West of Ireland Coring Programme (WICPro)

RV Celtic Explorer

Cork – Killybegs

6th March to 18th March 2014

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1 Executive Summary

This survey focussed on the provision of core material from several survey areas on the Irish western shelf and margin in support of differing research objectives. It represents a coming together of several Irish university research groups, and international collaborators, around a common purpose.

Despite some unfavourable weather at the start, the survey was a success with all objective met and valuable core material and supporting geophysical data acquired for all partners.

On-mound and off-mound cores were retrieved from the Moira Mounds in the eastern Porcupine Seabight. Cores were retrieved from the Porcupine Bank margin targeting glacial sequences down to 3000m water depth. Also on the Porcupine Bank, a small number of box cores and a gravity core were taken from the Porcupine Bank Canyons mounds (both on- and off-mound). Considerable effort was made to retrieve vibrocores from the western shelf to date the end of glaciations. These proved hard to get as they targeted reworked gravels and diamictons. However, successful cores and valuable site data were collected.

2 Background

This survey was undertaken to provide core material and data to support a broad range of ongoing scientific endeavours. These include:

- Studying environmental records from cold-water coral reefs
- Studying the history of glaciomarine deposition from the Porcupine Bank flank
- Studying ice limits and glacial processes on the western shelf

Three key target areas are identified where the retrieval of core material and seismic data was undertaken in pursuit of the above objectives. The background to these areas is outlined below.

Moira Mounds

The framework-building cold-water corals (CWC's) have a reef forming capacity generating positive topographic features on the seabed (reefs or carbonate mounds). These contain unique palaeoenvironmental archives (Thierens *et al*., 2010; 2012). These CWC autogenic, mound-building biota (Correa *et al*., 2012) form in areas with adequate hydrographic (temperature, surface productivity, pH, enhanced current speeds, salinity and food supply) and sedimentological attributes (substratum and sediment supply) (Dorschel *et al*., 2007; Foubert *et al*., 2011: Wheeler *et al*., 2007: 2011; Fink *et al*., 2012) in Ireland often found along continental margins at intermediate water depths (Dorschel *et al*., 2007). Knowledge of these specific environmental conditions not only allows an understanding of their contemporary occurrence but it also allow to reconstruct marine environmental change through time (Roberts *et al*., 2009).

Not only do CWC flourish in Irish waters today, but have done so for millions of years e.g. the Challenger Mound (Kano *et al*., 2007; Thierens *et al*., 2010). The continued favourable marine environmental conditions off the Irish continental margin has lead to successive reef development. Subsequently, Irish water is home to some of the largest and most dense coral carbonate mounds in the world (Roberts *et al.*, 2009).

Geologically, the subject of reef initiation has been relatively poorly documented and examined with only two papers directly addressing this: Squires (1964) and Wilson (1979a). Despite some work concerning reef initiation and development in more recent studies including Wheeler *et al.* (2011), Foubert *et al.* (2011), Dorschel *et al.* (2005) and Frank *et al.* (2005), these research are primarily concerned with the environment of reef initiation and development rather than the initiation process itself. Thus, with more advanced marine surveying techniques and data available, advance on both Wilson (1979a) and Squires' (1964) work are overdue.

Proposed Moira Mound target cores are all based on on-going research and previously collected data:

TOBI Side Scan Sonar (NOC, Southampton)
Box Cores (Uni. Fribourg, UCC, UniMiB)
Video data (VENTuRE survey, UCC)
Microbathymetry (UCC, AWI)
Videomosaic data (UCC, IFREMER)
CTD data (Uni. Fribourg, UCC, UniMiB)

Targets are selected in pairs; one targeting a specific mound build-up feature while the other targets its nearby off-mound counterpart. As shown by previous studies (i.e. Dorschel *et al.*, 2005; 2007, Lopez-Correa *et al.*, 2012, Douarin *et al*., 2013a; 2013b), the use of an off-mound core can act, not only as a stratigraphic correlation, but as a control for mound growth rate, background sedimentation, and percentage carbonate. While considering time, bad weather, proximity of targets, no. of participants and 24 hour operations a total five core pairs (10 cores) are proposed.

Furthermore, targets chosen by direct video observation, were specifically prioritised based on feature size and stage of growth (i.e. thicket or reef) to ensure that penetration to the base of targets is possible. A further parameter for selecting targets is based on geographical distribution from south to north. Video observations show a distinct gradation in mound vitality, size and stage of growth from south to north. The proposed targets aim to include this geographic distribution, encapsulating this mound gradation.

Porcupine Bank

The Porcupine Bank is also the site of cold-water coral mounds. A brief study of the Porcupine Bank Canyon Mounds will be undertaken to complement the above. In additional a number of cores recording glacio-marine sedimentation will be taken from the flanks of the Bank.

The NE Atlantic Ocean is a climatically sensitive region with proven potential for furnishing palaeoceaonographic records of ice sheet and ocean circulation change (e.g. Peck *et al.*, 2007, 2008; Scourse *et al*., 2009). The Rockall Trough sits at a critical gateway for the circulation of intermediate and deepwater currents that are integral to the meridional overturning circulation (New & Smythe-Wright, 2001). Sediment-based proxies for current velocity, coupled with isotopic and faunal data derived from foraminifera, can be used to elucidate variability in the vigour and configuration of past ocean circulation (e.g. Bianchi & McCave, 1999; Peck *et al.*, 2007; Siddall *et al*., 2007; Gherardi *et al*., 2009). The same sedimentary sequences also contain the “fingerprint” of ice sheet response from around the N Atlantic fringe in the form of ‘ice rafted detritus’ and so-called ‘Heinrich layers’ or BIIS IRE event layers which have been linked to catastrophic ice sheet collapse (Heinrich, 1988; Broecker *et al*., 1992; Bond & Lotti, 1995; Labeyrie et al., 2007).

The location of the Porcupine Bank means that it not only receives exotic material from the large, northern ice sheets of Greenland and N. America, but also records local inputs from the adjacent British-Irish Ice sheet (BIIS). In this way, analysis can provide further chronological constraints on BIIS history and correlate these changes with wider oceanographic variability and response of other ice masses adjacent to the N. Atlantic (Scourse *et al*., 2009; Hibbert *et al*., 2010).

The investigation will comprise recovery of gravity cores from selected locations on the western Porcupine Bank which will be analysed for sedimentology and micropalaeontology. Chronology will be established based on the INTIMATE protocol (Austin & Hibbert, 2012), using a combination of radiocarbon dates, oxygen isotope data, planktonic foraminiferal (%Nps) synchronisation to NGRIP and, if possible, tephrostratigraphy. Further stable isotope (C) and elemental (e.g. Mg/Ca) analysis of benthic and planktonic foraminfera will build on the work of Owen (2010) and explore evidence for sea ice extent and ocean circulation change during the interval from MIS4-2.

Each seismic profile used in Toms (2010) thesis shows the RTa megasequence which consist of sediments from the Early Pliocene to Holocene. They are thickest on the upper slope (< 1000 m) with low slope angles (<0.2°) and o the Rockall Trough floor. Along the mid and lower slope (1000 – 3000m water depth) the thickness is less and varies strongly. While the RTa sequence is more continuous in the south of the study area they are often interrupted by mounds or pock marks in the north. Also slumped contourite packages are detected. In summary the northern part seems more disturbed in case of the RTa sequence then the southern part.

However, cores of the Rockall Trough floor may also reveal great thicknesses of the past glacials and interglacials in both parts of the study area (north and south).

Western Shelf

Like modern ice-sheets, the former British-Irish Ice Sheet (BIIS), was a fundamental variable in the global climate system. Simultaneously, the BIIS affected and was affected by regional and global climate change through complex and interconnected global feedback mechanisms (Clark *et al*., 2012a); its marine-terminating margins were potentially the most sensitive areas to climate changes during the Quaternary. It is now widely accepted that modern glaciers and ice sheets are perhaps the most sensitive gauges of short-term climate change. Similarly, data evidencing the behaviour of extinct ice sheets, reveal critical information on the global climate system over millennial time-scales (McCabe & Clark, 1998).

Recently analysed Irish National Seabed Survey (INSS) data (multibeam and backscatter) has revealed glacial landforms consistent with a grounded BIIS to the west and northwest of Ireland (Benetti *et al*., 2010; Dunlop *et al.*, 2010; Ó Cofaigh *et al.*, 2012). This research has confirmed years of scientific speculation on ice sheet extent (e.g., Bowen *et al.*, 1986; 2002; Stoker & Holmes 1991; McCabe *et al.*, 2007). This minimum ice extent confirms the presence of large sections of marine-based ice and marine-terminating margins (Clark *et al.,* 2012b) and may be in agreement with a hypothesis of major ice-stream drainage (Greenwood & Clark 2009). An examination of the regional geomorphology has shown the presence of end/terminal moraines. This suggests ice drainage via several ice lobes (with terrestrial source ice in Ireland and Scotland) terminating at or near the shelf edge (Benetti *et al.*, 2010; Dunlop *et al.*, 2010; Ó Cofaigh *et al.*, 2012).

Despite this new data, and a century of research on the last BIIS, there is still critical need for continued study to clarify ice sheet dimensions and behaviour. The limitations of marine geoscience research (e.g. technical limitations, cost, reliance on good weather for sampling, and time required to gather data) have obscured offshore palaeoglaciological research in the past. However, it is only through palaeoglaciology that insight on ice sheet dynamism, timing and environmental interactions, from advance to collapse, can be revealed. Therefore offshore palaeoglaciological research must continue to be a priority.

3 Survey Rationale and Objectives

Different objectives attain to the different areas:

Objective 1: Moira Mounds (MM) - We aim to test hypotheses relating to cold-water coral reef initiation and development including the parameterisation of contemporary and palaeo- hydrographical and sedimentological dynamics in a zone of active coral growth in the eastern Porcupine Seabight. We will gravity core on mound and off-mound sites in an area of active patch reef growth. This adds a temporal dimension to existing extensive spatial data coverage in this area (Wheeler *et al.,* 2011).

Objective 2: W. Porcupine Bank (WPB) – To determine the effect of glaciation on the development of the outer western Porcupine Bank, to explore evidence for sea ice extent pro-glacial sediment supply and ocean circulation change during the interval from MIS4-2.

Objective 3: Western Shelf (WS) – To determine (sparker seismics) sites for coring on the BRITICE-CHRONO programme on the RSS James Cook. To collect Irish cores/sparker data a key sites to determine the nature of potential identified slope instability sites on the shelf edge and sample probable moraines for chronological and provenance studies.

4 Equipment

Research vessel - RV Celtic Explorer

The 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 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 Celtic Explorer is equipped with two Trimble 300-D GPS and has Dynamic Positioning.

On the aft deck is a 25 tonne A-frame with 4m outward and inward reach in addition to a 3m, 10 tonne starboard T-frame. The ship also comprises of a midship, forward and aft crane as well as a 6 tonne CTD winch.

Simrad EM 1002 Multibeam ecosounder

The Kongsberg Simrad EM 1002 multibeam echo sounder is designed for high resolution seabed mapping from the shoreline and down to a depth of approximately 1000 m. The EM 1002 has an accuracy surpassing the IHO standard, including the most stringent of the latest version, 4th edition.

The EM 1002 is a complete system with all necessary sensor interfaces, real-time compensation for vessel motion and ray bending, data displays for quality control including sensor calibration, and data logging included as standard.

The EM1002 system has a maximum ping rate of more than 10Hz, a large number of measurements per ping with 111 beams, 2.3 degrees beam width, and electronic roll stabilization. Mechanical pitch compensation is available with an optional hull unit. Across track coverage is up to about 1500 m in deeper waters, and in shallow waters up to 10 times depth beneath the transducer. The angular coverage is fully adjustable, and for surveying to the water surface along shorelines, river banks and man-made structures, the angular coverage to one or both sides maybe increased to 5 degrees above the horizontal.

The standard EM 1002 system has three different pulse lengths to maximize coverage in deeper waters.The system's nominal sonar frequency is 95 kHz. This frequency allows for small dimensions, good range capability and high tolerance to turbid waters. Integrated seabed acoustical imaging capability (side-scan) is included as standard. A combination of phase and amplitude detection is used, resulting in a measurement accuracy practically independent of beam pointing angle.

Geo-Source 400 sparker seismic system

The Geo-Source 400 sparker seismic system of the Marine Institute was used during the survey. This sparker seismic system consists of the Geo-Spark 6 kJ pulsed power supply which emits a pulse to the sparker source which is towed behind the vessel. The source comprises four electrode modules that are evenly spaced in a planar array. The return signal is picked up in Geo-Sense single channel hydrophone array. The system provides high resolution (<30cm) seismic profiles of the Shallow sub-bottom strata. The device achieves this level of accuracy due to its multi-tip array of sparker nodes, which are evenly spaced and set in-phase producing a very strong downward projection of acoustic energy. The system is designed to be towed on or just below the water-surface. High resolution seismic profiles of up to 300m depth can be imaged using the Geo-Spark 200 depending on the composition of the water column, sea conditions and the nature of the underlying geology.

Hull mounted ESE 5001S 3.5 kHz pinger system

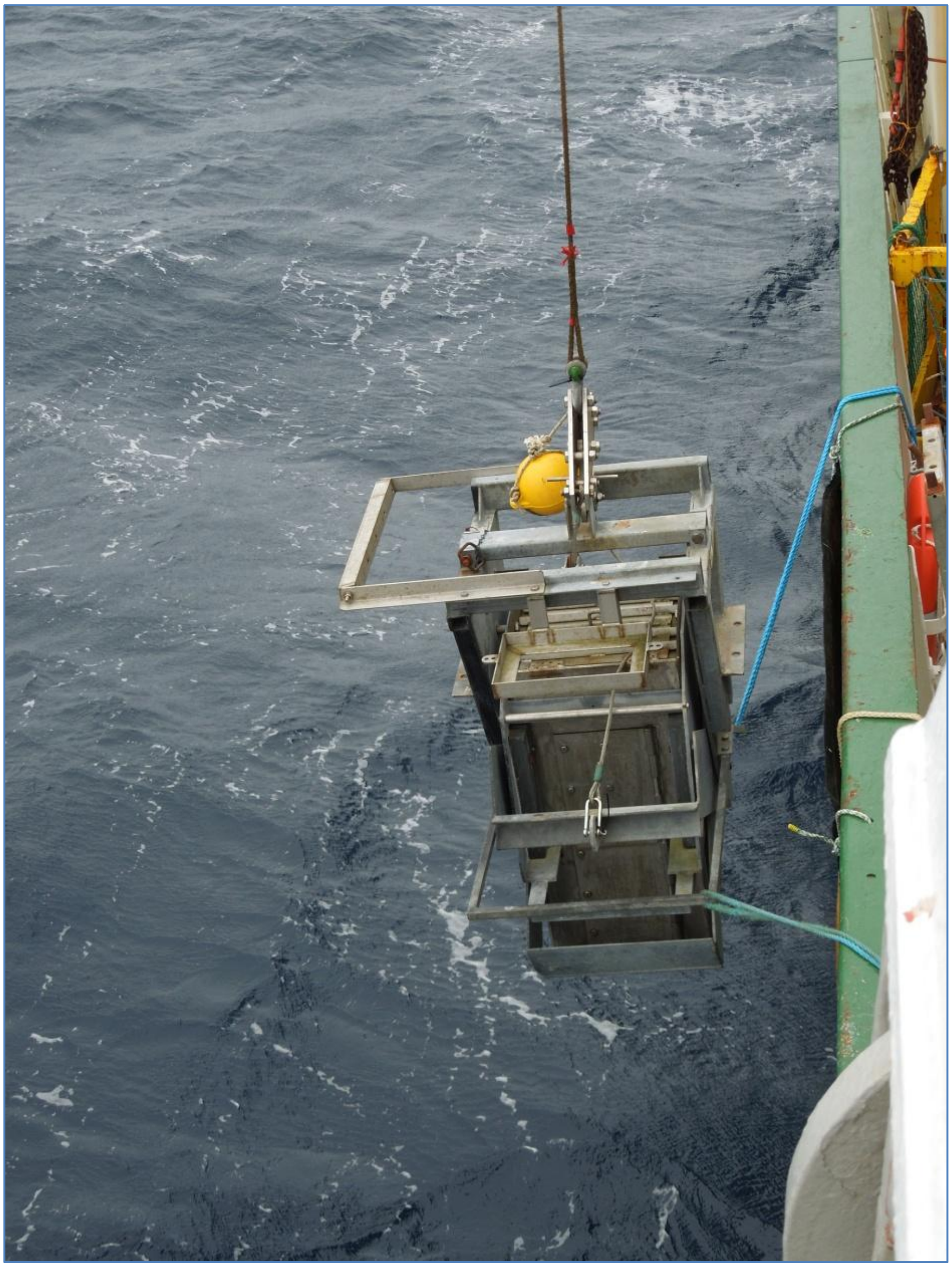
The Sonar Equipment Services Ltd Probe 5001S 3.5 kHz sub-bottom profiler comprises of a surface processor and a sub-surface transceiver. The processor is set up for 16 transducers (4 X 4 array). The transducers are located in starboard mid sea water ballast tank. Output Power is up to 10KW at an **o**perating frequency of 3.5 to 9.0 kHz. Maximum repetition rate is 10Hz
The system is triggered from a CODA DA2000.

Gravity core

An OSIL 800kg gravity corer with an 7cm diameter bore which can be deployed with a 3m or a 6m mode, the 6m mode being two coupled 3 m barrels. The 3 m mode is pictured below, the additional 3m barrel and coupling (yellow) is behind. The gravity corer is fitted with a core catcher.

Double spade box corer

The Duncan Associates Double Spade Box Corer is designed for oceanographic deployment up to 5000m. It is manufactured in mild steel, galvanized finish with an internal 316 stainless steel box/cabinet and a stainless steel yoke in a stand with lead ballast ingot weights. The sampling area is 500mm x 500mm x 1.2m high box cabinet.



Reineck box corer

A Reineck box-corer was used to take undisturbed sediment samples for biological assessment. It has a sampling box area of 10 cm x 17 cm with a maximum penetration depth of 26 cm.

Geo-Resources 6000 vibrocorer

A 6m vibrocore was used and deployed using the A-frame. The Celtic Explorer has Dynamic Positioning hence the corer wasn't necessarily restricted to times of slack water. The Geo Resources 6000 vibrocorer recovers cores of 6 metres depending on the sediment type, with best penetration in fine grained sediments. The vibrocorer consists of a six meter metal tube approximately 20cm in diameter, which contains an interior plastic pipe, or liner used to gather a core of sediment from the upper few metres of the sea bottom. The tube is set within a large support frame in order to keep it upright on the seabed. Once securely on the seafloor, the vibrocorer is driven down into the substrate by a pneumatic vibro-head. This heavy vibro-head uses a combination of gravity and low amplitude, high frequency pneumatic vibrations in order to penetrate the seafloor and gather undisturbed cores of marine sediment. The low amplitudes (a few millimetres) combined with the high frequencies (3,000 – 11,000 vibrations per minute) serve to mobilise a thin layer of material on either side of the plastic core liner, which causes the sediment to behave in an almost fluid manner and allows easy penetration of the seafloor by the vibrocorer.

SBE 911 CTD

The SBE 911 CTD with SBE 32 carousel includes the following equipment: Temperature and conductivity sensors, altimeter (for bottom detection), transmissometer, fluorometer, 24 position water samplers. The Sea-Bird 911*plus* CTD system consists of the SBE 9*plus* Underwater Unit and the SBE 11*plus* Deck Unit (for real-time readout using conductive wire). When a deck unit is employed, underwater unit power is supplied down the same single conductor armored wire used to carry data up to the surface. The deck unit decodes the serial data and passes it to a computer for display and logging to disk.

The Sea-Bird underwater hardware consists of a main pressure housing comprising power supplies, acquisition electronics, telemetry circuitry, and a suite of modular sensors all mounted within a stainless steel guard cage. Surface hardware includes the SBE 11plus Deck Unit and a computer. The temperature sensor (model SBE 3plus) is a compact module containing a pressure-protected high speed thermistor and 'Wein bridge oscillator' interface electronics. The thermistor is the variable element in the Wein-bridge, while a precision Vishay resistor and two ultra-stable capacitors form the fixed components. The conductivity sensor (model SBE 4C) is similar in operation and configuration to the temperature sensor, except that the Wein-bridge variable element is the cell resistance. The Digiquartz® pressure sensor also provides a variable frequency output. The sensor frequencies are measured using high-speed parallel counters and the resulting digital data in the form of count totals are transmitted serially to the SBE 11*plus* deck unit. The deck unit reconverts the count totals to numeric representations of the original frequencies.

Valeport SVX2 combined SVP/CTD
The Valeport SVX2 is fitted with a digital time of flight sound velocity sensor, high stability conductivity sensor, a high accuracy temperature compensated piezo-resistant pressure transducer and a fast response PRT temperature sensor. The instrument is depth rates to 6000m, weights 11.5 kg in its titanium housing.

Sonadyne Ranger 2USBL Positioning Beacon
Ranger 2 is a high performance acoustic position reference system designed for tracking underwater targets and positioning dynamically positioned (DP) vessels. The system (commonly referred to as a HPR system) uses the Ultra-Short Base Line (USBL) positioning method to calculate the position of a subsea target, by measuring the range and bearing from a vessel-mounted transceiver to an acoustic transponder fitted to the target. Multiple subsea targets over a wide area and range of water depths can be simultaneously and precisely positioned. In standard configuration, Ranger 2 allows up to 10 subsea targets to be simultaneously tracked from a surface vessel. Operating ranges of greater than 6,000 metres are achievable and the system supports all industry standard survey and DP output telegrams. One second position updates are achievable in any water depth.

5 Technical Difficulties

6th March 2014: *Windy with a moderate sea. Visibility poor*
Sea-state precludes any of the proposed work and shelter taken in Bantry Bay. Downtime effectively used by shaking down coring and seismic systems.

7th March 2014: *Sunny, westerlies 5-6 becoming 7-8 tonight.*
The new gravity corer was test in calm water (Bantry Bay) in muds. Performance was poor with the first deployment (**CE14004_01GC**) showing the barrel buried itself 3.2m into the seabed (apparent penetration) but only recovered 0.36m (11% recovery!). A modification to the valve was made at the top to let more water escape for the barrel and we manage to bury the barrel into the seabed to 3.2 m again apparent penetration (**CE14004_02GC**) and recovered 0.9m (28% recovery). Third attempt produced a better recovery with a slower deployment and a modified value to let the water flow out: 2.61m apparent penetration (**CE14004_03GC**) with a recovery of 1.83m (70% recovery). Conclusion is that the modified valve is an improvement but the narrow gauge of the gravity core is a problem.

8th March 2014: *Visibility poor, southerly Force 8*
Resumed testing the gravity corer, first in 6m mode (**CE14004_04GC**): apparent penetration of barrel 0.75 cm and recovery 1.30m. Clearly the core didn't go in right and the apparent penetration is also false. Second attempt (**CE14004_05GC**) was fast hauled to the seabed 10m of the bottom and gave an optimum result with 5.9m apparent penetration and 1.5m recovery (25% recovery). The same deployment protocol was used (10m off bottom and full speed into the seabed) with a 3m barrel but with no valve at the top (**CE14004_06GC**): apparent penetration 3.28 m, recovery 1.94 m (59% recovery). This seems to be the most optimal.

We tested both the MI and GSI streamers. They were both about the same in quality. We will therefore proceed with the MI streamer.

10th March 2014: *Low to moderate swell, Force 2-3*
Gravity core **CE14004_07GC** failed to work on soft mud. A core was eventually retrieved by slowly easing into the seabed. This technique proved most successful. We also had some core failures due to the presence of corals blocking the corer. Pushing hard did not improve penetration except on the last try.

11th March 2014: *Low swell*
A box core (**CE14004_18)** was taken in the Porcupine Bank Canyon area but sea-state was deemed hazardous for deployment. The box corer is heavy and has to be lifted over the gunwale. This can only be safely done in calm seas. This operation was abandoned in the hope that the sea would calm later on. During recovery the box-core was hit against the side and a bar was bent.

12th March 2014: *Force 6, moderate swell and chop, poor visibility*
In an attempt to straighten the box core bar, it broke off. The sea state was also considered too rough to deploy despite a slight sea. The much smaller Reineck was used as an alternative.

14th March 2014: *Slight sea. Force 3-5.*
Coarse gravels inhibited vibrocoring.

16th March 2014: *Moderate seas, force 6-7 falling to 3.*
Vibrocore not deployed in Force 4 as too rough

17th March 2014:
Vibrocore stopped working. Blue light came on and the motor failed to activate. Test of the aft showed this to be the case. It was identified that the magnetic switch which informs the deck box that it has received maximum penetration malfunctioned “on”. This then caused the motor to automatically shut down. The magnetic relay was bypassed and vibrocoring could continue. The vibrocore was out of action from 07.50 until 16.45.

6 Survey Narrative

6th March 2014:
Windy with a moderate sea. Visibility poor

Started mobilisation at 09.00 and left Cork Harbour at 11.00 into moderate seas. Transitted to the Moira Mounds study area heading into the swell, progress 8 kts dropping to 6 kts. Weather forecast deteriorated and decision was made at 18.00 to seek shelter behind Bere Island as predicted sea-state was to rough (5 m swell) to deploy the gravity corer on arrival at any of the proposed sites and deteriorating from thereon in.

7th March 2014:
Sunny, westerlies 5-6 becoming 7-8 tonight.

On DP sheltering behind Bere Island, Bantry Bay. 13.20 heading out to the middle of Bantry Bay to run a test sparker line. Commence MMO survey 13.40. Sparker and Pinger lines **CE14004_SL1** & **PL1** commenced at 15.42 and finished at 17.03. Three gravity cores were taken in the same place to test the 3m gravity core (**CE14004_01GC** to **CE14004_03GC**) commencing at 17.46. On optimum seabed, the corer performed poorly (see technical difficulties). Coring stopped at 20.29 and we recovered to shelter behind Bere Island

8th March 2014:
Visibility poor, southerly Force 8

On station, the same as yesterday, to trial the 6m gravity corer at 09.00 (**CE14004_04GC**). Two cores were taken with poor success (**CE14004_04GC** & **CE14004_05GC**). 3m core was also taken (**CE14004_06GC**). Coring operations ceased at 11.02. MMO starts at 11.30. Sparker and Pinger lines **CE14004_SL2** & **PL2** run to test different streamers commencing 12.45 and ending 15.20. All systems tested, heading for shelter behind Bere Island. In shelter behind Bere Island by 16.20.

9th March 2014:
Moderate swell, good visibility

Left safe haven behind Bere Island at 14.00. Transit to Moira Mounds site.

10th March 2014:
Low to moderate swell, Force 2-3

Arrive at the Moira Mounds 00.10. Start coring operations 00.17. **CE14004_07GC** & **CE14004_08G,** 2 attempts same site (10m slow fall on soft mud). **CE14004_09GC** same protocol as above. **CE14004_10GC** & **CE14004_11G**, 2 attempts on same site both with recovery. **CE14004_12A-E GC**, no recovery although **CE14004_12FGC** worked. **CE14004_13-15 GC**, all good cores with **CE14004_16GC** collecting only a few coral fragments. **CE14004_17 A&B GC** not recovery with **CE14004_17C GC** working. Finished coring at 23.12 and commenced transit to the Porcupine Bank Canyon Mounds.

<u>11th March 2014</u>:
Low swell

Arrive on station at the Porcupine Bank Canyon Mounds at 13.19. Box core (**CE14004_18B**) taken at 14.06 but sea state determine too poor to continue. Transited to Porcupine Bank sites arriving on station at 17.15. Began coring at 17.44. Initial core was short and sandy (**CE14004_19G)**, next three sites were relocated further up slope where more muddy sediment was encountered (**CE14004_20G - CE14004_24G)**. Finished coring up to **CE14004_21G** by 23.08.

<u>12th March 2014</u>:
Force 6, moderate swell and chop, poor visibility

Continued coring upslope transect finished coring **CE14004_24G** by 02.44. Started deeper sites at c. 3000m at 05.50 finishing at 15.40 (**CE14004_25G - CE14004_29G**). Made two attempts to take a final gravity coring near to existing core site ENAM97_04 at 836m water depth at 19.04 and 19.48 respectively (**CE14004_30G** & (**CE14004_31G**). Commenced transit back the Porcupine Bank Canyon Mounds at 20.00.

<u>13th March 2014</u>:
Low to moderate seas

Arrive at Porcupine Bank Canyon Mounds at 00.00. Collected two attempts were made to collect a Reineck box core on top of a second cold-water coral mound (**CE14004_32B - CE14004_33B**) between 00.23 and 01.02. The first hit hard ground with limited recovery and the second was successful. At CTD was then taken on the first cold-water coral mounds (site of **CE14004_18B**) (**CE14004_01CTD)** at 01.57 followed by a gravity core (**CE14004_34G**) at 02.53. Off mound Reineck box core was taken at 03.32 (**CE14004_35B).** An attempt to take a final CTD in the Canyon head failed. Finished operations at 04.50 and commenced transit to the western shelf site running multibeam on the way. Multibeam will run continuously from now on. On site for first vibrocore at 21.45 (**CE14004_36V**).

<u>14th March 2014</u>:
Slight sea. Force 3-5.

Continued vibrocoring until 05.10 (**CE14004_36V** to **CE14004_41V**) in the western shelf area. Took an SVP at 00.59 (**CE14004_1SV)** before commencing transit, with the multibeam and pinger running, for the Western Shelf area. On site for vibrocoring at 09.01 **(CE14004_42V)**. Continued vibrocoring Western Shelf site **(CE14004_42V** to **CE14004_46V)** until 12.18. MMO started observations at 11.15. Soft start complete, Pinger and Sparker data acquisition begins at 13.33 (**CE14004_SL5/PL5**) as well as multibeam. MMO finished at 14.10. Acquisition of pinger and sparker lines continues for the rest of the day (**CE14004_SL5/PL5** to **CE14004_SL16/PL16**).

<u>15th March 2014</u>:
Moderate sea Force 3-6.

Acquisition of pinger and sparker lines continues until 11.50 (**CE14004_SL17/PL17** to **CE14004_SL31/PL31**). Vibrocores (**CE14004_47V** to **CE14004_51V**) taken from 13.47 to 19.01. Transit made to Killary area with multibeam.

<u>16th March 2014</u>:
Moderate seas, force 6-7 falling to 3.

Vibrocoring abandoned at Killary area due to unfavourable seas (**CE14004_52V**). MMO started at first light and started sparker and pinger lines at 00.36 (**CE14004_SL32/PL32**) in the western shelf area. Finished sparker and pinger at 19.50 (**CE14004_SL43/PL43**). Proceeded in transit to the start of the Killary site. Started vibrocoring in favourable seas at 19.58 (**CE14004_53V**).

<u>17th March 2014</u>:
Slight to moderate seas.

Continued vibrocoring until 07.30 (**CE14004_60V**). Vibrocore stopped working at 07.50. MMO started observations at 9:30. Soft start began at 10:20. MMO observations completed at 11:10. Sparker and pinger data collection began at 11:20 (**CE14004_SL45/PL45**) continuing until 16.30 (**CE14004_SL51/PL51**). Two vibrocores were then taken at the north of the area (**CE14004_61V** & **CE14004_62V**) before doing a final sparker and pinger (**CE14004_SL52/PL52**). Transit to Killybegs commenced at 21.10.

<u>18th March 2014</u>:
In Shelter

Arrive at Killybegs ay 08.00. End of survey.

7 Summary of Areas

Bantry Bay

Tested gravity corer and sparker in shelter during bad weather. Seabed muddy with a rise in bedrock identified.

Moira Mounds

Station	*Core*	*Time*	*Water depth*	*Latitude*	*Longitude*	*Sample recovery*	*Comments*
11	07GC	00:45	1066m	51.43972	-11.8224	0.61m	
12	08GC	02:02	1068m	51.43959	-11.8224	2.06m	
13	09GC	03:32	1066m	51.43812	-11.8228		
14	10GC	05:08	1065m	51.43856	-11.8235	2.79m	
15	11GC	06:24	1061m	51.43857	-11.8232	2.71m	
17	12GC f	13:47	976m	51.48971	-11.8161	1.86m	
18	13GC	14:55	977m	51.4894	-11.8156	2.71m	
19	14GC	16:24	975m	51.48943	-11.8155	0.25m	
20	15GC	17:30	976m	51.48975	-11.816	2.75m	
21	16GC	19:11	965m	51.49455	-11.8192	0	2 coral fragments
23	17GC b	21:03	966m	51.49466	-11.819	0	Loose coral fragments
25	17GC c	23.12	1030m	51.43883	-11.8226	2.09m	

Core locations and sample recovery at the Moira Mounds target area.

The Moira Mounds are cold water coral reefs (~10m in height) located on lower slope of the eastern part of the Porcupine Seabight in the Belgica Mound Province. Located ~1000m below sea level, the western chain of the Moira Mounds are relatively abundant and increase in size from south to north. These have been groundtruthed by video data during previous surveys.

The basis for coring these Moira-type mounds in the north-west Belgica Mound Province is built on previously collected data; TOBI 30 kHz side scan sonar, box cores, CTD's, microbathymetry and ROV video. On-going research reveals coral patchiness on-reef as well as variation in mound size along the lesser-studied western chain of Moira Mounds.

Ten specific gravity core locations were planned (5 on-mound and 5 off-mound). 18 attempts were made to retrieve these 10 targets although only 12 of the 18 attempts retrieved core. Furthermore, only 6 of these cores exceeded 2m. Fortunately, we retrieved enough sample to enhance our data set (on-mound core and off-mound core).

Gravity core targets can be divided into two specific zones: the southern area and the northern area. Previously collected box cores and video data reveal that the southern area is relatively muddy. Hence, this area was targeted first (CE14004_06GC, 07GC, 08GC, 09GC, 17GCC, 10GC, 11GC). The length of core recovered in this area was variable (see table). Cores between stations 21 and 23 recovered no sediment sample. However, at these stations, fragments of hard coral and sponges found in the core catcher suggested the substrate was too hard to penetrate with the gravity corer.

In the northern area, 6 targets recovered core (CE14004_17GCb, 16GC, 12GCf, 15GC, 13GC, 14GC). Cores CE14004_17GC and CE14004_16GC targeted the 'Piddington Mound'. However, as seen by video observations, this mound is particularly patchy with targets approx. 1m in size. Due to the shelly-surface layer on this mound, both cores only retrieved some small coral fragments while other attempts on this mound did not recover sample (i.e. CE14004_17GCa). Gravity cores in the northern area are relatively shorter as the substrate is sandy and contains more bioclastic material.

Additionally, the area between the north and southern areas were targeted using TOBI 30 kHz backscatter. Specifically, an anomalous backscatter zone interpreted from the TOBI was targeted. Several attempts to retrieve sample from this area failed (CE14004_12GCa, 12GCb, 12GCc, 12GCd, 12GCe).

Our current research examines spatial variability over the mound chain with an emphasis on one specific Moira-type mound (the 'Piddington Mound') in the north of the chain. This newly acquired gravity core data set embellishes the spatial component of our data set and allows for examination of temporal patterns and variability through time. These are the first relatively long cores through the lesser-studied western chain of Moira Mounds. In addition, targeting these mounds using a USBL-guided gravity core allows to test the accuracy of our georeferenced maps and sample locations.

The Piddington Mound, the largest of the western chain Moira Mounds and the focus of previous surveys, is respectfully named here for the first time after the late Ray Piddington who sadly passed away at the start of this survey.

Porcupine Bank Canyon Mounds

The Porcupine Bank Canyon Mounds are c 50m high cold-water coral carbonate mounds existing at water depths c. 650m clustered around the head of the Porcupine Bank Canyon, the largest of the Porcupine Bank canyons. The area has been previously surveyed as part of the CARBONATE programme (RV Pelagia).

Two box cores and a gravity core targeted the summits of 2 mounds. These revealed main coral rubble and hardgrounds on the summits with limited live fauna. An off-mound core showed the surrounding seabed was sandy. A CTD on the mound showed limited water mass variation at the seabed although the signal of the Mediterranean Outflow Water (?) was a noted mid-water column. Echosound data showed a distinct inferred nephaloid layer at the seabed wafting into the canyon head, water samples were taken from this.

Western Porcupine Bank

Previous work on the Western Porcupine Bank slope has shown for the last glacial period evidence of Heinrich layers (Ovrebo, 2005; Owen, 2010 and Toms, 2010). Very thick layers are found on the base of the slope (Rockall Trough) and at the top of the slope (water depth <1200m). These areas are of interest for further coring, as previous coring programmes focused mainly on the slope itself.

8 sites are planned, 4 in shallow water and 4 in deep water. The positions were chosen in the hope that optimal thickness and undisturbed layers of the last glacial can (hopefully) be recovered. To gain least disturbed cores, positions near canyon systems were avoided, especially at the deep sites.

On the 11th of March at 17:44pm, the first core (CE14004_19GC) was taken on the southernmost shallow water site (Site 1) at around 1300m water depth. The recovery was 54cm mainly containing sand. The gravity corer was not able to go through too much sand. As mud was expected following a thin sandy layer, a second attempt (CE14004_20GCa) was undertaken a few hundred meters up-slope, resulting in no recovery at all.

As a consequence, all shallow water sites were moved further up-slope along the 1000m isobath line. The second site (CE14004_20GCb) confirmed this decision, with a total recovery of 1.84m. The top if the core was again sandy, but most of the core was mud as expected. The same sequence was found on site 3 (CE14004_21GC), although the recovery was less than 1.50m. A second attempt (CE14004_22GC) did not increase the recovery for site 3. Site 4 showed an inverse sequence with mud on top followed by sand. Again, the gravity core was unable to recover long cores (2 attempts: CE14004_23GC = 1.01m and CE14004_24GC = 0.54m).

On the 12th of March, the first deep water site was targeted and we started coring around 5am (on the bottom at 5:50am). Recovery of over 2m were reported from previous studies of these deep water sites, therefore the first attempt during this survey (CE14004_25GC) was unsuccessful with less than 1.50m. The second core (CE14004_26GC) was more successful with 2.10m. The next three deep water sites (CE14004_27GC, CE14004_28G and CE14004_29GC) showed the same trend, with a maximum length of 2.60m at site 8. Drift of the gravity core from the deployment position was up to 200m, but this did not have a significant impact on the targets for this research.

As Site 1 was unsuccessful, on the way to the next survey site, a further attempt was undertaken. To guarantee recovery, the site was shifted towards a well-known position of mainly mud in around 800m water depth. The first attempt was a miss (CE14004_30GC), but the second core (CE14004_31GC) retrieved a 1.50m long core.

In total we made 14 coring attempts, resulting in 12 sediment cores. The cores ranges from 0.54m to 2.60m, whereby 9 out of 12 were >1m and 4 out of 12 were >2m. Overall, the gravity coring programme at this site was a success.

References:

Ovrebo, L.K., Haughton, P.D.W. and Shannon, P.M., 2006. A record of fluctuating bottom currents on the slopes west of the Porcupine Bank, offshore Ireland-implications for Late Quaternary climate forcing. Marine Geology, 225, 279-309.

Owen, N. (2010). A multi-proxy palaeoceanographic investigation of slope deposits on the Porcupine Bank, NE Atlantic. PhD thesis, Trinity College Dublin, Dublin, Ireland.

Toms, L. (2010). Stratigraphy, sedimentation and facies distribution on the Porcupine Bank and links to Late Quaternary climate variability. PhD thesis, University College Dublin, Dublin, Ireland.

Western Shelf: Western shelf site

In total five vibrocores were retrieved from the southern area of the western shelf site. Core recovery was poor and exceeded the length 1m only once (CE14004_44VC, 0-1.025 cmbsf). This is due to a gravel and stiff diamicton layer that is close to the bottom of the seafloor. However, the succession of Holocene sandy deposits on the top of core CE14004_42VC and the stiff diamicton at its bottom may represent glacial retreat at this site that could give dates post the Last Glacial Maximum. Multibeam data shows a high backscatter surface indicating an acoustically hard seafloor which concurs with the poor vibrocore recovery. Pinger data reveals a chaotic reflector in between the seafloor and a second unit of a horizontal reflector at about 5 mbsf. It is suspected that this chaotic reflector correlates to layers of gravel and outwashed sediments that are preserved at the bottom of the retrieved sediment cores.

Sparker and pinger data along a transect between the southern and northern areas of the western shelf site was undertaken to better correlate seismic stratigraphies. Another 3 sites for vibrocoring were picked along this transect. At these locations, a layer of diamicton was expected to be penetrated by the vibrocorer between the first and second metre below seafloor. Sparker data shows one major strong reflector between 10 and 20 mbsf. Pinger data shows a good resolution (0.2 cm) which allowed identification of horizontal and chaotic reflectors of the uppermost 10 mbsf. Three vibrocores were taken, the southernmost penetrated 2.33 m but did not penetrate diamicton (sand overlying moderately sorted gravel), the northernmost contained diamicton in the core catcher underlying medium sands.

Sparker and pinger data from the northern area (east-west transect) reveals a hard substrate with limited acoustic penetration with some reflectors coming in the eastern part of the transect. The westernmost core penetrated 1.50m and sampled diamicton at the base, other cores gave poor penetration only sampling Holocene gravels or sands.

Western Shelf: Killary site and Clew Bay sites

The original sites for vibrocoring were amended according to the sparker, pinger and multibeam data with sites chosen where teh seabed was coreable. Hydroacoustic and seismic data clearly show a morainic ridge that is basically ran north-south through both the Killary and Clew areas. These findings are underpinned by the lithology of sediment cores. The lithology of core CE14004_59VC shows diamicton at its base which might allow for dating the ice sheet extend at this site to a certain period in the past. The top of the morainic system and the core locations beyond the ridge are characterized by gravelly outwash sedimentation at the bottom of the recovered vibrocores (CE14004_54VC, CE14004_61VC).

8 Weather Report

6th March 2014 – Cork to Bantry Bay
16.00: Wind SSW/5, low sea, mod-poor visibility
20.10: Wind 200°; pressure 22 kBar, mod-rough sea; visibility poor

7th March 2014 – in shelter Bere Island
08.00: Calm in sheltered waters, wind W'ly, pressure 20kBar, Fine + Clear. 1020 HPa
16.00: Wind lt airs, good visibility, calm seas

8th March 2014 – in shelter Bere Island
04.00: Wind S'ly/3-4, sheltered waters
08.00: Wind S'ly , calm sea, sheltered waters, visibility mod in rain
20.00: Wind 190°(T) 20 kts, calm sea in sheltered waters

9th March 2014 – in shelter Bere Island
04.00: Wind S'ly/4, sheltered waters, W/good visibility
08.00: Wind light /variable, calm sea, sheltered water, visibility <3miles
17.00: Wind NW'ly/5, low sea mod swell, good visibility
20.00: Wind 300° (T) 10 kts, low swell, good visibility

10th March 2014 – Porcupine Seabight
04.00: Wind NNW'ly /2-3, low sea, mod swell, good visibility

11th March 2014 – Porcupine Bank
04.00: Wind S'ly/4, calm sea, good visibility
08.00: Slight sea, wind SW 16 Kts
16.00: Low sea swell, good visibility, wind slight / Force 4
20.00: Slight to moderate sea, visibility good, wind slight 18 kts

12th March 2014 – Porcupine Bank
04.00: Low to moderate sea, good visibility, wind slight / Force 4
08.00: Moderate sea swell, visibility moderate, wind slight 20 kts
20.00: Wind 18 kts, moderate sea and swell

13th March 2014 – Porcupine Bank and transit to western shelf
08.00: Wind slight 8 kts, calm sea / slight swell, visibility good.
16.00: Wind S'ly/2, calm sea and swell, good visibility, overcast
20.00: Winds light, good visibility, overcast

14th March 2014 – Western shelf
04.00: Wind SW/3, low sea and swell, good visibility, overcast
08.00: Wind 250° /20 kts, slight sea and swell, good visibility

16.00: Wind W'ly/4-5, low sea and swell westerly, good visibility, overcast
20.00: Wind 290^{o}/13 kts, good visibility

15th March 2014 – western shelf
04.00: Wind W'ly/4, low sea and swell, good visibility, overcast
08.00: Wind 270^{o}/20 kts, slight sea and swell
16.00: Wind W'ly/4-5, low sea and swell, good visibility, overcast
20.00: Wind W'ly/20 kts, slight sea and moderate swell, good visibility, poor in fog
24.00: Wind W'ly/5-6, moderate sea and low swell, overcast

16th March 2014 – Killary area
04.00: Wind W'ly/6-7, moderate sea and low swell, moderate to good visibility, overcast
08.00: Wind W'ly/25 kts, moderate sea and swell, good visibility
1600: Wind W'ly/5, low sea and swell, overcast, good visibility

17th March 2014
04.00: Wind W'ly/4-5, low sea and swell.
08.00: Wind SW'ly/20 kts
16.00: Wind SW'ly/5, low sea and moderate swell, good visibility

Appendices

Appendix I

Personnel

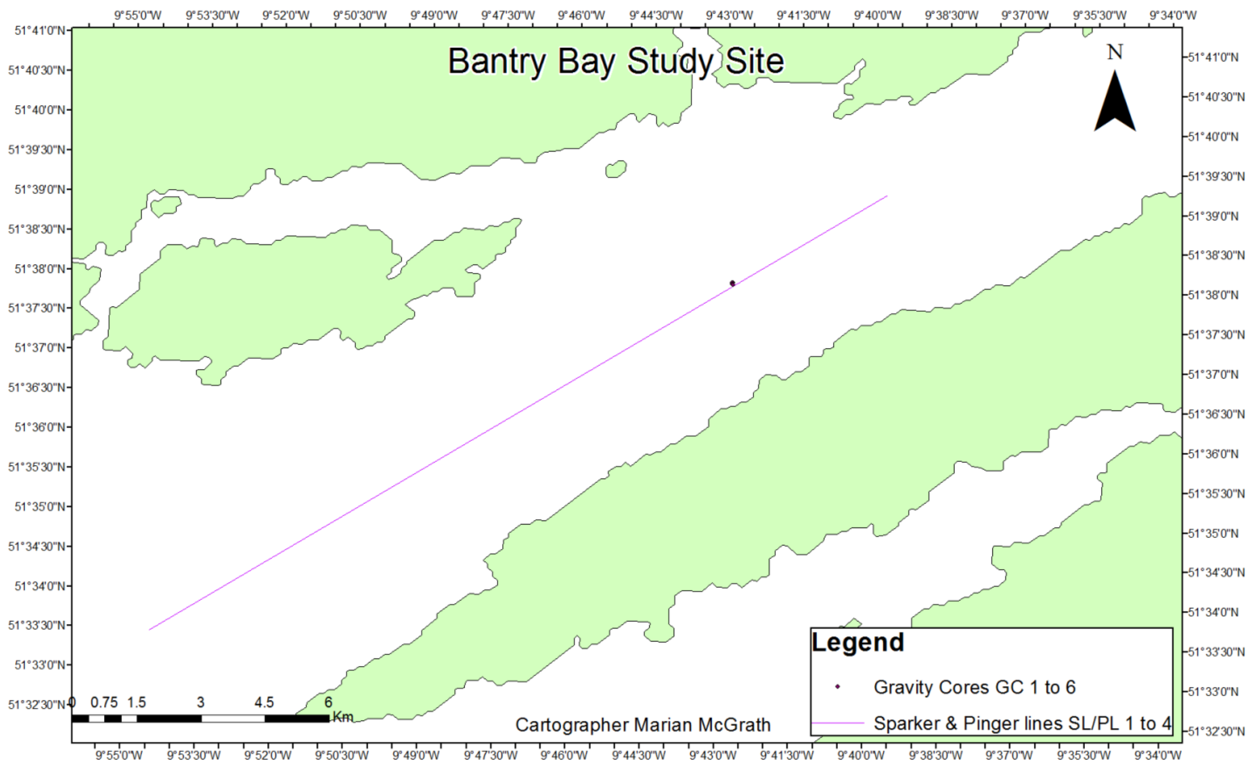
Ship's crew	**Scientific Party**
Antony Hobin Master	Prof. Andy Wheeler Chief Scientist (UCC)
Damien McCallig Chief Engineer	Aaron Lim PhD student/Day watchleader (UCC)
Kenny Downing Chief Officer	Jared Peters PhD student / Night watchleader (UUC)
Dave Stack 2nd Engineer	Dr. Fabio Sacchetti Marine Geophysist (MI)
Barry Hooper 2nd Officer	Marian McGrath PhD student/MMO/Geophysics (UCC)
Francis McGrail Extra 2nd Officer	Akram El Kateb PhD student (Uni. Fribourg)
Daniel Rose Extra 2nd Engineer	Findabhair Foalan MSc student (UCC)
Gerry Carty Bosun	Sabrina Renken PhD Student (TCD)
Ken O' Neil Bosun's Mate	Kevin Schiele PhD student (UUC)
Dave Stewart E.T.O	Dr. Agostina Vertino Researcher (Uni. Milano-Bicocca)
Paddy Kenny AB 1	Margaret Browne SMART TTRS/PhD student (MIC)
Philip Gunnip AB 2	
Tim O'Brien AB 3	
Jimmy Burke AB 4	
Brian Sharkey Technician	
Tony Reck Chief Cook	
Mickey Deagan Assistant Cook	
Declan Horan AB 5	

St. Patrick's Day Scientists
L-R back row: Andy Wheeler, Jarod Peters, Sabrina Renken, Agostina Vertino, Margaret Brown, Marian McGrath, Kevin Schiele
L-R front row: Fabio Sacchetti, Aaron Lim, Akram El Kateb, Findabhair Foalan

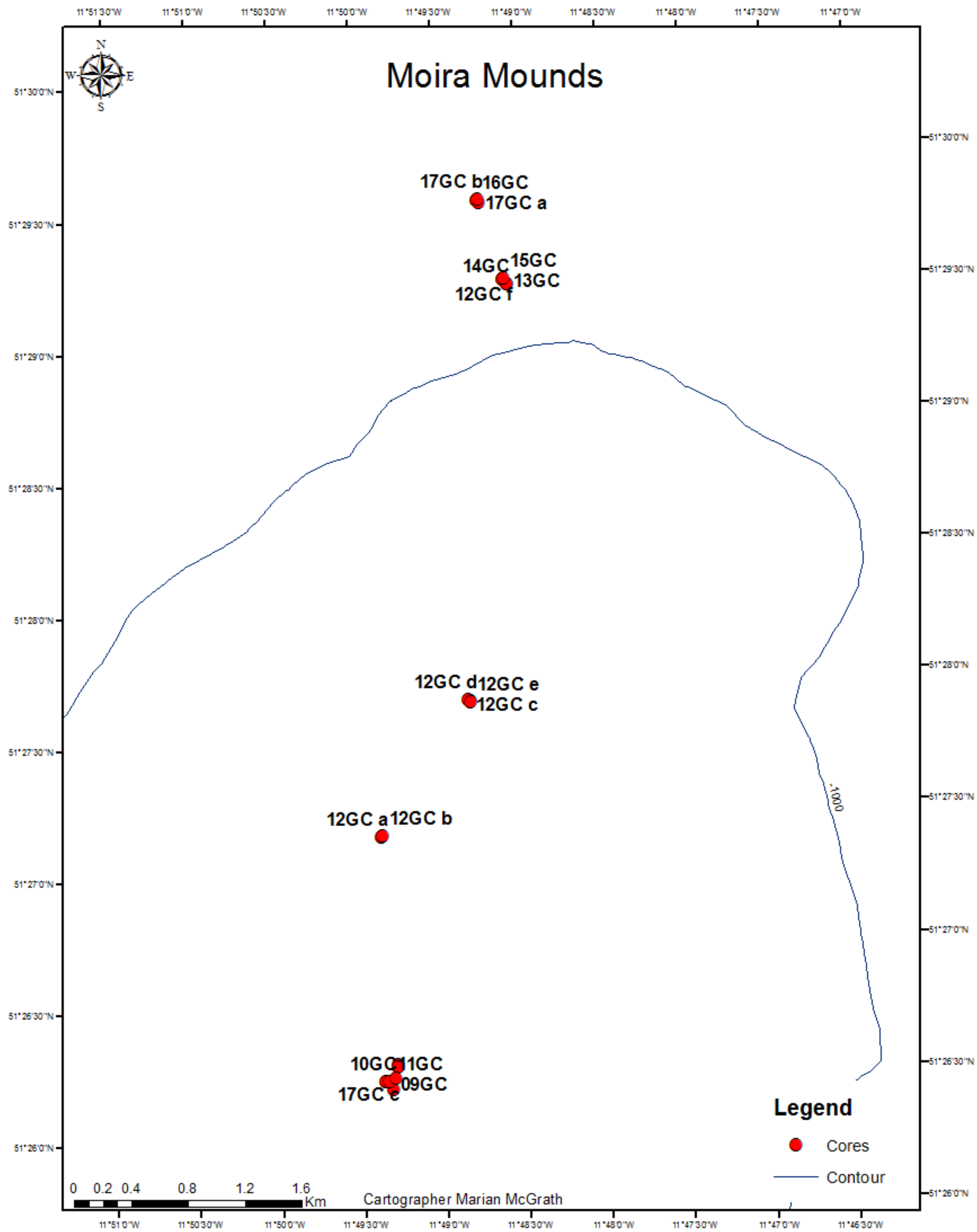
Appendix II

Area maps

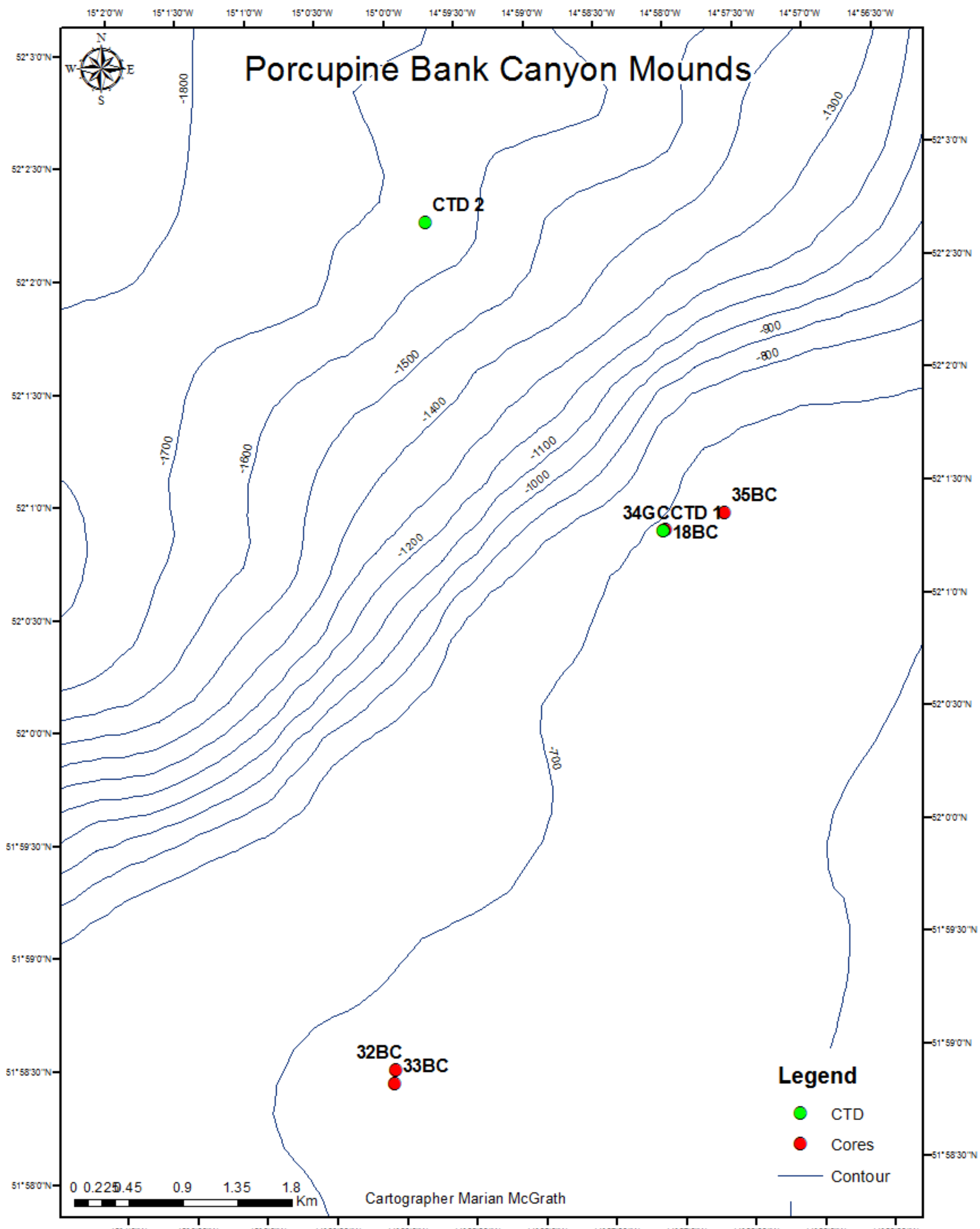
Bantry Bay



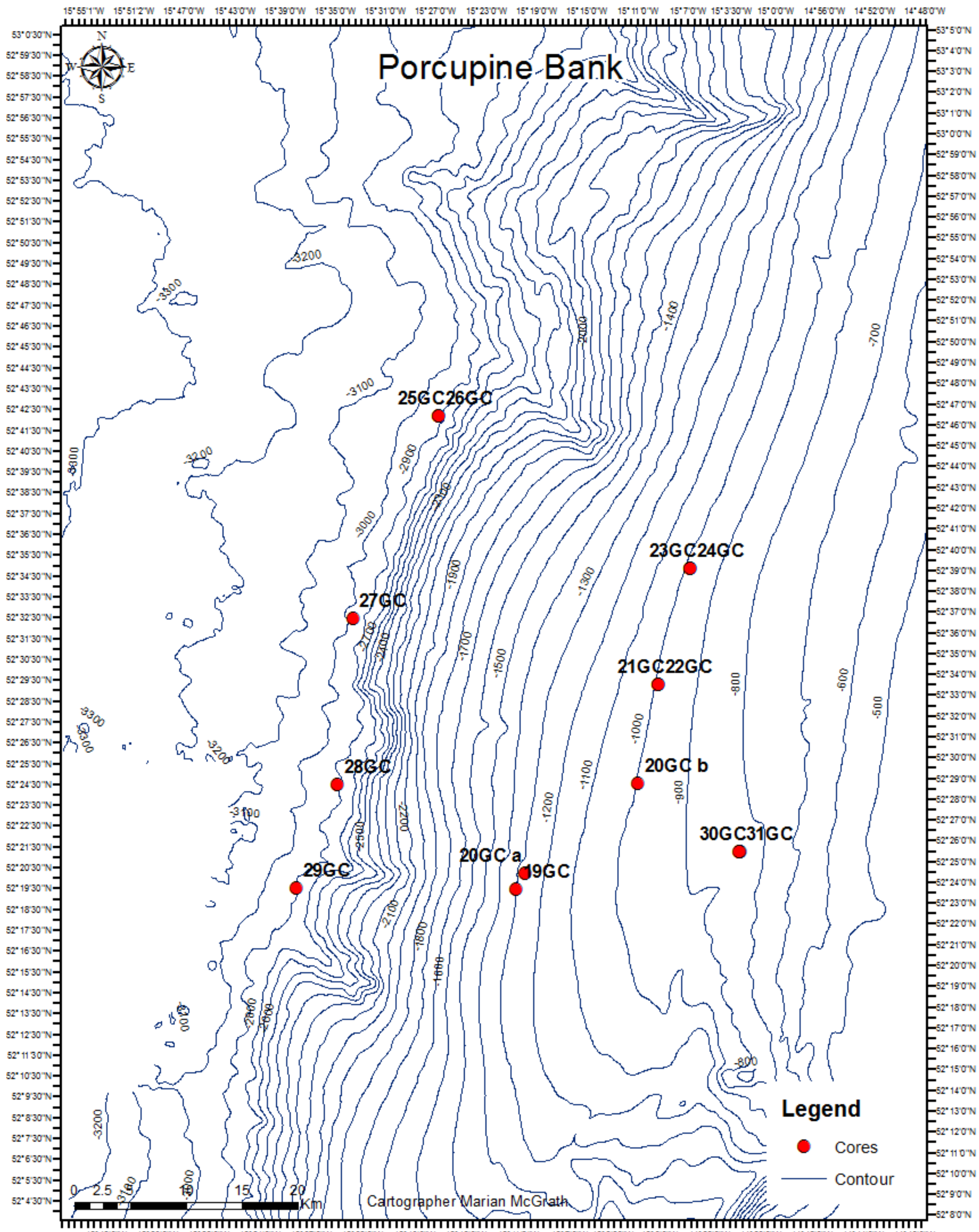
Moira Mounds



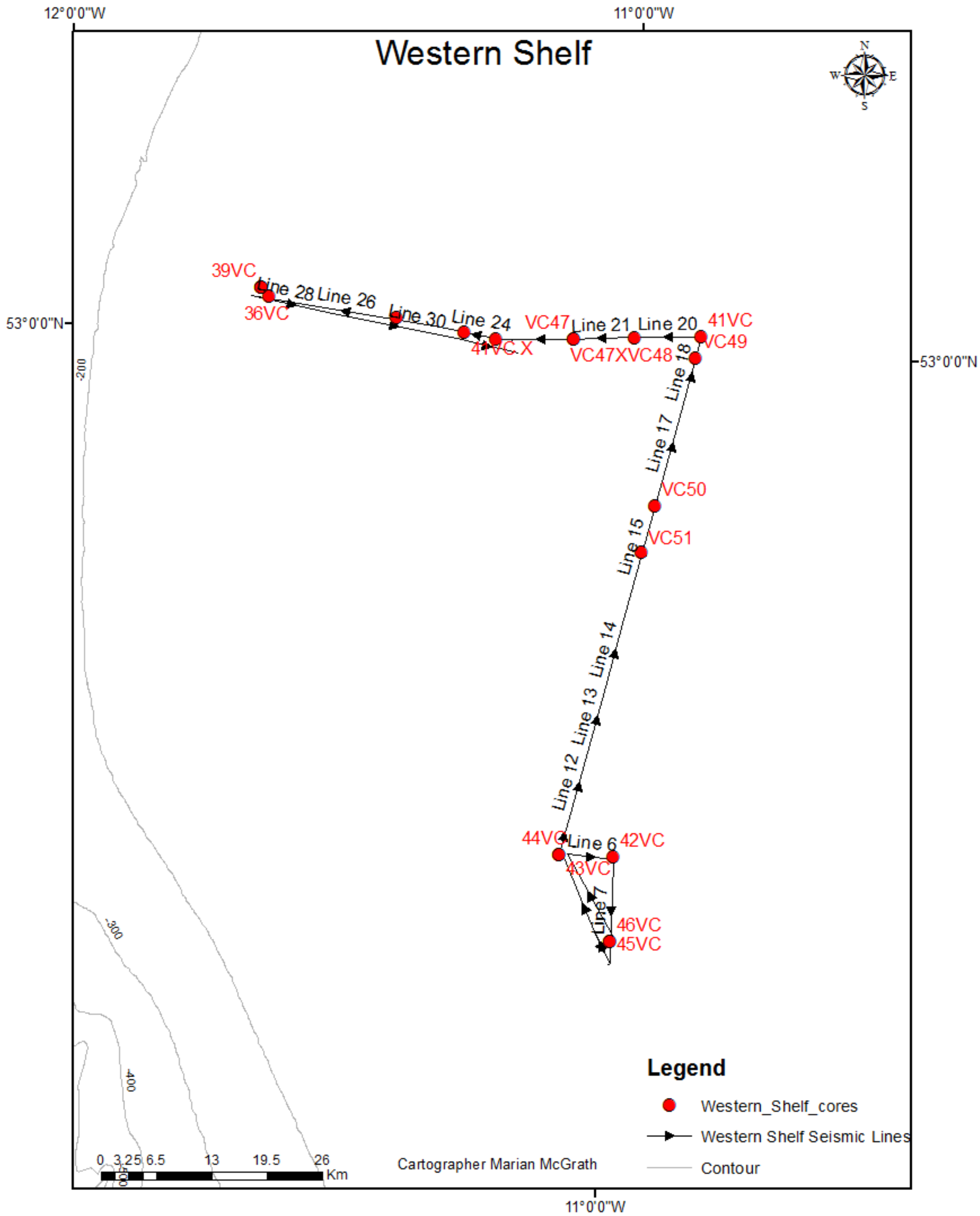
Porcupine Bank Canyon Mounds



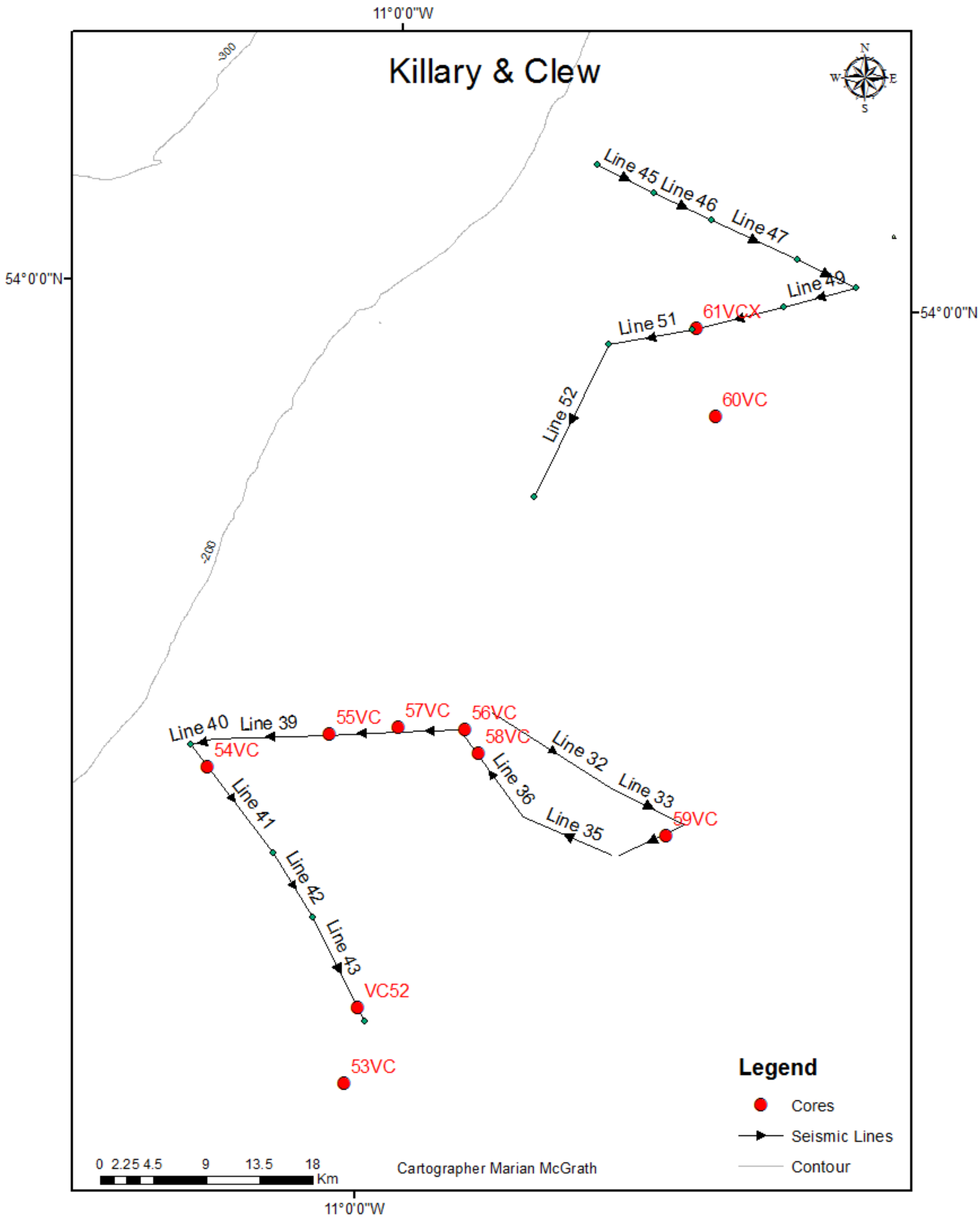
Western Porcupine Bank



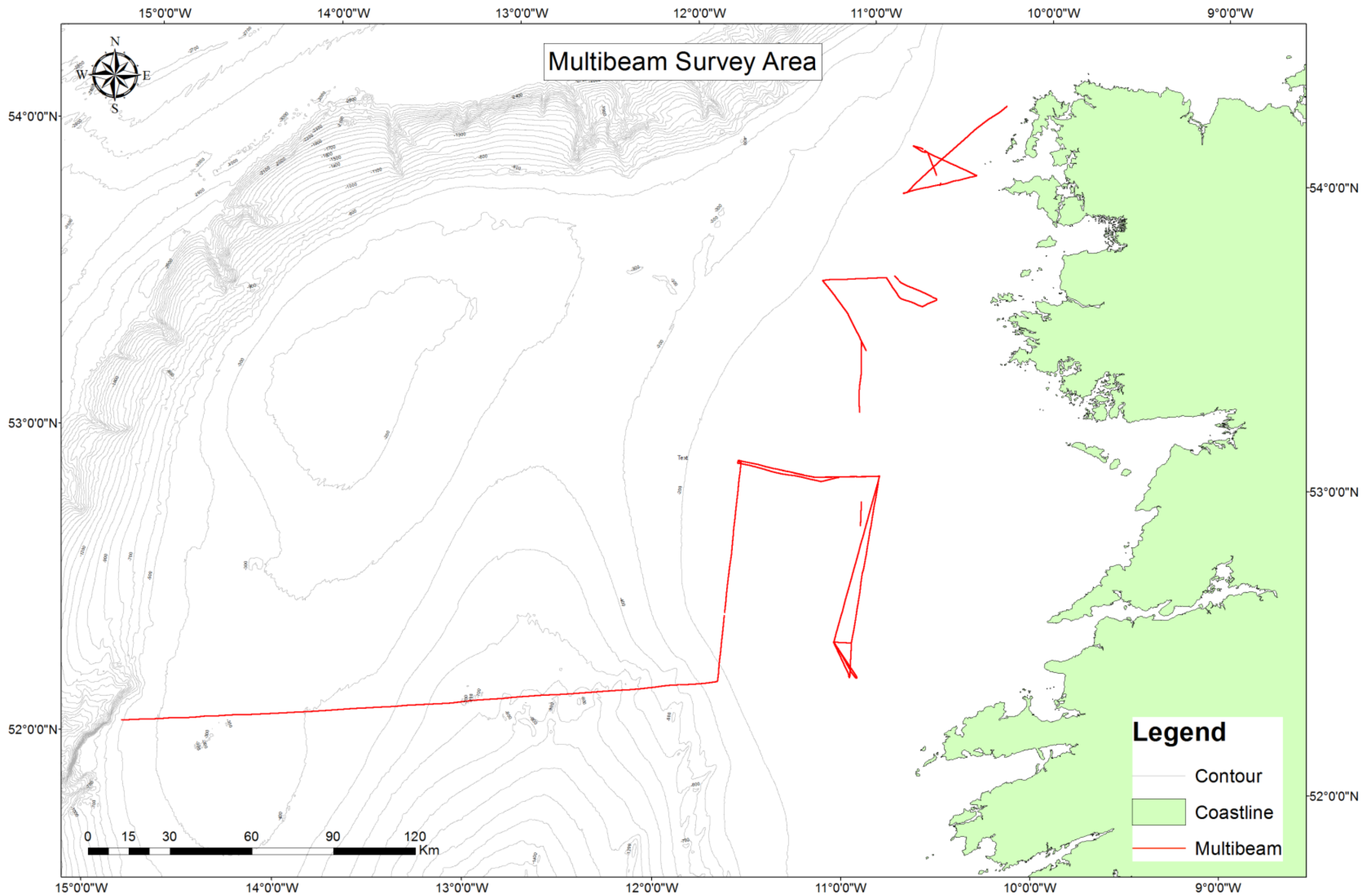
Western Shelf



Killary & Clew Bay areas



Multibeam lines



Appendix III

Station Lists

Cores

Station number	*Code*	*Date*	*Time (UTC)*	*Water depth (m)*	*USBL (on bottom) Lat*	*Long*	*Sample recovery (m)*	*Comments*	*General locality*
2	01GC	07/03/	18:00	42	51 38.0250	9 42.8157	0.36	UTM=USBL, LAT/LONG=SHIPS	Bantry Bay
3	02GC	07/03/	20:01	-	51 38.008	9 42.839	0.9	ALL SHIP POSITIONS	Bantry Bay
4	03GC	07/03/	20:29	-	51 38.0262	9 42.8336	1.83		Bantry Bay
5	04GC	08/03/	09:03	48.9	51 38.0133	9 42.8354	1.22		Bantry Bay
6	05GC	08/03/	09:31	56.9	51 38.0111	9 42.8274	1.5		Bantry Bay
7	06GC	08/03/	11:02	86.5	51 38.0021	9 42.8169	1.94		Bantry Bay
11	07GC	10/03/	0:45	1066.3	51 26.3830	11 49.341	0.61		Moira Mounds
12	08GC	10/03/	2:02	1068	51 26.3751	11 49.3441	2.06		Moira Mounds
13	09GC	10/03/	3:32	1066.5	51 26.2873	11 49.3658	223.5		Moira Mounds
14	10GC	10/03/	5:08	1065.3	51 26.3136	11 49.4126	2.79		Moira Mounds
15	11GC	10/03/	6:24	1061.3	51 26.3141	11 49.3905	2.71		Moira Mounds
16	12GC a	10/03/	8:08	1046	51 27.2425	11 49.5171	0	No core recovery	Moira Mounds
16	12GC b	10/03/	9:08	1046	51 27.2446	11 49.5139	0	No core recovery	Moira Mounds
17	12GC c	10/03/	10:35	1040	51 27.7769	11 49.0232	0	No core recovery	Moira Mounds
17	12GC d	10/03/	11:05	1031	51 27.7804	11 49.0339	0	No core recovery	Moira Mounds
17	12GC e	10/03/	12:07	1033	51 27.7725	11 49.0208	0	No core recovery	Moira Mounds
17	12GC f	10/03/	13:47	976	51 29.3827	11 48.9650	1.86		Moira Mounds
18	13GC	10/03/	14:55	977	51 29.3638	11 48.9359	2.71		Moira Mounds
19	14GC	10/03/	16:24	975	51 29.3656	11 48.9327	0.25		Moira Mounds
20	15GC	10/03/	17:30	976	51 29.3849	11 48.9590	2.75		Moira Mounds
21	16GC	10/03/	19:11	965	51 29.6729	11 49.1494	0	2 coral fragments	Moira Mounds

Station number	*Code*	*Date*	*Time (UTC)*	*Water depth (m)*	*USBL (on bottom) Lat*	*Long*	*Sample recovery (m)*	*Comments*	*General locality*
22	17GC a	10/03/	20:00	967	51 29.6670	11 49.1289	0	No core recovery	Moira Mounds
23	17GC b	10/03/	21:03	965.9	51 29.6796	11 49.1429	0	Loose coral fragments	Moira Mounds
25	17GC c	10/03/	23.12	1030	51 26.3300	11 49.3559	2.09		Moira Mounds
26	18BC	11/03/	14.06	641	52 01.1651	14 57.6149			Porc. Bank Canyon Mounds
27	19GC	11/03/	17.44	1309.6	52 21.7661	15 13.7442	0.54		Porc. Bank
28	20GC a	11/03/	18.45	1304	52 22.5901	15 13.1782	0	No core recovery	Porc. Bank
29	20GC b	11/03/	21.18	992.5	52 27.4580	15 05.0223	1.82		Porc. Bank
30	21GC	11/03/	23.08	992.3	52 32.2792	15 04.1607	1.47	Repeat	Porc. Bank
31	22GC	12/03/	00.02	998	52 32.2777	15 04.1603	1.13	2nd try for longer core	Porc. Bank
32	23GC	12/03/	01.50	985	52 37.9891	15 02.5700	1.01	Repeat	Porc. Bank
33	24GC	12/03/	02.44	986.5	52 37.9889	15 02.5695		try again faster	Porc. Bank
34	25GC	12/03/	05.50	2901.1	52 44.1148	15 23.6290	1.47	Repeat	Porc. Bank
35	26GC	12/03/	07.41	2901.3	52 44.0936	15 23.6345	2.1		Porc. Bank
36	27GC	12/03/	10.37	2960	52 33.9712	15 28.7518	2.47		Porc. Bank
37	28GC	12/03/	12.33	2918	52 25.9442	15 28.5703	2		Porc. Bank
38	29GC	12/03/	15.40	2920	52 20.7222	15 30.9421	2.6		Porc. Bank
39	30GC	12/03/	19.04	836	52 24.6320	14 56.3980	0	0-20.5cm in core catcher	Porc. Bank
40	31GC	12/03/	19.48	836	52 24.6323	14 56.4827	1.51		Porc. Bank
41	32BC	13/03/	00.29	622.9	51 58.657	14 59.1788		small sample	Porc. Bank
42	33BC	13/03/	01.02	615.8	51 58.5920	14 59.1710			Porc. Bank
44	34GC	13/03/	2.53	663.3	52 01.1599	14 57.6340	1.3	coral in core catcher	Porc. Bank
45	35BC	13/03/	3.32	667.9	52 01.2628	14 57.2057			Porc. Bank Canyon Mounds
47	36VC	13/03/	22.08	155.6	53 02.3688	11 38.1194	1.66		Western Shelf
48	37VC	13/03/	22.56	156.4	53 02.3478	11 38.9392	0.57	First time no drilling repeat	Western Shelf
49	38VC	13/03/	23.29	157.9	53 02.9512	11 38.9447	0	2nd Attempt	Western Shelf

Station number	*Code*	*Date*	*Time (UTC)*	*Water depth (m)*	*USBL (on bottom) Lat*	*Long*	*Sample recovery (m)*	*Comments*	*General locality*
49	39VC	14/03/	00.03	157.9	53 02.9505	11 38.9450	0.85	3rd attempt	Western Shelf
50	40VC	14/03/	01.38	148.1	53 01.4478	11 24.5726	0.19		Western Shelf
51	41VCX	14/03/	02.34	139.3	53 00.6774	11 17.4374	NA	BAGGED	Western Shelf
52	41VCXX	14/03/	03.19	139.7	53 00.3439	11 14.1776	NA	No core recovery	Western Shelf
53	41VC	14/03/ 4	05.10	138.7	53 01.0713	10 53.5889	0.85		Western Shelf
54	42VC	14/03/	09.18	121	52 27.9644	10 59.5819	0.74		Western Shelf
55	43VC	14/03/	10.20	125.3	52 27.9933	11 05.2261	0.6		Western Shelf
56	44VC	14/03/	10.44	124.2	52 27.9943	11 05.2357	1.02		Western Shelf
57	45VC	14/03/	11.52	120.4	52 22.6612	10 59.5971	0.15		Western Shelf
58	46VC	14/03/	12.18	120.3	52 22.6608	10 59.5971	0.58		Western Shelf
86	47VCX	15/03/	13.47	132.7	53 0.6032	11 5.9312	-	Large water volume	Western Shelf
87	47VC	15/03/	14.14	137	53 0.6060	11 5.9579	1.36		Western Shelf
88	48VC	15/03/	15.31	135	53 0.8306	10 59.6555	0.13		Western Shelf
89	49VC	15/03/	16.27	136.4	52 59.6566	10 53.1081	0.57		Western Shelf
90	50VC	15/03/	17.56	131.1	52 50.2575	10 56.7955	0.8		Western Shelf
91	51VC	15/03/	19.01	130.6	52 41.3120	10 57.9305	2.33		Western Shelf
92	52VC	16/03/	00.36	145.2	53 27.4427	11 0.3305	0.24		Western Shelf
106	53VC	16/03/	19.58	145.2	53 23.9868	11 1.1200	1.22		Western Shelf
107	54VC	16/03/	22.24	174.4	53 38.1163	11 12.5620	1.47		Western Shelf
108	55VC	16/03/	23.37	157.4	53 39.8226	11 03.3482	1.45		Western Shelf
109	56VC	17/03/	00.51	151.2	53 40.2773	10 53.0363	0.95	Liner cracked while capping, top of core lost	Killary & Clew
110	57VC	17/03/	01.19	150.9	53 40.2867	10 53.0842	1	2 try	Killary & Clew
111	58VC	17/03/	02.05	155.8	53 39.2546	10 51.8916	0.87		Killary & Clew
112	59VC	17/03/	03.48	132	53 35.8304	10 37.3172	3.47		Killary & Clew
113	60VC	17/03/	06.34	140	53 54.9804	10 34.6418	1.07		Killary & Clew

Station number	*Code*	*Date*	*Time (UTC)*	*Water depth (m)*	*USBL (on bottom) Lat*	*Long*	*Sample recovery (m)*	*Comments*	*General locality*
114	61VCX	17/03/	07.30	145	53 58.9595	10 36.3845	0	vibro corer broken	Killary & Clew
122	61VC	17/03/	16.45	141	53 58.9917	10 36.3351	0.21	vibro corer repaired	Killary & Clew
123	62VC	17/03/	18.10	173.2	54 5.4311	10 41.6351	1.04		Killary & Clew

CTD & SVP stations

Station number	*Code*	*Date*	*Time UTC*	*Water Depth*	*Lat*	*Long*	*Comments*	*General locality*
43	CTD1	13/03/14	1.57		57.6302	-14.9605	ships position 20m drift of CPT	Porcupine Bank
			2.15 bottle one fired	620m				
			2.17 bottle two fired	600m				
			2.18 other 4 bottles triggered in a row					
46	CTD2	13/03/14	4.18				Error message- stopped recording at water depth 650m & brought onboard at 05.00	Porcupine Bank
53A	SVP1	14/03/14	05.30	139	53 01.0502	10 52.6139		Western Shelf

Seismic lines

Station no.	*Line Name*	*Date*	*Type*	*Start time (UTC)*	*End time (UTC)*	*SOL_lat*	*SOL_lon*	*EOL_lat*	*EOL_lon*	*Trigger Rate (ms)*	*Speed (knts)*	*Layback (m) + 30m*	*Comments*
1	SL1	07 /03	Sparker	15.42	17.03	51 34.496	9 51.810	51 37.474	9 42.734	800	4	60	Sweeptime = 300ms
1	PL1	07 /03	Pinger	15.42	17.03	51 34.496	9 51.810	51 37.474	9 42.734	153	4	0	GSI streamer
8	SL2	08 /03	Sparker	12.45	13.30	51 36.593	9 46.54	51 35.212	9 50.2211	300	4	60	GSI streamer
8	PL2	08 /03	Pinger	12.45	13.30	51 36.593	9 46.54	51 35.212	9 50.2211	150	4	0	GSI streamer
9	SL3	08 /03	Sparker	13.51	14.14	51 36.1815	9 49.1115	51 36.9054	9 46.9835	900	4	60	GSI streamer
9	PL3	08 /03	Pinger	13.51	14.14	51 36.1815	9 49.1115	51 36.9054	9 46.9835	152	4	0	GSI streamer
10	SL4	08 /03	Sparker	14.32	15.18	51 37.6454	9 45.0076	51 39.4971	9 40.001	900	4	60	MI streamer
10	PL4	08 /03	Pinger	14.32	15.18	51 37.6454	9 45.0076	51 39.4971	9 40.001	152	4	0	MI streamer
24	ESL1	10 /03	Echosounder	21.38	22.19	51 29.7118	11 49.2006	51 26.6387	11 49.3348		4	0	
59	SL5	14 /03	Sparker	13.33	15.05	52 22.9329	10 59.2899	52 28.043	11 04.356	900	4	50	MI streamer
59	PL5	14 /03	Pinger	13.33	15.05	52 22.9329	10 59.2899	52 28.043	11 04.356		4	0	MI streamer
60	SL6	14 /03	Sparker	15.05	15.41	52 28.043	11 04.356	52 29.857	10 59.539	900	4	50	
60	PL6	14 /03	Pinger	15.05	15.41	52 28.043	11 04.356	52 29.857	10 59.539	0	4	0	
61	SL7	14 /03	Sparker	15.41	16.39	52 27.851	10 59.539	52 21.195	10 59.537	900	4	50	
61	PL7	14 /03	Pinger	15.41	16.39	52 27.851	10 59.539	52 21.195	10 59.537	0	4	0	
62	SL8	14 /03	Sparker	16.39	17.25	52 29.195	10 59.537	52 21.182	10 59.677	900	4	50	
62	PL8	14 /03	Pinger	16.39	17.25	52 29.195	10 59.537	52 21.182	10 59.677	0	4	0	
63	SL9	14 /03	Sparker	17.25	17.58	52 21.206	10 59.758	52 23.199	11 01.218	900	4	50	
63	PL9	14 /03	Pinger	17.25	17.58	52 21.206	10 59.758	52 23.199	11 01.218	0	4	0	
64	SL10	14 /03	Sparker	17.58	19.08	52 23.199	11 01.218	52 28.317	11 05.080	900	4	50	
64	PL10	14 /03	Pinger	17.58	19.08	52 23.199	11 01.218	52 28.317	11 05.080	0	4	0	
65	SL11	14 /03	Sparker	19.11	19.33	52 28.317	11 05.080	52 30.125	11 04.442	1300	4.1	50	140314.1911
65	PL11	14 /03	Pinger	19.11	19.33	52 28.317	11 05.080	52 30.125	11 04.442	0	4.1	0	140314.1911
66	SL12	14 /03	Sparker	19.33	20.28	52 30.125	11 04.442	52 34.557	11 02.700	900	4.5-5	50	1200J
66	PL12	14 /03	Pinger	19.33	20.28	52 30.125	11 04.442	52 34.557	11 02.700	0	4.5-5	0	
67	SL13	14 /03	Sparker	20.28	21.22	52 34.557	11 02.700	52 38.699	11 01.173	900	4.5-5	50	
67	PL13	14 /03	Pinger	20.28	21.22	52 34.557	11 02.700	52 38.699	11 01.173		4.5-5	0	
68	SL14	14 /03	Sparker	21.22	22.25	52 38.699	11 01.173	52 43.013	10 59.127	900	4.5-5	50	
68	PL14	14 /03	Pinger	21.22	22.25	52 38.699	11 01.173	52 43.013	10 59.127	0	4.5-5	0	
69	SL15	14 /03	Sparker	22.25	23.20	52 43.013	10 59.527	NA	NA	900	4.5-5	50	

Station no.	*Line Name*	*Date*	*Type*	*Start time (UTC)*	*End time (UTC)*	*SOL_lat*	*SOL_lon*	*EOL_lat*	*EOL_lon*	*Trigger Rate (ms)*	*Speed (knts)*	*Layback (m) + 30m*	*Comments*
69	PL15	14 /03	Pinger	22.25	23.20	52 43.013	10 59.527	NA	NA	0	4.5-5	0	
70	SL16	14 /03	Sparker	23.20	00.21	NA	NA	52 51.839	10 56.130	900	4.5-5	50	
70	PL16	14 /03	Pinger	23.20	00.21	NA	NA	52 51.839	10 56.130	0	4.5-5	0	
71	SL17	15 /03	Sparker	00.21	01.21	52 51.839	10 56.130	52 56.284	10 54.434	900	4.5-5	50	
71	PL17	15 /03	Pinger	00.21	01.21	52 51.839	10 56.130	52 56.284	10 54.434	0	4.5-5	0	
72	SL18	15 /03	Sparker	01.21	02.21	52 56.284	10 54.434	53 00.832	10 52.689	900	4.5-5	50	
72	PL18	15 /03	Pinger	01.21	02.21	52 56.284	10 54.434	53 00.832	10 52.689	0	4.5-5	0	
73	SL19	15 /03	Sparker	02.21	02.27	53 00.832	10 52.689	53 01.079	10 52.752	900	4.5-5	50	
73	PL19	15 /03	Pinger	02.21	02.27	53 00.832	10 52.689	53 01.079	10 52.752	0	4.5-5	0	
74	SL20	15 /03	Sparker	02.27	03.31	53 01.079	10 52.752	53 00.843	10 59.779	900	4.5-5	50	
74	PL20	15 /03	Pinger	02.27	03.31	53 01.079	10 52.752	53 00.843	10 59.779	0	4.5-5	0	
75	SL21	15 /03	Sparker	03.31	04.31	53 00.843	10 59.779	53 00.587	11 06.548	900	4.5-5	50	Moraine starts
75	SL21	15 /03	Pinger	03.31	04.31	53 00.843	10 59.779	53 00.587	11 06.548	0	4.5-5	0	
76	SL22	15 /03	Sparker	04.31	05.26	53 00.587	11 06.548	53 00.374	11 12.439	900	4.5-5	50	AOI
76	PL22	15 /03	Pinger	04.31	05.26	53 00.587	11 06.548	53 00.374	11 12.439	0	4.5-5	0	
77	SL23	15 /03	Sparker	05.26	05.37	53 00.374	11 12.439	53 00.340	11 13.697	900	4.5-5	50	
77	PL23	15 /03	Pinger	05.26	05.37	53 00.374	11 12.439	53 00.340	11 13.697	0	4.5-5	0	
78	SL24	15 /03	Sparker	05.37	06.35	53 00.340	11 13.697	53 00.944	11 20.122	900	4.5-5	50	Turn
78	PL24	15 /03	Pinger	05.37	06.35	53 00.340	11 13.697	53 00.944	11 20.122	0	4.5-5	0	
79	SL25	15 /03	Sparker	06.35	NA	53 00.944	11 20.122	NA	NA			50	
79	PL25	15 /03	Pinger	06.35	NA	53 00.944	11 20.122	NA	NA			0	
80	SL26	15 /03	Sparker	NA	08.36	NA	NA	53 22.590	11 35.074	900	4.8	50	
80	PL26	15 /03	Pinger	NA	08.36	NA	NA	53 22.590	11 35.074	0	4.8	0	
81	SL27	15 /03	Sparker	08.36	09.23	53 02.590	11 35.074	53 02.374	11 39.996	900	4.5-5	50	
81	PL27	15 /03	Pinger	08.36	09.23	53 02.590	11 35.074	53 02.374	11 39.996	0	4.5-5	0	
82	SL28	15 /03	Sparker	09.23	10.19	53 02.374	11 39.996	53 01.588	11 31.410	900	4.5-5	50	
82	PL28	15 /03	Pinger	09.23	10.19	53 02.374	11 39.996	53 01.588	11 31.410	0	4.5-5	0	
83	SL29	15 /03	Sparker	10.19	11.16	53 01.588	11 31.410	NA	NA	900	4.5-5	50	
83	PL29	15 /03	Pinger	10.19	11.16	53 01.588	11 31.410	NA	NA	0	4.5-5	0	
84	SL30	15 /03	Sparker	11.16	11.50	NA	NA	53 00.284	11 18.236	900	4.5-5	50	
84	PL30	15 /03	Pinger	11.16	11.50	NA	NA	53 00.284	11 18.236	0	4.5-5	0	
85	SL31	15 /03	Sparker	11.50	12.53	53 00.284	11 18.236	52 59.566	11 11.735	900	4.5-5	50	Change of power socket
85	PL31	15 /03	Pinger	11.50	12.53	53 00.284	11 18.236	52 59.566	11 11.735	0	4.5-5	0	
93	SL32	16 /03	Sparker	07.39	09.08	53 41.100	10 50.950	53 37.854	10 41.458	900	4.5-5	50	1200J
93	PL32	16 /03	Pinger	07.39	09.08	53 41.100	10 50.950	53 37.854	10 41.458	0	4.5-5	0	
94	SL33	16 /03	Sparker	09.08	09.55	53 37.854	10 41.458	53 36.365	10 35.948	900	4.5-5	50	

Station no.	*Line Name*	*Date*	*Type*	*Start time (UTC)*	*End time (UTC)*	*SOL_lat*	*SOL_lon*	*EOL_lat*	*EOL_lon*	*Trigger Rate (ms)*	*Speed (knts)*	*Layback (m) + 30m*	*Comments*
94	PL33	16 /03	Pinger	09.08	09.55	53 37.854	10 41.458	53 36.365	10 35.948	0	4.5-5	0	
95	SL34	16 /03	Sparker	09.55	10.39	53 36.365	10 35.948	53 34.873	10 40.840	900	4.5-5	50	
95	PL34	16 /03	Pinger	09.55	10.39	53 36.365	10 35.948	53 34.873	10 40.840	0	4.5-5	0	
96	SL35	16 /03	Sparker	10.39	11.55	53 34.873	10 40.840	53 36.424	10 48.336	900	4.5-5	50	
96	PL35	16 /03	Pinger	10.39	11.55	53 34.873	10 40.840	53 36.424	10 48.336	0	4.5-5	0	
97	SL36	16 /03	Sparker	11.55	13.01	53 36.424	10 48.336	53 40.305	10 53.417	900	4.5-5	50	
97	PL36	16 /03	Pinger	11.55	13.01	53 36.424	10 48.336	53 40.305	10 53.417	0	4.5-5	0	
98	SL37	16 /03	Sparker	13.01	13.41	53 40.305	10 53.417	53 40.058	10 58.172	900	4.5-5	50	
98	PL37	16 /03	Pinger	13.01	13.41	53 40.305	10 53.417	53 40.058	10 58.172	0	4.5-5	0	
99	SL38	16 /03	Sparker	13.41	14.27	53 40.058	10 58.172	53 39.795	11 03.666	900	4.5-5	50	
99	PL38	16 /03	Pinger	13.41	14.27	53 40.058	10 58.172	53 39.795	11 03.666	0	4.5-5	0	
100	SL39	16 /03	Sparker	14.27	15.38	53 39.795	11 03.666	53 39.385	11 12.313	900	4.5-5	50	
100	PL39	16 /03	Pinger	14.27	15.38	53 39.795	11 03.666	53 39.385	11 12.313	0	4.5-5	0	
101	SL40	16 /03	Sparker	15.38	15.55	53 39.385	11 12.313	53 39.079	11 13.986	900	4.5-5	50	
101	PL40	16 /03	Pinger	15.38	15.55	53 39.385	11 12.313	53 39.079	11 13.986	0	4.5-5	0	
102	SL41	16 /03	Sparker	15.55	17.08	53 39.079	11 13.986	53 34.342	11 07.268	900	4.5-5	50	
102	PL41	16 /03	Pinger	15.55	17.08	53 39.079	11 13.986	53 34.342	11 07.268	0	4.5-5	0	
103	SL42	16 /03	Sparker	17.08	17.52	53 34.342	11 07.268	53 31.462	11 04.038	900	4.5-5	50	
103	PL42	16 /03	Pinger	17.08	17.52	53 34.342	11 07.268	53 31.462	11 04.038	0	4.5-5	0	
104	SL43	16 /03	Sparker	17.52	18.58	53 31.462	11 04.038	53 26.867	10 59.730	900	4.5-5	50	
104	PL43	16 /03	Pinger	17.52	18.58	53 31.462	11 04.038	53 26.867	10 59.730	0	4.5-5	0	
105	SL44	16 /03	Sparker	18.58	NA	53 26.867	10 59.730	NA	NA	900	4.5-5	50	
105	PL44	16 /03	Pinger	18.58	NA	53 26.867	10 59.730	NA	NA	0	4.5-5	0	
115	SL45	17 /03	Sparker	11.20	12.00	54 06.259	10 44.557	54 05.028	10 40.079	700	4.5-5	50	800J
115	PL45	17 /03	Pinger	11.20	12.00	54 06.259	10 44.557	54 05.028	10 40.079	0	4.5-5	0	
116	SL46	17 /03	Sparker	12.00	12.39	54 05.028	10 40.079	54 03.909	10 35.574	800	4.5-5	50	1000J
116	PL46	17 /03	Pinger	12.00	12.39	54 05.028	10 40.079	54 03.909	10 35.574	0	4.5-5	0	
117	SL47	17 /03	Sparker	12.39	13.36	54 03.909	10 35.574	54 02.250	10 28.789	1000	4.5-5	50	1300J
117	PL47	17 /03	Pinger	12.39	13.36	54 03.909	10 35.574	54 02.250	10 28.789	0	4.5-5	0	
118	SL48	17 /03	Sparker	13.36	14.18	54 02.250	10 28.789	54 01.0423	10 24174	1000	4.5-5	50	
118	PL48	17 /03	Pinger	13.36	14.18	54 02.250	10 28.789	54 01.0423	10 24174	0	4.5-5	0	1300J
119	SL49	17 /03	Sparker	14.18	15.14	54 01.0423	10 24.174	54 00.112	10 29.614	1000	4.5-5	50	
119	PL49	17 /03	Pinger	14.18	15.14	54 01.0423	10 24.174	54 00.112	10 29.614	0	4.5-5	0	
120	SL50	17 /03	Sparker	15.15	15.54	54 00.098	10 29.724	54 59.287	10 34.402	1000	4.5-5	50	
120	PL50	17 /03	Pinger	15.15	15.54	54 00.098	10 29.724	54 59.287	10 34.402	0	4.5-5	0	
121	SL51	17 /03	Sparker	15.54	NA	54 59.287	10 34.402	53 58.881	10 36.732	1000	4.5-5	50	

Station no.	*Line Name*	*Date*	*Type*	*Start time (UTC)*	*End time (UTC)*	*SOL_lat*	*SOL_lon*	*EOL_lat*	*EOL_lon*	*Trigger Rate (ms)*	*Speed (knts)*	*Layback (m) + 30m*	*Comments*
121	PL51	17 /03	Pinger	15.54	NA	54 59.287	10 34.402	53 58.881	10 36.732	0	4.5-5	0	
124	PL52	17 /03	Pinger	20.24	21.10	53 58.067	10 43.138	53 57.036	10 48.398	0	4.5-5	0	

Multibeam lines

Day	*Line*	*Min Time*	*Max Time*	*Total Time*	*Heading*	*Length*	*Speed*	*Tide Applied*
2014-072	0000_20140313_161938_celtic_explorer	19:38.8	22:15.8	02:37.0	86.628	834.361	5.3144	GPS Datum Model
2014-072	0001_20140313_052359_celtic_explorer	23:59.8	23:58.8	59:59.0	86.839	18337.9	5.0953	GPS Datum Model
2014-072	0002_20140313_062359_celtic_explorer	23:59.8	23:58.8	59:59.0	86.707	18540.62	5.1516	GPS Datum Model
2014-072	0003_20140313_072359_celtic_explorer	23:59.8	23:58.8	59:59.0	86.882	18366.16	5.1031	GPS Datum Model
2014-072	0004_20140313_082359_celtic_explorer	23:59.8	23:58.8	59:59.0	86.101	18264.77	5.075	GPS Datum Model
2014-072	0005_20140313_092359_celtic_explorer	23:59.8	23:58.8	59:59.0	85.556	18684.26	5.1915	GPS Datum Model
2014-072	0006_20140313_102359_celtic_explorer	23:59.8	23:59.8	00:00.0	85.8	18573.04	5.1592	GPS Datum Model
2014-072	0007_20140313_112400_celtic_explorer	24:00.8	23:58.8	59:58.0	84.509	17913.02	4.9786	GPS Datum Model
2014-072	0008_20140313_122359_celtic_explorer	23:59.8	23:58.8	59:59.0	84.842	18612	5.1714	GPS Datum Model
2014-072	0009_20140313_132359_celtic_explorer	23:59.8	23:58.8	59:59.0	85.807	18511.42	5.1435	GPS Datum Model
2014-072	0010_20140313_142359_celtic_explorer	23:59.8	23:58.8	59:59.0	85.185	19563.81	5.4359	GPS Datum Model
2014-072	0011_20140313_152359_celtic_explorer	23:59.8	19:37.8	55:38.0	83.562	18124.3	5.4297	GPS Datum Model
2014-072	0011_20140313_162332_celtic_explorer	23:31.8	23:31.8	00:00.0	64.939	19031.05	5.2864	GPS Datum Model
2014-072	0012_20140313_172332_celtic_explorer	23:32.8	23:31.8	59:59.0	5.204	18908.65	5.2539	GPS Datum Model
2014-072	0014_20140313_182719_celtic_explorer	27:19.8	27:18.8	59:59.0	5.65	18610.48	5.171	GPS Datum Model
2014-072	0015_20140313_192719_celtic_explorer	27:19.8	27:18.8	59:59.0	5.26	18480.86	5.135	GPS Datum Model
2014-072	0016_20140313_202719_celtic_explorer	27:19.8	27:18.8	59:59.0	5.462	17598.92	4.8899	GPS Datum Model
2014-072	0017_20140313_212719_celtic_explorer	27:19.8	27:18.8	59:59.0	341.759	1689.397	0.4694	GPS Datum Model
2014-072	0018_20140313_222719_celtic_explorer	27:19.8	27:18.8	59:59.0	323.23	1563.677	0.4345	GPS Datum Model
2014-073	0020_20140314_015239_celtic_explorer	52:39.8	52:38.8	59:59.0	101.691	9333.305	2.5933	GPS Datum Model
2014-073	0021_20140314_025239_celtic_explorer	52:39.8	21:33.8	28:54.0	101.396	2844.566	1.6405	GPS Datum Model
2014-073	0021_20140314_032435_celtic_explorer	24:35.8	24:34.8	59:59.0	88.154	14670.25	4.0762	GPS Datum Model
2014-073	0022_20140314_042435_celtic_explorer	24:35.8	42:54.8	18:19.0	88.921	5796.771	5.2746	GPS Datum Model
2014-073	0023_20140314_044255_celtic_explorer	42:55.8	42:54.8	59:59.0	105.467	5517.815	1.5332	GPS Datum Model

Day	*Line*	*Min Time*	*Max Time*	*Total Time*	*Heading*	*Length*	*Speed*	*Tide Applied*
2014-073	0024_20140314_054255_celtic_explorer	42:55.8	42:54.8	59:59.0	188.649	18136.04	5.0392	GPS Datum Model
2014-073	0025_20140314_064255_celtic_explorer	42:55.8	42:54.8	59:59.0	189.457	18435.56	5.1224	GPS Datum Model
2014-073	0026_20140314_074255_celtic_explorer	42:55.8	42:59.8	00:04.0	187.724	18744.03	5.2009	GPS Datum Model
2014-073	0027_20140314_084300_celtic_explorer	43:00.8	24:17.8	41:17.0	190.386	5634.517	2.2747	GPS Datum Model
2014-073	0027_20140314_095759_celtic_explorer	57:59.8	59:05.8	01:06.0	273.509	114.62	1.7367	GPS Datum Model
2014-073	0028_20140314_095917_celtic_explorer	59:17.8	59:16.8	59:59.0	183.034	1319.352	0.3666	GPS Datum Model
2014-073	0029_20140314_105917_celtic_explorer	59:17.8	59:16.8	59:59.0	148.363	11357.65	3.1558	GPS Datum Model
2014-073	0030_20140314_115917_celtic_explorer	59:17.8	15:58.8	16:41.0	139.493	102.573	0.1025	GPS Datum Model
2014-073	0030_20140314_122934_celtic_explorer	29:33.8	29:33.8	00:00.0	51.688	7737.827	2.1494	GPS Datum Model
2014-073	0031_20140314_132934_celtic_explorer	29:34.8	29:33.8	59:59.0	325.676	7746.705	2.1525	GPS Datum Model
2014-073	0032_20140314_142934_celtic_explorer	29:34.8	04:51.8	35:17.0	333.149	4331.224	2.0459	GPS Datum Model
2014-073	0033_20140314_150452_celtic_explorer	04:52.8	04:51.8	59:59.0	117.747	8587.468	2.3861	GPS Datum Model
2014-073	0034_20140314_160452_celtic_explorer	04:52.8	04:51.8	59:59.0	181.738	7358.028	2.0445	GPS Datum Model
2014-073	0035_20140314_170452_celtic_explorer	04:52.8	23:18.8	18:26.0	183.611	2358.069	2.1321	GPS Datum Model
2014-073	0036_20140314_172319_celtic_explorer	23:19.8	23:18.8	59:59.0	334.41	7939.124	2.2059	GPS Datum Model
2014-073	0037_20140314_182319_celtic_explorer	23:19.8	23:18.8	59:59.0	345.482	8903.314	2.4738	GPS Datum Model
2014-073	0038_20140314_192319_celtic_explorer	23:19.8	33:37.8	10:18.0	13.318	1562.395	2.5281	GPS Datum Model
2014-073	0039_20140314_193338_celtic_explorer	33:38.8	35:31.8	01:53.0	13.661	287.18	2.5414	GPS Datum Model
2014-073	0039_20140314_193708_celtic_explorer	37:08.8	37:07.8	59:59.0	14.903	9133.627	2.5378	GPS Datum Model
2014-073	0040_20140314_203708_celtic_explorer	37:08.8	37:07.8	59:59.0	14.563	8722.702	2.4236	GPS Datum Model
2014-073	0041_20140314_213708_celtic_explorer	37:08.8	37:07.8	59:59.0	14.777	8393.293	2.3321	GPS Datum Model
2014-074	0042_20140314_223708_celtic_explorer	37:08.8	37:07.8	59:59.0	14.452	8450.821	2.3481	GPS Datum Model
2014-074	0043_20140314_233708_celtic_explorer	37:08.8	37:07.8	59:59.0	14.657	8498.391	2.3613	GPS Datum Model
2014-074	0044_20140315_003708_celtic_explorer	37:08.8	37:07.8	59:59.0	14.667	8510.683	2.3647	GPS Datum Model
2014-074	0045_20140315_013708_celtic_explorer	37:08.8	37:07.8	59:59.0	2.643	8183.228	2.2737	GPS Datum Model
2014-074	0046_20140315_023708_celtic_explorer	37:08.8	37:07.8	59:59.0	268.363	7345.718	2.041	GPS Datum Model
2014-074	0047_20140315_033708_celtic_explorer	37:08.8	37:07.8	59:59.0	267.985	7338.624	2.0391	GPS Datum Model
2014-074	0048_20140315_043708_celtic_explorer	37:08.8	37:07.8	59:59.0	268.413	7614.686	2.1158	GPS Datum Model

Day	*Line*	*Min Time*	*Max Time*	*Total Time*	*Heading*	*Length*	*Speed*	*Tide Applied*
2014-074	0049_20140315_053708_celtic_explorer	37:08.8	37:07.8	59:59.0	280.845	7690.962	2.137	GPS Datum Model
2014-074	0050_20140315_063709_celtic_explorer	37:08.8	37:07.8	59:59.0	281.67	7667.006	2.1303	GPS Datum Model
2014-074	0051_20140315_073708_celtic_explorer	37:08.8	37:07.8	59:59.0	282.894	8079.81	2.245	GPS Datum Model
2014-074	0052_20140315_083708_celtic_explorer	37:08.8	37:07.8	59:59.0	265.089	8445.791	2.3467	GPS Datum Model
2014-074	0053_20140315_093708_celtic_explorer	37:08.8	37:07.8	59:59.0	103.461	9108.343	2.5308	GPS Datum Model
2014-074	0054_20140315_103709_celtic_explorer	37:08.8	37:07.8	59:59.0	101.297	8850.91	2.4593	GPS Datum Model
2014-074	0055_20140315_113709_celtic_explorer	37:08.8	37:07.8	59:59.0	100.773	8856.582	2.4608	GPS Datum Model
2014-074	0056_20140315_123709_celtic_explorer	37:08.8	37:07.8	59:59.0	82.089	9542.975	2.6516	GPS Datum Model
2014-075	0057_20140315_133709_celtic_explorer	37:08.8	08:43.8	31:35.0	287.71	392.408	0.2071	GPS Datum Model
2014-074	0057_20140315_133709_celtic_explorer	37:08.8	08:43.8	31:35.0	287.71	392.408	0.2071	GPS Datum Model
2014-075	0058_20140315_194032_celtic_explorer	40:32.8	12:58.8	32:26.0	0.805	8726.428	4.4843	GPS Datum Model
2014-075	0058_20140315_221935_celtic_explorer	19:35.8	19:34.8	59:59.0	1.63	15176.91	4.217	GPS Datum Model
2014-075	0059_20140315_231935_celtic_explorer	19:35.8	17:38.8	58:03.0	359.911	11264.3	3.2341	GPS Datum Model
2014-075	0060_20140316_074910_celtic_explorer	49:10.8	04:38.8	15:28.0	137.13	2147.869	2.3145	GPS Datum Model
2014-075	0060_20140316_080733_celtic_explorer	07:33.8	07:32.8	59:59.0	114.931	8535.361	2.3716	GPS Datum Model
2014-075	0061_20140316_090733_celtic_explorer	07:33.8	40:39.8	33:06.0	114.644	4647.557	2.3402	GPS Datum Model
2014-075	0061_20140316_094349_celtic_explorer	43:49.8	43:48.8	59:59.0	231.766	8356.944	2.322	GPS Datum Model
2014-075	0062_20140316_104350_celtic_explorer	43:49.8	59:10.8	15:21.0	291.52	1839.967	1.9978	GPS Datum Model
2014-075	0062_20140316_110054_celtic_explorer	00:54.8	00:53.8	59:59.0	293.701	7090.055	1.97	GPS Datum Model
2014-075	0063_20140316_120054_celtic_explorer	00:54.8	00:53.8	59:59.0	325.28	8245.795	2.2911	GPS Datum Model
2014-075	0064_20140316_130054_celtic_explorer	00:54.8	00:53.8	59:59.0	266.731	8035.675	2.2328	GPS Datum Model
2014-075	0065_20140316_140054_celtic_explorer	00:54.8	00:53.8	59:59.0	267.106	8036.116	2.2329	GPS Datum Model
2014-075	0066_20140316_150054_celtic_explorer	00:54.8	00:53.8	59:59.0	259.563	8069.431	2.2421	GPS Datum Model
2014-075	0067_20140316_160054_celtic_explorer	00:54.8	00:53.8	59:59.0	141.339	9585.851	2.6635	GPS Datum Model
2014-075	0068_20140316_170054_celtic_explorer	00:54.8	00:53.8	59:59.0	147.949	8984.492	2.4964	GPS Datum Model
2014-075	0069_20140316_180054_celtic_explorer	00:54.8	00:53.8	59:59.0	152.369	8840.686	2.4564	GPS Datum Model
2014-075	0070_20140316_190054_celtic_explorer	00:54.8	15:25.8	14:31.0	152.746	2160.038	2.48	GPS Datum Model
2014-076	0071_20140317_092240_celtic_explorer	22:40.8	22:39.8	59:59.0	331.012	10491.83	2.9152	GPS Datum Model

Day	*Line*	*Min Time*	*Max Time*	*Total Time*	*Heading*	*Length*	*Speed*	*Tide Applied*
2014-076	0072_20140317_102240_celtic_explorer	22:40.8	22:39.8	59:59.0	306.405	6100.762	1.6951	GPS Datum Model
2014-076	0073_20140317_112240_celtic_explorer	22:40.8	38:51.8	16:11.0	110.594	2195.466	2.261	GPS Datum Model
2014-076	0073_20140317_114405_celtic_explorer	44:05.8	44:04.8	59:59.0	116.357	8302.446	2.3069	GPS Datum Model
2014-076	0074_20140317_124405_celtic_explorer	44:05.8	44:04.8	59:59.0	113.656	8408.241	2.3363	GPS Datum Model
2014-076	0075_20140317_134405_celtic_explorer	44:05.8	18:37.8	34:32.0	116.241	4640.444	2.2396	GPS Datum Model
2014-076	0076_20140317_141838_celtic_explorer	18:38.8	18:37.8	59:59.0	255.609	6760.882	1.8785	GPS Datum Model
2014-076	0077_20140317_151838_celtic_explorer	18:38.8	14:27.8	55:49.0	254.857	7451.469	2.225	GPS Datum Model
2014-076	0078_20140317_192933_celtic_explorer	29:33.8	29:37.8	00:04.0	254.762	8936.687	2.4797	GPS Datum Model
2014-076	0079_20140317_202938_celtic_explorer	29:38.8	12:43.8	43:05.0	254.049	5763.254	2.2295	GPS Datum Model
2014-076	0080_20140317_211658_celtic_explorer	16:58.8	17:02.8	00:04.0	45.736	17966.39	4.9851	GPS Datum Model
2014-076	0081_20140317_221703_celtic_explorer	17:03.8	16:57.8	59:54.0	47.804	17532.06	4.8781	GPS Datum Model
2014-076	0082_20140317_231658_celtic_explorer	16:58.8	01:10.8	44:12.0	53.128	13203.56	4.9787	GPS Datum Model

Appendix IV

Box core descriptions

PORCUPINE BANK CANYON MOUNDS (ON-MOUND) CE 14004 - 18BC

Fig. 1

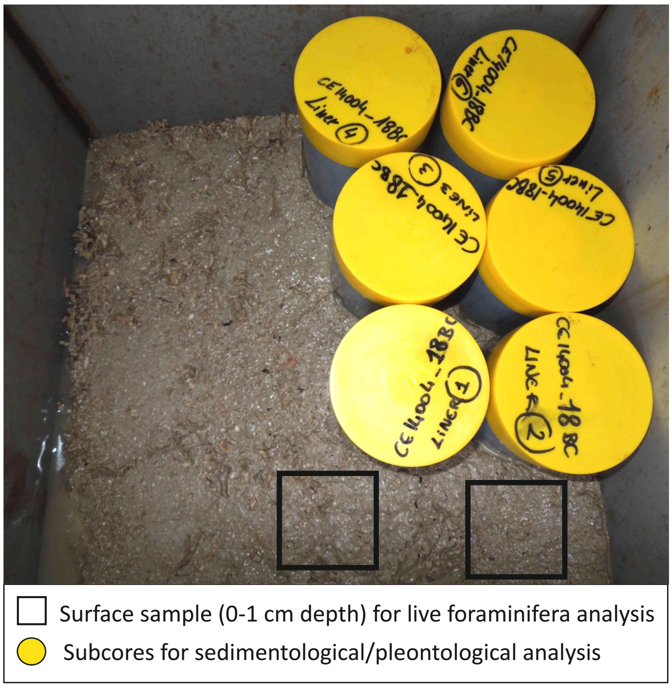


Fig. 2

Fig. 3

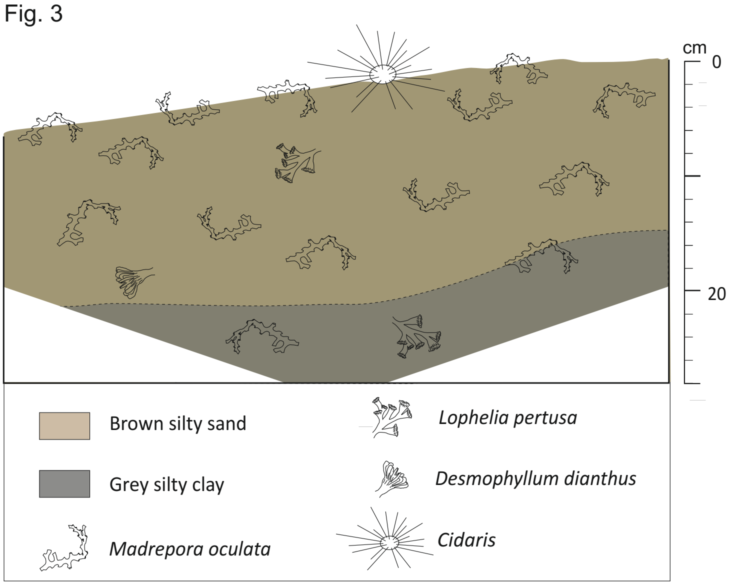


Fig. 4

On board processing

After the water was siphoned, the box-core surface was photographed and the live macrofauna collected and preserved in ethanol 70%. For the purpose of sedimentological, macro- and micropalentological studies, six 10 cm diameter liners were pushed to the bottom of the box-core (Figs. 2-3) and two subsamples (7x7 cm^2) were removed from the surface layer. The remnant sediment was split in four parts (0-2 cm, 2-7 cm, 7-12 cm, 12 cm-base) and sieved using 2mm, 1mm, 0.5 mm sieves.

Description

Surface (Figs. 1-2)**:** Slightly inclined, consisting of silty sand and coral fragments. Corals are concentrated on one side (black arrow in Fig. 1), due to the movement of the box-corer during retrieval, and mostly cinsist of *Madrepora*, rare *Lophelia* and *Desmophyllum*. Coral fragments are heavily bioeroded and slightly stained by Fe-Mn oxides. Other bioclasts include bivalves, tiny gastropods, echinoderm spines and plates, rare pteropods, brachiopods, serpulids and bryozoans. The living fauna consists of both mobile (cidarids, Fig. 5, munidids, Fig. 6, decapods, polychaetes, ophiuroids) and sessile (mostly Arcidae bivalves, sponges, bryozoans, scyphozoans, hydroids, tunicates) organisms.

Vertical section: Coral rubble along the entire section, embedded in brownish silty sand (in the upper 20 cm) evolving into grey silty clay toward the bottom. The dominant coral is *M. oculata*, *Lophelia* fragments and *Caryophyllia* specimens can be found below 5 cm sediment depth.

Fig. 5

Fig. 6

PORCUPINE BANK CANYON MOUNDS (ON-MOUND) CE 14004 - 32BC

☐ Surface sample (0-1 cm depth) for live foraminifera analysis

Fig. 7

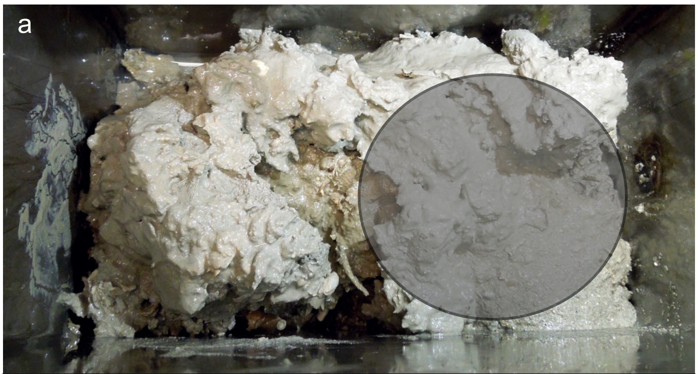
On board processing

The box-core surface was photographed and the live macrofauna collected and preserved in ethanol 70%. For the purpose of micropalentological studies, one subsample (7x7 cm^2; Fig. 7) was collected from the surface layer. The remnant sediment was sieved using 63 micron sieve.

Description

The collected sediment, only 2 cm thick, consists of coral rubble in coarse muddy sand. Most corals (*Lophelia, Madrepora, Pliobothrus*) are bioeroded and slightly stained by Fe-Mn oxides. Other bioclasts include bivalves, tiny gastropods, echinoderm spines and plates, rare pteropods, brachiopods, serpulids and bryozoans. Foraminifera are very common and some miliolids are up to 2 mm in size. One *Lophelia* fragment is embedded in a hardground piece with a matrix made of foram grainstone and mudstone. The living macrofauna consists of only mobile polychaetes and ophiuroids.

PORCUPINE BANK CANYON MOUNDS (ON-MOUND) CE 14004 - 33BC



● Subcores for sedimentological/paleontological analysis

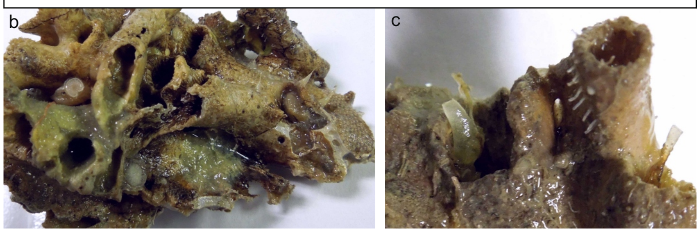


Fig. 8a-c

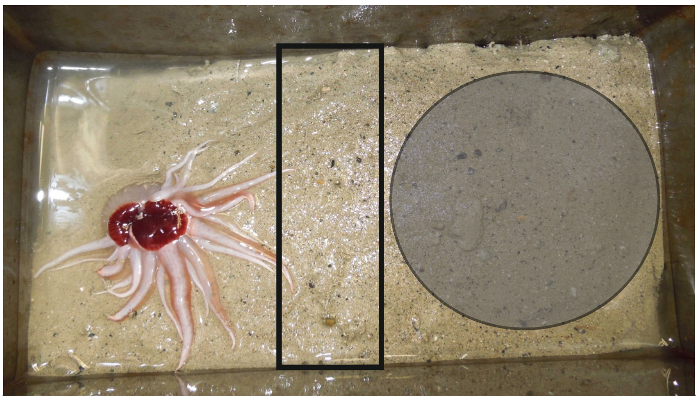
On board processing

The box-core surface was disturbed during retrieval. After photographing, the live macrofauna was collected from the sample surface and preserved in 70% ethanol. For the purpose of sedimentological and paleontological studies, one liner (7 cm in diameter; Fig. 8a) was pushed to the bottom of the box-core. The disturbed surface layer was removed and put aside. Both this layer and the remnant sediment were sieved using 2 mm, 1 mm and 0.5 mm sieves. The living fauna was extracted from the upper layer (0-2cm) and the lower layer (2-8 cm) separately.

Description

The collected sample, up to 8 cm thick, consists of coral rubble and muddy sand. Most corals (*Lophelia, Madrepora, Desmophyllum,* tiny *Stylaster*) are bioeroded and slightly stained by Fe-Mn oxides. Other bioclasts include bivalves, tiny gastropods, echinoderm spines and plates, brachiopods, serpulids and reteporiform bryozoans. Large foraminifera are less common than in sample BC_32, but some specimens of *Hyrrokkin sarcophaga* can reach up to 2 mm in size. The living macrofauna consists of mobile (polychaetes, ophiuroids) and sessile (Fig. 8b: encrusting and boring sponges, bryozoans; Fig. 8c: hydrozoans, scyphozoans, tunicates; bivalves) organisms colonising coral fragments.

PORCUPINE BANK CANYON MOUNDS (OFF-MOUND) CE 14004 - 35BC



☐ Surface sample (0-1 cm depth) for live foraminifera analysis

● Subcores for sedimentological/paleontological analysis

Fig. 9

On board processing

After siphoning the water and photographing the box-core surface, the sea anemone (Fig. 9) was collected and preserved in 70% ethanol. For the purpose of sedimentological and macro- and micropaleontological studies, one liner (7 cm in diameter) was pushed to the bottom of the box-core and a subsample (10x2 cm) was collected from the core surface. The upper 2 cm of sediment was sieved using a 63 micron sieve. The remaining sediment was split in two portions (2-10 cm, 10-15 cm) and sieved using 2 mm, 1 mm and 0.5 mm sieves. Part of the 10-15 cm layer was sieved with a 63 micron sieve.

Description

The collected sample, up to 15 cm thick, consists of foraminiferal sand. The living macrofauna consists of a sea anemone and an infaunal bivalve.

Appendix V

Marine mammal observer report

Marine Mammal Observer Report

R.V. Celtic Explorer

CE14004

West of Ireland Coring Programme (WICPro)

Western Continental Shelf, Porcupine Bank and Porcupine Seabight

06th - 18th March 2014

MMO: Marian McGrath

Contents

1.0 Introduction

Ireland’s Exclusive Economic Zone (EEZ) has one of the most important marine mammal habitats in Europe. All marine mammal species in Irish waters are protected by the 1976 wildlife act (and wildlife amendment act 2000). The Habitats Directive applies within Ireland's 200 nautical mile limit for the protection of species and the continental Shelf for habitats (Arts, Heritage and the Gaeltacht, 2014). The National parks and Wildlife Service (NPWS) has set aside Special Areas of Conservation (SACs) and Special Protected Areas (SPAs) under this wildlife act to ensure no operations can take place in areas where an abundance of marine mammals are present. Such operations include seismic surveys, multi-beam and side-scan sonar which have been set aside in a code of practice published by the NPWS (Anon. 2007).

A comprehensive review of Irish cold water coral reefs was undertaken in 2003 by the National Parks and Wildlife Service of the Department of the Environment, Heritage and Local Government and the Marine Institute. The purpose of the review was to identify representative sites that were suitable for designation and protection. The conclusion of the review in 2005 was that four sites were to be regarded as biogenic forms of the Annex 1 habitat Reefs and set aside as SACs. These are: the North-West Porcupine Bank, the South-West Porcupine Bank, the Hovland Mound Province and the Belgica Mound Province. These cover over 2,500 km2 within the Irish EEZ (Department of the Environment, Heritage and Local Government, 2006).

Marine Mammal Observers (MMO) are required by law to be aboard any vessel which is carrying out seismic surveys within Irish waters. It has been recognised that the sound generated by seismic sources has the potential to cause both disturbance and injury to marine mammals (JNCC, 2010). The minimum acoustic source level to achieve the desired results should be used. In unprotected areas an MMO is required to carry out a 30 minute pre seismic watch followed by a 30 minute watch during the soft start. In coral reef areas which fall within SACs the MMO has to the survey the area for 60 minutes before the soft start begins. If marine mammals are seen within 2000 metres of the centre of the sound source then the sound source should be delayed until they have moved away, allowing adequate time after the last sighting for the animals to leave the area (60 minutes). If marine mammals do not leave the area then the vessel has to alter its course to ensure the animals are not within the 2000 metre exclusion zone. Soft starts should then achieve the maximum or desired output after 40 to 60 minutes.

2.0 Date & Location of Survey

06th to 18th March 2014

Western Continental Shelf, Porcupine Basin and Porcupine Seabight

3.0 Survey Vessel

R.V Celtic Explorer

4.0 Marine Mammal Observers/Qualifications

Qualified MMO: Marian McGrath

Casual Observations: Bridge and deck crew

5.0 Survey Areas

This survey was undertaken to provide core material and data to support a broad range of ongoing scientific endeavours. These include:

- Studying environmental records from cold-water coral reefs
- Studying the history of glaciomarine deposition from the Porcupine Bank flank
- Studying ice limits and glacial processes on the western shelf

Three key target areas are identified where the retrieval of core material and seismic data was undertaken in pursuit of the above objectives. The cruise was delayed for four days in Bantry Bay due to bad weather at the start of the survey so some test seismic lines were run in the bay also. The survey sites are shown below (Figure 1, 2, 3, 4,5 & 6).

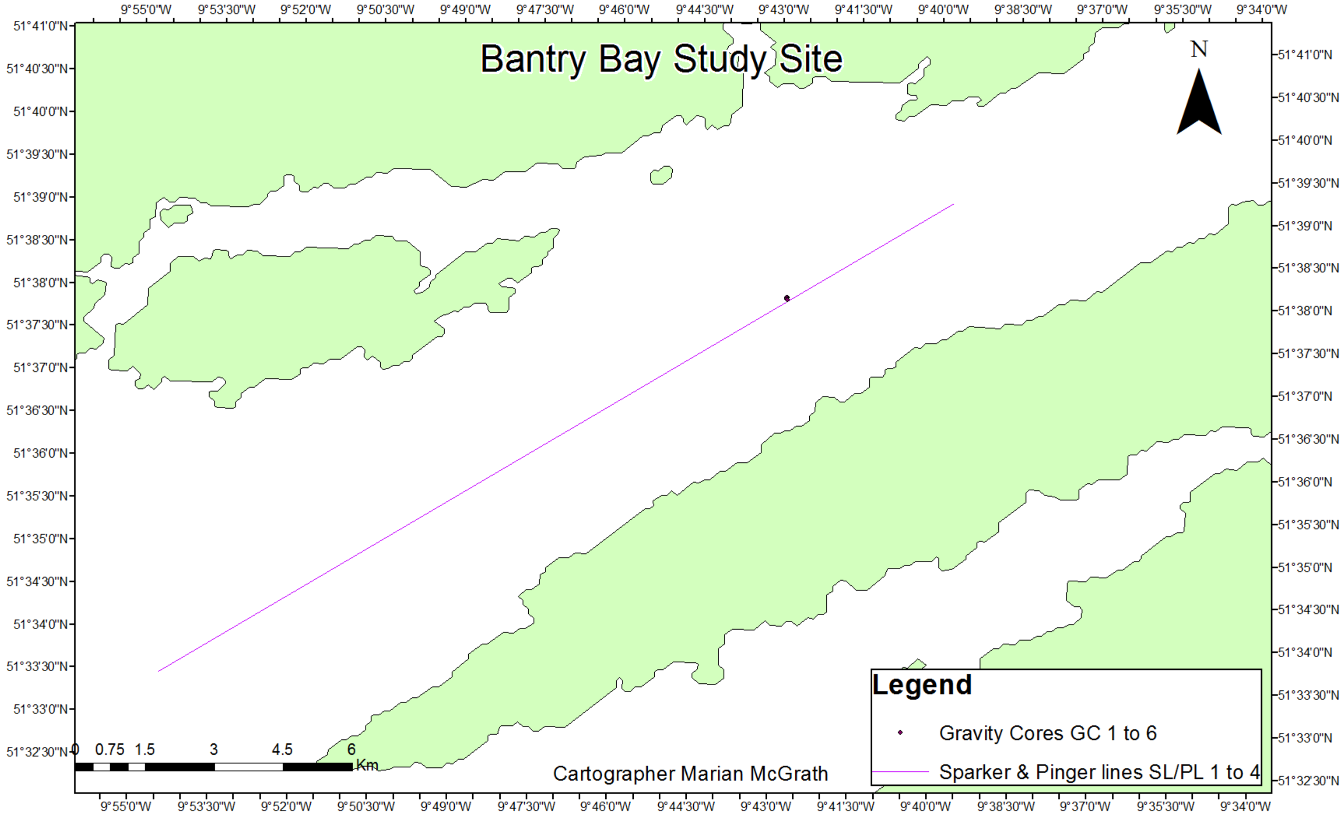


Figure 1. Seismic Lines and cores collected in Bantry Bay during bad weather down time

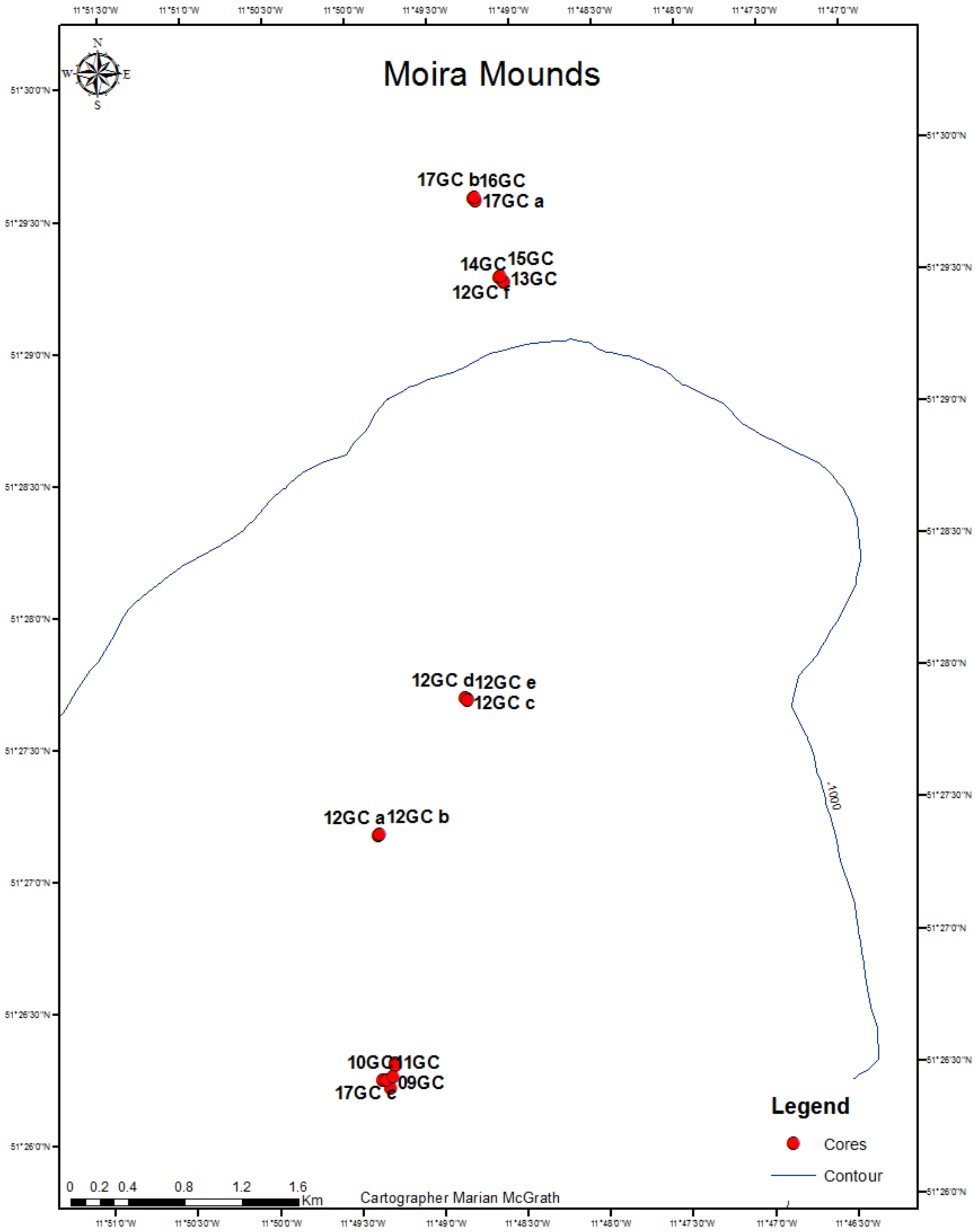


Figure 2. Cores collected from the Moira Mounds, Belgica Mound Province, Eastern Porcupine Seabight.

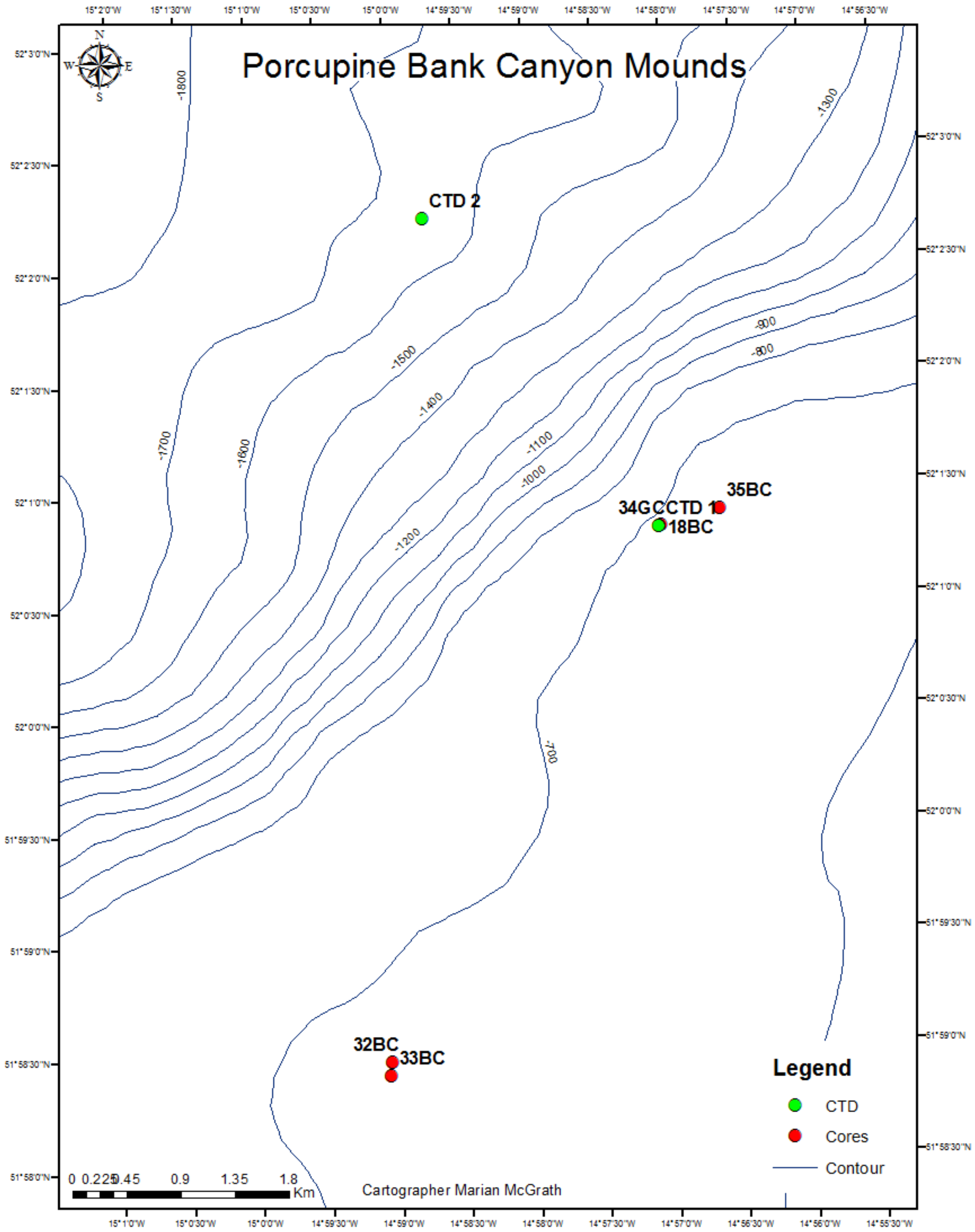


Figure 3. Cores collected from the Porcupine Bank Canyon Mounds

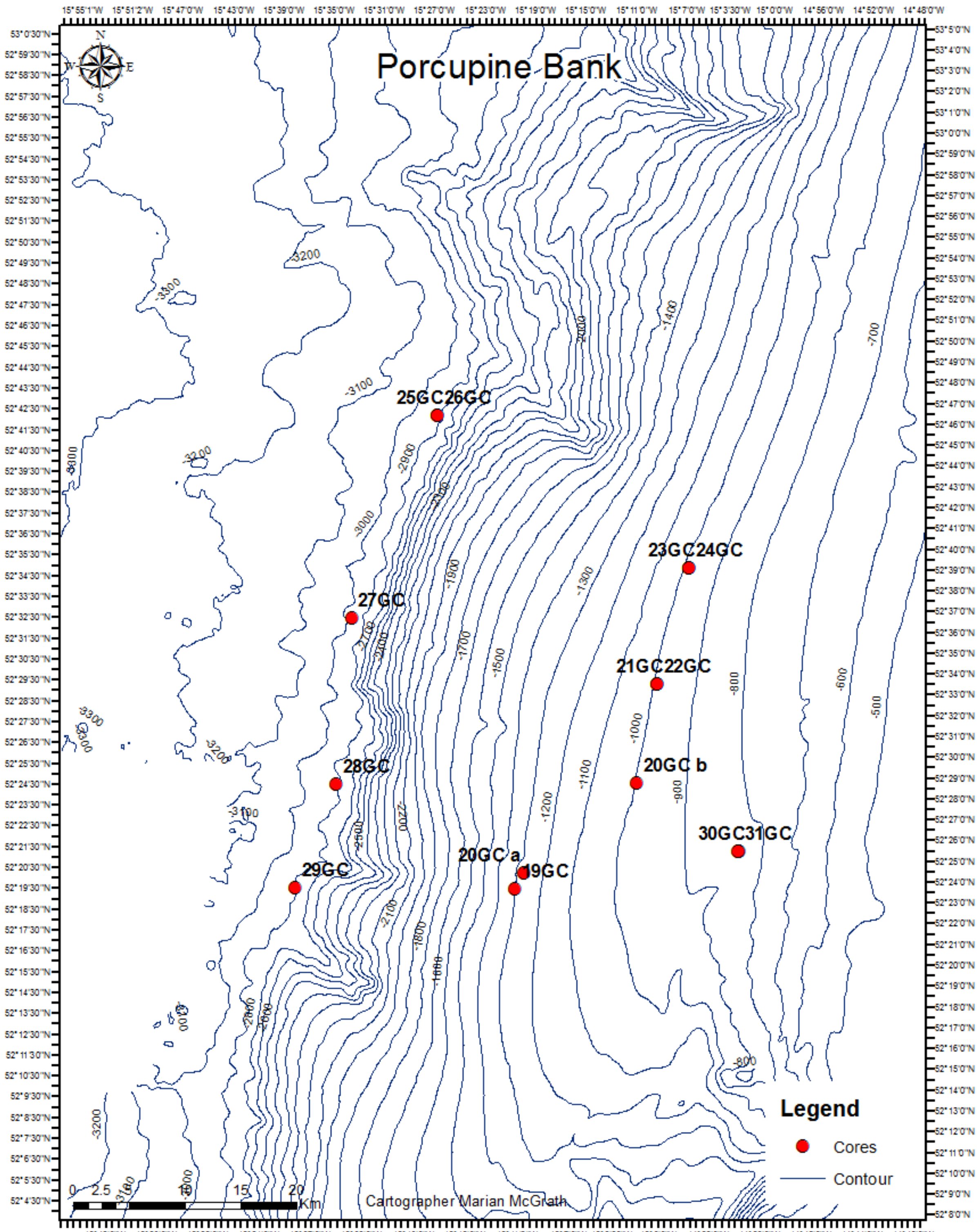


Figure 4. Cores collected from the Porcupine Bank

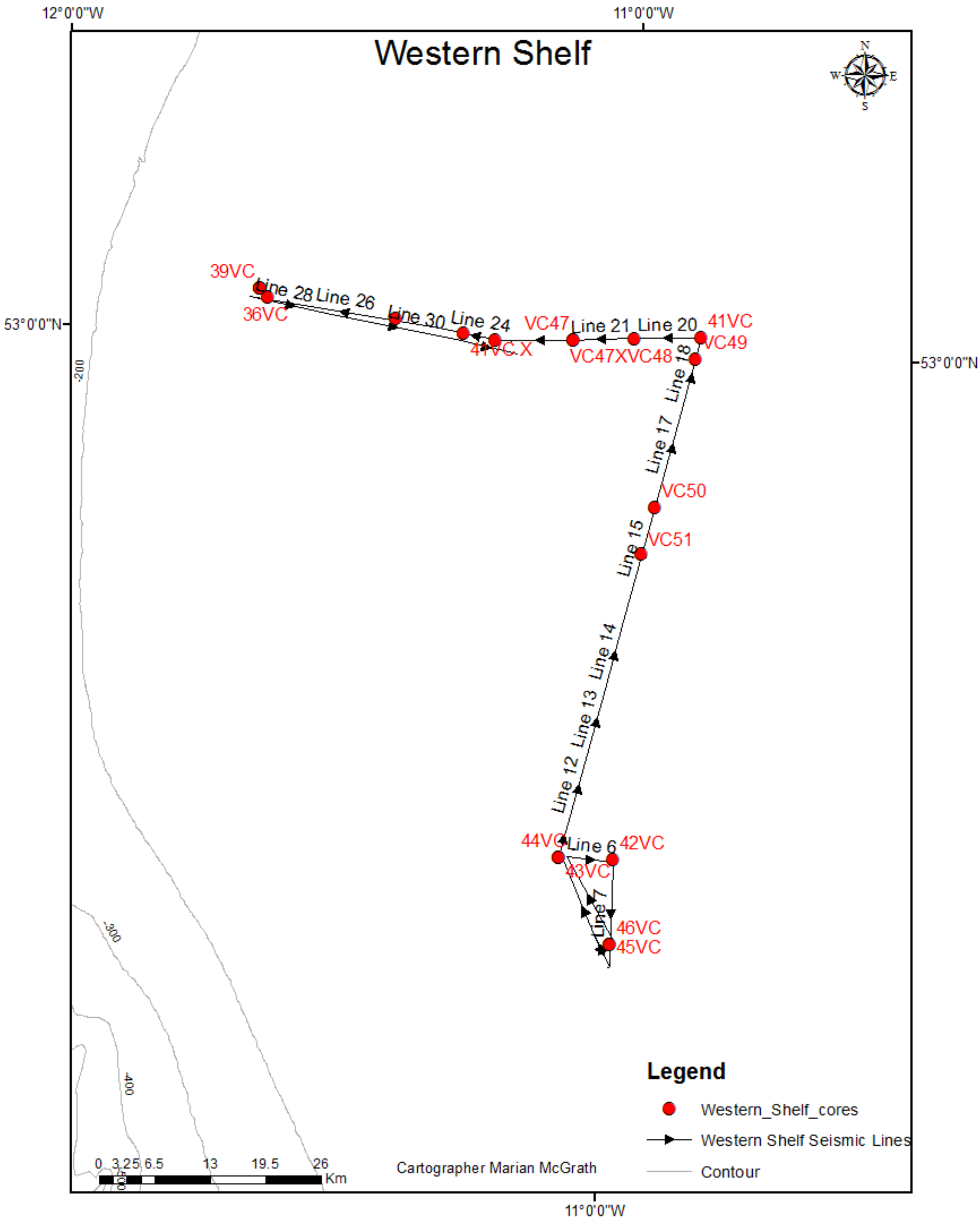


Figure 5. Cores and Seismic Lines collected from the Western Shelf

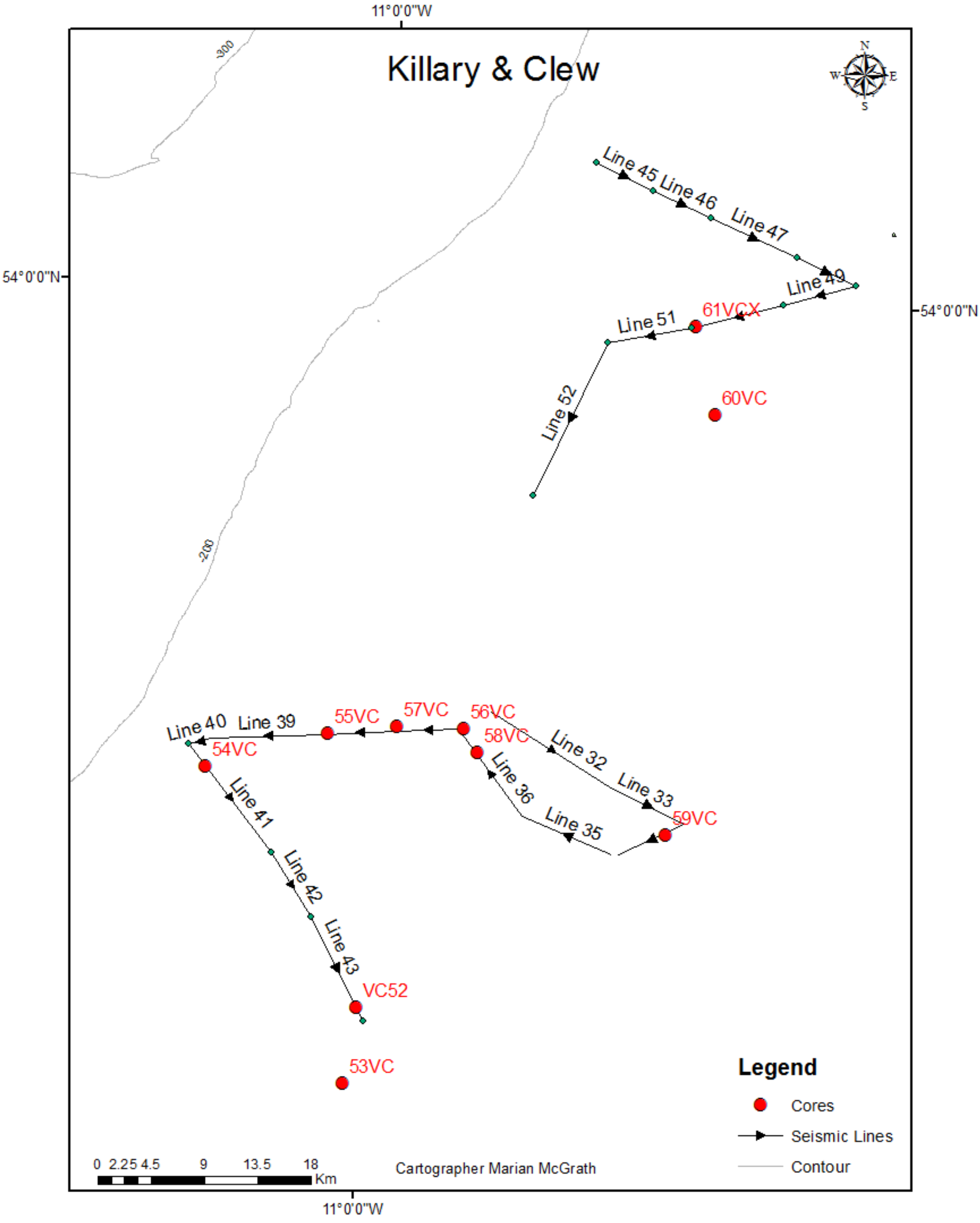


Figure 6. Cores and Seismic Lines collected from the Killary and Clew area

6.0 Equipment

Research vessel - RV Celtic Explorer

The Celtic Explorer is a 65.5 m multi-purpose research vessel (Figure 7). The vessel has wet, dry and chemical laboratories, which are permanently fitted with standard scientific equipment 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 Celtic Explorer is equipped with two Trimble 300-D GPS and has Dynamic Positioning.

On the aft deck is a 25 tonne A-frame with 4m outward and inward reach in addition to a 3m, 10 tonne starboard T-frame. The ship also comprises of a midship, forward and aft crane as well as a 6 tonne CTD winch.

Figure 7. RV Celtic Explorer

Geo-Source 400 sparker seismic system

The Geo-Source 400 sparker seismic system of the Marine Institute was used during the survey (Figure 8). This sparker seismic system consists of the Geo-Spark 6 kJ pulsed power supply which emits a pulse to the sparker source which is towed behind the vessel. The source comprises four electrode modules that are evenly spaced in a planar array. The return signal is picked up in Geo-Sense single channel hydrophone array. The system provides high resolution (<30cm) seismic profiles of the Shallow sub-bottom strata. The device achieves this level of accuracy due to its multi-tip array of sparker nodes, which are evenly spaced and set in-phase producing a very strong downward projection of acoustic energy. The system is designed to be towed on or just below the water-surface. High resolution seismic profiles of up to 300m depth can be imaged using the Geo-Spark 200 depending on the composition of the water column, sea conditions and the nature of the underlying geology.

Figure 7. Sparker Seismic System

Hull mounted ESE 5001S 3.5 kHz pinger system

The Sonar Equipment Services Ltd Probe 5001S 3.5 kHz sub-bottom profiler comprises of a surface processor and a sub-surface transceiver. The processor is set up for 16 transducers (4 X 4 array). The transducers are located in starboard mid sea water ballast tank. Output Power is up to 10KW at an operating frequency of 3.5 to 9.0 kHz. Maximum repetition rate is 10Hz The system is triggered from a CODA DA2000.

7.0 Marine Mammal Observations

Marine mammal observations were carried out from the bridge. This gave the best view point of both sides and in front of the vessel. Prior to commencement of the acoustic survey in SACs a 60 minute watch was carried out in SACs and in non SACs a 30 minute watch was carried out. Weather conditions were favourable during MMO watches.

Observations were undertaken using a reticular binoculars and also by the naked eye. Distance to marine mammals is determined using this reticular binoculars and height above sea level. To determine the range one of the divisions present in the binoculars is placed on the horizon. A formula is then used to determine the distance of the mammal from the ship. The formula is:

Distance (m) = (height of eye above sea level (m) x 1000/ no. of mils down from horizon)

No marine mammals were spotted during this survey.

8.0 Pre-Shoot Searches

As detailed in the NPWS code of Practice, a 30 minute watch was carried out in non SACs and a 60 minute watch in SACs prior to shooting the Sparker for mammals within 2000m range of the equipment. If marine mammals were spotted within this area, Sparker would have to be halted for a certain period of time or the vessel would have to move to a different area of the survey. If no marine mammals were seen within the watch time then a soft start would commence. A Sparker soft start was carried out each time the acoustic equipment was switched on.

A normal soft start comprises of a ramp up of source power of acoustic emission over at least 30 minutes until full power is reached. The Sparker was stopped during transit between study areas so soft starts were carried out each time it was re-started. The Sparker was always started during daylight hours to allow for MMO watches to be carried out prior to soft starts. The MMO watch was continued till the Sparker reached full power. Watches do not need to be carried out once the Sparker is already operating on full power. Throughout the duration of this survey no marine mammals were seen during the watches prior to the soft starts.

9.0 References

Anon. 2007. Code of Practice for the Protection of Marine Mammals during Acoustic Seafloor Surveys in Irish Waters. National Parks and Wildlife Service.

JNCC. 2010. Joint Nature Conservation Committee guidelines for minimising the risk of disturbance and injury to marine mammals from seismic surveys.

Arts, heritage and the Gaeltacht. 2014. Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters.

Department of the Environment, Heritage and Local Government. 2006. Code of Practice for Marine Scientific Research at Irish Coral Reef Special Areas of Conservation.

Record of Operations Forms

MARINE MAMMAL RECORDING FORM - RECORD OF OPERATIONS

Ship: RV Celtic Explorer **Client:** UCC **Seismic Contractor:** UCC **PAD No:** N/A

Complete this form every time the airguns are used, including overnight, whether for shooting a line or for testing or for any other purpose.
(Times should be in GMT)

Once the Sparker was started it was kept running during transit between short lines. It was turned off during longer transits and an MMO watch was carried out before each re-start

Date	**Seismic activity**						**Pre-shooting search**					**Action necessary**		
	Time when soft start began	**Time when airguns reached full power**	**Time of start of line**	**Time of end of line**	**Time output reduced to 150 dB (if relevant)**	**Time when airguns stopped**	**Who carried out a search for marine mammals? (Job title)**	**Time when pre-shooting search for marine mammals began**	**Time when search for marine mammals ended**	**Was there any reason why marine mammals may not have been seen? (e.g. dark, fog, swell, etc.)**	**Were hydro-phones used?**	**Were marine mammals present before the airguns began firing?**	**If yes, give time when marine mammals were last seen**	**If marine mammals were present, what action was taken? (e.g. delay shooting)**
07/03/2014	15.00	15.30	15.42	17.03		17.03	MMO	13.30	16.00	No	Yes	No		
08/03/2014	12.22	12.52	12.45	15.18		15.18	MMO	11.30	12.52	No	Yes	No		
14/03/2014	12.53	13.23	13.33	12.53 15/03/14		12.53 15/03/14	MMO	11.15	13.23	No	Yes	No		
16/03/2014	07.20	07.50	07.39	18.58		18.58	MMO	06.30	07.50	No	Yes	No		
17/03/2014	10.20	11.10	11.20	15.54		15.54	MMO	09.30	11.10	No	Yes	No		