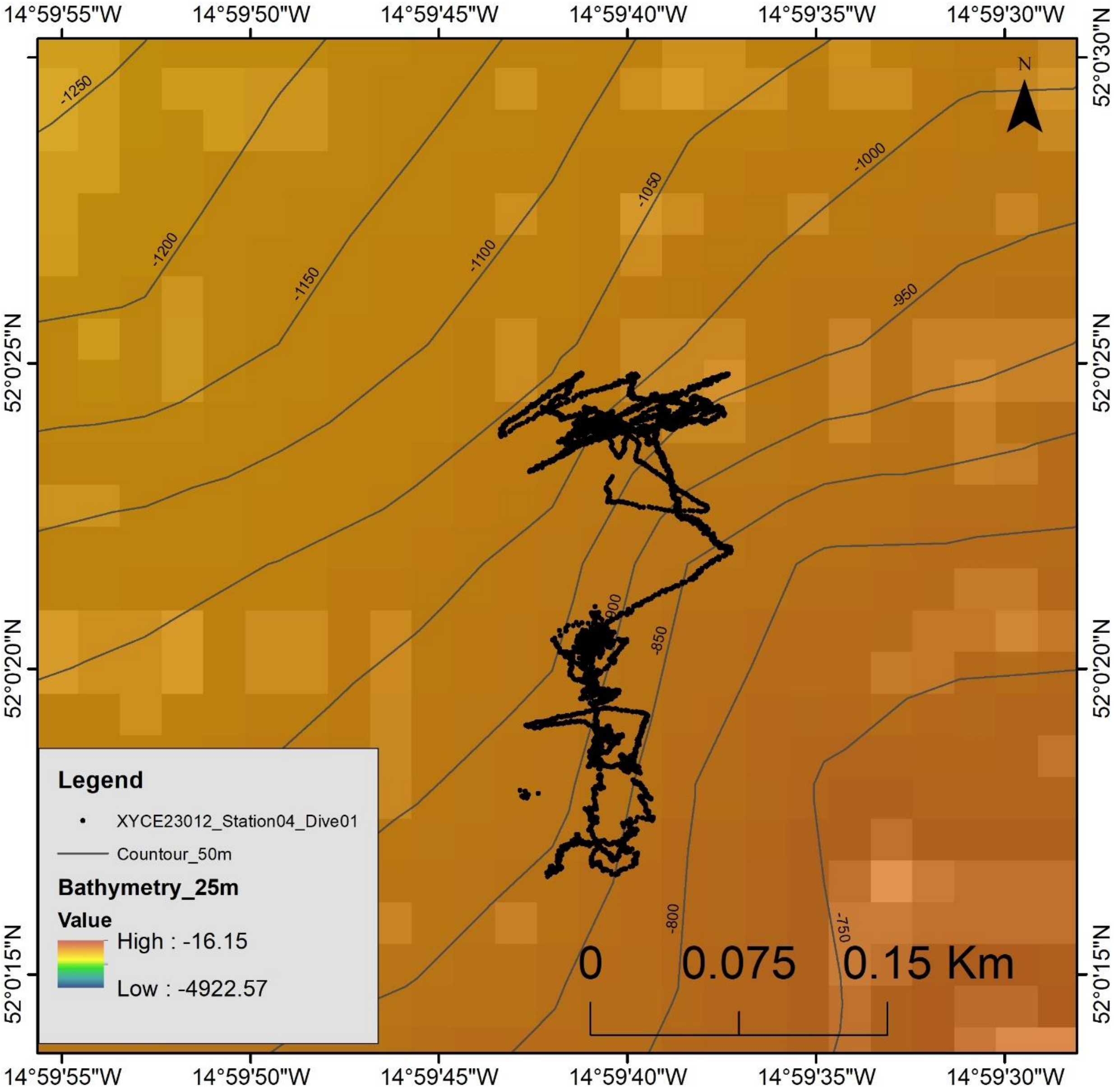


Figure 30: Survey track St4_ROV dive 1

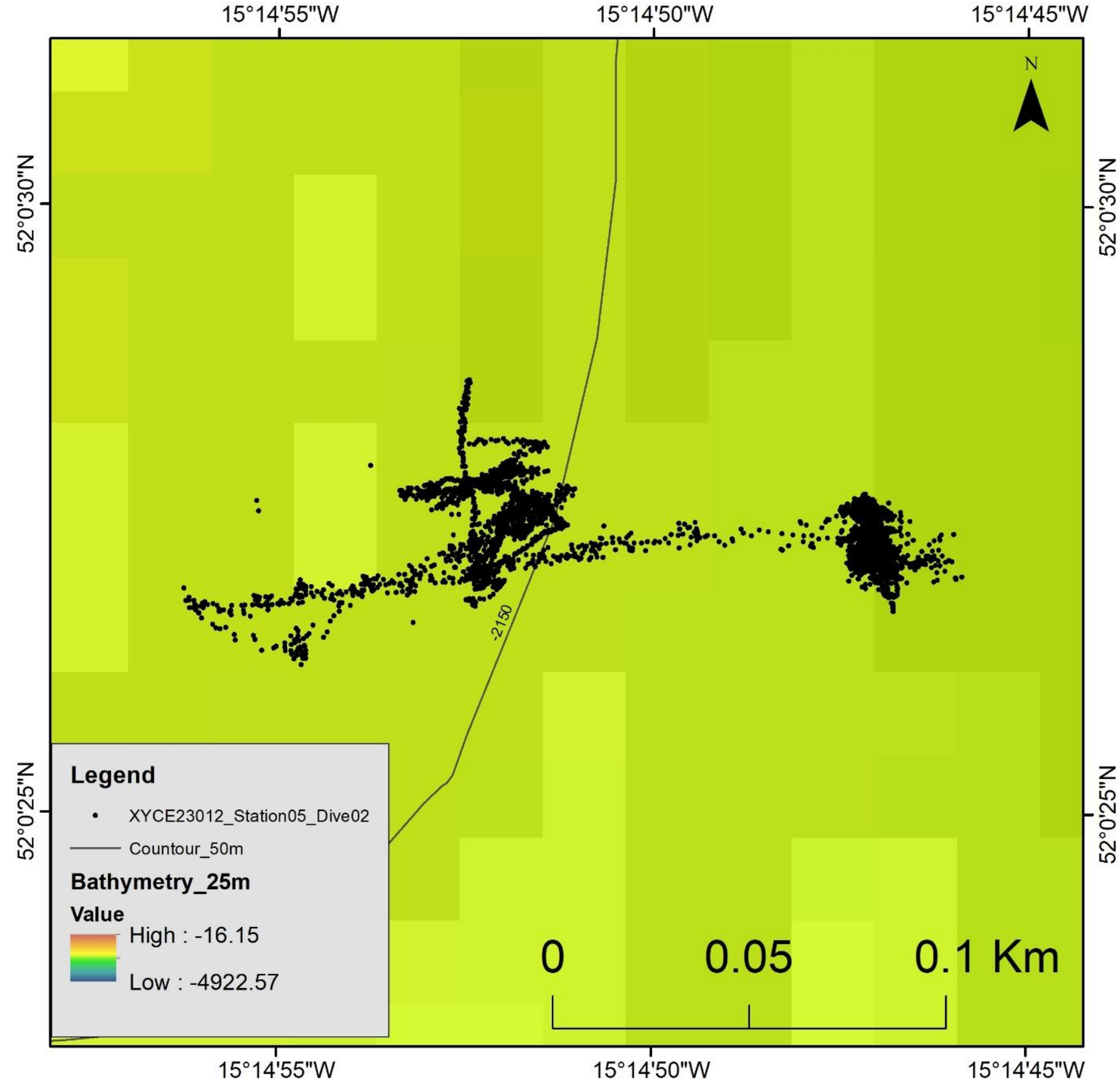


Figure 31: Survey track St5_ROV dive 2

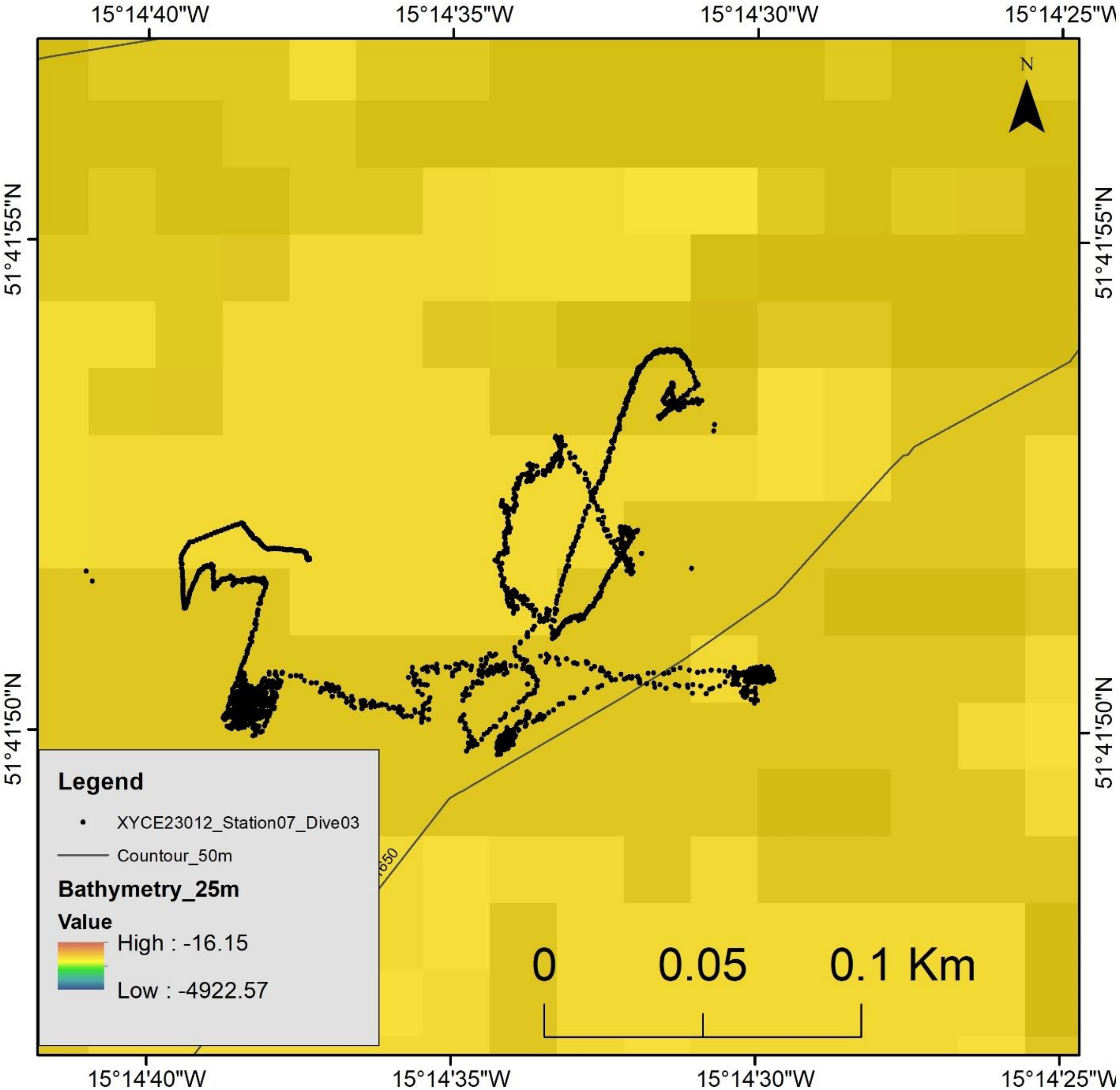


Figure 32: Survey track St7_ROV dive 3

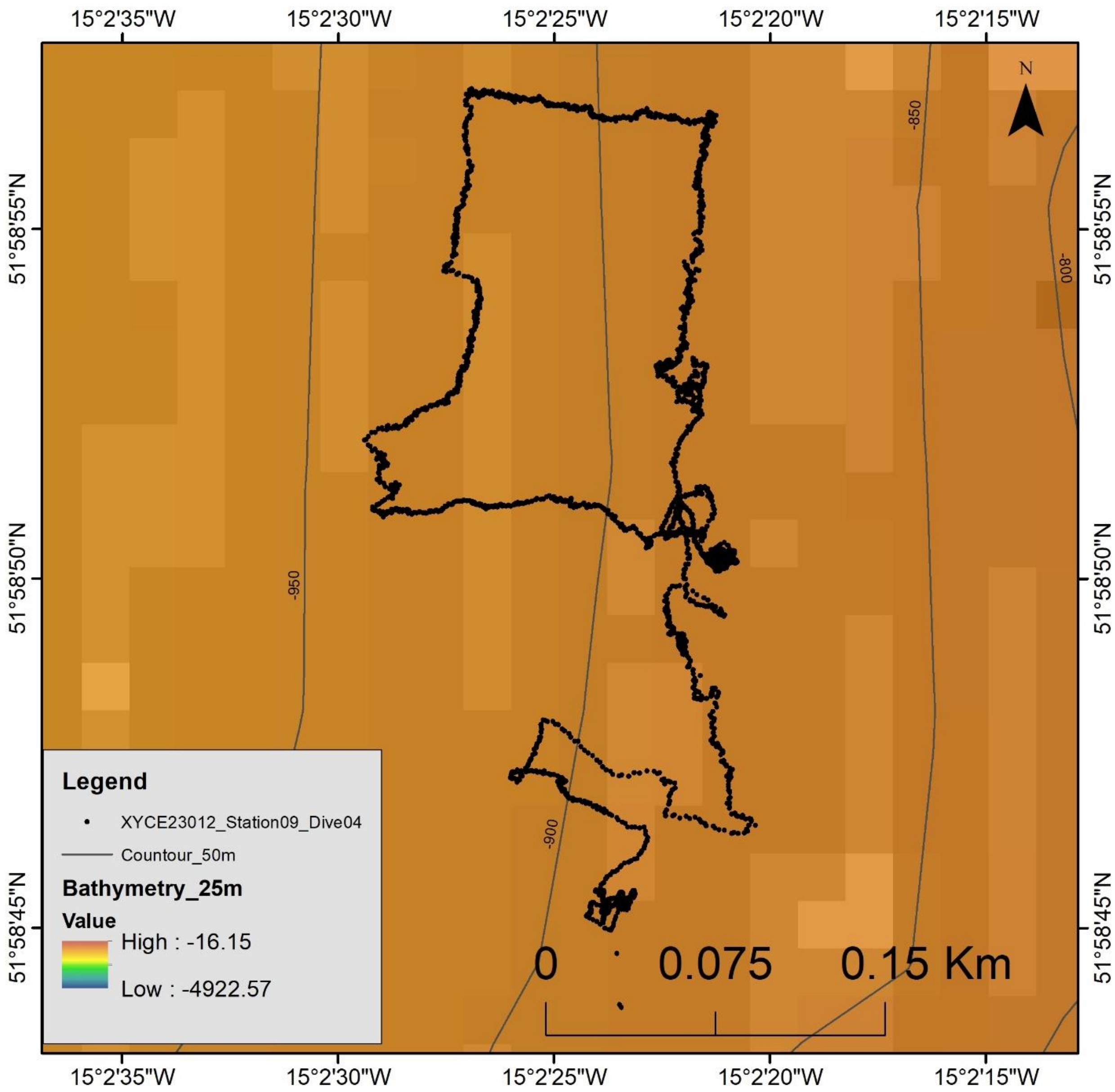


Figure 33: Survey track St9_ROV dive 4

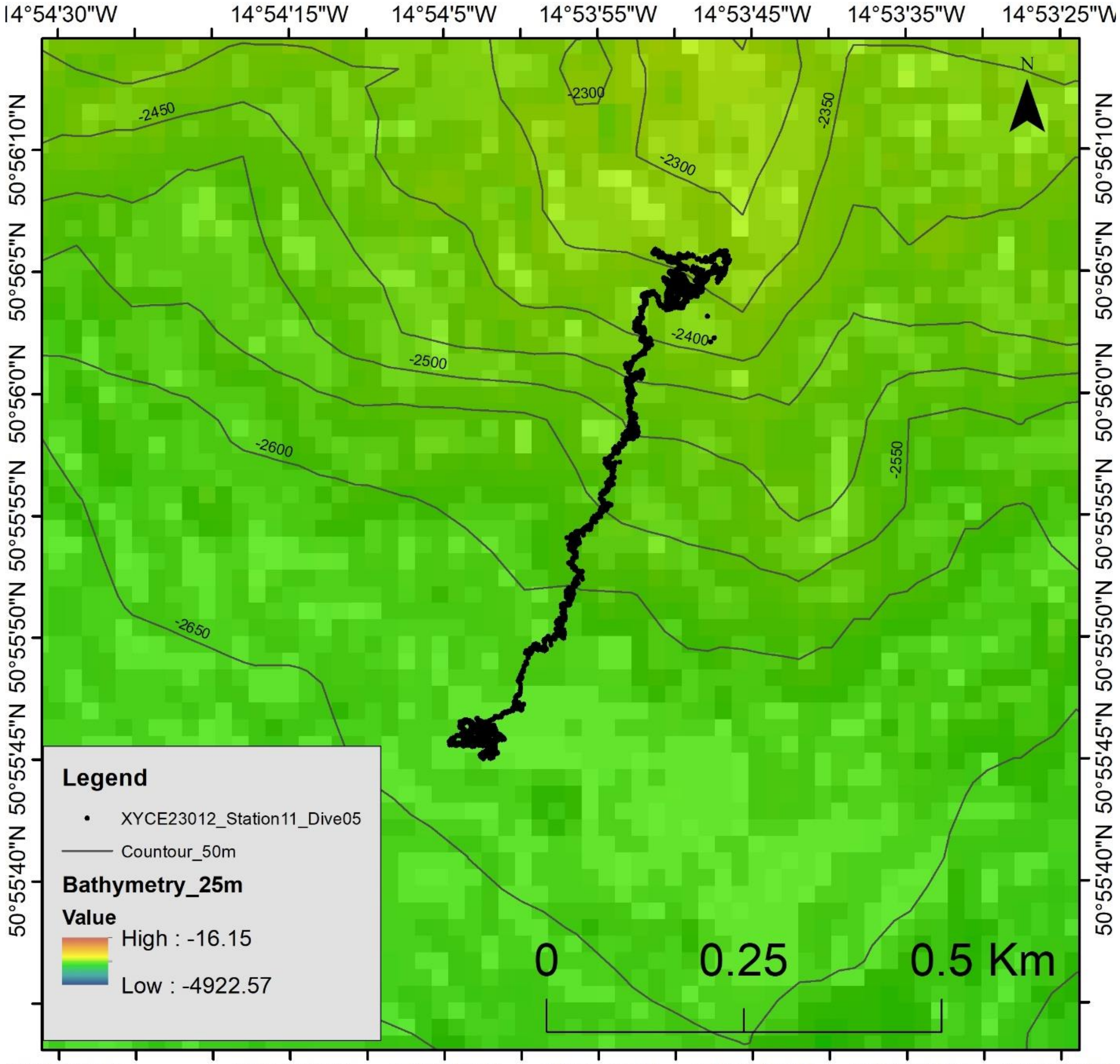


Figure 34: Survey track St11_ROV dive 5

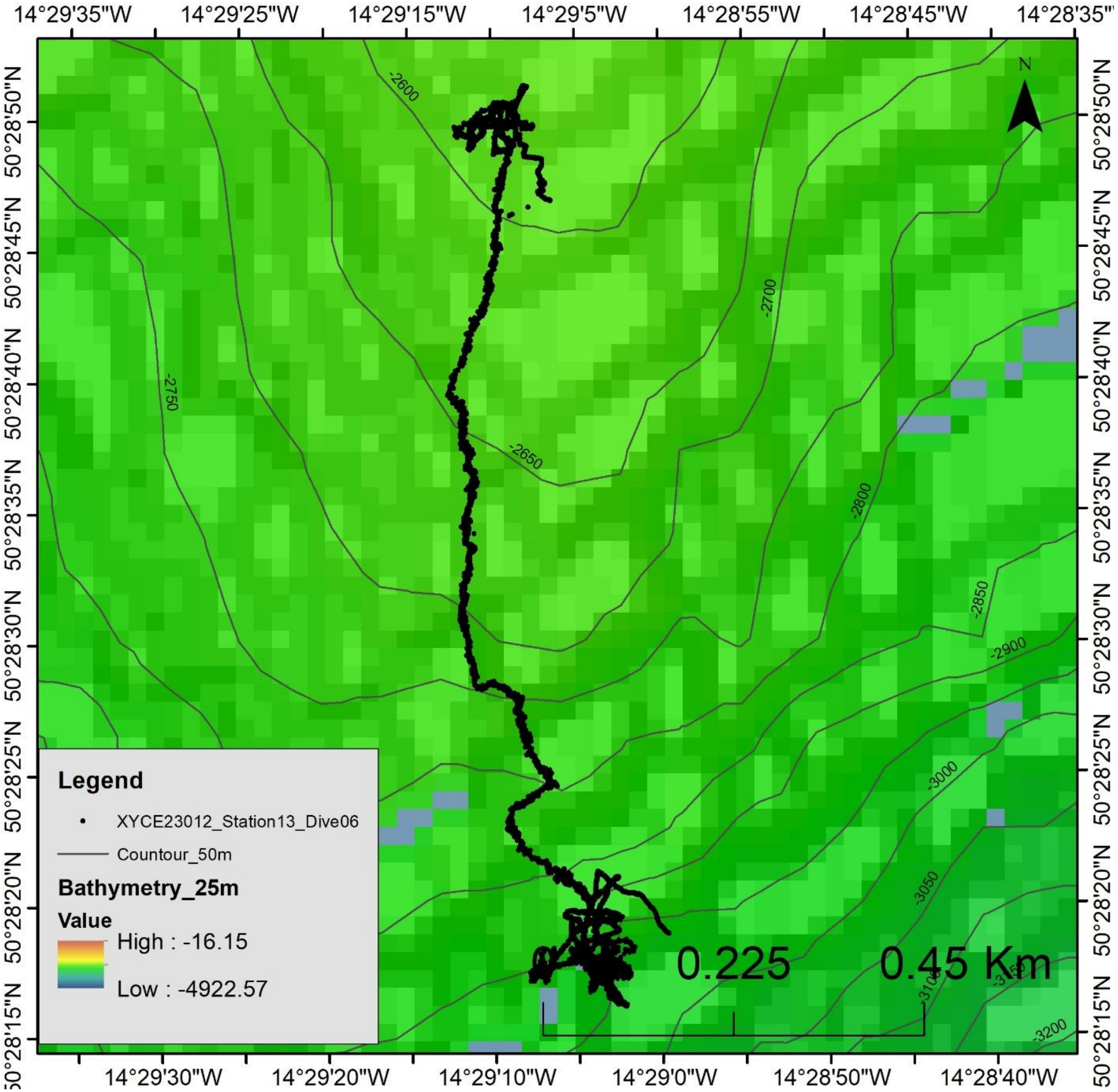


Figure 35: Survey track St13_ROV dive 6

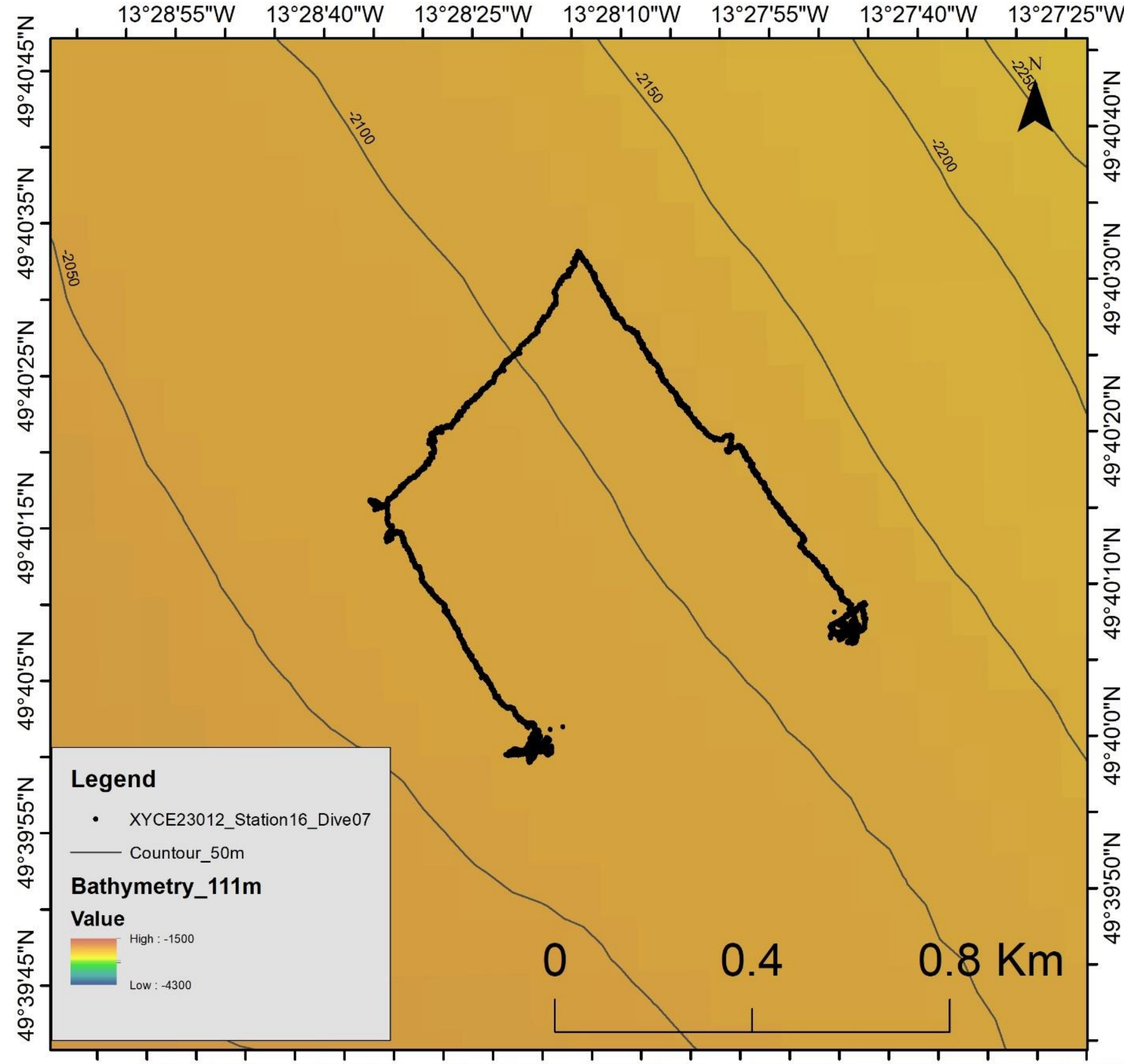


Figure 36: Survey track St16_ROV dive 7

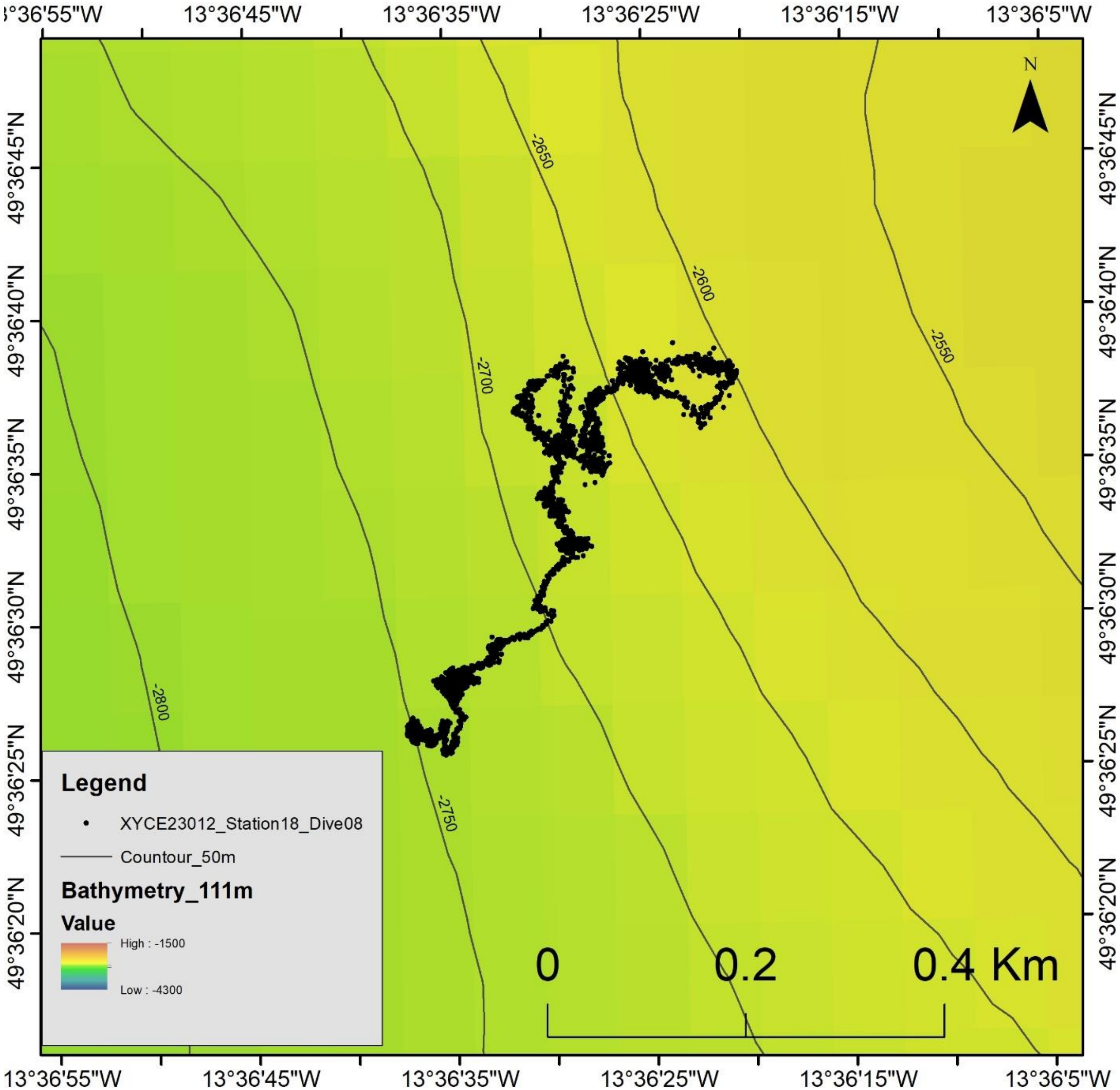


Figure 37: Survey track St18_ROV dive 8

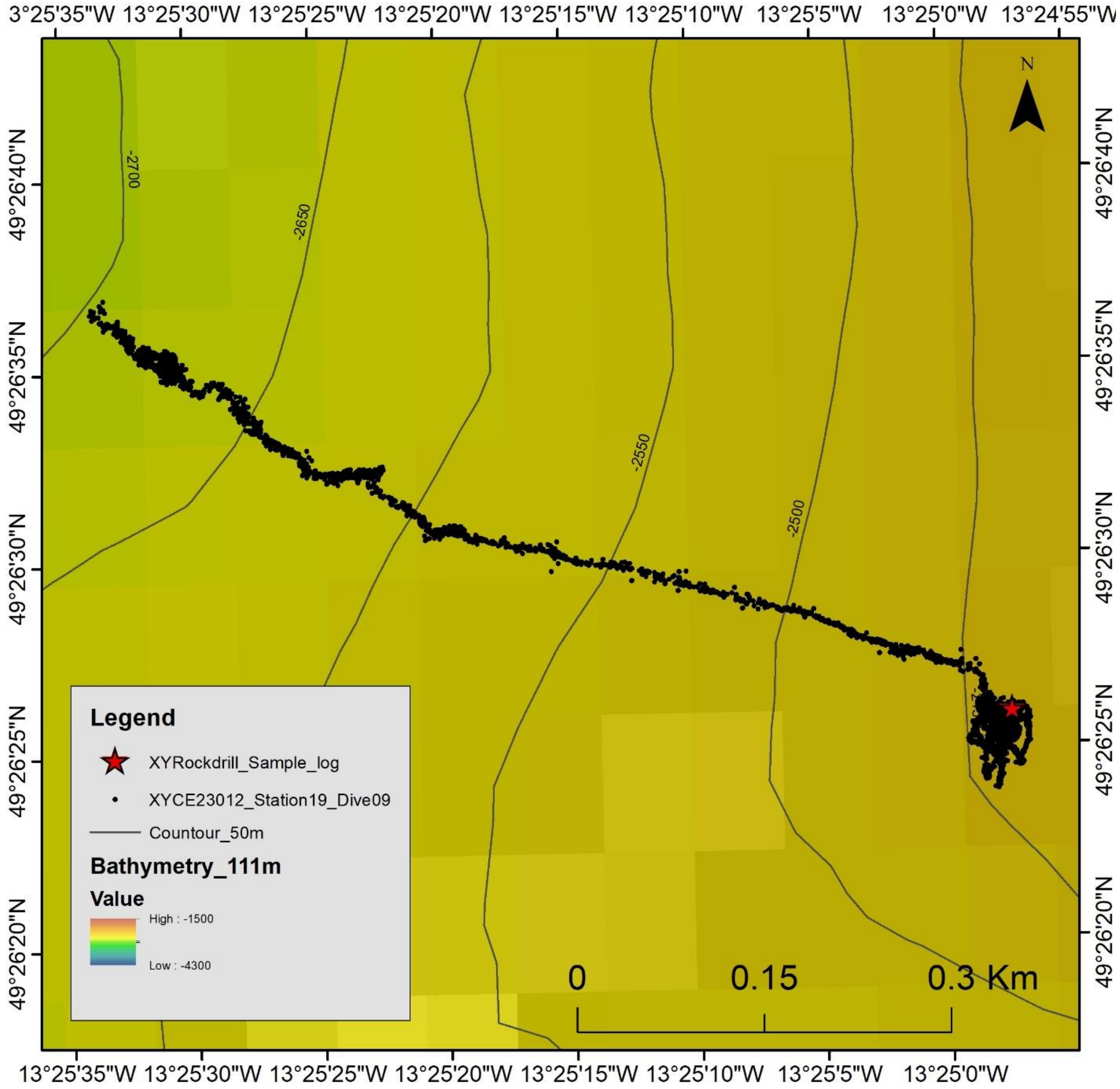


Figure 38: Survey track St19_ROV dive 9

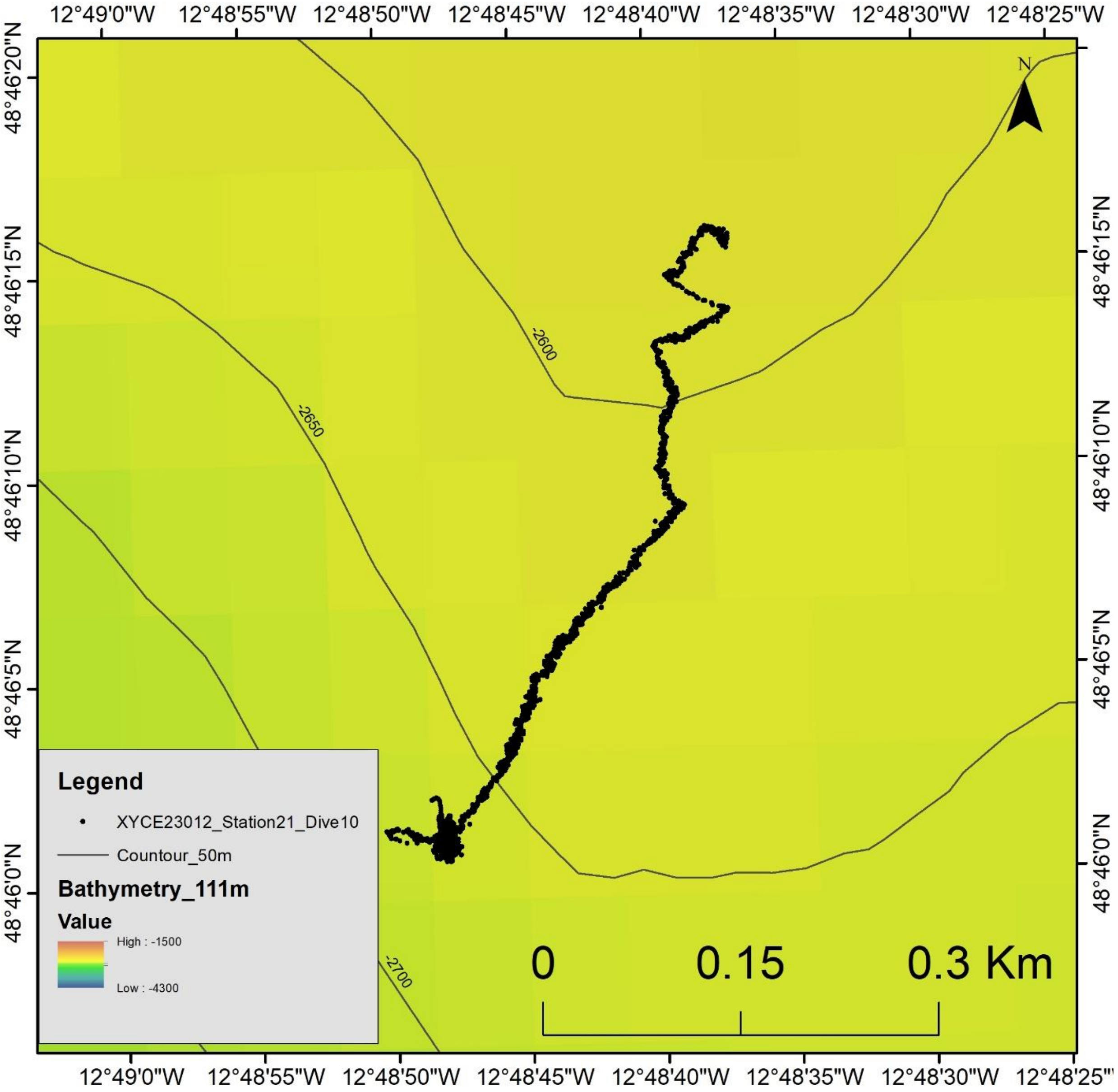


Figure 39: Survey track St21_ROV dive 10

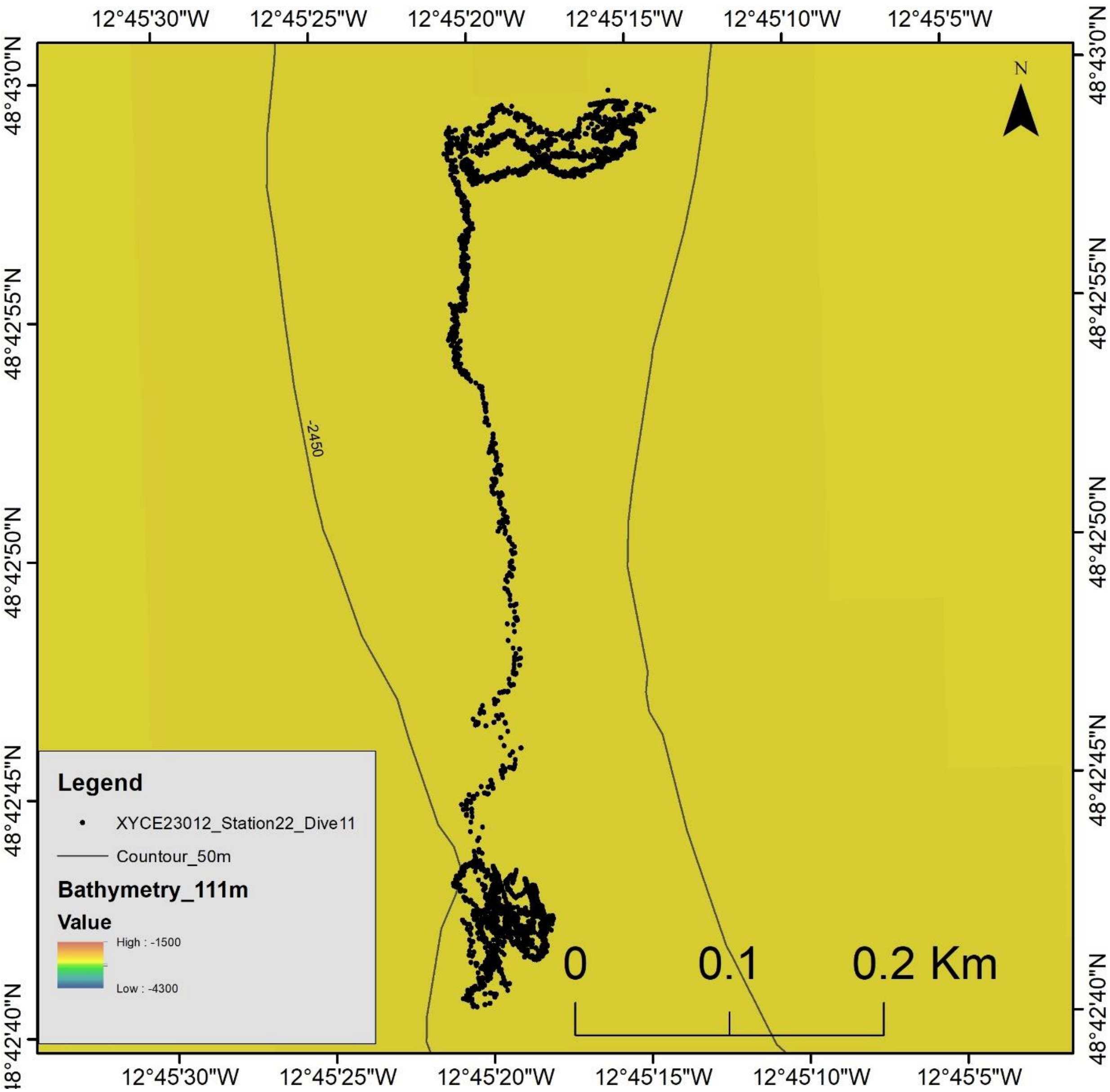


Figure 40: Survey track St22_ROV dive 11

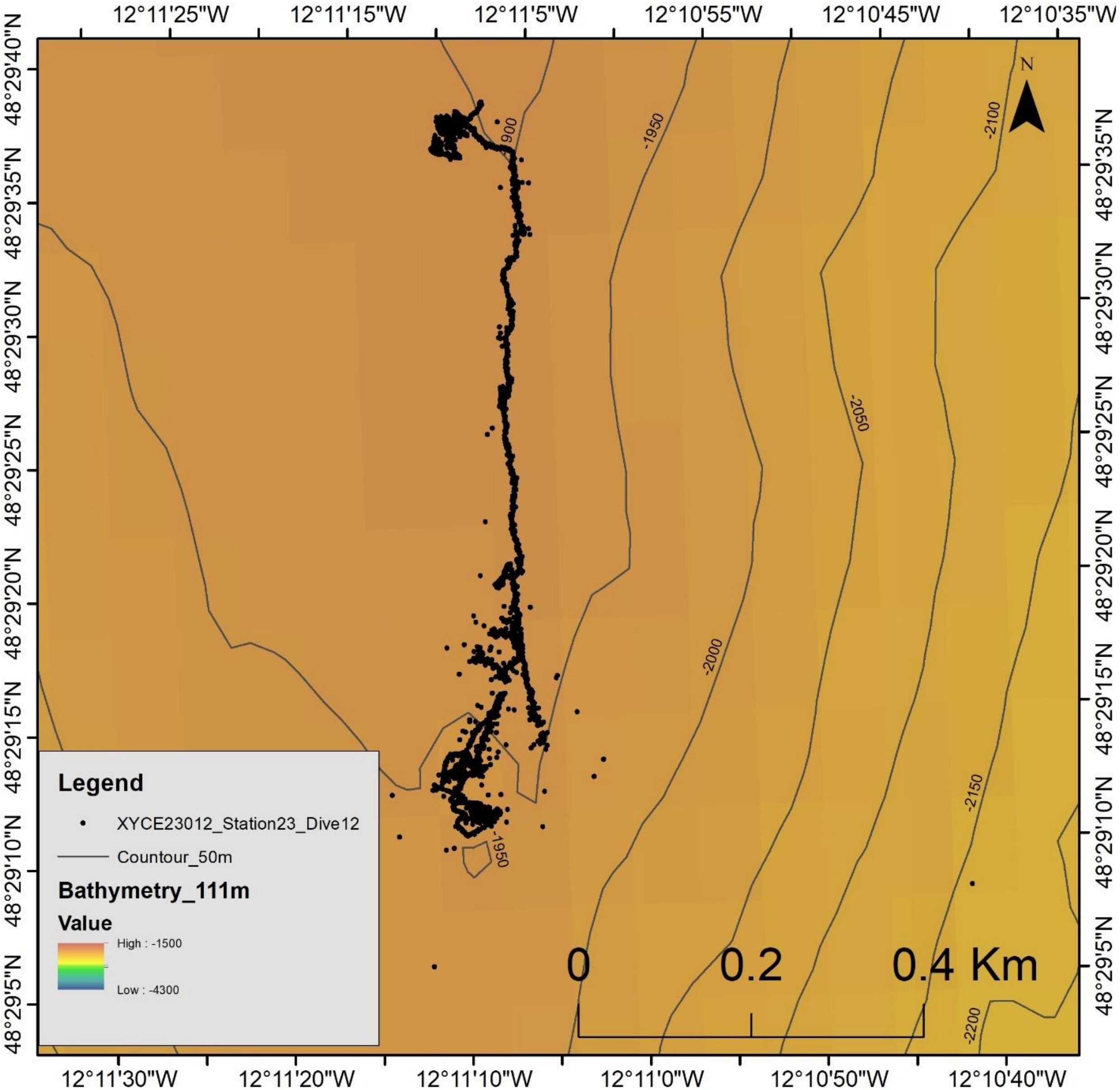


Figure 41: Survey track St23_ROV dive 12

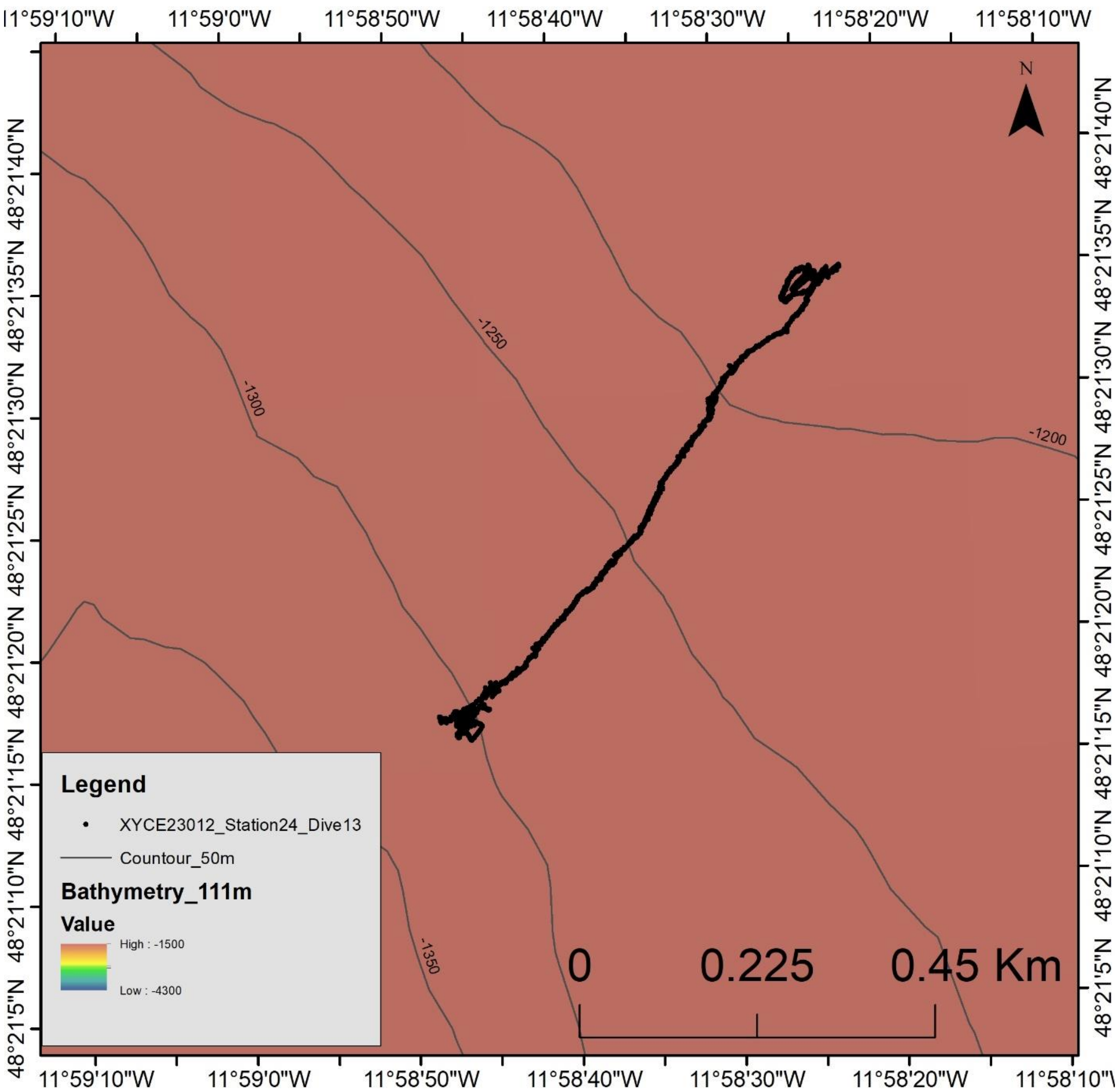


Figure 42: Survey track St24_ROV dive 13

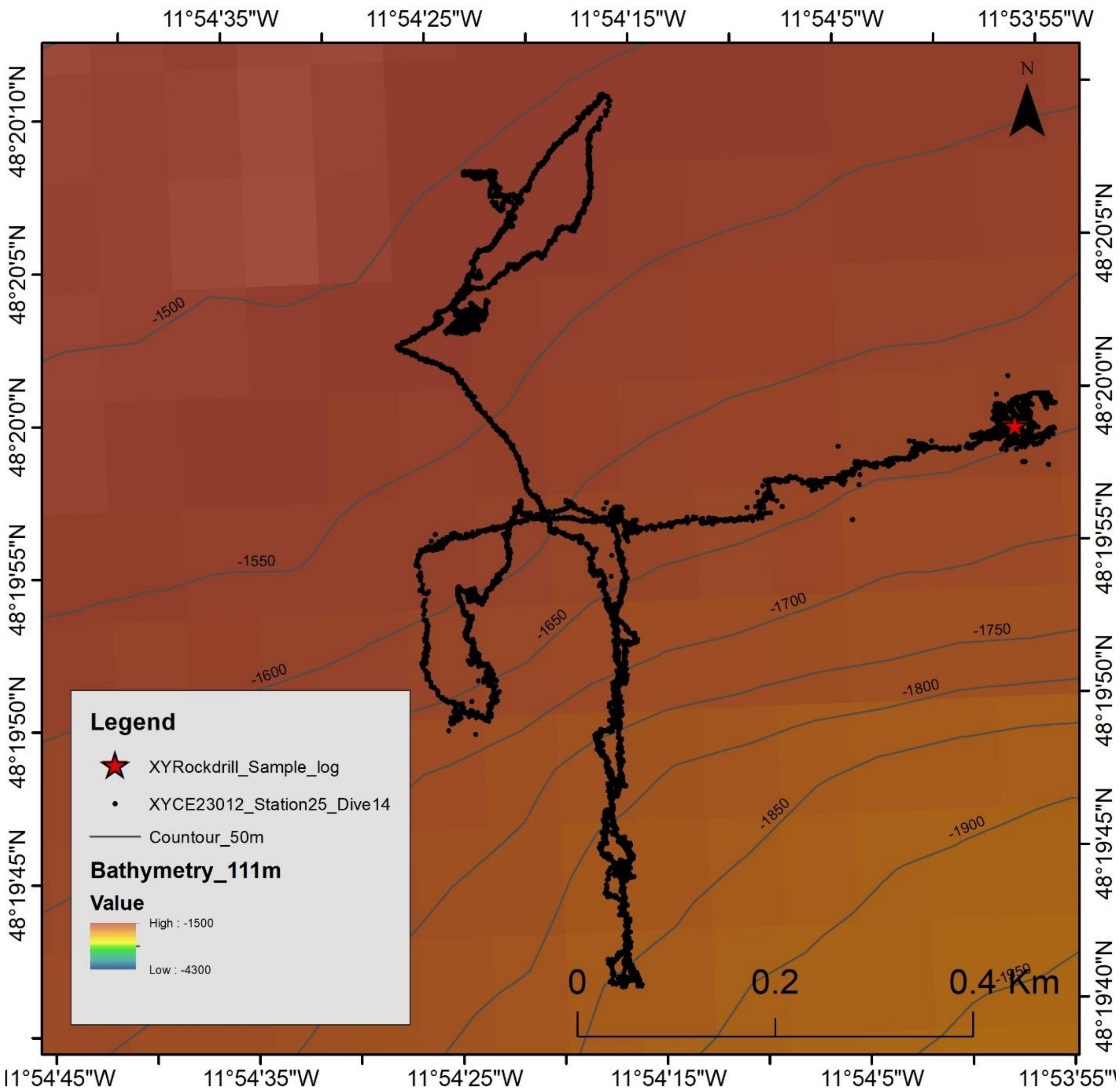


Figure 43: Survey track St25_ROV dive 14

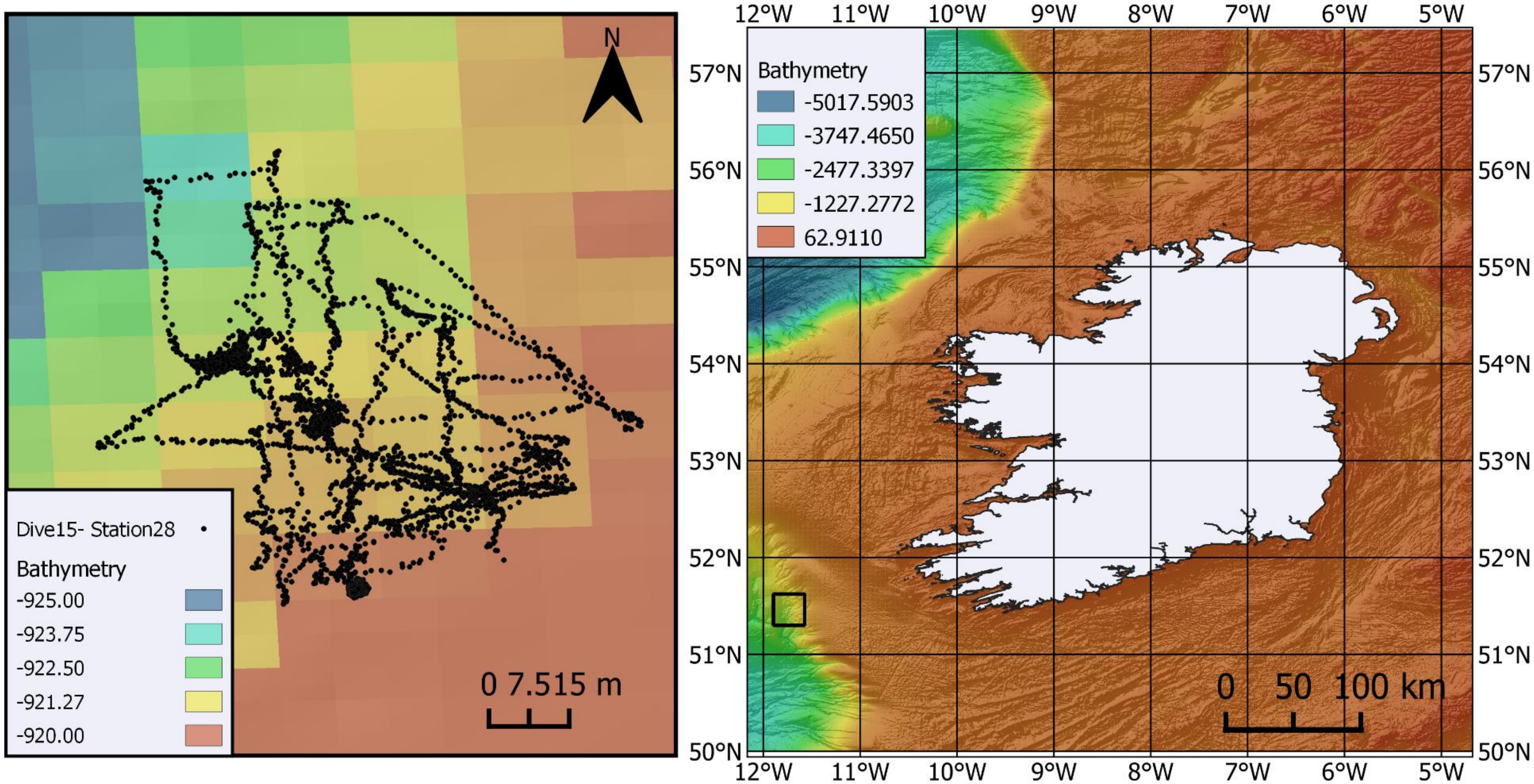
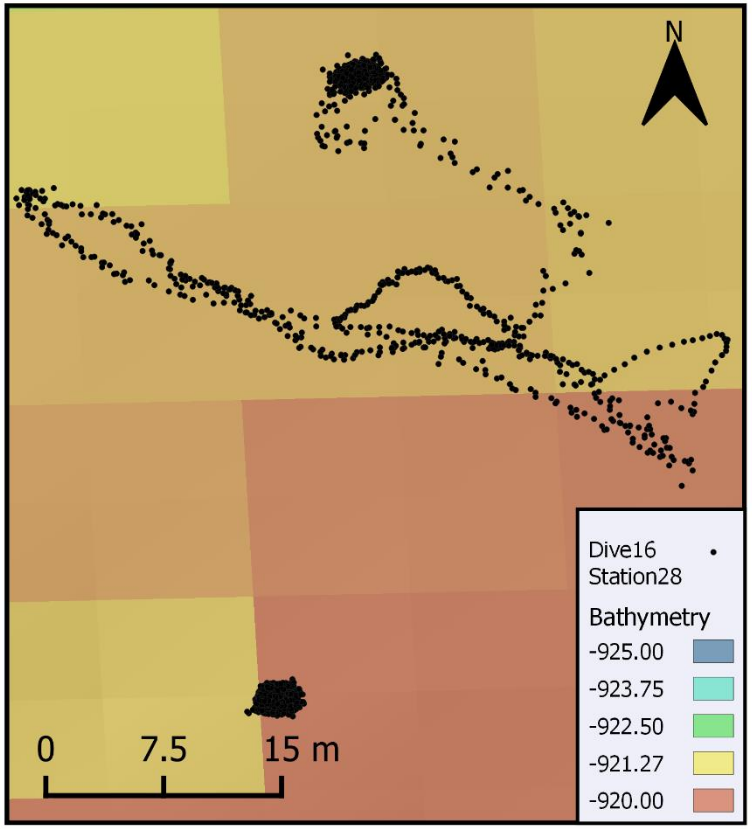


Figure 44: Survey track St28_ROV dive 15 (Charlotte lander recovery and coral sampling)



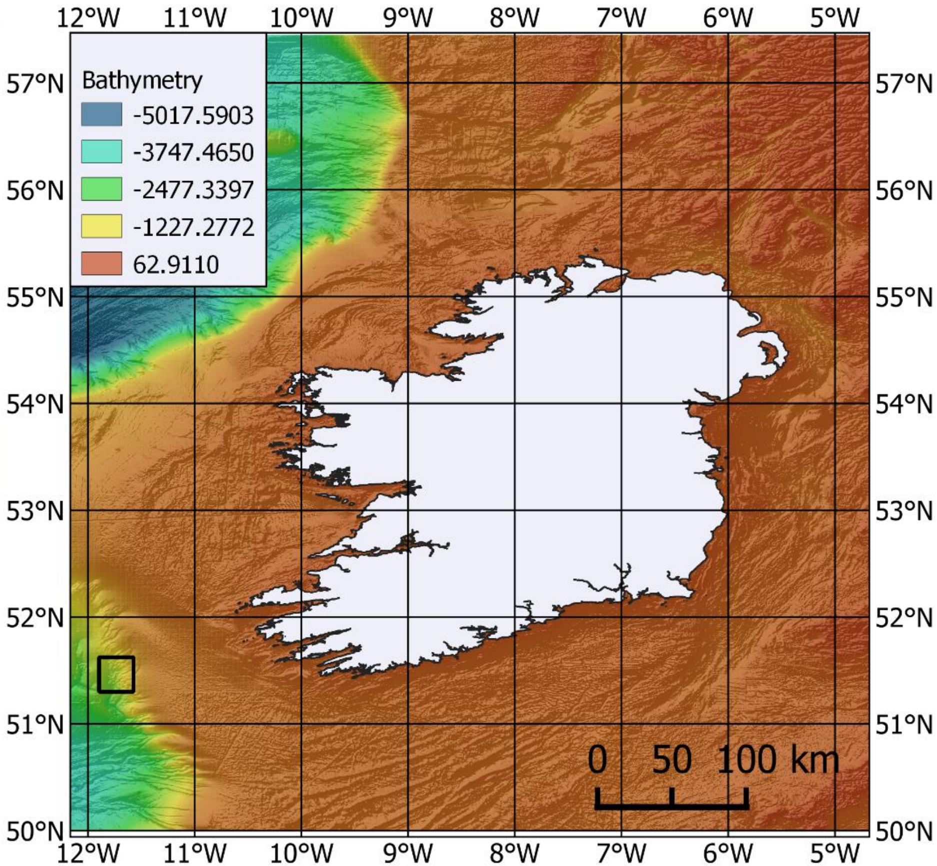


Figure 45: Survey track St28_ROV dive 16 (Apollo lander recovery)

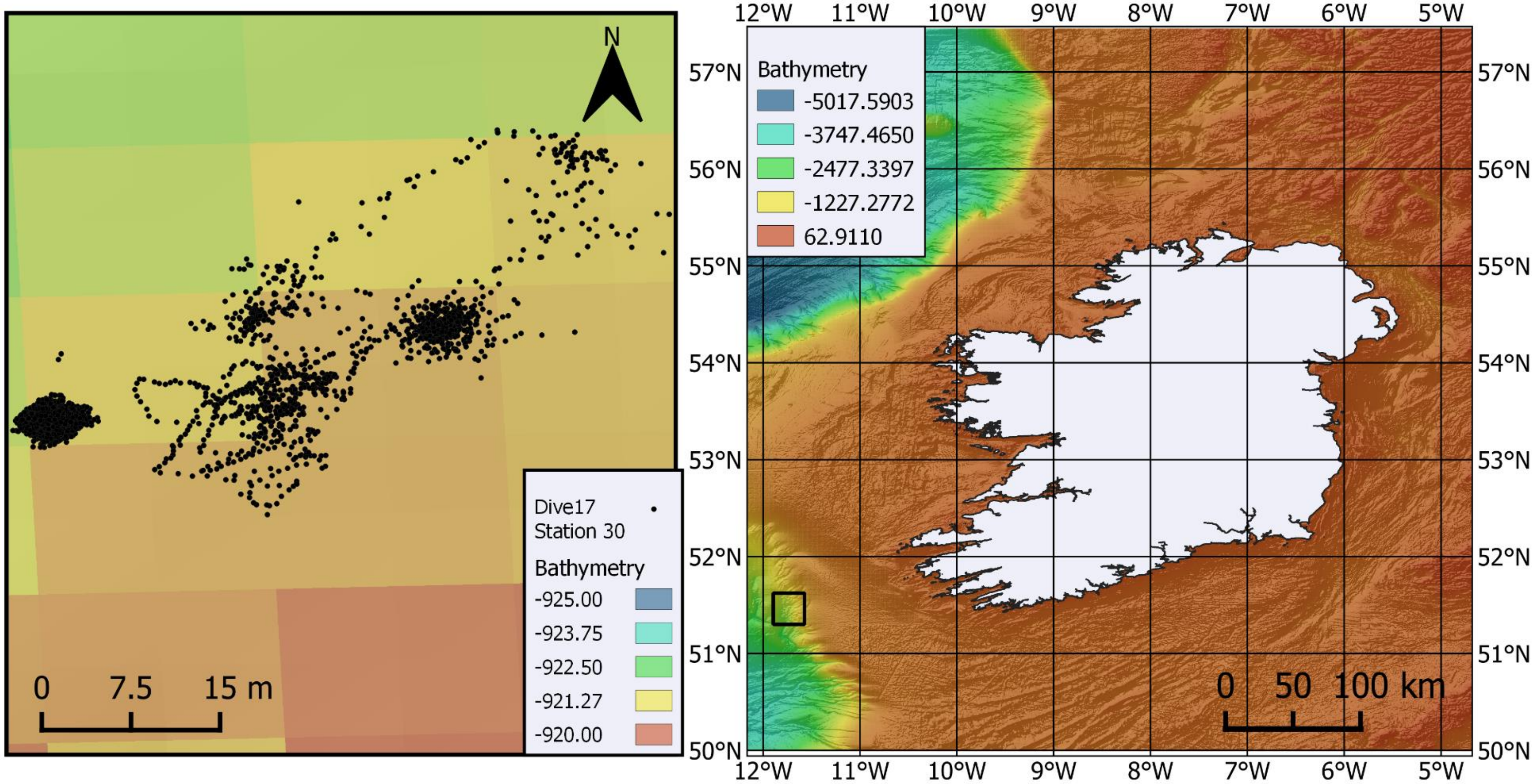


Figure 46: Survey track St30_ROV dive 17 (Vibrocores)

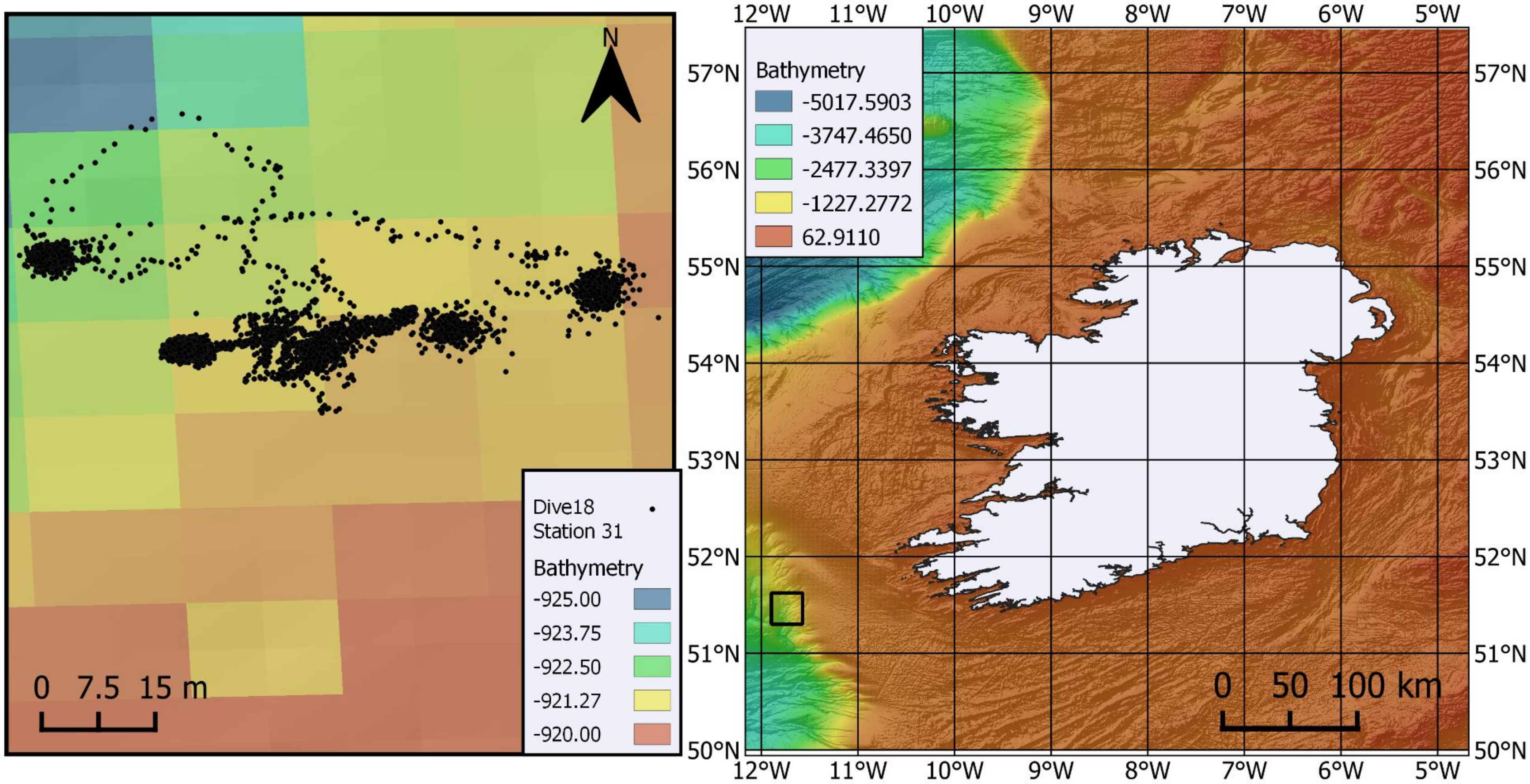


Figure 47: Survey track St31_ROV dive 18 (Vibrocores)

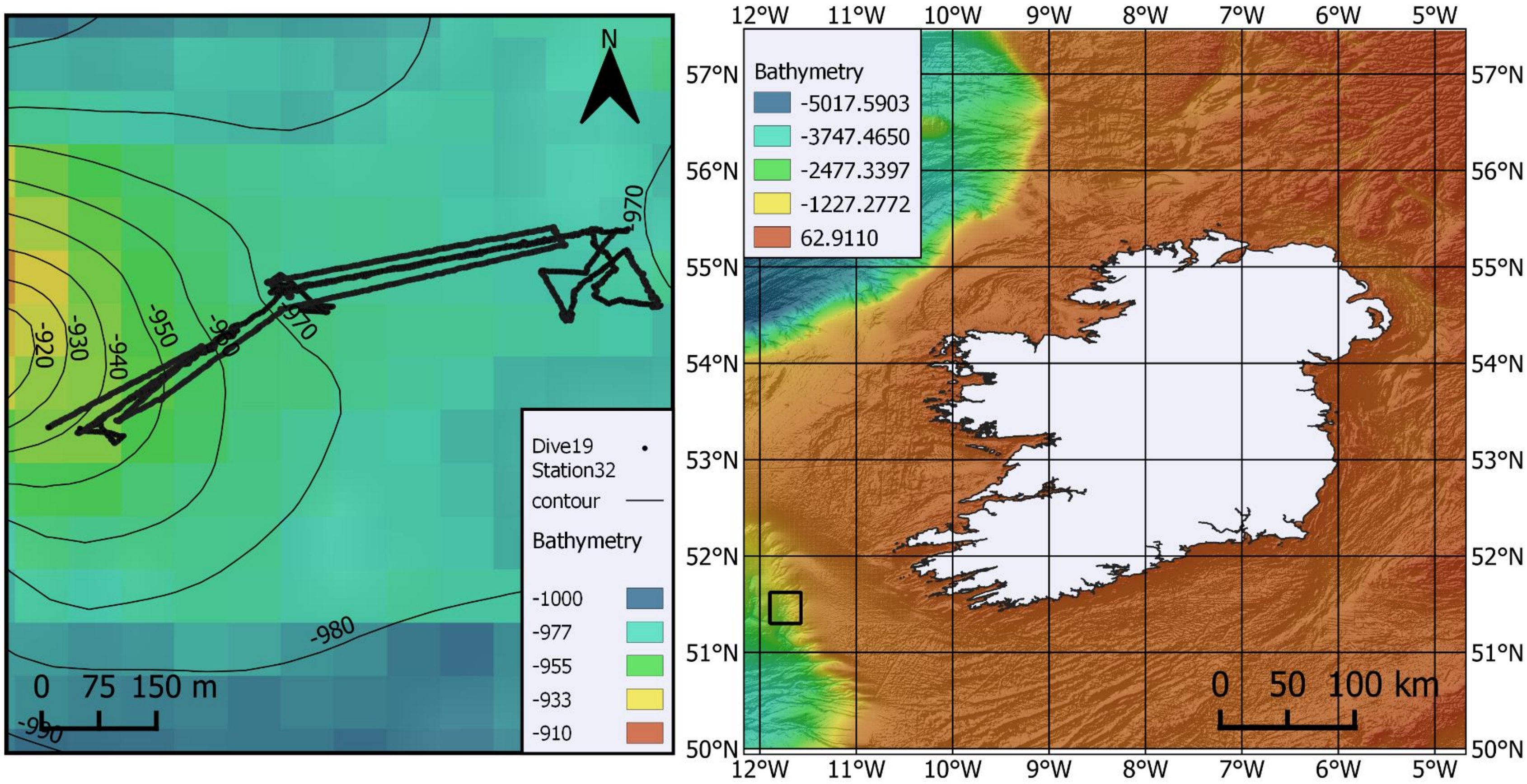


Figure 48: Survey track St32_ROV dive 19 (MBES Patch test)

(For St33_ROV dives 19-22 (MBES survey) see ROV Multibeam Echosounder Log and Map)

ROV Multibeam Echosounder Log and Map (all time UTC)

Multibeam Log					Time	SOL		EOL				y/n	
Station Number	Dive Number	Line Number	MBES file number	Date	(UTC)	Lat	Long	Lat	Long	Eol time	MBES kHz	WCD	Notes
32	19	1	0	12-Sep	06:12	51.417	-11.75666667	51.418	-11.75133333	06:52	300	no	for roll correction - patch test done at 50m
32	19	2	2	12-Sep	07:10	51.41666667	-11.7495	51.4176667	-11.75116667	07:34	300	no	for heading correction
32	19	3	3	12-Sep	07:44	51.41616667	-11.75116667	51.4176667	-11.75116667	07:54	300	no	for heading correction
32	19	4	4	12-Sep	08:04	51.41766667	-11.75116667	51.4166667	-11.75616667	08:37	300	no	for roll correction
32	19	5	6	12-Sep	08:31	51.4165	-11.75616667	51.414	-11.76016667	09:04	300	no	pitch (0.5kn) off track 4m due to currents
32	19	6	7	12-Sep	09:12	51.414	-11.76016667	51.4165	-11.75616667	09:29	300	no	pitch (0.5kn) off track 5m
32	19	7	8	12-Sep	09:36	51.41583333	-11.758	51.414	-11.76016667	10:19	300	no	time delay correction (0.2kn), slow speed
33	20	1	10	12-Sep	10:36	51.4145	-11.76083333	51.485	-11.71866667	18:37	300	no	line 1 - fly at 150m
33	20	2	26	12-Sep	19:15	51.48583333	-11.72483333	51.4153333	-11.76566667	03:24	300	no	line 2 - (23:00) 51o26.35' , -11o45.33' (data gap)
33	20	3	43	13-Sep	03:55	51.41666667	-11.77116667	51.4168333	-11.77166667	03:58	300	no	line 3 - line terminated (vessel turned to 180;wind)
33	20	4	44	13-Sep	04:07	51.41683333	-11.77166667	51.4591667	-11.74666667	09:18	300	no	survey stopped due to bad weather
33	21	5	55	13-Sep	19:03	51.45976667	-11.76178333	51.4518967	-11.726485	21:54	300	no	crossline 20:31 deviated 30m to port (north) to better cover gap 20:53 turning back 30m starboard back onto the line at 20:55
33	21	6	62	13-Sep	22:50	51.44961333	-11.73304333	51.4836667	-11.713	02:14	300	no	
33	21	7	70	14-Sep	02:38	51.4815	-11.70966667	51.487	-11.73466667	04:18	300	no	crossline at 04:18 ROV recovered due to hydraulic failure at the EOL
33	22	8	74	14-Sep	07:08	51.4875	-11.73	51.4583333	-11.747	10:12	300	no	
33	22	9	81	14-Sep	10:29	51.49383333	-11.7505	51.4296667	-11.76866667	14:30	300	no	initially offtrack 9m @14:28 shifting 30m to west as too close to parallel line (line 3) (51o25.7919, -11o46.1243) - new line activated (line 10) * ship repositioning
33	22	10	90	14-Sep	14:30	51.42983333	-11.769	51.4178333	-11.77616667	16:17	300	no	,@14:40 Rise in ROV altitude to 160m coming up slope on west side of Therese Mound (51o25.68, -11o46.21) @15:06 Reduce altitude to 150m as slope gradient reduced (51o25.56,-11o46.28) @15:15 geographic view froze, decision to continue line on functional R22HELMSMAN and cross track; restart user interface after EOL @16:17 reset GUI - EOL 10
33	22	11	94	14-Sep	17:11	51.41916667	-11.782	51.438	-11.769	19:26	300	no	
33	22	12	98	14-Sep	19:27	51.43816667	-11.76883333	51.4616667	-11.755	21:59	300	no	
33	22	13	104	14-Sep	22:32	51.46183333	-11.76216667	51.4365	-11.7755	01:29	300	no	heading 200o
33	22	14	109	15-Sep	01:31	51.4365	-11.7755	51.4285	-11.77883333	02:23	300	no	heading 145o

Multibeam Log					Time (UTC)	SOL		EOL				y/n	
Station Number	Dive Number	Line Number	MBES file number	Date		Lat	Long	Lat	Long	Eol time	MBES kHz	WCD	Notes
33	22	15	111	15-Sep	02:23	51.4285	-11.77883333			02:24	datagap	(line divert	data gap observed (line terminated and rerun 20m ahead @208o)
33	22	16	112	15-Sep	02:25	51.41833333	-11.779	51.42	-11.786	03:25	300	no	heading 208o
33	22	17	115	15-Sep	03:54	51.42283333	-11.78733333	51.4141667	-11.74933333	06:50	300	no	crossline
33	22	18	121	15-Sep	07:18	51.41283333	-11.75466667	51.4226667	-11.749	08:26	300	no	aborded due to weather

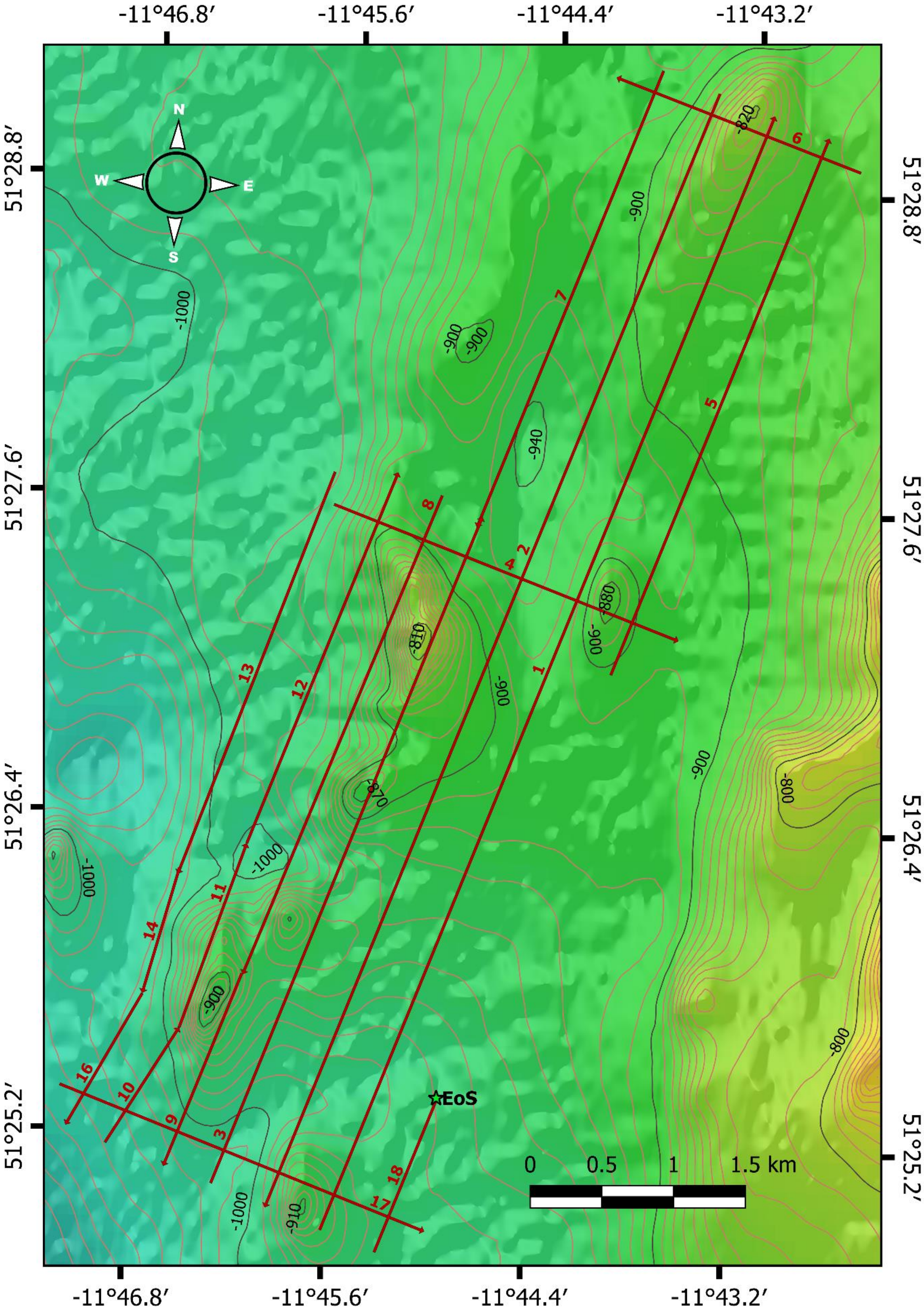


Figure 49. ROV Multibeam Echosounder lines, Belgica Mound Province, NE Porcupine Seabight. Contours courtesy of Beyer et al. (2006)

ROV Rockdrill Core Log and Map (all time UTC)

Sample	Date	Time UTC	Lat	Long	Depth	Penetration	Notes
St19_R1	04/09/2023	23.45	49.440515°	-13.41596°	2440 m	71 cm	Beige, massive, well sorted, angular quartz arenite (sandstone) with a black oxidised top and black oxides in occasional fractures. Core is broken into 5 pieces with 2^{nd} piece from the top being the longest
St25_R2	06/09/2023	01.28	48.332993	-13.899101	1589 m	16.5 cm	Cream colour sparry limestone with a black oxidised top. The upper c.6 cm is slightly darker and contains cm scale sub-angular, light brown siliclastiic clasts in a calcareous matrix. Below this is a layer with red oxide colouration. The rest of the rock core is a sparry limestone with voids partially infilled by sparite and also with some small cherty veins near the base.

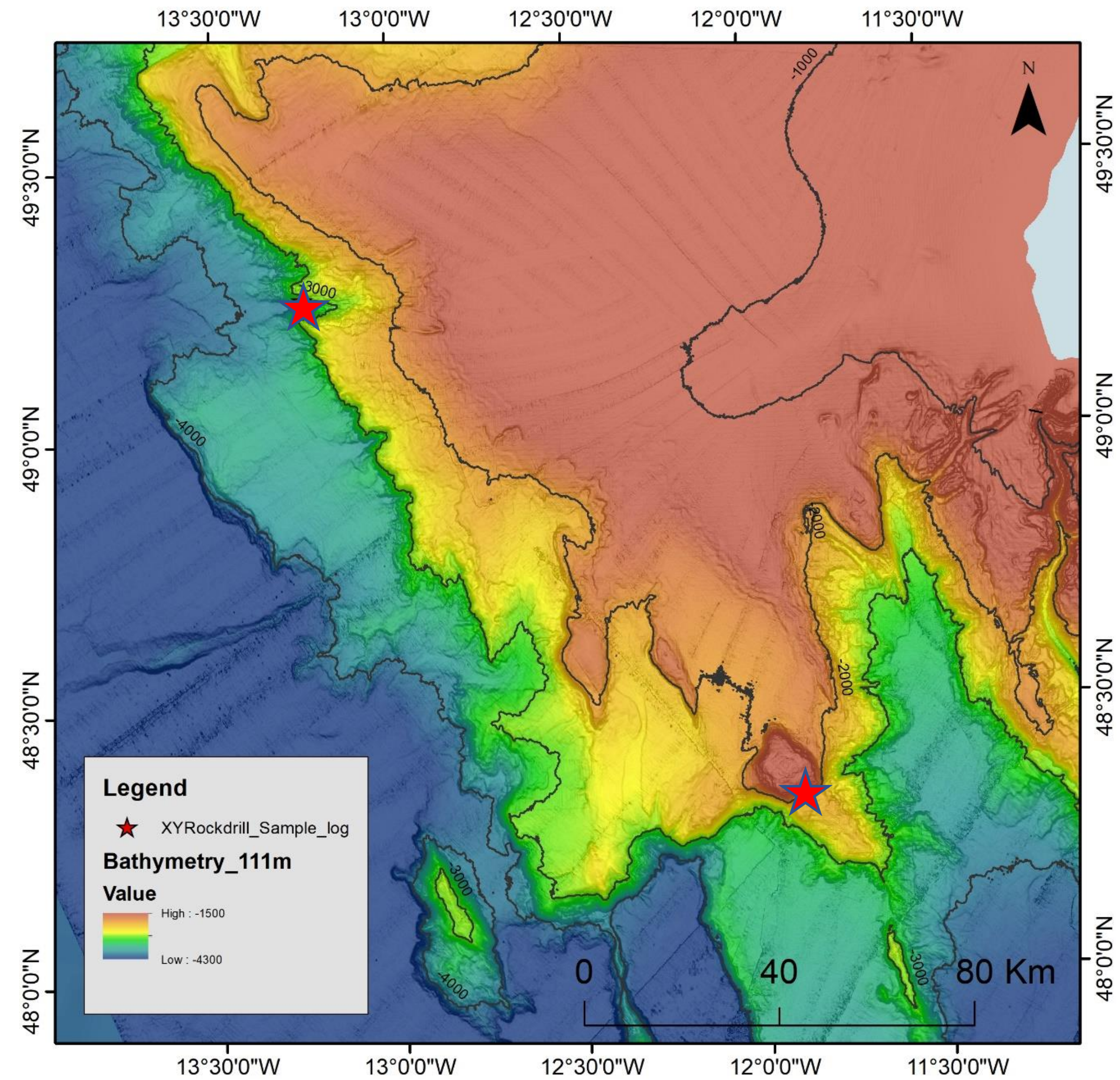


Figure 50. Rock drill sample locations (St.19_R1 top; St25_R2 bottom)

Figure 51. Left and Middle: **St19_R1**: 71 cm long core consisting of a massive, well sorted, angular quartz arenite (sandstone). Right: **St25_R2**: 16.5 cm long core consisting of sparite (limestone) overlain by a calcareous matrix-supported breccia and metaliferous oxide crust.

ROV Coral Sample Log and Map (all time UTC)

ROV Sample Log sheet			Time (UTC)	Coordinates							(cm)		
Station Number	Dive #	Date		Lat Degrees	Lat decMinutes	Long Degrees	Long decMinutes	Depth (m)	Sample type	Sample name	Sample size	Location	Description/notes
28	15	10/09/2023	22:11	51	27.6264	11	44.0239	916	Living Lophelia pertusa on dead LP framework infested with parasitic polycheate worms (20 cm). Living Madrepora occulata living on dead MO framework infested with parasitic polychaete worms (18cm). A 20 cm colony of dead MO covered in feromanganese crust. Lots of branches and coral rubles. Sponges (probably glass sponges and staghorns, etc), barnacles, bryozoans, brittle star...	St28_S1	3 colonies of around 20 cm with lots of branches and coral rubbles	left drawers of the ROV	Recovered next to Charlotte lander above one of the ridges
28	15	10/09/2023	22:55	51	27.6142	11	44.0115	915.8	Living MO colony (30 cm). Living colony of LP with elongated branches growing on old framework infested with parasitic polychaete worms. (25cm), one solitary cup coral growing on the framework (Desmophyllum dianthus). Multiple branches of LP cut from the colony. Sponges (probably glass sponges and staghorns, etc), barnacles, bryozoans, brittle star...	St28_S2	2 colonies of 25 and 30 cm, lots of broken branches of 10-15cm	right drawers of the ROV	Recovered next to Apollo lander in between two ridges

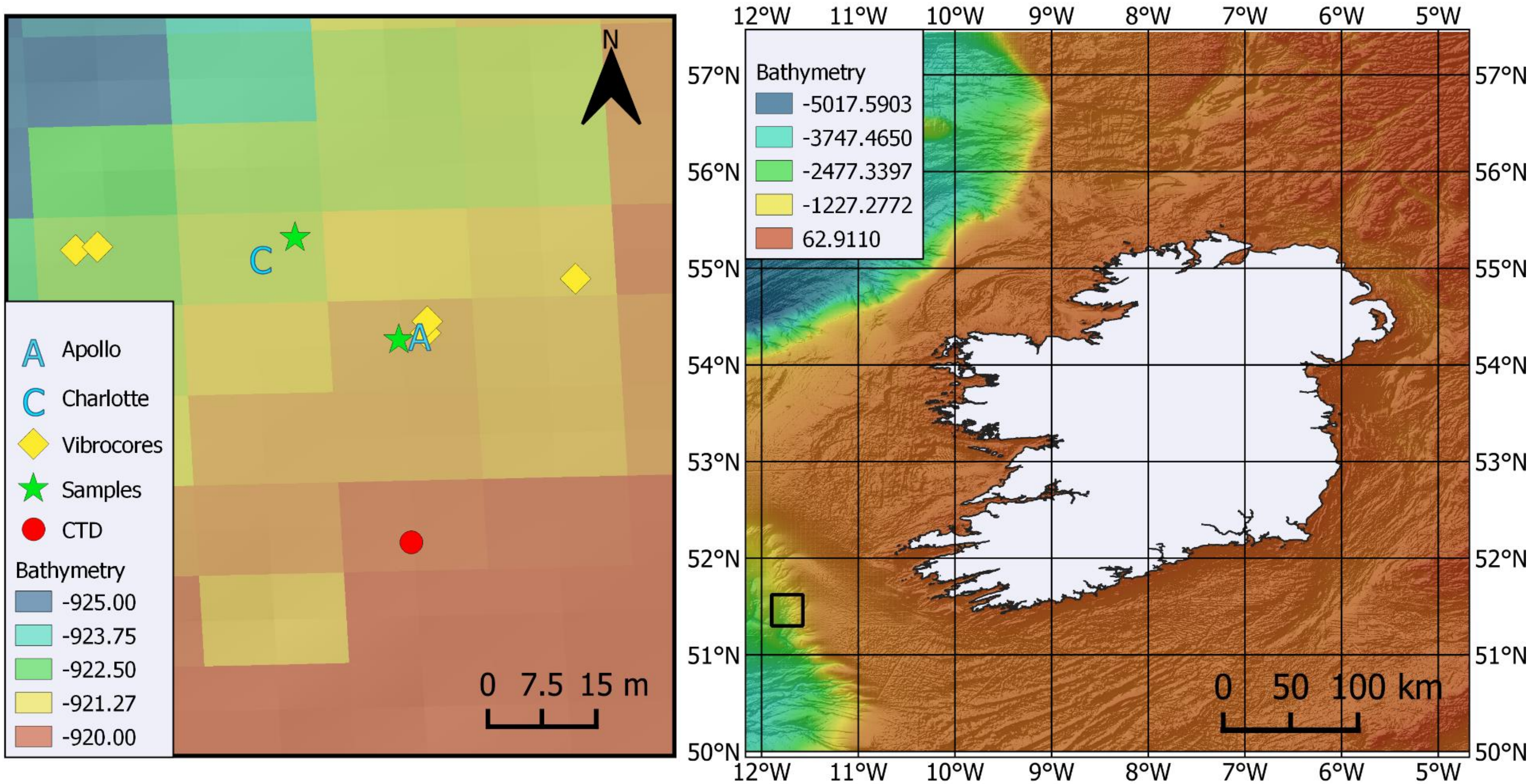


Figure 52. (left) Sample and lander recovery stations, and (right) location of sample map

Figure 53a: Coral samples from the Apollo lander site: (top left) *Lophelia pertusa* with a larger solitary *Desmophyllum dianthus* growing on it, (top right) *Lophelia pertusa,* and (bottom) *Madrepora oculat*a with bryozoans on the left.

Figure 54a: Coral samples from the Charlotte lander site: (top left) old dead *Lophelia pertusa* overthicken by *Eunice* worms with some bryozoans, (top right) *Lophelia pertusa*, and (bottom) *Lophelia pertusa* growing on old overthickened *Lophelia pertusa*

Figure 54b: Coral samples from the Charlotte lander site: (top left) *Lophelia pertusa* overthickened by *Eunice* worms (top right) staghorn sponges, (bottom left) *Lophelia pertusa* overthickened by *Eunice* worms, and (bottom right) fragments of *Madrepora oculata* and bryozoans

.

Little MonSta Lander Recovery Log and Map (all time UTC)

				time	dd	dd	
Station Number	Dive #	Date	Depth (m)	ROV on deck	ROV on bottom Lat	ROV on bottom Long	Comments
28	15	11-Sep	916	0.50	51o27.626	-11o44.0242	Charlotte recovered (in trough)
28	16	11-Sep	920	2.43	51o27.6117	-11o44.0143	Apollo recovered (on ridge)

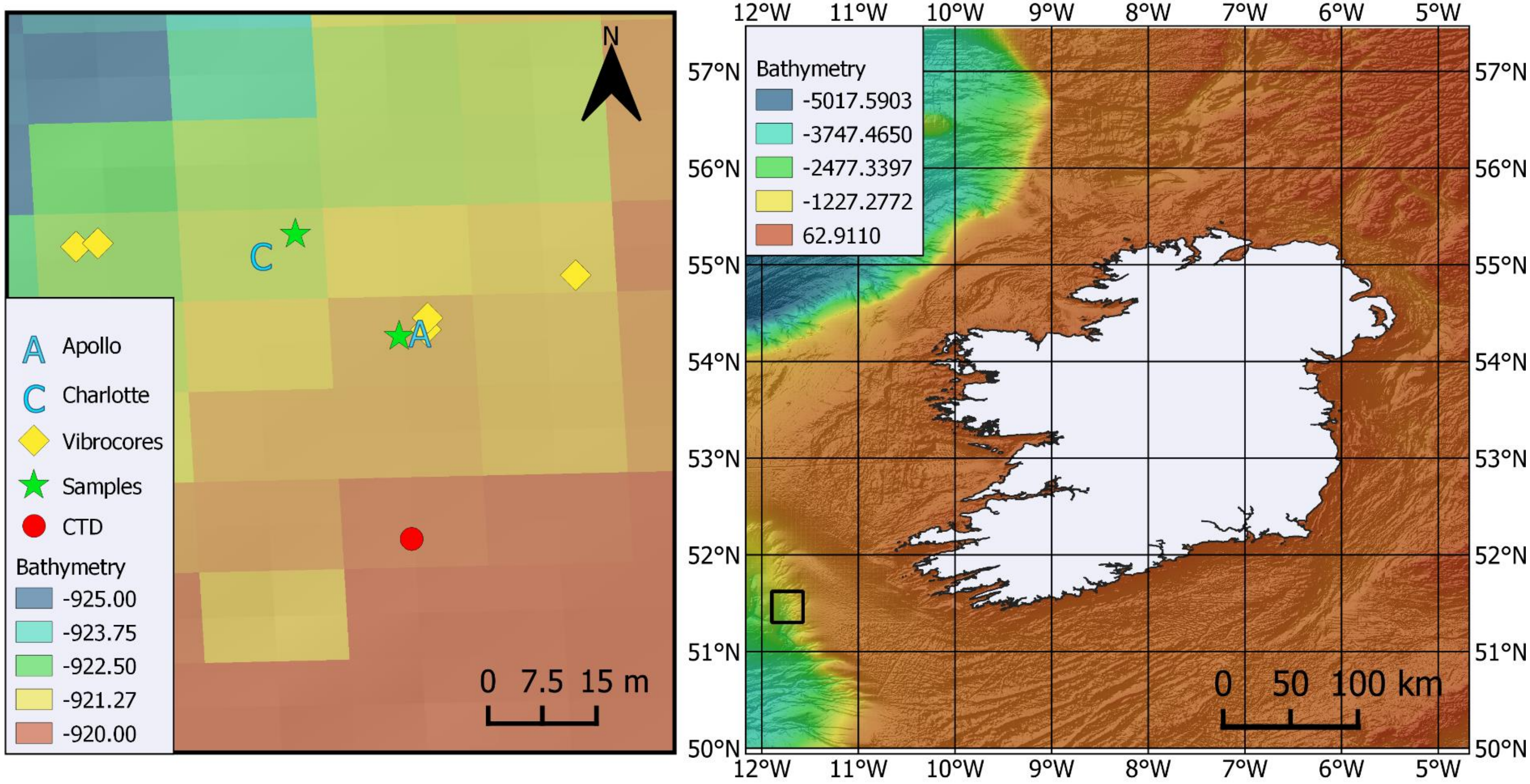


Figure 55. (left) Sample and lander recovery stations, and (right) location of sample map

ROV Vibrocore Log and Map (all time UTC)

Vibrocore log			Time (UTC)	Coordinates							CE23012	(cm)	(cm)	
Station Number	Dive #	Date		Lat Degrees	Lat decMin	Lat DD	Long Degrees	Long decMin	Long DD	Depth (m)	Core	Pentration	Recovery	comments
30	17	11/09/2023	16:05	51	27.615	51.46025	-11	44.0083	-11.7334717	916	VC1	110	85	Disturbed core bottom of trough
31	18	11/09/2023	18:07	51	27.6164	51.4602733	-11	44.0081	-11.7334683	916	VC2	190	143	Sandy trough
31	18	11/09/2023	19:03	51	27.6215	51.4603583	-11	43.9904	-11.7331733	917	VC3	190	150	Higher on ridge
31	18	11/09/2023	19:27	51	27.6249	51.460415	-11	44.0501	-11.7341683	918	VC4	58	3	Very slow penetration. On Ridge, sample bulked
31	18	11/09/2023	20:12	51	27.6253	51.4604217	-11	44.0475	-11.734125	918	VC5	190	147	Slow start than good penetration speed On Ridge

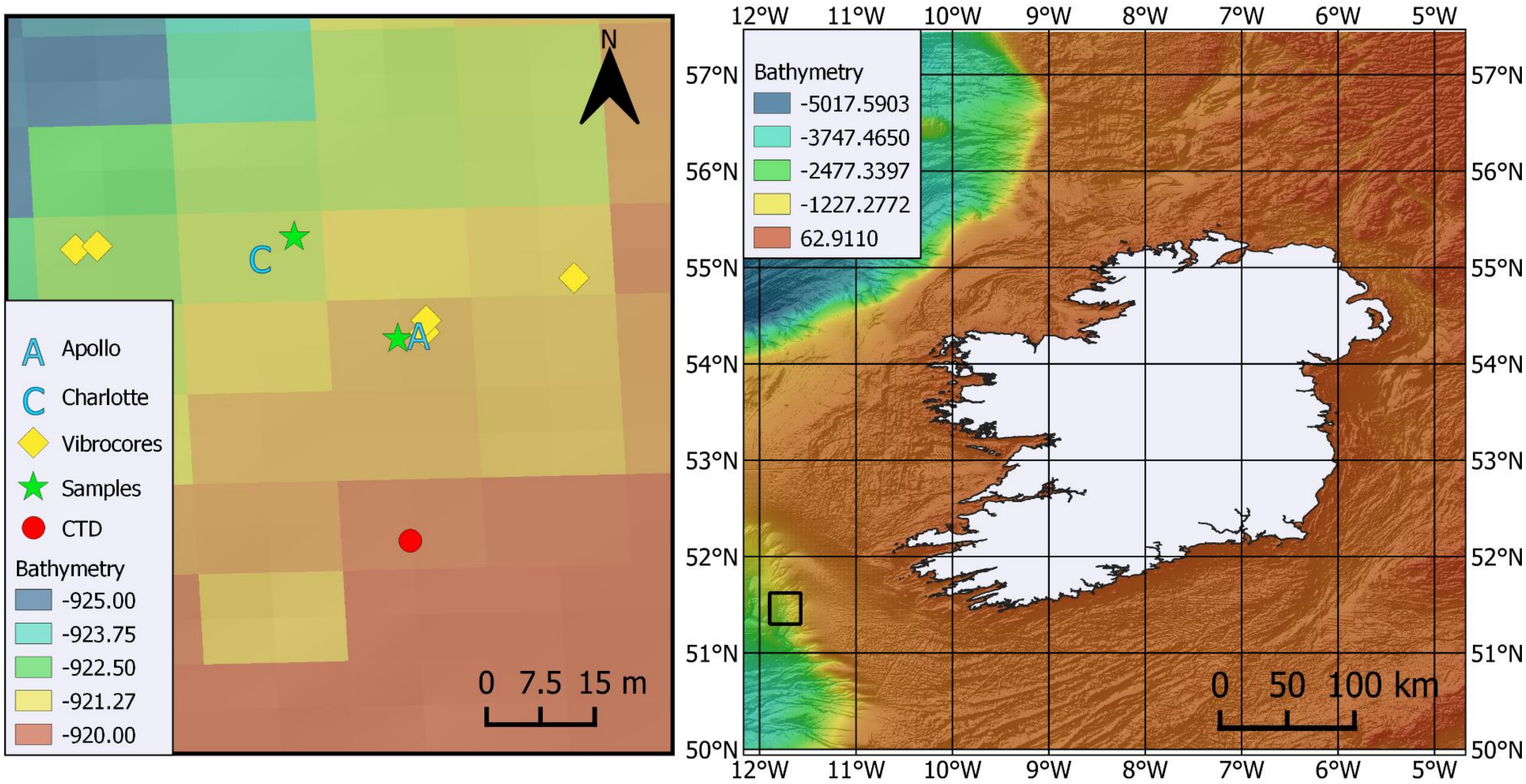


Figure 56. (left) Sample and lander recovery stations, and (right) location of sample map

CTD Log and Map

CTD Log				Coordinates START				Depth (m)						CTD bottles
Station Number	CTD #	Date	Time (UTC)	Lat Degrees	Lat decMinutes	Long Degrees	Long decMinutes	Water depth	CTD depth	CTD data	SVP File name	Bottle(s) fired	Acoustic release check	Comments
27	1	10/09/2023	18:50	51	27.59	-11	44.01	919	910	Yes		1+ 2	Yes	9 m above bottom
27	1	10/09/2023	19:07	51	27.59	-11	44.01	919	905	Yes		3 + 4		14 m above bottom
27	1	10/09/2023	19:27	51	27.59	-11	44.01	919	900	Yes		5 + 6		19 m above bottom
29	1	11/09/2023	13:30	51	27.59	-11	44.01	1059	1054	Yes	Yes	None		5m above bottom
34	1	13/09/2023	15:45	51	27.57	-11	45.69	960	955	Yes	Yes	None		5m above bottom

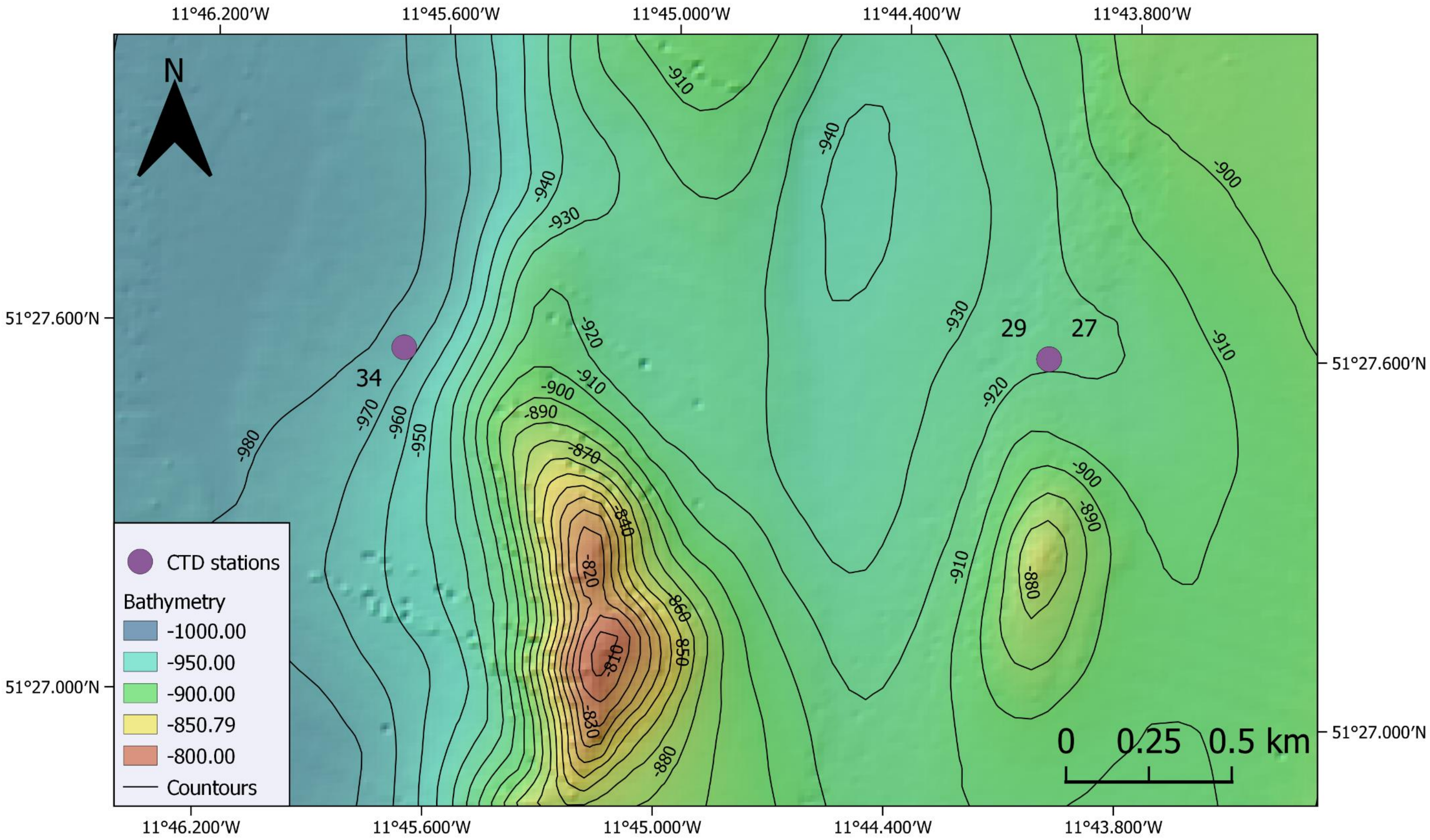


Figure 57. CTD stations in the Belgica Mounds Province, Porcupine Seabight. Contours courtesy of Beyer et al.,(2006)

ADCP Log and Map (all time UTC)

STATION	ADCP Log		Date	Start time (UTC)	End time (UTC)	Coordinates (START)		Coordinates (END)		Comments (Switching on or off? transect details, command file details etc..)
	Bottom tracking (on/off)	SOG (knots)				Lat	Long	Lat	Long	
3	ON	6.1	01/09/2023	11:00	13:23	52.1118	-14.5303	52.0065	-14.9950	From top of PORC BK to PBC #017
6	ON	9-9-5	02/09/2023	00:15	02:20	52.0047	-15.2425	51.6920	-15.2397	From start of station 5 to station 7 #018
8	ON	9	02/09/2023	08:57	10:52	51.7043	-15.2367	51.9743	-15.0373	Transit #019
10	ON	9.7	02/09/2023	15:09	21:51	51.9758	-15.0390	50.9287	-14.9010	Transit 5 down PORC BANK #020
12	ON	4.3	03/09/2023	05:46	09:15	50.8413	-14.8082	50.4930	-14.5017	Transit from ST-11 to ST-13 #021
14	ON	8.9	03/09/2023	14:29	15:34	50.4827	-14.4900	50.6137	-14.6440	Transit from ST-13 to ST-14 (SBP tests)
15	ON	9.7	03/09/2023	23:00	04:19	50.3192	-14.2710	49.6727	-13.4648	Transit to Goban Spur #022
20	ON	9	05/09/2023	05:04	10:40	49.4405	-13.4155	49.7673	-12.8132	Transit from ST-19 to ST-21 #025
34	ON	0.2	10/09/2023	17:55	00:00	51.3627	-10.9707			SOL Transit from Cork #26
34	ON	10	15/09/2023	00:00	13:23			51.8295	-11.1808	EOL to PSB to west shelf #26

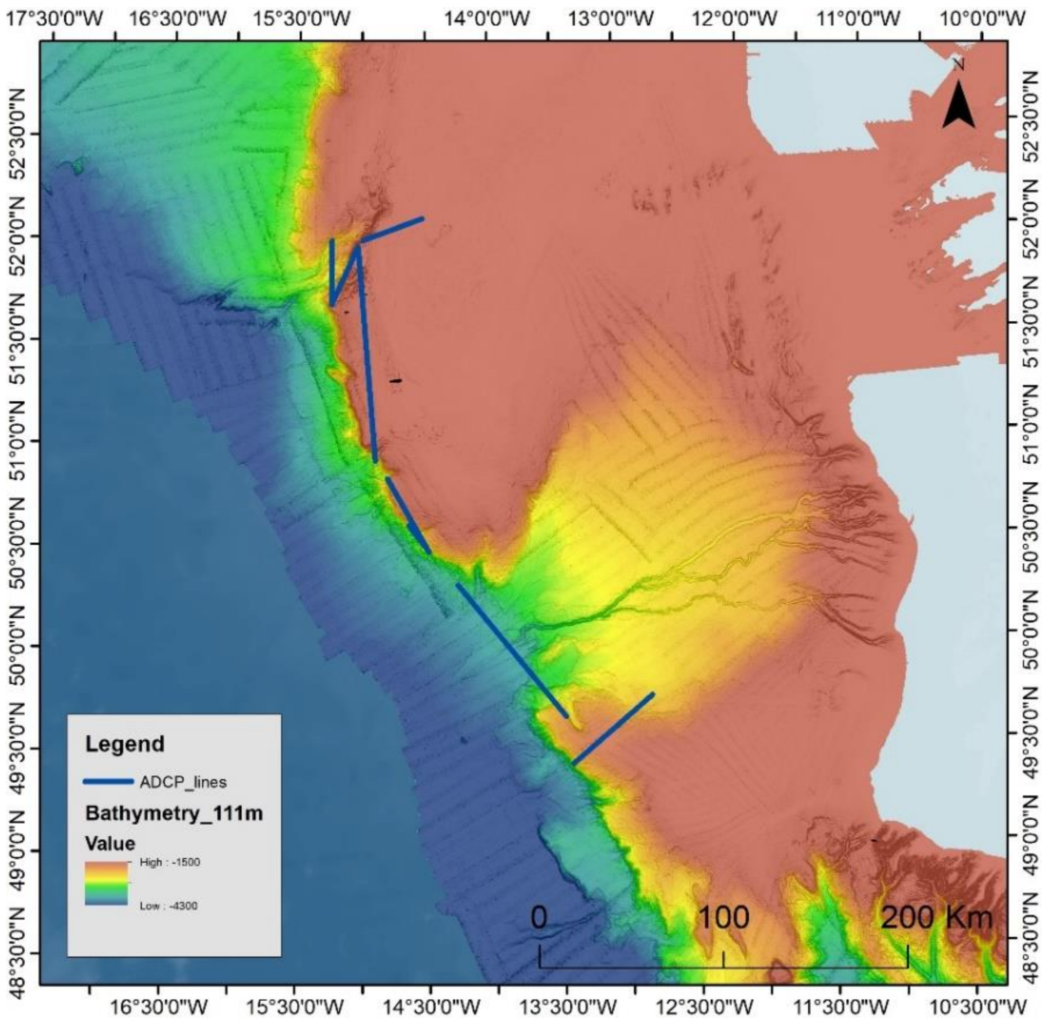


Figure 58. ADCP locations (Leg 1)

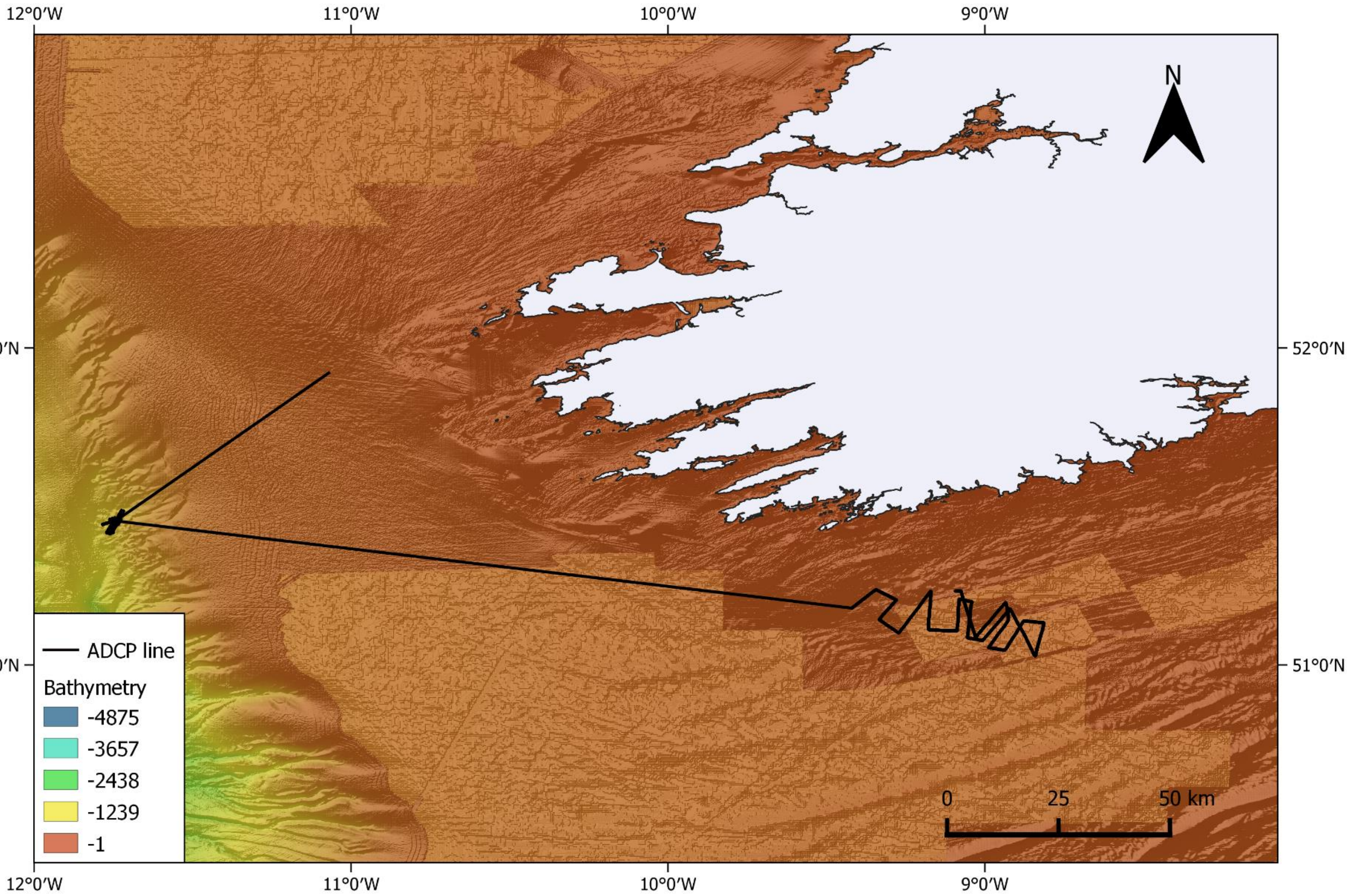


Figure 59. ADCP locations (Leg 2)

Lander deployment tests (all time UTC)

16th September 2023, North Sound, Galway Bay, 42m water depth

03.36 Apollo lander and acoustic release readied in deck. Height from Apollo feet to acoustic release USBL z position is 346cm (87cm USBL + 89cm rope + 170cm Apollo). Apollo hangs plumb after some rope adjustments.
03.49 Apollo in water
03.51 Apollo lowered to 20m. It is not streaming but hangs vertically. Depth of Apollo feet = USBL depth + 3.5m. Ship echosounder depth is below the keel reading + 7.5m (draught + errors)
04.04 ROV in water
04.14 ROV has visual of Apollo and follows it to the bottom as Apollo is lowered
04.19 Apollo on the bottom and depths checked (ship's echosounder correction is 7.5m). Water depth is 49.5m
04.25 Apollo lifted **1m** off the bottom
04.27 Apollo dropped by acoustic release and filmed by the ROV. It lands vertically, all feet at once and a little heavy
04.39 Apollo picked up by ROV
04.47 ROV and Apollo off the bottom
04.54 ROV and Apollo on deck

05.07 Apollo hangs plumb on deck after some adjustment
05.09 Apollo in water and lowered to 33.8m (USBL)
05.18 ROV in water
05.29 ROV on the bottom and Apollo lifted **3m** off the bottom
05.32 **Apollo dropped by acoustic release and filmed by the ROV. It lands at a slight angle with the foot nearest the sediment trap motor and a little heavy**
05.48 ROV and Apollo on deck

06.03 Hole drilled in Apollo casing to let air escape
06.08 ROV in water
06.15 ROV on the bottom and Apollo lifted **5m** off the bottom
06.19 **Apollo dropped by acoustic release and filmed by the ROV. It lands vertically, all feet at once and a little heavy**
06.21 Acoustic release recovered to deck
06.32 ROV and Apollo off the bottom
06.36 ROV and Apollo on deck. It is noted that the Apollo feet are a little splayed with the bolts holding the legs on widening their holes. These were adjusted and tightened

07.33 Apollo plumb on deck and in the water
07.37 ROV in the water
07.41 ROV visual of Apollo but there was a hydraulic failure resulting in a dead sub
07.44 ROV recovered to deck and work started to fix the hydraulics
07.53 Apollo recovered to deck
08.22 ROV fixed

08.24 Apollo in the water
08.32 ROV in the water
08.32 ROV visual of Apollo which was followed to the bottom and then Apollo was raised **10m**
08.43 **Apollo dropped by acoustic release and filmed by the ROV. It landed on 2 legs at an angle and then fell over**
09.05 ROV and Apollo recovered to deck. Trail over

We learned that we cab deploy the lander with an acoustic release up to 5m off the bottom in calm waters with minimal currents. Higher than that it will fall over. In deep water, 5m may be within the vertical error and swell heave of the USBL

USBL calibration report

CASIUS Calibration Report

Sonardyne
SOUND IN DEPTH

Vessel: Celtic Explorer

Date/Time: 11 September 2023 06:06:57

Transceiver Settings:

Name	Device No	X/Y Offset Error	Depth Offset Error
Transceiver 1	007386	1.0m	0.5m

GNSS Settings:

Name	Forward Offset	Starboard Offset	Height Offset
GPS 1	2.920m	0.220m	24.950m

Pitch, Roll & Heading Settings:

Name	Usage	Pitch Offset	Roll Offset	Heading Offset
PitchRoll 1	Pitch, Roll & Heading	0.00°	0.00°	0.00°

Beacon Settings:

Name	Received Signal	X/Y Error	Depth Error
2906	IRS 2906	30.0m	5.0m

Sound Speed:

	Surface	Average (Initial)	Average (Computed)
Sound Speed	1503.4m/s	1502.8m/s	1497.5m/s
Error	15.0m/s	15.0m/s	0.4m/s

Beacon 2906 Result:

	Beacon Latitude	Beacon Longitude	Beacon Depth	Beacon Eastings	Beacon Northings
Before	51.45956861°	-11.73435775°	918.364m	310048.918m	5704479.108m
Calculated	51.45955295°	-11.73434621°	853.902m	310049.655m	5704477.337m
Calculated Accuracy			0.232m	0.047m	0.047m

X

	Before CASIUS (distance)	After CASIUS (distance)	Before CASIUS (% depth)	After CASIUS (% depth)
39.4% Beacon Positions (1 sigma)	2.42m	2.14m	0.28	0.25
50.0% Beacon Positions (CEP)	2.90m	2.36m	0.34	0.28
63.2% Beacon Positions (1 Drms)	3.41m	2.64m	0.40	0.31
86.5% Beacon Positions (2 sigma)	4.38m	3.48m	0.51	0.41
95.0% Beacon Positions	5.10m	4.05m	0.60	0.47

Transceiver 'Transceiver 1' Result:

X

	Transceiver Starboard Offset	Transceiver Forward Offset	Transceiver Depth Offset	Transceiver Pitch Offset	Transceiver Roll Offset	Transceiver Heading Offset
Before	0.210m	9.990m	10.380m	-1.85°	-1.49°	2.31°
Calculated	0.672m	9.878m	10.380m	-1.84°	-1.52°	1.71°
Calculated Accuracy	0.049m	0.046m	0.000m	0.00°	0.00°	0.01°

Summary Stats:

	Range RMS	Direction Cosine RMS	Observations	Excluded	Iterations
Box-in	0.228m		1763	0	4

11 September 2023 10:28:01 1 of 4 Version 6.4.0.7520

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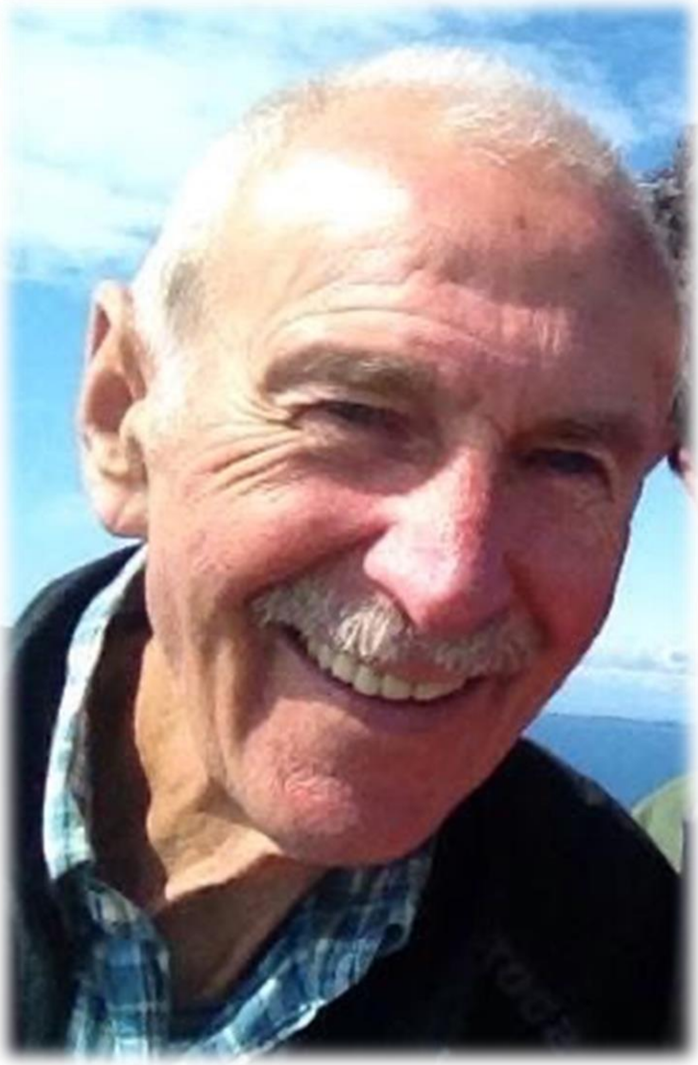
Alf Wheeler and the Alf Reefs



The Alf Reefs (Belgica Mound Province, NE Porcupine Seabight) are named after the Chief Scientist father who passed away this year.

Alfred Wheeler (1941 -2023), Rest in Peace