Rockall-North Channel MESH Geophysical Survey, *RRS Charles Darwin* Cruise CD174, BGS Project 05/05 Operations Report

Marine, Coastal and Hydrocarbons Programme

Internal Report IR/05/132

BRITISH GEOLOGICAL SURVEY

MARINE, COASTAL AND HYDROCARBONS PROGRAMME

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Foreword

This report covers the operation of *RRS Charles Darwin* cruise CD174, BGS Project 05/05, a regional geophysical survey in the Rockall Trough area, carried out from 11th August to 8th September 2005. This field operation was planned and executed as part of the BGS Marine, Coastal and Hydrocarbon Programme. It also contributed to MESH (Mapping European Seabed Habitats, a European Union Interreg IIIb project).

Acknowledgements

Any offshore programme is a team effort, with each and every person playing their full part in the continuous 24-hour operations. A full list of the BGS personnel taking part is included in the report and their contribution to the success of the operations is acknowledged. Grateful thanks are also due to Capt. Philip Gauld, the crew of RRS Charles Darwin and the technical support provided by the Research Ship Unit and NOCS UKORS.

Mr Thomas Furey (Marine Institute, Eire), Mr Matthew Owen (post-graduate student) and Mr Ewan Wakefield (cetacean and bird observer) also took part and contributed to the success of the cruise.

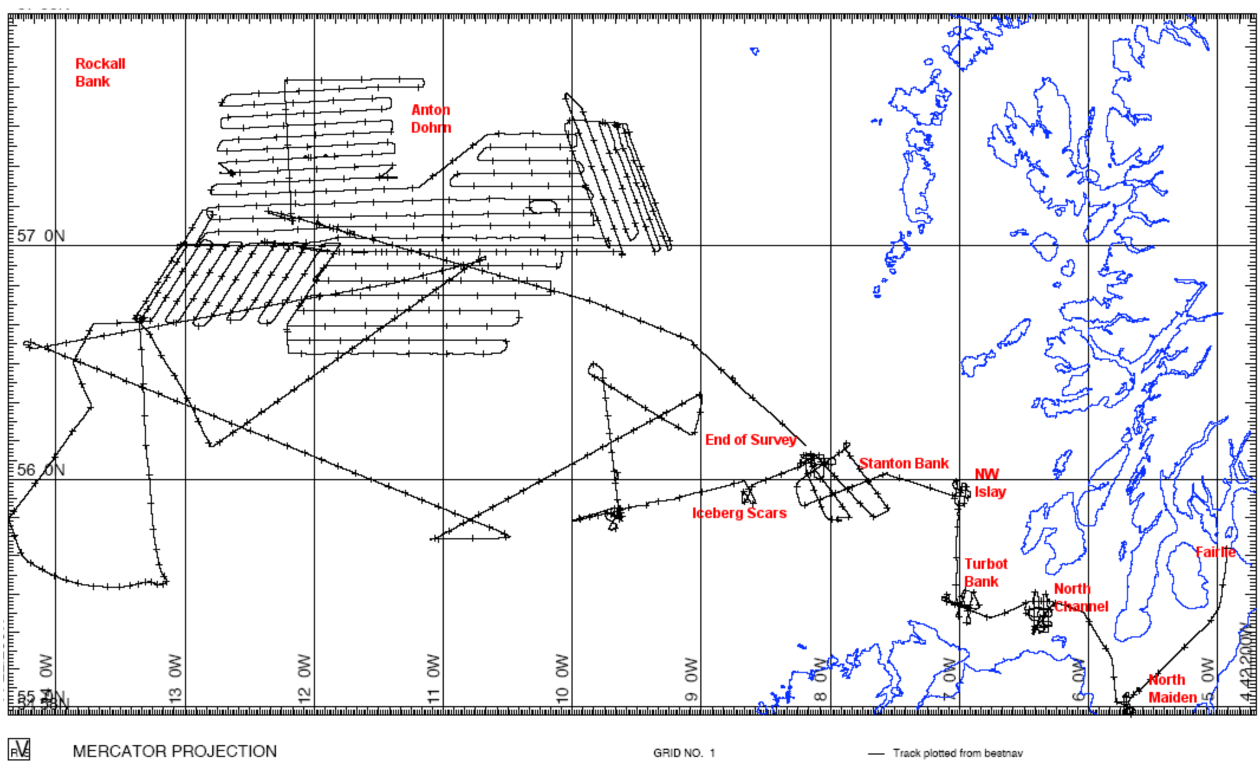
Contents

Summary

This report describes the operation of the Charles Darwin Cruise CD174, BGS Project 05/05, carried out during August and early September 2005, as part of the Mapping European Seabed Habitats (MESH) survey off the west coast of Scotland. The area surveyed was in UK and Irish waters and lies between 55° 50' and 57° 50' North and between 8° and 14° West. This work was planned to integrate with existing UK, Irish and French multibeam data and also with multibeam data collected July-August 2005 during the UK Department of Trade and Industry (DTI) Strategic Environmental Assessment Surveys (SEAS) in the Rockall Trough.

The first week was focused on subsea structures in shallower waters and utilised surface tow sparker and boomer. The following three weeks were in much deeper water using BGS airgun and the EM12 swath bathymetry system mounted on the *RRS Charles Darwin*. Some of the work was in Irish waters, thus allowing the Irish and British datasets to be joined together at the median line. Gravity and magnetic data were also collected, with UKORS LaCoste and Romberg S40 marine gravity meter and BGS L&R S75 marine gravity meter, allowing comparison between the two meters at sea.

Summary Track Plot



1 Introduction

The vessel mobilised at Fairlie on the Ayrshire coast, just south of Largs on 9th/10th August and sailed on 11th August. The first part of the survey with surface tow sparker and boomer took just under one week and then the vessel proceeded north and west towards the Rockall Bank. The second part of the survey consisted of a small (4 X 40 cubic inch) single channel airgun survey in Irish waters, allowing their sub-seabed data and ours to be linked, followed by extensive swath bathymetry (hull-mounted Simrad EM12) in the Rockall Trough. Previous swath survey data from a multitude of sources had left large gaps in the overall data set and this survey was in order to join together the various isolated segments of data.

All times used in this report are GMT

2 Narrative

2.1 GRAVITY

A marine gravity meter (LaCoste and Romberg S40) was provided by UKORS allowing the opportunity for BGS to run their own marine gravity meter (L&R S75) simultaneously during the survey. This has enabled BGS to confirm that their recently refurbished meter may be used with confidence as to correct operation on future cruises.

The initial Base-tie readings were taken at 0850 on the 11th of August, immediately prior to the vessel departing Fairlie. The concluding base-tie readings were taken at 1120 on the 8th September. The Base Station reading for the Fairlie Jetty has been established for previous cruises, in particular D273 on *RRS Discovery* in August 2003.

11/08/05	0840 GMT	LaCoste and Romberg S40 Corrected Base	1454.94Units
11/08/05	0840 GMT	LaCoste and Romberg S75 Corrected Base	12314.94Units
Fairlie Jetty Corrected Base Value			981581.06mGal
08/09/05	1120 GMT	LaCoste and Romberg S40 Corrected Base	1455.50Units
08/09/05	1120 GMT	LaCoste and Romberg S75 Base Reading	12310.80Units
Fairlie Jetty Uncorrected Base value			9815780.91mGal

These show a drift of less than 1mGal for S40 and a drift of 4.1mGal for S75. Over a 4-week period this is thought to be well within acceptable values. The base-tie forms are shown in the appendices complete with the measurements taken at the time.

2.2 MESH HABITAT SURVEY

The vessel sailed from Fairlie at 0915 and immediate preparations were made to run the first lines, which were some 4 hours steaming from the port.

At roughly 15 kilometres from the first line, in the North Maidens area, the vessel slowed down to allow the initial deployment of the boomer and sparker complete with their hydrophones. At this stage we were not going to deploy the magnetometer as the water depths were expected to be less than the tow depth. At this time the Precision Echosounder (PES) and the 3.5kHz Pinger were also deployed and switched on.

Both the boomer and sparker were using Teledyne 7 channel streamers, using only the central channels as the water depth precluded having a large horizontal spread on the data.

Immediately after switching on the HV unit, arcing was heard and seen between the container housing the HV power supplies and the deck. After some investigation, earthing the outside of the container to a deck bolt cured this. (In future the outside of the container should be bonded to the large earth copper strip inside the container.) The first four lines were run, cutting one short due to extremely shallow water, before it was discovered that owing to a 'mis-trigger' on the recording equipment, no boomer data had been recorded. The data recorded were sparker source run through the boomer hydrophone and filters. This was corrected for all subsequent lines. North Maiden area was covered with lines 1 to 4.

After leaving the North Maiden area the vessel proceeded to an area in the North Channel where further sparker and boomer lines were run. At this area it was found that running the sparker HV power supply over its rated capacity caused it to shut down while it could cool down again. This resulted in some data loss as the fault was difficult to trace and it took some hours before the power supply had cooled down sufficiently to give uninterrupted operation. Meantime the sparker and boomer HV units had been exchanged and most of the data loss was confined to the boomer, before the power supply had cooled down again. North Channel was surveyed with lines 5 to 16.

The next area surveyed was at Turbot Bank. During this part of the survey there were problems with an internal oil leak from the main engine and all gear was recovered on two separate occasions. The first was when the ship's engineers put the vessel onto an auxiliary engine to allow repairs to be made and the second when they returned the vessel to main engine power. During the changeover process it was thought possible that total power loss might occur and having all gear inboard was considered the safest option. In fact everything went as planned and it is estimated that around 1 hour of survey time was lost due to this. The Turbot Bank area was surveyed by lines 17 to 21.

The survey then moved to the north west of Islay and consisted of 5 lines in a simple grid. Due to a long swell from the NW the boomer data are poor in this area and, particularly on line 25, the following swell made the whole towing configuration difficult to control. NW Islay was surveyed by lines 22 to 26.

The next survey area was at Stanton Bank where a more complex series of lines, with some particularly shallow parts, were surveyed with boomer and sparker. As the next area (Iceberg Ploughmark) was fairly close to the Stanton Bank it was decided to link the two together with an extended line. However, immediately after completing the Stanton Bank work, all towed gear were recovered and the vessel brought to a complete halt in 140metres water depth to run the first sound velocity (SV) dip. This then allowed the Simrad EM12 multibeam bathymetry system to be run, as water depths prior to this time were considered too shallow for reliable data from the EM12. Stanton Bank was surveyed by lines 27 to 36.

Following the SV dip, the boomer and sparker were redeployed and line 37 started on Stanton Bank, with the intention of running it right through to the Iceberg Ploughmark area, doglegging onto the first line at Iceberg Ploughmark. The magnetometer was deployed for the first time on this line and the EM12 was run with a view to getting a feel for the operation of this multibeam equipment. BGS experience of swath bathymetry was fairly limited and it was felt prudent to gain some experience prior to using it 'in anger' during the latter part of the cruise. The Iceberg Ploughmark area is surveyed by lines 37 to 39.

Approaching midnight on the 16th August all the gear was recovered at the end of line 39, completing the first part of the cruise; surveying in shallower water.

2.3 AIRGUN LINES IN IRISH WATERS.

From midnight on 17th August, the weather having increased to force 7, the vessel was waiting on weather until first light. Proceeding slowly towards the next SV dip location, the vessel hove-to at 0710 and the SV probe deployed. Two hours later, the SV data having been entered into the EM12, course was set for the first airgun line, running the EM12 as we steamed in order to acquire some preliminary multibeam bathymetry.

From 1800 on the 17th August until about 1200 on the 22nd August, lines 40 to 46 were run across the boundary with the Irish sector. These lines were run with airgun and sparker, using the best Teledyne streamer (hydrophone) for the sparker and the new SIG streamer for the airgun. During this part of the survey, where data acquired were to be shared with the Irish, it was demonstrated beyond doubt that the new SIG streamer was significantly better than the older Géoméchanique streamers used by BGS in the past. Part of line 44 was run with both Géoméchanique and SIG streamers deployed, the water depth being too great for the sparker and this allowed a direct comparison between the two hydrophones.

There were initially some problems with the airgun compressors, notably concerning the unloader valve diaphragm and the rating of power cabling from the ship's supply. However these problems were dealt with during line 40 and the early part of line 44, losing about 1½ hours to repairs (but without data loss) in the process.

2.4 SWATH BATHYMETRY

Following the end of line 46 the vessel steamed to the proposed start of the swath bathymetry survey area and carried out an initial SV dip at 1930 hrs on 22nd August in worsening weather. The first swath lines using the EM12 multibeam equipment in fresh unsurveyed areas lasted only 8 hours at the start of 23rd August. Faced with a very poor forecast, the decision was made to recover the magnetometer and head south to try to avoid the worst of the approaching storm. In fact observed wind speeds rarely exceeded 50knots on the vessel and by midday on 24th August the wind had dropped sufficiently to allow some progress back towards the survey area.

The main object of the swath survey was to integrate with existing areas of swath data, principally between work done by the *Kommandor Jack* for the DTI on the Rockall Bank and Anton Dohrn Seamount, work carried out by IFREMER around the Hebrides Terrace and at the southern limit, the Irish/UK territorial boundary, the recently completed Irish swath survey of their waters. Tracks were planned to secure at least 20% overlap and to allow for 10-15 minutes for the motion sensors to settle following vessel turns onto existing and new tracks.

At 2200 hrs on the 24th August the magnetometer was redeployed and swath recommenced on the southeastern slope of the Rockall bank.

Swath was then run more-or-less continuously until 6th September. There were interruptions to this routine, notably during the evening of 28th September and the following morning when the weather increased to a force 9 and the vessel was hove-to for about 15 hours. The swath system could normally acquire data in rougher weather than was the norm for traditional seismic systems and it could also operate at speeds up to 10 knots. This allowed a much greater rate of data acquisition than had been expected.

In order to allow the onboard processing to be carried out without undue effort, the swath survey area was sub-divided and each area run as a separate unit. These units were run so that the vessel course was more-or-less parallel to the contours in the area, allowing better coverage to be obtained. The first area was on the southeastern flank of the Rockall Bank, running northeast/southwest. Then came an area immediately to the north of the Irish sector running east/west, up to the edge of the Hebrides Terrace. Following that was an area at the eastern side, running north/south along the Hebrides Platform edge, up to water depths of ~500 metres.

However it became apparent when the first contour plots were produced onboard that there was something amiss with the calibration of the EM12 and considerable effort thereafter went into trying to find the cause for the furrows in the seabed that lined up exactly with the vessel track. This was on the evening of 31st August and resulted in a series of correspondence between the ship and the RSU/UKORS staff in Southampton regarding the cause of these errors.

In essence these furrows were caused by an apparent offset between the EM12 transducer head and the Pitch/Roll (Hippy) sensor that caused the extremities of the swath to be raised or lowered by some 20 metres. The difficulty in correcting this became apparent when it was realised that simply adjusting the offset angle between the transducer head and the Hippy only worked on alternate swaths. For some, as yet unknown, reason there was a directional bias in the application of this offset error. The problem is still under discussion as this report is being written.

In an effort to try to track down these errors a number of calibration runs were undertaken, along with a series of SV (sound velocity) dips to try to gain some measure of the SV profiles in the area being surveyed.

The first swath calibration was undertaken on 17th August after completing the initial MESH surveys and before the airgun work between the Irish and UK sectors. An SV dip was undertaken before the calibration run. This run was found later to be inconclusive, as the movement of cases stored in the same locker had switched off the Hippy at some point.

A further calibration was attempted in rough weather when there was an opportunity to run a reverse course along a line already surveyed. This was attempted immediately the problem of the offset was detected and owing to the rough weather was inconclusive.

Finally, during the last day of surveying, the airgun line was broken off and a reverse course steamed for over an hour in fine weather, before returning to the original heading and completing the survey. This last calibration was considered to be as good as could be obtained in the circumstances and did reduce the offset error slightly.

In total 8 SV dips were taken, spread fairly well across the area and these are shown in Appendix 4. A short report from Martin Bridger of UKORS is also included in Appendix 4, describing the EM12 operation during the cruise. Martin Bridger’s report is also included in Appendix 4.

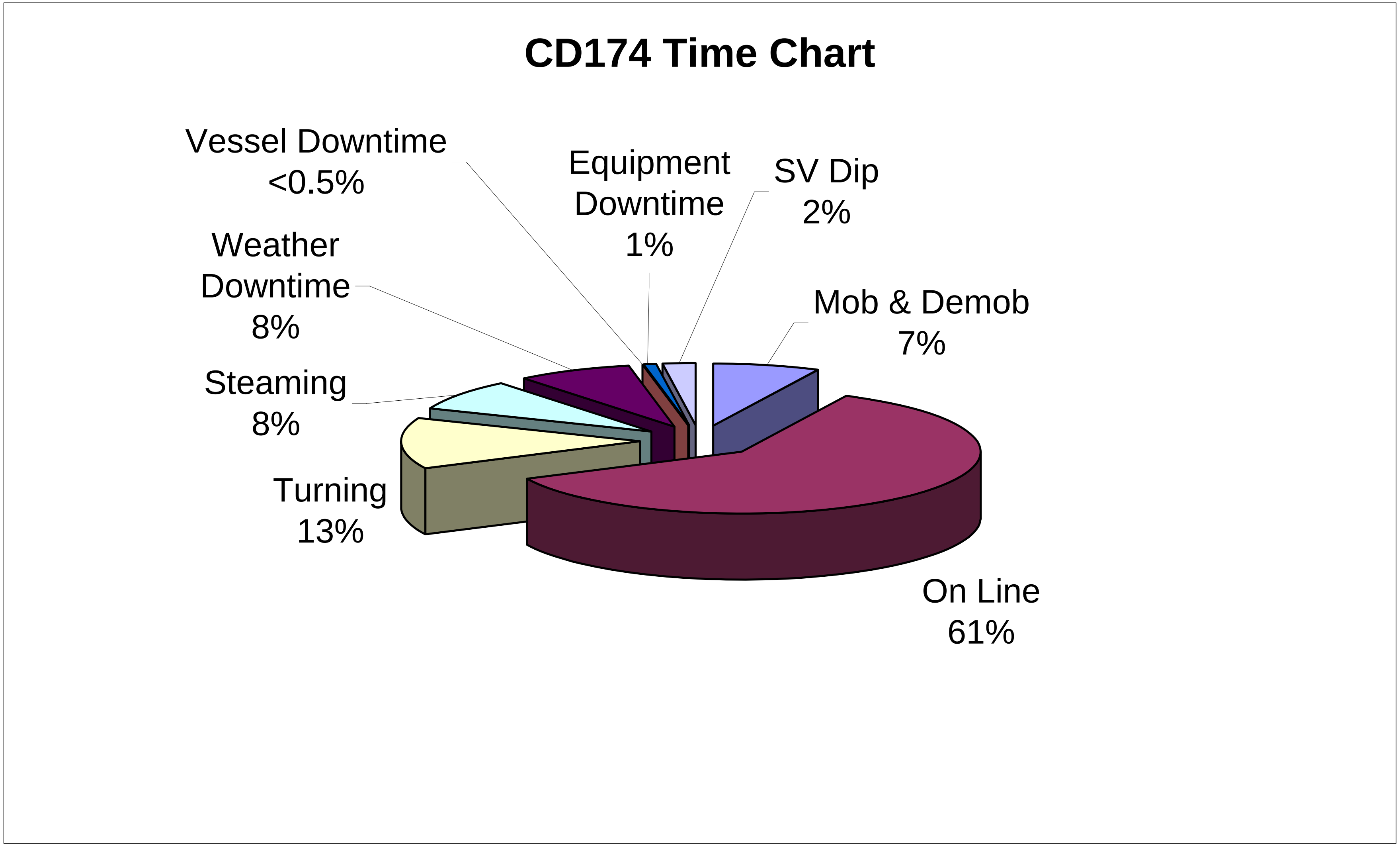


Figure 1 Time Use Chart

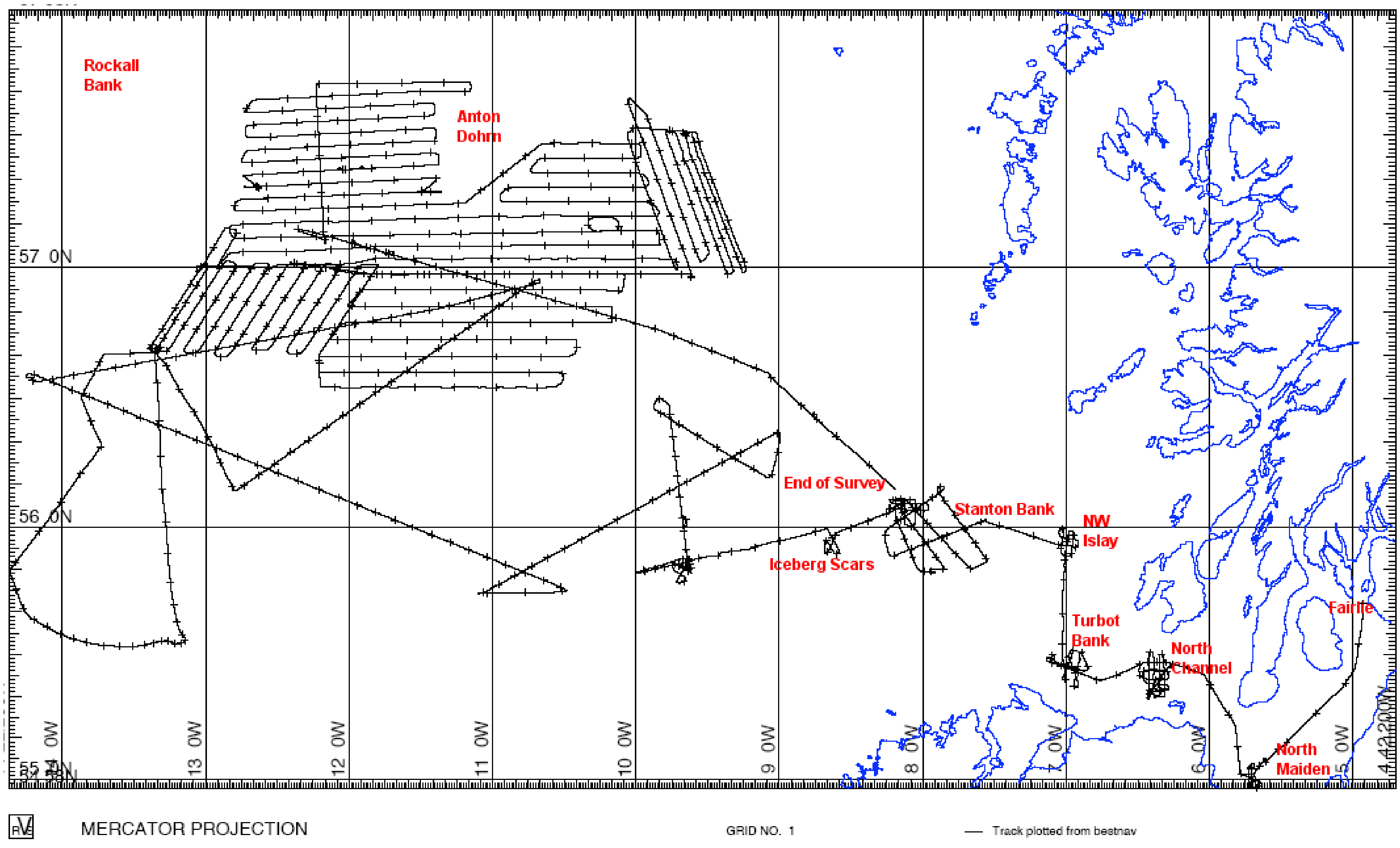


Figure 2 Vessel Trackplot

3 Equipment Used

3.1 SPARKER SYSTEM

Source: EG&G, nine candle, multi-tip array with 135 tips. This is supplied from an Applied Acoustic Engineering CSP2200 HV capacitor discharge unit, generally running at 1700 Joules per pulse. This whole being supplied from the ship's main 240 V 'domestic' power supply using a 16A circuit breaker.

Hydrophone: Teledyne 10 metre, 7 channel streamer with all channels summed to give a single channel output. In shallower water (<100metres) only 3 or 4 of these channels are used, in order to reduce the blurring effect from the greater horizontal receiver spread.

Laboratory Amplifier: This is the BGS own-design summing amplifier complete with low pass and anti-alias filters. For sparker the filter bandpass is between 100 and 1730Hz.

Recording: The recording system is a CODA DA200 modified for twin displays and set up to digitally record two seismic sources simultaneously. The output data is stored onto hard drive with an archive copy on Exabyte tape in CODA or SEGY format. The sparker signal was sampled at 6000Hz.

On-Line Linescan Record During the acquisition of the boomer and sparker data during the first week at sea, the sparker record was routinely printed onto thermal film using an Ultra 120 linescan recorder. This record had time varied gain (TVG), time varied filtering (TVF), trace mixing and swell filtering, when necessary, applied, in order to produce a field record for the geologist onboard. During the acquisition of airgun and sparker data the sparker was simply recorded for playback later.

3.2 SURFACE TOW BOOMER

Source Surface towed Applied Acoustic Engineering (AAE) catamaran fitted with an EG&G boomer plate. As above the power (up to 300Joules per pulse) was applied using an AAE CSP2200 HV discharge unit. The firing rate was every ¾ of a second.

Hydrophone As above for sparker.

Laboratory Amplifier This is the BGS own-design summing amplifier complete with low pass and anti-alias filters. For boomer the filter bandpass is between 450 and 4500Hz.

Recording The CODA DA200 system as above was used with the sampling frequency for boomer being 12000Hz.

No on-line linescan record was produced for boomer. At the geologists' request some lines were played back later during the cruise.

3.3 SINGLE CHANNEL AIRGUN

Source This was a frame holding five Bolt 600b 40 cubic inch airguns, running at 2000 pounds per square inch, of which no more than 4 guns were generally in use at any one time. For shallower water the gun count was reduced to only one gun, as the return signal was excessive for the streamer and amplifier. The solenoid pulse at each gun was monitored and the guns synchronised using a BGS design variable delay unit.

Hydrophone This was the newly acquired SIG 16 four channel streamer that came complete with its own surface preamplifier and depth monitor unit. The leading end has a depth sensor that transmits to the lab unit, resulting a displayed tow depth. The tow cable was enclosed in a hosepipe that could be filled or pumped out with water as required in order to vary the tow depth. In practice this resulted in accurate monitoring of the tow depth and correction as required for sea state or vessel speed. The resultant data from the amplifier were considerably less noisy than BGS older Geomech streamers and tests during the cruise confirmed this.

Laboratory Amplifier This is the BGS own-design summing amplifier complete with low pass and anti-alias filters. For airgun the filter bandpass is between 20 and 800Hz.

Recording The CODA DA200 system as above was used with the sampling frequency for airgun being 3000Hz.

On-Line Linescan Record During the acquisition of the airgun data, the airgun record was routinely printed onto thermal film using an Ultra 120 linescan recorder. This record had time varied gain (TVG), time varied filtering (TVF), trace mixing and swell filtering, when necessary, applied, in order to produce a field record for the geologist onboard.

3.4 SUB-BOTTOM PROFILER (PINGER)

This is the IOS 3.5kHz system, which is now completely controlled by a CODA/Octopus 360 recording and display unit. The towfish contains four TR109F Massa transducers, being driven by a Raytheon PTR105B transceiver, producing up to 6kWatts of acoustic power. The transceiver signal is then displayed and recorded on a CODA/Octopus 360 unit in SEGY format, with an optional analogue output available onto paper using a Waverley 3710 linescan recorder.

3.5 GRAVITY METER

There were two meters in use during the cruise. The ship already had LaCoste and Romberg S40 supplied by UKORS fitted on board, with the stable platform and sensor in a store off the engine control room and the recording computer in the small lab immediately forward of the main lab. BGS also fitted their own meter, (LaCoste and Romberg S75) situated in the lab forward of the main lab, alongside the recording and control unit for S40. The purpose of running two meters was to allow confirmation that BGS meter was still operating correctly by comparing the two records.

Gravity from both meters was measured continuously and the gravity, spring tension and cross coupling correction values logged, at a one second interval on the ship’s logging and processing system. Both meters had colour lineprinter outputs for purposes of quality control.

3.6 MAGNETOMETER

This system is a Barringer M123 marine proton precession magnetometer with 1 gamma sensitivity. The sensor was towed 220metres astern and the system was triggered by the seismic control at the same time as the sparker trigger. This eliminated electrical interference from the sparker system. The magnetometer operation this year was much better than in previous years and this is put down to the major overhaul carried out following the last survey. Data were logged using the ship’s internal logging system.

3.7 PRECISION ECHO-SOUNDER

A Simrad EA500 hydrographic echosounder with a 9 element tow fish operating at 10kHz was used. Serial data showing depth in metres were logged on the ship’s internal logging system. During operation a colour display showed an echogram of the seabed and the water depth in metres.

3.8 SIMRAD EM12 MULTIBEAM ECHOSOUNDER

This is a ship mounted swath echosounder, which was supplied as a service by UKORS, along with an experienced operator to ensure proper operation. The system had been used previously and the ship's officers had some experience in acquiring swath data using this instrument. In order to obtain correct depths from the unit, a series of sound velocity (SV) dips were undertaken every time a new survey area was reached. By and large this device worked well, apart from a systematic error, unresolved at present, which caused the resulting echogram to be tilted and showed as furrows along the edge of the swath, directly mapping the course taken by the vessel.

3.9 GPS POSITIONING

This is achieved using a combination of the following GPS receivers: Trimble 4000 DS; Ashtech ADU2. Differential corrections are received on a Fugro Seastar c/w Ashtech G12 HSD Ship-Shore link. The positions logged are the best available from the above combination and are all referenced to the vessel mainmast.

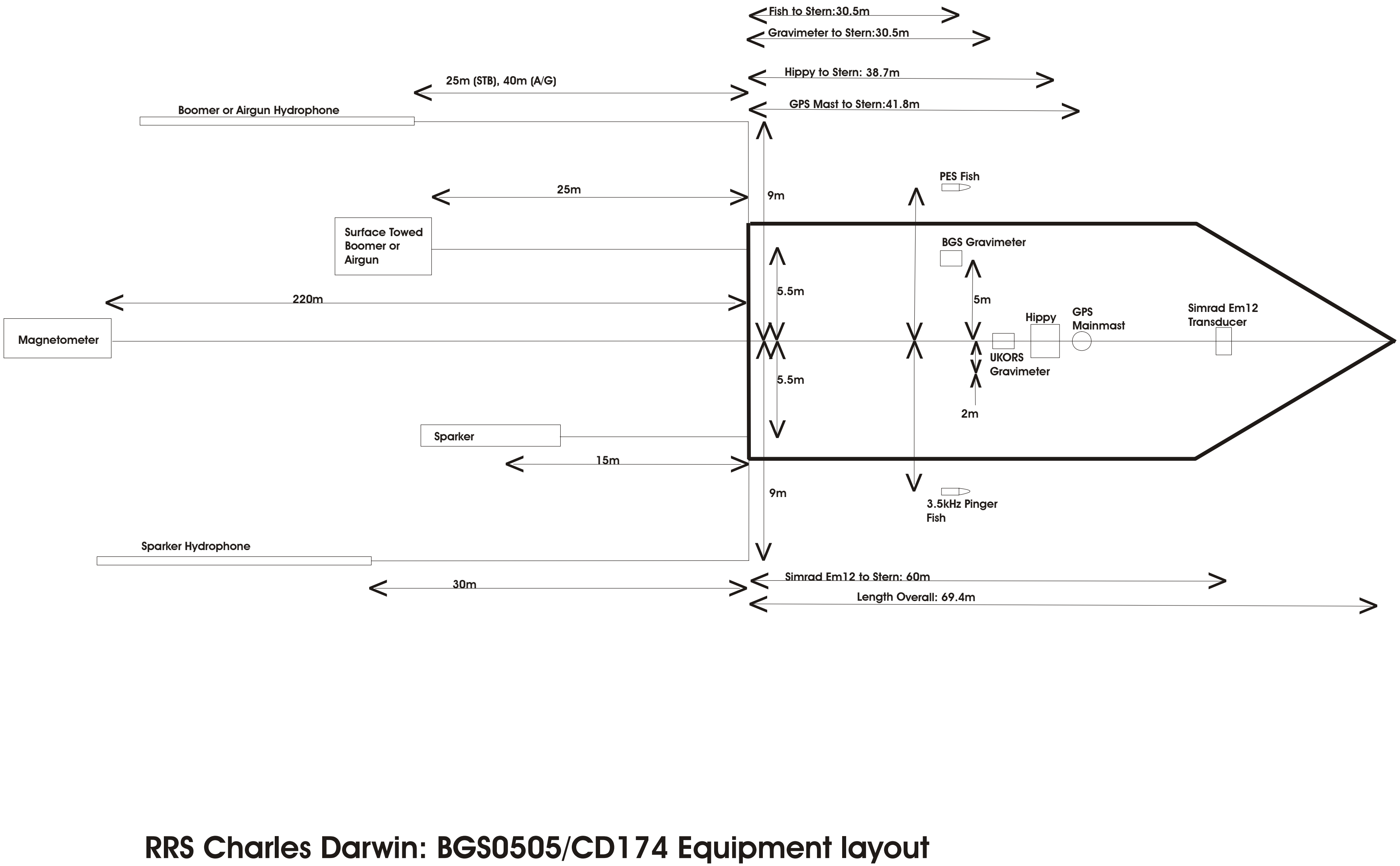


Figure 3 Equipment Deployment Diagram

4 Personnel

BGS	David Wallis	Electronics Engineer	Principal Scientist
	Richard Holmes	Geologist	
	David Long	Geologist	
	Michael Wilson	Electronics Engineer	Shift Leader
	Colin Brett	Marine Geophysicist	
	John Derrick	Mechanical Engineer	
	Neil Campbell	Mechanical Engineer	
Marine Institute (Eire)	Thomas Furey	Marine Geophysicist	
Scottish Marine Mammal Unit	Ewan Wakefield	Cetacean Observer	
UCL	Matthew Owen	Student	
RRS Charles Darwin	Philip Gauld	Master	
	Peter Newton	Chief Officer	
	Martin Holt	Chief Engineer	
UKORS	Martin Bridger	Electronics, computer technician	

5 Preliminary Interpretation of Geological Data

5.1 MESH SHELF SURVEY

BGS cruise 05/05

Survey area summaries

Author: David Long

5.1.1 North Maiden

The four sparker profiles show well-layered country rock, presumed to be Permo-Trias sandstones and siltstones dipping at about 3° to the south with evidence for normal faulting. The seabed frequently shows a step-like topography with rises up to 12 m in height, reflecting differential erosion of the outcropping sedimentary rock. Through these rocks an intrusion rises 80 m above the surrounding seafloor. The flanks show angles in excess of 30°. The top is predominantly flat, tilted to the south. Pinnacles of 10 - 20 m height rise up from a lower level on the southern flank.

There is little evidence of any sediment cover of the bedrock. The most likely area is a hollow within the intrusion on the north side where the seabed appears smooth and horizontal over a distance of at least 150 m. This swept topography fits with basal current predictions by POL of 1 - 1.25 m/s. There may be small sediment drifts, <3 m height, more than 2 kilometres south east of the intrusion. There is no evidence of sediment backed against the intrusion.

5.1.2 North Channel

Ten profile lines (sparker and boomer) show well-layered country rock, presumed to be Permo-Trias sandstones and siltstones gently dipping with normal faulting. The dip of reflectors and the frequency of anticlines and synclines increase to the south and east. Where the top of the bedrock is buried it often shows a step-like topography, suggestive of differential erosion of the sedimentary rock. In addition there are at least two intrusions of acoustically opaque rocks at Laconia Bank and one at Shamrock Bank. These intrusions form steep cliffs up to 60° and 100m high. In the northwest corner, on Middle Bank, the exposed bedrock, acoustically opaque, appears to have two type topographies. An outer smooth surface with bedrock close to and only occasionally breaching the seabed and a hummocky one at the limits of the survey with trough to crests heights up to 30m.

The most extensive unconsolidated sediments occur south of Shamrock Bank where the bedrock is covered by 30ms (~24m) of sediment with an acoustic facies reminiscent of glacial deposits. These extend a short way around the western end of Shamrock Bank into the trough with Laconia Bank. In this trough there are extensive areas of bare rock but sediment banks or drifts can be seen, most notably in the centre at each end of the trough, possibly reaching 30m in height. Other drifts occur on Laconia Bank itself between local highs of the different intrusions, reaching 10-12m in height. The top of the intrusions on Laconia Bank show gullies 3m deep, 10-20m wide which may relate to fracturing pattern. North of Laconia Bank rockhead is close to surface but often with a cover of coarse sediments including possible gravel banks that appear as mounds 5m high and up to 100m wide. The eastern end of some survey lines suggest a deeper basin of acoustically well-layered sediments lies close.

5.1.3 Hempton's Turbot Bank

This feature comprises both a major sand bank and a series of large and smaller sand waves both on and off the bank. The bank has a horizontal base and reaches 24 m in thickness. However at the eastern end it just edges on to an area of more uneven topography (variations 1-2 m max). On top of the bank and extending 8 km to the east are numerous sand waves including 4 large ones, 20 m in height and many small ones. These are frequently asymmetrical such that when the wave occurs on the north and western parts of the bank it faces southeast and reverses on the southern side. The large sand waves in the centre of the bank appear symmetrical. The waves at the eastern end of the bank and beyond face northwest. Internal reflectors can be seen in some sand waves and they tend to parallel the steeper face of the wave. At the western end of the bank is a thin sequence of westerly dipping fine layering abutting the sand bank.

The base of the bank of slightly uneven topography noted under the eastern end extends as the seafloor north and east of the bank. It has a hard acoustic signature and is considered to be zone of winnowing of outcropping glacial material (?morainic). This is based on the few internal reflectors seen below and their irregular shape. Beneath most of the sand bank and beyond it to the west are a series of gently westerly dipping reflectors. These appear to overlie an extension of the irregular morainic(?) material. A similar sequence of dipping reflectors is seen in the northeast corner dipping to the north. Bedrock varies from 60 to 120ms below seabed and shows internal reflectors dipping to the north. In a few places there is evidence that these reflectors influence the geometry of the bedrock unconformity.

5.1.4 NW Islay

This area of sediment waves with their crests aligned WNW – ESE is in 50-60m of water. These waves are up to 10m in height, and overlie a similar thickness of the same sediment in the south but much less in the north of the area where the sediment below the troughs between waves is thin and may be absent. In this area gravelly sediments probably occur. The overwhelming majority of sediment waves are asymmetric with steeper northern faces. Reflectors between waves indicate that some climb the backs of others. There is a strong basal reflector to the sediment wave unit that is clearly erosive.

The underlying Quaternary reflectors dip to the west dividing opaque and well-layered units, the latter predominant in the west. These well layered units often eroding underlying units. A small deltaic unit close to the base of the sediment waves has been detected in the southeast of the area with foresets indicating sedimentation migrating northwestwards.

Bedrock with weak sub horizontal bedding can be seen through the multiple more than 200m below seabed

5.1.5 Stanton Banks / buried channels

The seabed varies from well-layered units in the Malin Deep, presumed to be muds that infill between the outcrops of Lewisian rock on SB3 and SB1 that are likely to be coarse grained and show no fine-scale differentiation. The depth of infill appears to relate to the wider bank rather than influence by local outcrops. This together with the presence of a possible sediment drift on the north side of SB3 suggests much reworking of the seabed sediments on the banks. Small-scale troughs (~1m deep) are seen at the seabed leading into the deeper water.

The layered unit at the seabed in the Malin Deep shows asymmetric infilling of the basin, possibly from the southeast, though could be a meandering sedimentary body.

Below seabed the profiles show several units and unconformities. They appear to indicate a patchy distribution of morainic / proximal glaciomarine deposits in a deeply eroded basin cut into sedimentary rocks followed by a long period of quiet sedimentation. This was interrupted by regression and transgression leading to the planation of these finely layered sediments followed by a period of deposition of coarser-grained sediments from the sides, (small fans?) possibly from Stanton Bank. This was followed by a return to fine-grained sedimentation presumably as water depths increased leading up to the present day seabed where sedimentation has ceased and shows signs of modification and minor erosion probably due to reworking. Channel infill indicates a debris slide towards the eastern end although alternative explanations of local unconformity and shallow gas can not be ruled out..

5.1.6 Iceberg Ploughmark area

This study consisted of three short lines across an area of iceberg ploughmarks identified on sidescan / swath surveys. A line was run from Stanton Banks 3 to this area to provide correlation of seismic sequences.

West of about 8°27'W small depressions (2ms) were seen in the seabed reflector recorded by the sparker system. These are probably iceberg ploughmarks occurring in water depths less than 140m depth (185ms), and increase in frequency westwards and with the shallowing seabed. These depressions are not so clearly seen on the boomer record, and certainly not any infilling sediment. Bedrock consisting of bedded sediments with several anticlines extends from Stanton Banks 3 to about half way to the Iceberg Ploughmark area before going out of range, 440ms depth.

Within the ploughmark area the Quaternary stratigraphy is very uniform with reflectors varying very little in height. A channel approximately 2 km wide can be traced E-W at 55° 56.5'N. Overlying this at 320ms depth is a layer of well-bedded sediments up to 25ms thick, possibly dipping to the north but cut out to the north by massive units of glacial deposits. The top of the massive unit shows buried ploughmarks with a frequency greater than that seen at the seabed.

5.2 ROCKALL TROUGH MULTIBEAM AND AIRGUN SURVEY

Author: Richard Holmes

CD174 regional surveys were planned and completed from the Irish zone to approximately 57° 40' North in areas that had not been previously surveyed with multibeam and single-channel seismic reflection acquisition systems (Figure 1). The airgun single-channel reflection penetrated to 5 seconds two-way time and revealed new insights on the evolution of the Rockall Trough in the UK and Irish zones from near-top Eocene to seabed, particularly on the evolution of the Barra and Donegal fans. At the time of writing, although the multibeam data were faulty, new interpretations are possible on the extent and catastrophic impacts of very large submarine landslides on the shaping of the Rockall Trough from approximately 5 million years ago to present day. Combinations of the multibeam and single-channel sub-seabed seismic reflection data have allowed new insights on the historical and modern regional processes influencing the modern seabed environments (Figure 2). The regional multibeam and 3.5kHz pinger data are to be integrated to the climate-change research initiative currently with the BGS and extending from the present day to approximately 250,000 years before present. Accounts of data types and qualities are given elsewhere in this report.

Figure 4 CD 174 data acquisition in relation to pre-existing surveys

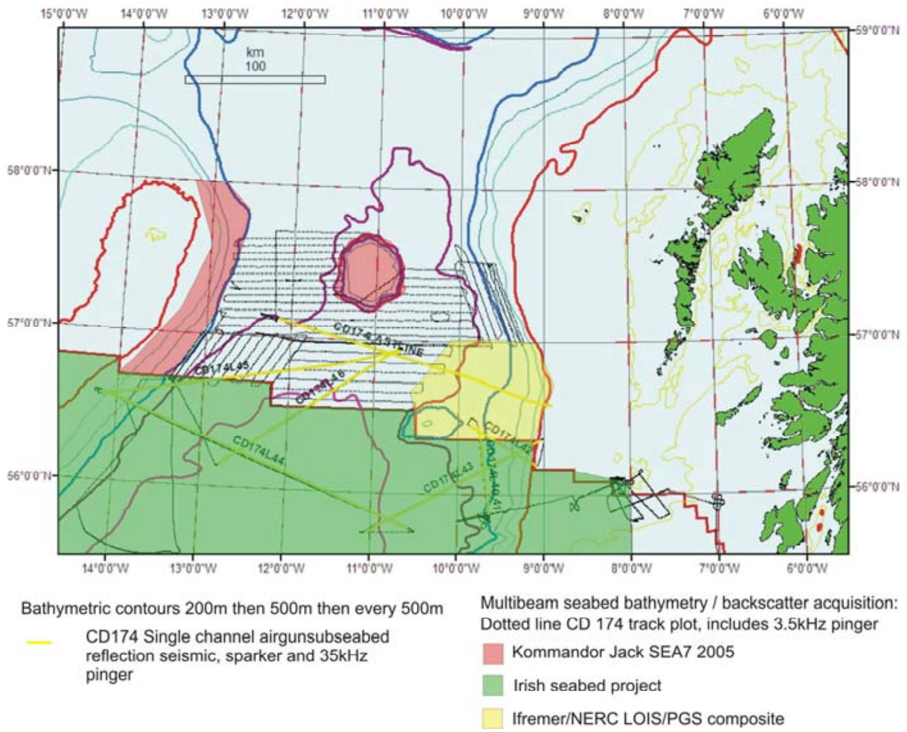
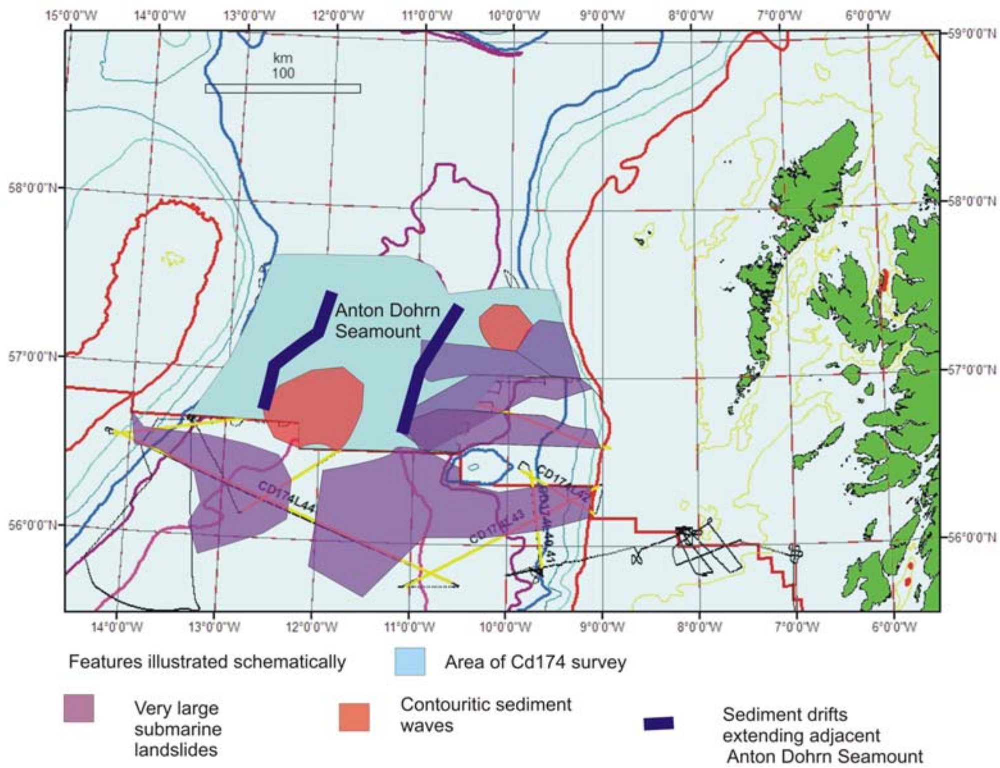


Figure 5 Schematic illustration of major seabed features surveyed CD174



Appendix 1 Daily Log

Daily Summary Log

Date: 09/08/05 JD: 221

Time	
1100	Commence mobilisation. All equipment transported to Fairlie and loaded on vessel.
	Containers fitted down, some cables run, lab layout arranged.
	BGS Personnel overnight ashore.

Total km of completed lines: 0

	Today (hours)	Total (hours)
Setting up	13	13
On Line	0	0
Turning	0	0
Steaming	0	0
Weather Downtime	0	0
Vessel Downtime	0	0
Equipment Downtime	0	0

Daily Summary Log

Date: 10/08/05 JD: 222

Time	
0900	Continue mobilisation.
	Personnel join vessel
	Hydrophone fault. John Derrick and Colin Brett to Loanhead for spares.
	Hydrophone repaired.

Total km of completed lines: 0

	Today (hours)	Total (hours)
Setting up	24	37
On Line	0	0
Turning	0	0
Steaming	0	0
Weather Downtime	0	0
Vessel Downtime	0	0
Equipment Downtime	0	0

Daily Summary Log

Date: 11/08/05 JD: 223

Time	
0730	Safety briefing onboard.
0850	Gravity base-tie completed. S75 12315.3 S40 1455.3
0915	Vessel leaves berth.
1000	Science briefing.
1340	Approaching 10 mile setup point for first survey area.
1350	Slowing to deploy gear.
1411	Precision echosounder and 3.5kHz pinger fish deployed.
1425	Surface boomer, sparker and hydrophones deployed.
1446	Sparker deployed.
1505	HV container earth fault. Visible sparks to deck. Corrected with additional external earth connection.
1515	Boat drill.
1718	SOL 1 running sparker, surface tow boomer, E/S, pinger and gravity.
1816	EOL1.
1828	SOL2.
1820	CODA pc crash – restarted.
1920	EOL2.
2039	SOL3.
2122	EOL3.
2230	SOL4.
2350	EOL4.

Total km of completed lines: 35

	Today (hours)	Total (hours)
Setting up	9.25	46.25
On Line	4	4
Turning	2.75	2.75
Steaming	8	8
Weather Downtime	0	0
Vessel Downtime	0	0
Equipment Downtime	0	0

Daily Summary Log

Date: 12/08/03 JD: 224

Time	
0010	Sparker, boomer and hydrophones recovered to deck. Proceeding next area.
0345	Slowed to deploy gear.
0415	Sparker, boomer operating, commence run-in to line.
0500	SOL5. Sparker, ST boomer, E/S, pinger and gravity.
0520	Increase sparker power to 1200 Joules. This showed mis-triggering with ST Boomer.
0550	Trigger problems resolved.
0600	EOL5. To be re-run.
0733	SOL6.
0829	EOL6.
0901	SOL7.
0947	EOL7.
1037	SOL8.
1111	EOL8.
1140	SOL9.
1242	EOL9.
1244	Sparker stopped. Reset and continued. Problem unresolved.
1331	SOL10.
1450	UKORS L&R gravity meter S40 pc ‘hung’. PC restarted.
1547	EOL10.
1607	SOL11. Sea flat calm. Sea state 0-1.
1704	Sparker HV power unit failure. Continuing with boomer only.
1812	EOL11. Sparker/boomer HV power units exchanged, while fault investigated.
1831	SOL12. ST boomer intermittent throughout line as fault was eventually diagnosed as excessive power demands by sparker, resulting in overheating and auto-shutdown. Sparker power reduced to 900Joules
2038	EOL12.
2110	SOL13. Sparker, ST boomer, E/S, pinger, gravity.
2310	EOL13.
2350	SOL14.

Date: 12/08/03 JD: 224

Total km of completed lines: 156

	Today (hours)	Total (hours)
Setting up	0	46.25
On Line	12	16
Turning	12	14.75
Steaming	0	8
Weather downtime	0	0
Vessel downtime	0	0
Equipment downtime	0	0

Daily Summary Log

Date: 13/08/03 JD: 225

Time	
0000	On line 14. Sparker, ST boomer, E/S, pinger, gravity.
0133	EOL14.
00228	SOL15.
0307	Boomer hydrophone noisy.
0342	EOL15.
0353	Sparker inboard. Candles trimmed.
0519	Sparker deployed.
0555	SOL16.
0720	ST Boomer data increasingly noisy.
0733	Boomer power reduced to 200J from 300J.
0812	EOL16.
0820	Hydrophone exchange to find noise fault. Little change. ‘Phones back to original config.
0840	Ship request to pull in all gear to allow engine changeover. (oil leak.)
0850	All gear inboard.
1013	Boomer and hydrophone redeployed for test purposes. Inboard amplifier replaced with spare.
1105	Sparker and hydrophone redeployed.
1127	SOL17.
1224	EOL17.
1405	SOL18.
1557	EOL18.
1640	SOL19.
1740	EOL19.
1755	All gear recovered for ship’s engine changeover. (oil leak now fixed)
1825	Heading for line 20.
1845	Gear redeployed.
1924	SOL20.
2039	EOL20.
2107	SOL21.
2216	EOL21.
2220	Commence recovery of gear.
2230	All gear onboard for transit to next area.

2330	Intermittent fire alarms. Seems greater as ship rolls.
2334	Making ship roll to check fire alarm problem.

Total km of completed lines: 230

	Today (hours)	Total (hours)
Setting up	0	46.25
On Line	11.25	27.25
Turning	9.75	24.5
Steaming	0.5	8.5
Weather Downtime	0	0
Vessel Downtime	1	1
Equipment Downtime	1.5	1.5

Daily Summary Log

Date: 14/08/03 JD: 226

Time	
0000	On passage to survey area
0114	Slowing to deploy gear.
0133	All gear deployed in moderate conditions. (Poor for boomer)
0228	SOL22.
0322	EOL22.
0358	SOL23.
0450	EOL23.
0548	SOL24.
)640	EOL24.
0732	SOL25. Large following swell on this line. Difficult to control towed gear.
0818	EOL25.
0901	SOL26.
0906	Alter course to starboard for fishing vessel.
0955	EOL26.
1020	All gear inboard for transit to next site.
1220	Commence redeployment of gear.
1230	All gear (Sparker, ST Boomer, Hydrophones) in water and running.
1246	SOL27.
1759	EOL27.
1935	SOL28.
2234	EOL28.
2319	SOL29.

Total km of completed lines: 365

	Today (hours)	Total (hours)
Setting up	0	46.25
On Line	13	40.25
Turning	7.5	32
Steaming	3.5	1
Weather Downtime	0	0
Vessel Downtime	0	1
Equipment Downtime	0	1.5

Daily Summary Log

Date: 15/08/03 JD: 227

Time	
0000	On line 29.
0155	Boomer HV cable protection slipping down cable. Pulled in boomer briefly and reattached protective tube.
0359	EOL29.
0415	Increase speed to 6 knots for transit to next line.
0455	Slowed for approach towards line.
0506	SOL30. Wind and sea picking up. Boomer on weather side and hydrophone lifting out of surface occasionally.
0634	Vessel apparently moving off-line. Now 180m to starboard. Check with Bridge for correct coordinates in their navigation system.
0651	Stop and restart TRAC C. Now making sense. Line had been in the wrong place on the L/R display.
0727	Request for small increase in speed. Gear too deep.
0845	Asked to bring gear in at end of line for engine changeover.
00917	EOL30.
0929	All gear recovered. Sparker trimmed. Vessel now running on smaller engine.
0952	All gear redeployed.
1020	SOL31.
1435	EOL31.
1450	Gear recovered to deck. Faulty sparker candle replaced.
1620	Gear redeployed. (Sparker, ST Boomer, 2 X Hydrophones) Approaching line 32.
1630	CODA Disk 1 out of CODA. CODA Disk 2 into CODA. This for backup purposes.
1728	SOL32.
2054	EOL32.
2127	SOL33.
2235	EOL33. CODA lines 1-31 inclusive now all backed up.
2314	SOL34.
2335	Found sparker TVG operating from start, causing shading on first part of record. Reset to operate from seabed.
2340	Swell filter not appearing to operate. Scale lines remain straight. However swell is working – lost lock briefly on sparker is the giveaway.

Total km of completed lines: 475

	Today (hours)	Total (hours)
Setting up	0	46.25
On Line	17.5	57.75
Turning	5	37
Steaming	0	12
Weather Downtime	0	0
Vessel Downtime	0	1
Equipment Downtime	1.5	3

Daily Summary Log

Date: 16/08/03 JD: 228

Time	
0000	On line 34. Weather F3 + swell.
0034	EOL34.
0222	SOL35.
0401	EOL35.
0440	SOL36.
0620	EOL36. All gear recovered and hove to for a Sound Velocity dip in 147m water.
0723	SV probe lowered. **SV DIP#1**
0732	SV probe back on deck.
0750	Some difficulty in reading SV data. Three data files found on probe.
0807	SV data good, preparing to deploy gear.
0825	All gear deployed, (ST Boomer, Sparker, 2 X Hydrophones) leaving Stanton Bank.
0904	SOL37. This is a linking line between Stanton Bank and the 'Iceberg Ploughmark' areas.
0910	Request small speed increase.
0943	Magnetometer deployed.
1005	Magnetometer working and data being logged successfully.
1140	Magnetometer failed for ~40 seconds – loose plug.
1244	Waypoint for dogleg turn onto next line.
1345	Weather deteriorating. Sea state 4-5, Wind 25knots.
1403	EOL37.
1504	SOL38.
1546	EOL38.
1623	SOL39.
1716	EOL39 Recovering gear.
1730	Sparker, Boomer 2 X hydrophones on deck. Departing Stanton Bank/Iceberg Ploughmark for Irish waters.
2150	Magnetometer recovered. All gear inboard and tied down. Weather poor.
2345	Proceeding very slowly towards SV dip point. Will review weather situation at first light.

Total km of completed lines: 546

	Today (hours)	Total (hours)
Setting up	0	46.25
On Line	10.5	68.25
Turning	5	42
Steaming	6.5	18.5
Weather Downtime	0	0
Vessel Downtime	0	1
Equipment Downtime	0	3
SV Probe Dip	2	2

Daily Summary Log

Date: 17/08/03 JD: 229

Time	
0000	WOW. Force 7 wind.
0540	Turning to head slowly back to SV dip area.
0640	Remainder of Sparker/Boomer data backed up to second hard disk drive.
0710	Turning to heave to for SV dip.
0720	SV dip underway. 1400m water. **SV DIP#2**
0833	SV probe back on deck. New SIG hydrophone marked up. Blue = 10m, Red = 50m.
1100	Running swath bathymetry.
1810	Commence deployment of airgun, sparker, hydrophones, magnetometer.
1840	Adjusting tow for start of line.
1900	Airgun, sparker adjusted for start of line, setting course for line 40.
1921	SOL40. Sparker, Airgun, Magnetometer, Gravity. 4 Airguns.
2101	Reduce to 3 guns.
2129	EOL40. Compressor problems. Position 56º 01.447 N 9º 40.425W.
2220	Repairs sufficient for restart of line. Proceeding to restart position.
2240	SOL41. Three airguns on one compressor only. Seven second cycle.

Total km of completed lines: 613

	Today (hours)	Total (hours)
Setting up	0	46.25
On Line	8.5	76.75
Turning	3	45
Steaming	4	22.5
Weather Downtime	6	6
Vessel Downtime	0	1
Equipment Downtime	1	4
SV Probe Dip	1.5	2.5

Daily Summary Log

Date: 18/08/03 JD: 230

Time	
0000	On line 41 Weather/sea 3-4 + swell.
0020	Second compressor repaired. Sparker off. Increase airguns to 4 and decrease cycle to 6 seconds.
0135	Wire on Rexroth winch taking some of the airgun strain on gun frame tow. Slackened off.
0358	EOL41. Cycle slowed to 16 seconds.
0540	SOL42. Cycle upped to 6 seconds and 4 guns.
0914	Tried to start sparker. Trigger problems.
0930	Sparker on.
1106	Reduce from 4 airguns to 3. Water becoming shallower.
1120	Reduce from 3 airguns to 1 airgun.
1140	EOL42.
1406	SOL43. 1 airgun only.
1500	Increase to 2 airguns.
1733	Increase to 3 airguns.
1940	Sparker off. Water too deep.
1950	Sparker and hydrophone recovered.
1959	Increase to 4 airguns.
2315	Pumped air into hydrophone cable. Rose quickly from ~3m to less than1m. Let air out again to return to 2m.

Total km of completed lines: 811

	Today (hours)	Total (hours)
Setting up	0	46.25
On Line	20	96.75
Turning	4	49
Steaming	0	22.5
Weather Downtime	0	6
Vessel Downtime	0	1
Equipment Downtime	0	4
SV Probe Dip	0	3.5

Daily Summary Log

Date: 19/08/03 JD: 231

Time	
0000	On line 43. Weather 4/5 with a large swell.
0015	Rexroth winch wire under tension at top of swell – as last night but with a longer swell – let out more slack.
0500	Swell building steadily – but wind steady. Difficult to maintain steady speed.
0511	Gun 5 on. Now with 5 guns instead of 4 in 2480m water.
0532	2500m water depth.
0620	Data having deteriorated steadily over last few hours and now marginal. Following discussion with OOW decided to pull in gear at EOL before turning towards new line. Will need higher speed to turn and then reassess situation at next line start, also in v deep water.
0646	EOL43. Slowing to recover gear.
0712	All gear recovered.
0730	Heading back towards start of next line to heave to and WOW.
0930	Emergency drill carried out.
1010	Hove to SE of start of potential next line. WOW.
1030	Decision to deploy gear to attempt NW line.
1059	Airgun and hydrophone deployed for test run-up to line. Requested survey speed.
1125	SOL44. Using 5 airguns.
1144	Magnetometer deployed.
1616	Power failure to compressor #2. Reduce to 3 airguns. Electrical repairs.
1650	Return to 5 airguns.
1822	Reduce to 3 airguns. More electrical repairs.
1931	Back to 5 airguns.

Total km of completed lines: 1051

	Today (hours)	Total (hours)
Setting up	0	46.25
On Line	19.75	116.5
Turning	0.25	49.25
Steaming	0	22.5
Weather Downtime	4	10
Vessel Downtime	0	1
Equipment Downtime	0	4
SV Probe Dip	0	3.5

Daily Summary Log

Date: 20/08/03 JD: 232

Time	
0000	On line 44. Weather conditions improved to ¾ with reduced swell.
0113	Stopped airgun 5.
0530	Redeployed Géoméchanique hydrophone from starboard side to compare with SIG 40. 2470m water depth. Géoméchanique much noisier with poor s/n ratio. Further test indicated Géoméchanique hydrophone was significantly poorer than SIG 40 in deep water.
1130	Sparker deployed and switched on. Ditto Teledyne hydrophone.
1140	Sparker on line and recording
1332	3 airguns from 4.
1445	EOL44.
1613	SOL45. 3 airguns and Sparker.
1736	Sparker deck lead changed. Noisy record.
1833	3 airguns.
1850	Compressor #1 failure. Still ok on compressor #2 with 3 airguns. Sea state 3, light winds.
1952	Compressor #1 on line again.
1956	4 airguns.
2050	Sparker off.
2055	Sparker and hydrophone recovered to deck.

Total km of completed lines: 1272

	Today (hours)	Total (hours)
Setting up	0	46.25
On Line	22.5	139
Turning	1.5	50.75
Steaming	0	22.5
Weather Downtime	0	10
Vessel Downtime	0	1
Equipment Downtime	0	4
SV Probe Dip	0	3.5

Daily Summary Log

Date: 21/08/03 JD: 233

Time	
0000	On line 45. Conditions calm with virtually no wind. Gentle swell.
0558	Gravity printer paper jammed.
0720	Air blown into SIG40 hydrophone to adjust tow depth back to 1.7-1.9m.
1700	New coordinates for end of next line obtained. Sea state 2-3.
1712	EOL45.
1754	SOL46. 4 airguns, Magnetometer.
1827	3 airguns –compressor maintenance.
1900	Return to 4 airguns.

Total km of completed lines: 1424

	Today (hours)	Total (hours)
Setting up	0	46.25
On Line	22.25	162.25
Turning	0.75	51.5
Steaming	0	22.5
Weather Downtime	0	10
Vessel Downtime	0	1
Equipment Downtime	0	4
SV Probe Dip	0	3.5

Daily Summary Log

Date: 22/08/03 JD: 234

Time	
0000	On line 46. Sea sate 4, wind 25 knots.
0530	Swell building steadily – ship speed variable. Sea state 4-5, wind 20-25 knots.
1211	EOL46.
1240	All gear inboard.
1900	At Sound Velocity dip location. Dip postponed due to weather conditions. 35 knots wind.
1940	Commence SV dip. 25 knots wind.
1947	SV probe lowered. **SV DIP#3**
2100	SV probe back on deck.
2230	Approaching first swath only line.
2235	Magnetometer deployed.

Total km of completed lines: 1424

	Today (hours)	Total (hours)
Setting up	0	46.25
On Line	12.5	175
Turning	2	53.5
Steaming	6	28.5
Weather Downtime	1.25	11.25
Vessel Downtime	0	1
Equipment Downtime	0	4
SV Probe Dip	2	5.5

Daily Summary Log

Date: 23/08/03 JD: 235

Time	
0000	Started 1st swath line SW01 on east Rockall flank.
0030	Large roll stopped UKORS gravity meter as part of its rack became unmounted. After brief break UKORS technician tidied up meter and secured.
0150	UKORS gravity meter not yet restarted.
0200	UKORS gravity meter restarted and back on line again.
0336	EOL SW01
0357	SOL SW02
0820	In face of very poor forecast the decision was made to pull in magnetometer at EOL and head south to avoid, if possible, full force of storm forecast.
0830	EOL. Slowing down to recover magnetometer.
0845	Magnetometer recovered – all secure. All other back deck gear tidied and secured for weather.
0900	Underway, heading south
1830	Wind 45-50 knots. Position: 55° 35’ N 13° 10’ W.

Total km of completed lines: 1424

	Today (hours)	Total (hours)
Setting up	0	46.25
On Line	8	183
Turning	1	54.5
Steaming	0	28.5
Weather Downtime	15	26.25
Vessel Downtime	0	1
Equipment Downtime	0	4
SV Probe Dip	0	5.5

Daily Summary Log

Date: 24/08/03 JD: 236

Time	
0000	Hove to WOW. Wind force 9. More than 50 knots.
0400	Wind eased slightly. Now only gale force 8.
0800	Wind 30 knots. Very large swell.
1300	Wind/Swell dropping. Gradually making for work area.
1400	Steaming for work area.
2000	Wind down to 14 knots.
2204	Magnetometer deployed.
2215	Restart of swath north of Irish sector.

Total km of completed lines: 1424

	Today (hours)	Total (hours)
Setting up	0	46.25
On Line	1	184
Turning	1	55.5
Steaming	8	36.5
Weather Downtime	14	40.25
Vessel Downtime	0	1
Equipment Downtime	0	4
SV Probe Dip	0	5.5

Daily Summary Log

Date: 25/08/03 JD: 237

Time	
0000	Running swath and magnetometer in good conditions. Sea 4/5 with swell. Survey speed 8 knots.
0055	EOL SW03. turning.
0145	SOL SW04. SW
0432	EOL SW04.
0513	SOL SW05. NE
0803	EOL SW05.
0840	SOL SW06. Very poor turn onto line with considerable overshoot.
1136	EOL SW06.
1225	SOL SW07. Running TIFF file replays on CODA.
1515	EOL SW07.
1550	SOL SW08.
1845	EOL SW08.
1930	SOL SW09. Wind 25 knots.
2150	EOL SW09.
2241	SOL SW10.

Total km of completed lines: 1414

	Today (hours)	Total (hours)
Setting up	0	46.25
On Line	18.75	202.75
Turning	5.25	60.75
Steaming	0	36.5
Weather Downtime	0	40.25
Vessel Downtime	0	1
Equipment Downtime	0	4
SV Probe Dip	0	5.5

Daily Summary Log

Date: 26/08/03 JD: 238

Time	
0000	Running swath SW10. Wind 25 knots, large swell. Very uncomfortable at survey speed of 7.5 knots.
0132	EOL SW10.
0217	SOL SW11.
0600	EOL SW11.
0637	Requested speed increase – dropped back to 7-7½ knots.
0844	SW12 – dogleg on SW12.
0935	EOL SW12. SOL SW13. Due east.
1520	EOL SW13.
1605	SOL SW14. Due west.
2238	EOL SW14.
2305	SOL SW15. Due east. At far western end of line swath profile slightly curved downwards. – SV dip required at east end.

Total km of completed lines: 1424

	Today (hours)	Total (hours)
Setting up	0	46.25
On Line	19.25	222
Turning	4.75	65.5
Steaming	0	36.5
Weather Downtime	0	40.25
Vessel Downtime	0	1
Equipment Downtime	0	4
SV Probe Dip	0	5.5

Daily Summary Log

Date: 27/08/03 JD: 239

Time	
0000	Running swath SW15 due east. Conditions calm with swell. Wind 10-15 knots.
0432	EOL SW15.
0612	SOL SW16. Due west. Wind picked up and ship speed dropped to 8-8½ knots.
1209	EOL SW16.
1244	SOL SW17. Wind 15 knots.
1842	EOL SW17.
1915	SOL SW18.

Total km of completed lines: 1424

	Today (hours)	Total (hours)
Setting up	0	46.25
On Line	21.25	243.25
Turning	2.75	68.25
Steaming	0	36.5
Weather Downtime	0	40.25
Vessel Downtime	0	1
Equipment Downtime	0	4
SV Probe Dip	0	5.5

Daily Summary Log

Date: 28/08/03 JD: 240

Time	
0000	Running swath SW18 due west. Conditions 4 with swell.
0115	UKORS L&R S40 gravity meter failure.
0130	Pinger tuned in to give reasonable record.
0135	Wind 25 knots.
0220	EOL SW18.
0250	UKORS Waverley 3710 pinger printer failed. Exchanged for BGS 371 printer.
0306	SOL SW9.
0320	Pinger back onto BGS recorder
0430	Wind now 30 knots+
0512	Water entered lab through cable access on starboard side.
0530	Magnetometer increasingly noisy. Planning to bring Magnetometer on board at end of line due to bad weather.
0555	Force 9 'for a time' forecast.
0800	UKORS S40 gravity meter back on line again. Potential gravity tare error.
0933	Request Bridge to alter course to starboard to maintain overlaps.
0953	EOL19.
1005	Magnetometer recovered on board.
1045	SOL20.
1540	EM12 swath 'lost lock'. Wind speed 30 knots.
1605	EM12 back on line again. EM12 unable to cope with vessel motion.
1658	EM12 swath 'lost lock' again. Vessel extreme movement.
1700	Vessel hove to. Sea state 8, wind gale force 8. EOL 20.

Total km of completed lines: 1424

	Today (hours)	Total (hours)
Setting up	0	46.25
On Line	15.25	258.5
Turning	1.75	70
Steaming	0	36.5
Weather Downtime	7	47.25
Vessel Downtime	0	1
Equipment Downtime	0	4
SV Probe Dip	0	5.5

Daily Summary Log

Date: 29/08/03 JD: 241

Time	
0000	Hove to. WOW.
0200	Wind gusting 40 knots. Vessel unable to turn.
0750	Turning to head back towards line.
0945	Restart SW20 from west and running east.
1711	EOL SW20. Preparing for SV dip.
1729	SV probe deployed. **SV DIP#4**
1810	SV probe at 1840 metres. (WD 1845m)
1849	SV probe on deck.
1900	Underway for SW21 – NNW heading – expecting adverse vessel motion.
1912	SOL SW21.
2300	EOL SW22 – Vessel running on due to other ship in way of planned turnaround.

Total km of completed lines: 1424

	Today (hours)	Total (hours)
Setting up	0	46.25
On Line	11.25	269.75
Turning	2.75	72.5
Steaming	0	36.5
Weather Downtime	8	55.25
Vessel Downtime	0	1
Equipment Downtime	0	4
SV Probe Dip	2	7.5

Daily Summary Log

Date: 30/08/03 JD: 242

Time	
0000	Still running on to avoid shipping at start of next line. Now over 8 miles beyond SOL.
0005	Turning towards next line.
0055	Speed 7.5 – 8 knots – After checking with Bridge this is the maximum possible in this direction.
0128	SOL SW22.
0140	Power level on pinger reduced due to 'Excess Duty' warning. Level now at –8dB.
0141	OED (UKORS) laptop for gravity meter S40 crashed. Still recording apparently.
0230	Speed coming up to 8+ knots. Suspected change of current.
0518	EOL SW22
0545	SOL SW23.
0845	EOL SW23. Run-on ¼ mile to fill data gap.
0904	SOL SW24.
0935	Alter course to starboard to avoid fishing vessel.
1000	Back on line again.
1346	EOL SW24.
1414	SOL SW25.
1738	EOL SW25. Preparing for SV dip.
1844	SV dip completed and SV probe back on deck again. WD 994 metres. Probe fault, prepare for redip after tests showed that probe should have worked but didn't for some reason.
1915	Redeploy SV probe. **SV DIP#5**
2020	SV probe on deck again. Sound Velocity data present and correct this time.
2035	SOL SW26.

Total km of completed lines: 1424

	Today (hours)	Total (hours)
Setting up	0	46.25
On Line	18.25	288
Turning	3	75.75
Steaming	0	36.5
Weather Downtime	0	55.25
Vessel Downtime	0	1
Equipment Downtime	0	4
SV Probe Dip	2.75	10.25

Daily Summary Log

Date: 31/08/03 JD: 243

Time	
0000	Running swath sW"6. Wind force 5, large swell.
0125	EOL SW26.
0148	SOL 27. Request vessel to move to starboard and slow for better coverage.
0510	EOL SW27.
0514	SOL SW28.
0655	EOL SW28.
0714	SOL SW29. (Bridge has line noted as SW30. they became 'out-of-step' at line 12/13.)
0715	Swath bathymetry surface transducer sound velocity value 'locked' at same value as 0100.
1042	EOL SW29.
1043	Swath rebooted to try to clear surface SV fault. To no avail. Decision to continue but use manually entered SV values.
1105	SOL SW30. Surface SV probe U/S at present.
1405	Magnetometer deployed and operating.
1855	EOL SW30. SOL SW31. Now heading west for Rockall Bank.
2142	SV values from Probe 3 input to EM12 swath to use as calibrated values. This is SW corner of Rockall Trough area and previous values were in shallower water on Hebrides Terrace.
2354	EOL SW31

Total km of completed lines: 1424

	Today (hours)	Total (hours)
Setting up	0	46.25
On Line	22.75	310.75
Turning	1.25	77
Steaming	0	36.5
Weather Downtime	0	55.25
Vessel Downtime	0	1
Equipment Downtime	0	4
SV Probe Dip	0	10.25

Daily Summary Log

Date: 01/09/03 JD: 244

Time	
0000	Between lines, conditions good.
0020	SOL SW32. Swath line running SW to NE on edge of Rockall Bank.
0128	EOL SW32.
0157	SOL SW33.
0250	EOL SW33.
0340	SOL SW34. Now heading due east.
0459	Asked Bridge to skip first waypoint and head directly for second. Too much overlap.
1331	EOL SW34.
1408	SOL SW35.
1535	Swath offline for Surface SV probe repairs. Vessel turning in large circle to the north.
1805	Swath on again. SV probe now operational following repairs. Continuing with circle.
1825	Vessel now back on track at point before where survey ceased for repairs. Coverage maintained.
2115	Vessel slowed to allow the pinger fish to be raised and lowered again while running. This was to test for the possibility of a surface 'ghost' reflection in the data. Result: No ghost present.

Total km of completed lines: 1424

	Today (hours)	Total (hours)
Setting up	0	46.25
On Line	19	329.75
Turning	4	81
Steaming	0	36.5
Weather Downtime	0	55.25
Vessel Downtime	0	1
Equipment Downtime	1	5
SV Probe Dip	0	10.25

Daily Summary Log

Date: 02/09/03 JD: 245

Time	
0000	Running swath line SW34. Conditions good with swell.
0310	EOL SW34.
0342	SOL SW35.
0600	Moving to starboard of line – unanticipated water depth and coverage becoming thin.
0930	Emergency Drill (Friday).
1310	EOL SW35.
1311	Two phone calls: 0044 131 650 0278; 2min 57sec. 0044 131 664 7801; 3min 37sec.
1311	EOL SW36.
1404	SOL SW37.
1600	Following discussion Martin Bridger/Richard Holmes. Martin suggested that an SV was unnecessary at this time for the area of study.
1730	EOL SW37.
1807	SOL SW38. Water Depth 1330 metres.
1828	Water depth 2000 metres. Position 57° 18.33’N, 10° 44.66’W.
1847	Water depth 2300 metres. Position 57° 18.33’N, 10° 39.00’W.
1930	Wind 25 knots.
2112	EOL SW38.
2148	SOL SW39. 270°.

Total km of completed lines: 1424

	Today (hours)	Total (hours)
Setting up	0	46.25
On Line	21.25	351
Turning	2.75	83.75
Steaming	0	36.5
Weather Downtime	0	55.25
Vessel Downtime	0	1
Equipment Downtime	0	5
SV Probe Dip	0	10.25

Daily Summary Log

Date: 03/09/03 JD: 246

Time	
0000	Running swath line SW39. conditions good. Wind ~20knots.
0020	EOL39.
0055	SOL SW40. Heading east.
0319	EOL SW40.
0350	SOL SW41.
0615	EOL SW41.
0616	Transit to SW42.
0629	Pinger and Pinger record stopped for transit.
0947	SOL SW42.
1642	EOL SW42. Turning for next line.
1710	SOL SW43.
2223	EOL SW43. Magnetometer off and commence recovery.
2235	Magnetometer on deck. Preparing for SV dip.
2315	Stopped for Sound Velocity dip. Water depth 2070 metres.
2340	SVP deployed.

Total km of completed lines: 1424

	Today (hours)	Total (hours)
Setting up	0	46.25
On Line	17.25	368.25
Turning	5.75	89.5
Steaming	0	36.5
Weather Downtime	0	55.25
Vessel Downtime	0	1
Equipment Downtime	0	5
SV Probe Dip	0	11.25

Daily Summary Log

Date: 04/09/03 JD: 247

Time	
0000	Conducting sound velocity dip west of Anton Dohrn. Calm conditions. **SV DIP#6**
0027	SVP being retrieved.
0107	SVP recovered to deck.
0200	SOL SW 44. Magnetometer not deployed at this time.
0623	EOL SW44.
0628	Transit 3 miles back along course to find deeper water for next SV dip. Pinger switched off.
0656	Stopped for SV dip. Water depth 1778 metres. **SV DIP#7**
0828	Recovered SVP.
0840	Heading back towards start of next line.
0910	Pinger switched on at reduced power level.
0932	SOL SW45. Magnetometer deployed and switched on.
1215	Manual fix #2 on TRAC C to note breaking off line for swath calibration. Weather calm.
1235	Manual fix #3 on return leg.
1255	Manual fix #4 turning offline again.
1318	Manual fix #5 on line again at same position as fix #4.
1337	Manual fix #6. Passing original fix #3.
1526	EOL SW45.
1554	SOL SW46. 267°
2007	EOL SW46.
2038	SOL SW47. 87°

Total km of completed lines: 1424

	Today (hours)	Total (hours)
Setting up	0	46.25
On Line	18	386.25
Turning	3	92.5
Steaming	0	36.5
Weather Downtime	0	55.25
Vessel Downtime	0	1
Equipment Downtime	0	5
SV Probe Dip	3	14.25

Daily Summary Log

Date: 05/09/03 JD: 248

Time	
0000	On line SW47. Conditions calm, foggy.
0055	EOL SW47
0122	SOL SW48. Heading west.
0524	EOL SW48.
0552	SOL SW48.
1007	EOL SW48.
1031	SOL SW50.
1445	EOL SW50.
1515	SOL SW51.
1530	Calls to Colin Day at NOC. 3m02; 1m28; 3m20;
1600	Following failure to contact Geraint West by telephone.
1800	SIG hydrophone flaked out on deck. Tap test.
2001	EOL SW51.
2020	SOL SW52.
2356	EOL SW52.

SW52.

Total km of completed lines: 1424

	Today (hours)	Total (hours)
Setting up	0	46.25
On Line	21.75	408
Turning	2.25	94.75
Steaming	0	36.5
Weather Downtime	0	55.25
Vessel Downtime	0	1
Equipment Downtime	0	5
SV Probe Dip	0	14.25

Daily Summary Log

Date: 06/09/03 JD: 249

Time	
0005	SOL SW57 Direction south.
0400	EOL SW57.
0405	Slowing to recover magnetometer.
0415	Magnetometer on deck. Slowing to a halt to recover pinger.
0419	Pinger inboard.
0430	SV probe deployed. 2015m water depth. **SV DIP#8**
0557	SV probe recovered.
0603	Pinger redeployed.
0605	Heading back towards run-in to airgun line to deploy airguns, etc.
0650	Slowing and turning before deploying guns.
0708	Guns deployed. Fired each in sequence. Firing two guns – slow start.
0712	Firing 4 guns Numbers 1-4.
0715	SIG Hydrophone deployed
0718	Magnetometer deployed. Request survey speed.
0800	SOL 47. Airgun, Magnetometer, Gravity, Pinger, Swath, PES. Heading 110°.
1012	Latest SV profile input to swath.
1151	EOL 47. Fix 1. Commence turn to retrace line for swath calibration purposes.
1152	SOL 48. Fix 2. Commence reverse course along previous line. Heading 290°.
1428	EOL 48. Fix 3. Commence turn to original heading ESE on airgun line.
1500	SOL 49. Fix 4. Return to original airgun line and course. Heading 110°. Weather gradually deteriorating. Sea state ¾.
1632	Passing original position as at Fix 1 above.
1830	Wind 25knots. Sea state 6. Some noise apparent on data.

Total km of completed lines: 1654

	Today (hours)	Total (hours)
Setting up	0	46.25
On Line	18.25	426.25
Turning	3.75	98.5
Steaming	0	36.5
Weather Downtime	0	55.25
Vessel Downtime	0	1
Equipment Downtime	0	5
SV Probe Dip	2	16.25

Daily Summary Log

Date: 07/09/03 JD: 250

Time	
0000	Running line 49. Airgun, magnetometer, pinger, swath, PES. Weather conditions good. Wind 15-20 knots, following sea.
0725	Request to Bridge for slight speed increase. To just under 5 knots.
1130	EOL 49. Commence recovery. End of survey
1148	All stern towed gear inboard. Set course for Fairlie.

Total km of completed lines: 1654

	Today (hours)	Total (hours)
Setting up	0	46.25
On Line	11.5	426.25
Turning	0	98.5
Steaming	12.5	49
Weather Downtime	0	55.25
Vessel Downtime	0	1
Equipment Downtime	0	5
SV Probe Dip	0	16.25

Daily Summary Log

Date: 08/09/03 JD: 251

Time		
0930	Tied up Fairlie	
1120	BGS Gravity meter reading	12310.8
	UKORS Gravity meter reading	1455.5
	Quay to water height	3.3metres
1430	BGS crew depart vessel	

Total km of completed lines: 1654

(In addition some 3600km of swath bathymetry was completed at ~8kts.)

	Today (hours)	Total (hours)
Setting up and Demobilising	5	51.25
On Line	0	437.75
Turning	0	98.5
Steaming	9.5	58.5
Weather Downtime	0	55.25
Vessel Downtime	0	1
Equipment Downtime	0	5

Line Summary Log Sheets

British Geological Survey Marine Operations Line Summary Log Sheet 1 of 2

PROJECT 05/05 MESH - Rockall 2005 GEOPHYSICAL SURVEY Vessel: RRS Charles Darwin

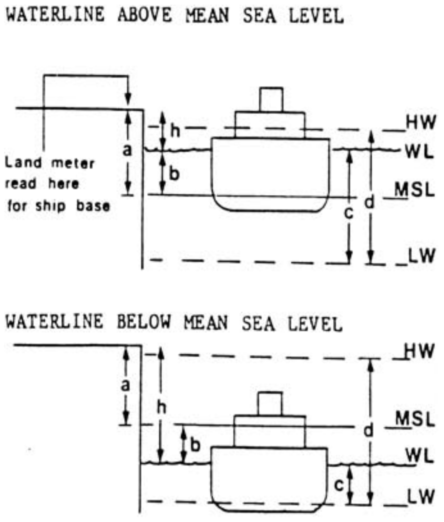
Line	Start			End			Length	Total	Equipment Run							Comments
No.	Date	J. Day	Time	Date	J. Day	Time	(km)	(km)	Airgun	Sparker	Gravity	Magnetic	Pinger	E/S	S/T Boomer	
1	11-Aug	223	17:18	11-Aug	223	18:16	8	8		x	x		x	x		Boomer run lines 1-4 but not
2	11-Aug	223	18:28	11-Aug	223	19:20	9	17		x	x		x	x		recorded due to wrong trigger set up.
3	11-Aug	223	20:39	11-Aug	223	21:22	9	26		x	x		x	x		
4	11-Aug	223	22:30	11-Aug	223	23:50	9	35		x	x		x	x		
5	12-Aug	224	5:00	12-Aug	224	6:10	7	42		x	x		x	x	x	Data quality poor - sea ,to be rerun
6	12-Aug	224	7:33	12-Aug	224	8:29	8	50		x	x		x	x	x	Sparker 1200J
7	12-Aug	224	9:01	12-Aug	224	9:47	7	57		x	x		x	x	x	
8	12-Aug	224	10:34	12-Aug	224	11:11	8	65		x	x		x	x	x	
9	12-Aug	224	11:40	12-Aug	224	12:42	7	72		x	x		x	x	x	
10	12-Aug	224	13:31	12-Aug	224	15:47	18	90		x	x		x	x	x	Sparker problems
11	12-Aug	224	16:07	12-Aug	224	18:12	17	107		Part	x		x	x	x	Problem with one HV unit
12	12-Aug	224	18:31	12-Aug	224	20:38	18	125		x	x		x	x	Part	Boomer problems
13	12-Aug	224	21:10	12-Aug	224	23:11	17	142		x	x		x	x	x	
14	12-Aug	224	23:50	13-Aug	225	1:33	14	156		x	x		x	x	x	Calm sea
15	13-Aug	225	2:28	13-Aug	225	3:42	7	163		x	x		x	x	x	Re-run of 5
16	13-Aug	225	5:55	13-Aug	225	8:12	18	181		x	x		x	x	x	Boomer poor, Hydrophone amp fault
17	13-Aug	225	11:27	13-Aug	225	12:24	11	192		x	x		x	x	x	Data moderate sea state 4/5
18	13-Aug	225	14:05	13-Aug	225	15:51	12	204		x	x		x	x	x	"" ""
19	13-Aug	225	16:40	13-Aug	225	17:44	9	213		x	x		x	x	x	""
20	13-Aug	225	19:24	13-Aug	225	20:39	9	222		x	x		x	x	x	""
21	13-Aug	225	21:07	13-Aug	225	22:16	8	230		x	x		x	x	x	"" Boomer poor
22	14-Aug	226	2:28	14-Aug	226	3:22	6	236		x	x		x	x	x	Sea state 4/5 Boomer poor
23	14-Aug	226	3:58	14-Aug	226	4:50	6	242		x	x		x	x	x	Sea state 4/5 Boomer poor
24	14-Aug	226	05:48	14-Aug	226	06:40	6	248		x	x		x	x	x	Sea state 4/5 Boomer poor

British Geological Survey Marine Operations Line Summary Log Sheet 2 of 2

Line	Start			End			Length	Total	Equipment Run							Comments
No.	Date	J. Day	Time	Date	J. Day	Time	(km)	(km)	Airgun	Sparker	Gravity	Magnetic	Pinger	E/S	S/T Boomer	
25	14-Aug	226	07:32	14-Aug	226	08:18	7	255		x	x		x	x	x	
26	14-Aug	226	09:01	14-Aug	226	09:55	7	262		x	x		x	x	x	
27	14-Aug	226	12:46	14-Aug	226	17:59	42	304		x	x		x	x	x	Sea state 2
28	14-Aug	226	19:35	14-Aug	226	22:34	25	329		x	x		x	x	x	
29	14-Aug	226	23:19	15 Aug	227	03:59	36	365		x	x		x	x	x	Sea state 3/4
30	15 Aug	227	05:06	15 Aug	227	09:17	36	401		x	x		x	x	x	
31	15 Aug	227	10:20	15 Aug	227	14:35	34	435		x	x		x	x	x	
32	15 Aug	227	17:28	15 Aug	227	20:54	28	463		x	x		x	x	x	
33	15 Aug	227	21:27	15 Aug	227	22:35	6	469		x	x		x	x	x	
34	15 Aug	227	23:14	16-Aug	228	0:34	6	475		x	x		x	x	x	
35	16-Aug	228	2:22	16-Aug	228	4:01	10	485		x	x		x	x	x	
36	16-Aug	228	4:40	16-Aug	228	6:20	10	495		x	x		x	x	x	
37	16-Aug	228	9:04	16-Aug	228	14:03	39	534		x	x	Part	x	x	x	
38	16-Aug	228	15:04	16-Aug	228	15:46	5	539		x	x	x	x	x	x	Sea state 4/5
39	16-Aug	228	16:23	16-Aug	228	17:16	7	546		x	x	x	x	x	x	
40	17-Aug	229	19:21	17-Aug	229	21:40	19	565	x	x	x	x	x	x		Compressor problems. Restart as L41
41	17-Aug	229	22:40	18-Aug	230	3:58	48	613	x	Part	x	x	x	x		Part too deep for sparker
42	18-Aug	230	5:40	18-Aug	230	11:40	56	669	x		x	x	x	x		
43	18-Aug	230	14:06	19-Aug	231	6:46	142	811	x		x	x	x	x		Data poor towards end - poor weather
44	19-Aug	231	11:25	20-Aug	232	14:45	240	1051	x	Part	x	x	x	x		Sparker on near EOL in shallower water
45	20-Aug	232	16:13	21-Aug	233	17:12	221	1272	x	Part	x	x	x	x		Sparker on at start in shallower water
46	21-Aug	233	17:54	22-Aug	234	12:11	152	1424	x		x	x	x	x		
47	6-Sep	249	7:50	6-Sep	249	11:51	33	1457	x		x	x	x	x		Weather conditions good
48	6-Sep	249	12:52	6-Sep	249	14:28	13	1470	x		x	x	x	x		Weather conditions good
49	6-Sep	249	15:00	7-Sep	250	11:30	184	1654	x		x	x	x	x		Weather conditions good

Appendix 2 Gravity Base-Ties

Name of Ship: RRS Charles Darwin	**Date:** 11/08/2005 **Julian Day: 223**



Gravity Meter Observation Fairlie Jetty
Harbour Base Connection

Time(GMT)	Place	Reading
Base Readings Established 02/09/2002 for RRS Discovery Cruise D265		

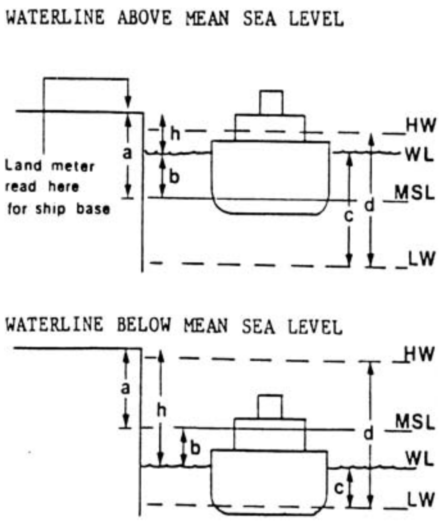
Calculation of Height of Tide	
Use Admiralty tide tables. Times GMT.	
Time of Observation	0850
Interval from High Water	At Low Water
All heights in metres	
Height of preceding HW or LW	3.3m
Height of Succeeding HW or LW	0.7m
Predicted Tide Range **(d)**	2.6m
Factor for time interval (from curve for standard port).	_____
Height of Tide above LW **(c)**	0m
Half Tide Range **d/2**	1.3m
Height of Tide above MSL = **c – d/2 = b**	-1.3m
Height of ship base above Waterline **(h)**	4.9m
Height of ship base above MSL=**h + b = a**	3.6m

Portable Meter calibration Factor (p)	---
Meter diff. to ship corrected for drift(q)	---
Harbour Station Value	---
Diff. to ship (p X q)	----
Uncorrected ship base value	981579.89
Free air correction = 0.31 X a (Add)	1.12
Ship base corrected for FA	981581.01
Bouguer correction for water slab. Pier=0.04b, Wall=0.02b. (Subtract)	-0.05
Corrected ship base value	**981581.06**

Ship borne Meter Harbour Reading **BGS L&R S75**

Ship meter cal factor (k)	0.9911
Time (GMT)	0850
Ship borne meter reading	12315.3
FA correction= 0.13b/k (Add)	-0.41
FA corrected value	12314.89
Bouguer correction. Pier=0.04b/k. Wall=0.02b/k (Subtract)	-0.05
Corrected Harbour Reading	**12314.94**

Name of Ship: **RRS Charles Darwin**	**Date: 11/08/2005** **Julian Day: 223**



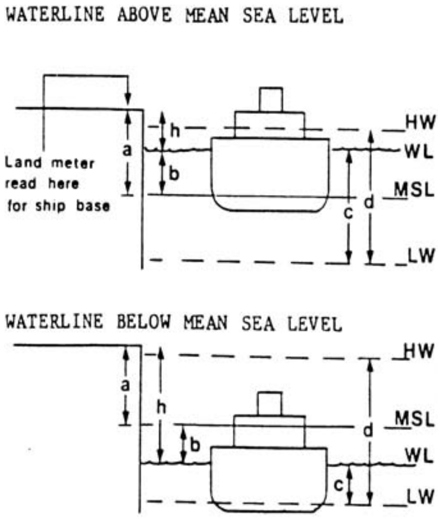
Gravity Meter Observation Fairlie Jetty Harbour Base Connection		
Time(GMT)	Place	Reading
Base Readings Established 02/09/2002 for RRS Discovery Cruise D265		

Calculation of Height of Tide	
Use Admiralty tide tables. Times GMT.	
Time of Observation	0850
Interval from High Water	LW
All heights in metres	
Height of preceding HW or LW	3.3m
Height of Succeeding HW or LW	0.7
Predicted Tide Range **(d)**	2.6m
Factor for time interval (from curve for standard port).	---
Height of Tide above LW **(c)**	0
Half Tide Range **d/2**	1.3m
Height of Tide above MSL = **c – d/2 = b**	-1.3m
Height of ship base above Waterline **(h)**	4.9m
Height of ship base above MSL=**h + b = a**	3.6m

Portable Meter calibration Factor (p)	---
Meter diff. to ship corrected for drift(q)	---
Harbour Station Value	---
Diff. to ship (p X q)	---
Uncorrected ship base value	981579.89
Free air correction = 0.31 X a (Add)	1.12
Ship base corrected for FA	981581.01
Bouguer correction for water slab. Pier=0.04b, Wall=0.02b. (Subtract)	-0.05
Corrected ship base value	**981581.06**

Ship borne Meter Harbour Reading**UKORS L&R S40**	
Ship meter cal factor (k)	0.9917
Time (GMT)	0850
Ship borne meter reading	1455.3
FA correction= 0.13b/k (Add)	-0.41
FA corrected value	1454.89
Bouguer correction. Pier=0.04b/k. Wall=0.02b/k (Subtract)	-0.05
Corrected Harbour Reading	**1454.94**

Name of Ship: RRS Charles Darwin	**Date: 08/09/2005** **Julian Day: 251**



Gravity Meter Observation Fairlie Jetty
Harbour Base Connection

Time(GMT)	Place	Reading
Base Readings Established 02/09/2002 for RRS Discovery Cruise D265		

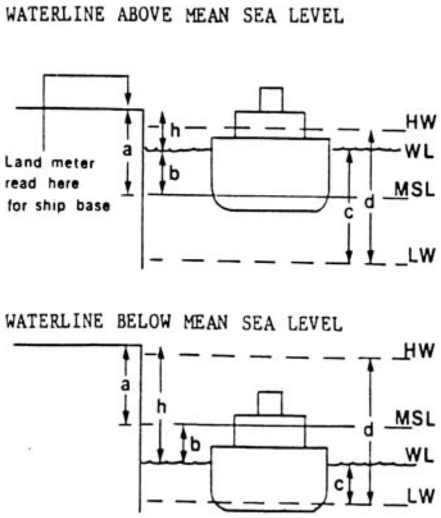
Portable Meter calibration Factor (p)	---
Meter diff. to ship corrected for drift(q)	---
Harbour Station Value	
Diff. to ship (p X q)	
Uncorrected ship base value	981579.89
Free air correction = 0.31 X a (Add)	1.02
Ship base corrected for FA	981580.91
Bouguer correction for water slab. Pier=0.04b, Wall=0.02b. (Subtract)	0
Corrected ship base value	**981580.91**

Calculation of Height of Tide	
Use Admiralty tide tables. Times GMT.	
Time of Observation	1120
Interval from High Water	3hrs
All heights in metres	
Height of preceding HW or LW	0.5m
Height of Succeeding HW or LW	3.1m
Predicted Tide Range **(d)**	2.6m
Factor for time interval (from curve for standard port).	0.5
Height of Tide above LW **(c)**	1.3
Half Tide Range **d/2**	1.3
Height of Tide above MSL = **c – d/2 = b**	0
Height of ship base above Waterline **(h)**	3.3
Height of ship base above MSL=**h + b = a**	3.3

Ship borne Meter Harbour Reading **BGS L&R S75**

Ship meter cal factor (k)	0.9911
Time (GMT)	1120
Ship borne meter reading	12310.8
FA correction= 0.13b/k (Add)	0
FA corrected value	12310.8
Bouguer correction. Pier=0.04b/k. Wall=0.02b/k (Subtract)	0
Corrected Harbour Reading	**12310.8**

Name of Ship:	Date: Julian Day:



Gravity Meter Observation Fairlie Jetty
Harbour Base Connection

Time(GMT)	Place	Reading
Base Readings Established 02/09/2002 for RRS Discovery Cruise D265		

Calculation of Height of Tide	
Use Admiralty tide tables. Times GMT.	
Time of Observation	1120
Interval from High Water	1120
All heights in metres	
Height of preceding LW	0.5m
Height of Succeeding HW	3.1m
Predicted Tide Range **(d)**	2.6m
Factor for time interval (from curve for standard port).	0.5
Height of Tide above LW **(c)**	1.3m
Half Tide Range **d/2**	1.3m
Height of Tide above MSL = **c – d/2 = b**	0
Height of ship base above Waterline **(h)**	3.3m
Height of ship base above MSL=**h + b = a**	3.3m

Portable Meter calibration Factor (p)	
Meter diff. to ship corrected for drift(q)	
Harbour Station Value	---
Diff. to ship (p X q)	---
Uncorrected ship base value	981579.89
Free air correction = 0.31 X a (Add)	1.02
Ship base corrected for FA	981580.91
Bouguer correction for water slab. Pier=0.04b, Wall=0.02b. (Subtract)	---
Corrected ship base value	**981580.91**
Ship borne Meter Harbour Reading**UKORS L&R S40**	
Ship meter cal factor (k)	0.9917
Time (GMT)	1120
Ship borne meter reading	1455.5
FA correction= 0.13b/k (Add)	0
FA corrected value	1455.5
Bouguer correction. Pier=0.04b/k. Wall=0.02b/k (Subtract)	0
Corrected Harbour Reading	**1455.5**

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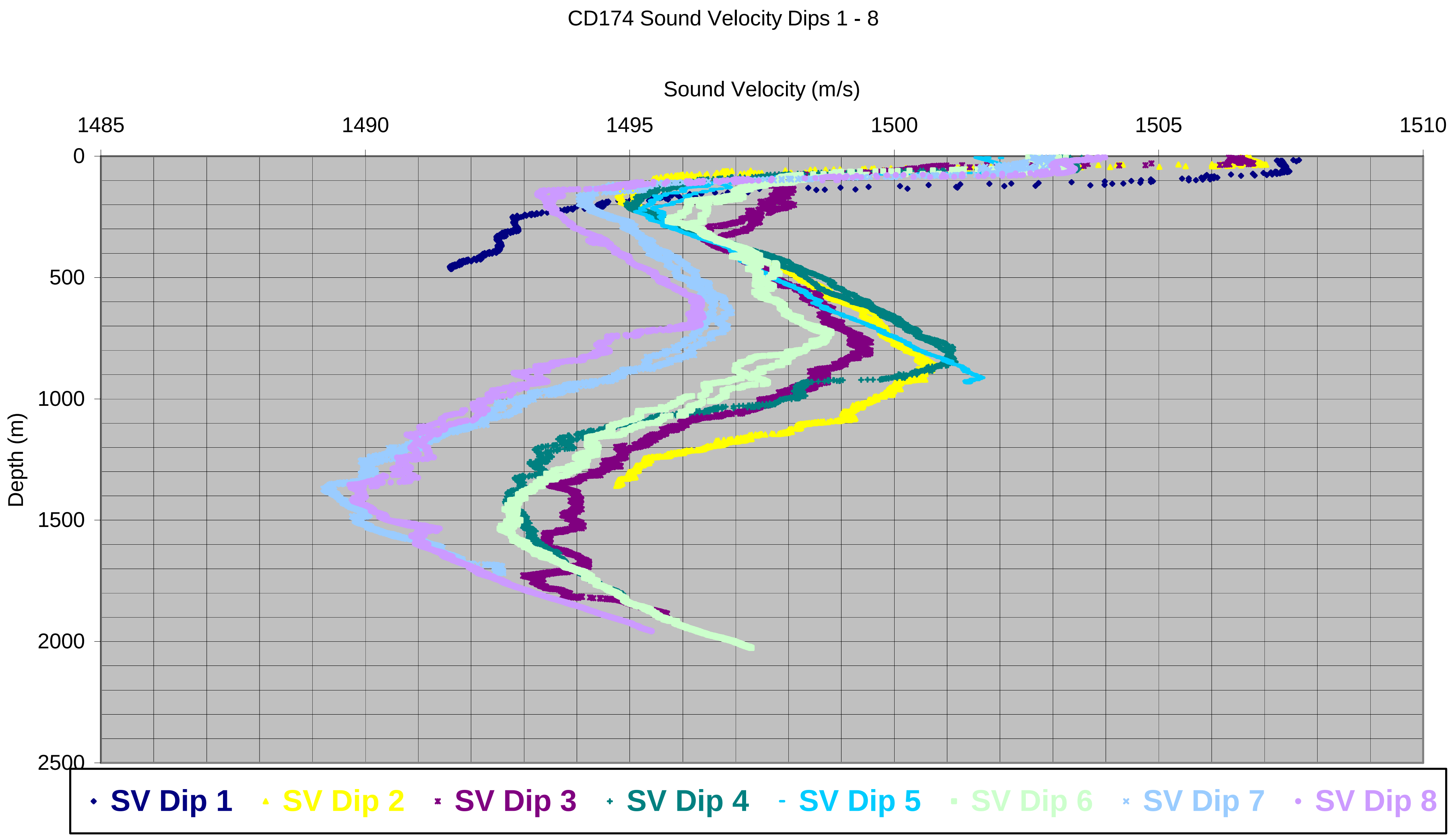
Appendix 3 SV Dips and Swath calibration

Timetable of Sound Velocity Dips and Swath Calibration Runs				
	Date	Time	Latitude	Longitude
Dip 1	16/08/2005	07:27:00	56 4.32N	8 13.91W
Dip 2	17/08/2005	08:04:10	55 52.44N	9 37.92W
Swath Cal 1	17/08/2005	11.39		
Dip 3	22/08/2005	20:26:50	56 41.10N	13 19.90W
Swath Cal 2	28/08 and 29/08	Overnight	Poor conditions	
Dip 4	29/08/2005	18:11:10	56 57.89N	9 36.88W
Dip 5	30/08/2005	19:41:40	57 2.44N	9 39.20W
Dip 6	04/09/2005	00:24:30	57 17.26N	11 29.88W
Dip 7	04/09/2005	07:51:30	57 18.15N	12 37.83W
Dip 8	06/09/2005	05:14:20	57 6.42N	12 10.34W
Swath Cal 3	06/09/2005	10:30 to 16:00		


CD174 Sound Velocity Dips 1 - 8
Sound Velocity (m/s)
1485
1490
1495
1500
1505
1510
Depth (m)
0
500
1000
1500
2000
2500
SV Dip 1
SV Dip 2
SV Dip 3
SV Dip 4
SV Dip 5
SV Dip 6
SV Dip 7
SV Dip 8

Appendix 4 EM12 Swath Bathymetry

Author: Martin Bridger, NATIONAL OCEANOGRAPHY CENTRE, SOUTHAMPTON

United Kingdom Ocean Research Vessel Services

Royal Research Ship Charles Darwin

Cruise 174

8th August – 9th September 2005

Cruise participants, British Geological Survey, UKORS, RSU

EM12 Multibeam Swath Bathymetric Report

Swath Equipment:

Simrad EM12s multibeam

Hippy 120S motion sensor

Simrad supplied vessel mounted sound velocity probe made by Applied Microsystems

Swath logging and processing system:

Sun workstations

Sun Ultra1 running Mermaid for logging and Merlin for real-time visualization.

2 x Sun Ultra 10 running Merlin for data processing and gridding. CFloor for terrain modelling and for producing plots.

Cruise Breakdown:

The cruise was broken down into two parts. The first part of approximately 7-10 days was involved mainly in airgun lines from inshore depths to full ocean depth. The swath was used to log tracks following these lines. The second part concentrated in filling in bathymetric survey in the Rockall Trough, between data produced by Kommandor Jack and that obtained from Ifremer.

The EM12 was switched on shortly after leaving Fairlie, for the first few days the depth was less than 100m, and the system was unable to obtain satisfactory data. Once the water depth increased to more than 150m data was being collected more consistently.

Initial Calibration:

The pre-survey calibration was done during the first leg. 4 lines were sailed. Line 1 from point A to B at full survey speed, line 2 from point D to C at half survey speed. Line 3 was from A to B at half survey speed, and line 4 from point D to C at full survey speed. Lines 1 & 2 are sailed over the same line, and lines 3 & 4 are sailed over the same line. The A-B line is parallel to C-D and the beams overlap by approx 40-50%. Then a 5th line sailed perpendicular so to intersect the four previous lines. Each line was in excess of 30mins long. After the lines were run an attempt was made to perform the calibration check. Something didn't look quite right with the calibration, but initial thoughts were that the weather was to blame.

No changes were made to the offsets held in the EM12.

Hippy Motion Sensor:

Further investigations found that Hippy motion sensor had been inadvertently switched off by the careless storage of items in the sonar locker situated in the crew accommodation. It was not known how long the hippy had been off, or whether it had been on or off during the calibration.

Failure of Vessel Mounted Sound Velocity Probe.

The watchkeepers noted that the readings from the vessel mounted sound velocity probe weren't changing for a number of hours. The second time this was noticed, the decision was made to restart the EM12 system, upon restarting the SV appeared to be working again. (The first time it started working by itself). A few days later the same thing happened with the SV probe, the same solution was tried, but this time it was not working. Investigations showed that everything else was OK. It took 2 full days of investigation to trace the fault to the cabling between the probe and the interface unit. The fault was rectified, and was worked correctly for the rest of the cruise.

Neptune Processing:

Neptune software was used to process and clean the data. Once the second leg had started and a coherent survey planned, the watchkeepers split the data into 1 hour lines. Each line was converted into the necessary format for Neptune, then position processed. This involves editing the ship track and removing spurious parts as well as all turns. The Hippy takes up to 15 mins to settle after a turn and thus the data during and just after a turn are discarded. The line is the processed with a merge/smooth rule which filters and cleans the track. The next step is to depth process the line. During this phase, it was noted that certain outer beams were not performing too well, but instead of removing these beams, it was decided to use the vertical reference error to flag out the bad data from these beams. The bad beams centred on 4 and 78. With adjacent beams 3, 5, 77, 79 containing less errors, and 2, 6, 76, 80 even less errors.

The depth processing was also the tool to introduce post-processing roll/pitch/gyro offsets.

Data cleaning/batch processing/binstat:

It was requested that the data be gridded to 100m grids. I advised that the data was not of sufficient quality for that resolution given the ship speed, weather and ocean depth. I made the point that the number of valid points per grid was far below that which would enable satisfactory data cleaning by statistical processes. In general there were less then 5 valid points per grid cell, whereas to do the job properly required in excess of 20, usually 20-30 would be a good figure. The scientists insisted that they were used to looking through noise, to see the features, and would rather not lose survey resolution, so I did as they asked. However, I did process the entire second leg and grid that to a 200m grid, this offered more valid points and in some cases it approached the 20 required.

Cfloor:

Cfloor software was used to import the xyz gridded soundings from binstat and produce a seabed using the seabed algorithm. Again this was made to 100m grids on one machine and 200m grid on the other. However once I had started to produce contour plots of the work area it was suggested by the scientists that there was something wrong with the data. Indeed the contour plots suggested that there was an incorrect roll offset. Much time was spent re-processing the data to try to determine whether this was just an artefact, or indeed an incorrect calibration. It was decided to perform another calibration, but unfortunately it was inconclusive, and actually indicated the opposite, later inspection lead the conclusion to be that this calibration was rushed and didn't give the Hippy enough time to settle after turning.

A final calibration was done this time with sufficient time for the hippy to settle, and it suggested a roll offset of 0.2 degrees. At the same time it was suggested that the gyro was showing signs of being inaccurate. The gyro was compared to the Ashtec GPS based Attitude Detection Unit heading reading over 30 minute averages in multiple directions. It was noted that there was a difference between the two, and that the difference was not consistent. It averaged at approximately 0.5 degrees (exact figure was supplied to the scientific party at the end of the cruise).

These offsets were then applied to the entire dataset and reprocessed.

The look of the data looked to be an improvement in some areas, but in other areas it made no difference, or actually had a detrimental effect, although the overall result was slightly better.

Sound Velocity Dips

As well as continuous measurements of near surface sound velocity with the vessel mounted sound velocity probe in bottom of the engineroom, an over-the-side sound velocity probe was employed to gather near full ocean depth sound velocity profile. During the cruise, 9 such dips were done, and the data manually entered in the EM12 system. Readings from the surface probe, and the lowered probe (surface measurements) were compared, and a difference was noted. The table of readings (scientists have a copy) indicated a difference that can lead to an error of around 0.1 degrees at the outer beams.

From the Simrad manual:

A difference of 1.5m/s in the sound velocity will influence the accuracy of the beam steering at the outer beams of 0.1 degrees.

Points to consider

It was made clear at the cruise planning meeting that the level of swath processing to be performed onboard is intended as a first look, a preview of the dataset. If the customer requires a fully processed survey, then this is outside of the cruise agreement. Any further processing required is to be born by the customer, there is no facility or agreement in place to carry out such work.

The EM12 was operated using 120 degree mode, in depths of around 2000m. Minimal overlap (10%) and speeds in excess of 6 knots were made in order to meet the scientists' coverage requirement.

Weather conditions were poor.

With this system, under ideal weather conditions, with an exact SV profile, perfect roll, pitch, heading calibration, perfect motion sensor, and surface SV measurements, the vertical accuracy of the system can be as good as 6m at the outer beams.

Simrad: The EM12 has 81 beams, in 120 degree mode of equidistant beam spacing, the maximum coverage is 3.5 x depth, usable range 50-5500m, and horizontal beam spacing is 0.043 x depth (=90m)

The EM12 uses 13kHz frequency, which is required for a good coverage in deep waters. It is possible that under some special bottom conditions, the sound pulse will penetrate into the top layer without appreciable attenuation, causing the measured depth to be too large.

Martin Bridger

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Monday, September 26, 2005

Appendix 5 Seabird and Marine Mammal Observations

Summary of seabird and marine mammal observations made onboard the RSS Charles Darwin during British Geological Survey cruise CD174 in the Rockall Trough, August-September 2005.

AUTHOR:EWAN WAKEFIELD

November 2005

Throughout cruise CD174 Ewan Wakefield carried out a line transect survey of marine mammals and seabirds on behalf of the Department of Trade and Industry. Data from this survey will be used during the ongoing Strategic Environmental Assessment of SEA area 7. Within this area little data has previously been collected to the west of the continental shelf.

The standard Seabirds at Sea Team methodology was used, with birds being recorded in a 300 m transect. Ranges and bearings to all marine mammals were also recorded. The total length of the on-effort seabird and marine mammal survey track was 2281 km, covering an area of 684 km^2 in 74 ¼ ICES rectangles. Seabird and marine mammal observations were made in the Firth of Clyde; the North Channel and adjacent continental shelf; the Rockall Trough, as far as the eastern margin of the Rockall Bank and along the southern margins of Anton Dohrn Seamount. For much of the cruise the weather was very poor for surveying and data was frequently collected in marginal conditions.

In total 7578 birds of 37 species were recorded. Of these 26 species were seabirds and the remainder were migrant waders (such as whimbrels and turnstones) passerines (such as wheatears and meadow pipits), hirundines (house martins) and geese (Brent geese). The most abundant group (59% of birds seen) was the Procellariiformes (tube-noses), followed by gannets (21%) and gulls (7%). The most abundant species was the fulmar which accounted for almost half (47%, 3571 birds) of all birds recorded, followed by gannets (21%, 1578 birds) and interestingly great shearwaters (9%, 702 birds). The latter species may have been more abundant because of atypically strong westerly winds. Interestingly the main prey species observed for all of the most abundant seabirds in the area was the snake pipefish *Entelurus aequorius*.

Throughout the cruise many birds were associated with the ship, either following behind (e.g. storm petrels and fulmars), circling the ship (e.g. sooty and great shearwaters), following and landing in front of the ship (e.g. gannets) or landing on the ship (e.g. gulls and passerines). Every effort was made to exclude these birds from the survey but inevitably some of them will have been recorded. The problem of ship associates was especially acute when the ship generally travelled at low (<10 knots) speeds.

Sea conditions were rarely good for detecting marine mammals during the survey so results should be regarded as under representing the true density of marine mammals in the area.

However, a total of 341 animals of five species were recorded whilst the surveyor was on effort. Additionally 68 animals were recorded incidentally. Short-beaked common dolphins were the most abundant cetacean, followed by long-finned pilot whales and sperm whales. An unusual sighting for the area was of a sei whale, which was recorded in the Rockall Trough.

Other sightings included one blue shark, one sunfish and one unidentified shark, which was probably a basking shark. Seabird and cetacean densities were low in much of the study area but were elevated on the continental shelf, especially near the Stanton Bank, at the southern margins of the Anton Dohrn Seamount and along the eastern margin of the Rockall Bank.

Although the quality of the data collected was not of the highest standard (because of the weather and slow ship speed) a number of trends were apparent. As would perhaps be expected the North Channel and continental shelf showed both a relatively high density and diversity of seabird species. The Stanton Bank is clearly an ecologically important feature, with a high concentration of species such as gannets and short-beaked common dolphins feeding there. The continental shelf break and slope seemed especially important for fulmars and the shearwaters as well as for lesser black-backed gulls. Surprisingly the Hebrides Terrace Seamount area did not stand out as having a particularly diverse or abundant avifauna. The deeper waters of the Rockall Trough itself did not hold a great abundance of any particular species but fulmars, great shearwaters and lesser lack-backed gulls were present throughout this area and were often seen feeding. Densities of many species were greater at the western margin of the Rockall Trough, where the water shallows towards the Rockall Bank.

The most outstanding deeper water area in terms of diversity and abundance of seabirds and cetaceans was the southern margin of the Anton Dohrn Seamount. In this area the density of most seabirds was relatively high. Great and Manx shearwaters, lesser black-backed gulls, kittiwakes and Arctic terns were all present in quite high numbers. Furthermore, all of the sperm whales and most of the long-finned pilot whales recorded whilst on effort were seen in this area, especially in the channel between the seamount and the Rockall Bank.

The high number of great shearwaters seen during the survey deserves further comment. This species is often regarded as being somewhat scarce in UK waters but during this survey it was the third most frequently seen bird. It would be interesting to know whether this was due to the atypically strong westerly winds experienced during the survey or whether it is in fact more widespread than had previously been supposed in the Rockall Trough area during the late summer.