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Geological Survey**

NATURAL ENVIRONMENT RESEARCH COUNCIL

# Hatton–Rockall Geophysical Survey RRS Discovery Cruise D273 BGS Project 03/01 Operations Report

Continental Shelf and Margins Programme

Internal Report IR/03/177



BRITISH GEOLOGICAL SURVEY

INTERNAL REPORT IR/03/177

Hatton–Rockall Geophysical Survey  
RRS Discovery Cruise D273  
BGS Project 03/01 Operations Report

C P Brett and D B McInroy

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*Key words*

Seismic, Hatton-Rockall,  
Geophysics

*Bibliographical reference*

Brett CP & McInroy DB 2003.  
Hatton-Rockall Geophysical  
Survey, RRS Discovery Cruise  
D273, BGS Project 03/01,  
Operations Report. *British  
Geological Survey Internal  
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## Foreword

This report covers the operation of Discovery Cruise D273, BGS Project 03/01, a regional geophysical survey in the Hatton-Rockall area, carried out from 13<sup>th</sup> to 28<sup>th</sup> August 2003. This field operation was part of an ongoing survey of this part of the UK Continental Shelf. Earlier work had been funded by the BGS Rockall Consortium of oil companies (1992-2000) and by a Science Funded cruise on James Clark Ross in 2002 (JR76, BGS Report IR/02/152). Discovery cruise D273 was funded from the BGS Science Budget.

## 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. Robin Plumley, the crew of RRS Discovery and the technical support provided by the Research Ship Unit and SOC UKORS.

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## Summary

This report describes the operation of Discovery Cruise D273, BGS Project 03/01, a regional geophysical survey of the UK Continental Shelf in the Hatton–Rockall area, carried out from 13<sup>th</sup> to 28<sup>th</sup> August 2003. Due to ongoing difficulties with the Discovery winch replacement programme, the duration of the cruise was cut, initially from 21 to 17 days and then by a further two days shortly before the start. Since the programme was planned for 21 days operations it was always going to be impossible to complete it. The vessel proved to be excellent for the work and the survey was very successful, with the above caveat. A total of 1677km of good quality data were collected.

The survey was a part of the BGS Offshore Mapping and Modelling Project (E1281S73) and was allocated Discovery Station Number 15232.

# 1 Narrative

The vessel sailed from Govan at 0710 (all times GMT) on 13<sup>th</sup> August on completion of equipment mobilisation and proceeded down the River Clyde. At 0930 the vessel commenced compass correction movements off Greenock before dropping the pilot at 1030 and commencing passage to the survey area. The ship's EM log was calibrated en route in the Firth of Clyde. Equipment preparations continued throughout the day and a boat drill/safety exercise was carried out during the afternoon. Passage continued overnight and the vessel slowed at 0730 to commence vector magnetometer calibration. This required stopping and then making two very slow 360° turns, as near to rotation about a point as possible, to each of port and starboard. This was completed shortly after 0830 and full speed passage recommenced, before slowing again at 1300 to commence equipment deployment, starting with the pinger and PES towfish. The airguns were deployed next but, as usual on first deployment, some difficulties were experienced with getting all guns to seal. The airgun problems were overcome by 1500 and the sparker, two hydrophones and magnetometer were also deployed. All equipment systems were then run up using the optimum tow configuration that had been established on previous surveys. This tow configuration is shown in Fig. 1. Survey operations commenced with the start of Line 1 at 1750.

The first line was an extremely long one, running for 46 hours and completed on 16<sup>th</sup> August at 1550. Throughout the early part of the line, intermittent problems were experienced with the sparker failing to fire. This proved to be a difficult fault to isolate and only after exhaustive tests with a combination of different HV units and sparkarrays, was it established that the fault lay with the manufacturer supplied trigger/remote lead. The problem was overcome by replacing this lead with a BNC cable running directly from the seismic control system to the HV unit. Also, the magnetometer suffered from short, occasional periods of noisy signal, a problem which persisted throughout the survey without being satisfactorily resolved. The line continued to run without interruption since the primary system, the airguns, were operating without disruption. Operations continued until midday on 17<sup>th</sup> August when the combination of deteriorating weather conditions and depth of water, resulted in poor quality sparker data and the sparker equipment was recovered. The line was completed with the remaining equipment which was not so weather sensitive. At the end of Line 2, all equipment was recovered for a long transit at full speed to the start of the next line. Line 3 was started without the sparker, but it was brought into operation as the sea conditions improved. Operations then continued uninterrupted until 1600 on 20<sup>th</sup> August when Line 9 had to be terminated in rapidly deteriorating weather conditions. All gear was recovered and the vessel hove to in up to severe gale Force 9 conditions for the next 36 hours or so. Conditions moderated in the early hours of 22<sup>nd</sup> August and operations were able to recommence with Line 10 starting at 0810 that morning. There were no further weather interruptions throughout the remainder of the survey. The only further disruption was caused by a compressor failure at the end of Line 12 on 24<sup>th</sup> August. The spare compressor was connected up, but this caused an earth leakage alarm in the engine room. Almost two hours were lost whilst this problem was sorted out by rewiring the compressor. Thereafter, survey operations were uninterrupted until Line 15 was completed at 1010 on 26<sup>th</sup> August, marking the end of available survey time. All equipment was recovered, vector magnetometer calibration turns were carried out and the vessel commenced passage to Govan at 1115 that morning, docking at 0730 on 28<sup>th</sup> August. Equipment demobilisation was commenced on docking and completed the same morning.



With the exception of the extremely poor weather midway through the cruise, the sea conditions were generally good resulting in good quality data throughout. As observed last year there were considerable problems throughout with the UKORS echo sounder tracking the seabed. However, this was finally traced to being interference from the pinger and careful juggling between use of hull mounted and towfish transducer, minimised this disruption. A total of 15 survey lines were run, totalling 1677km of good quality seismic data.

Figure 2 shows a summary of the time utilisation and Figure 3 gives a summary track chart.

## 2 Equipment Used

### 2.1 AIRGUN SYSTEM

**Source:** An array of 5 x 40 cu.in. Bolt 600B airguns with waveshape kits and time break solenoids. Routinely, up to four guns were fired simultaneously, keeping the fifth gun as a ready spare. The number of guns used was varied with water depth, with a minimum of two being used in the shallower areas. The firing rate varied from 6 – 8 seconds depending on water depth. Gun synchronisation was achieved by monitoring the time break solenoids and manually adjusting as required. This introduced a short time delay into the system of approximately 50 msec and thus the sea-bed return time was not an absolute measurement of depth. Air was supplied by BGS containerised Compair Reavell VHP 36 compressors. Three units were available, two in a standard 20' container and a third in a separate container. The pair in the single container were regarded as the main source with the third one as back-up.

**Hydrophone:** Two channel Geomechanique summed to give a single channel 30m active length. The summing amplifier used was a newly developed BGS unit, which also incorporated low pass and anti-alias filters.

**Recording:** CODA DA200 four channel digital recording and processing system. The data was recorded on Exabyte tape in CODA format with a sampling interval of 0.2 msec, record length of 4 seconds and bandpass filter of 20-800Hz. The start of recording was delayed in deep water to permit a minimum of 2 seconds (TWTT) of data below the sea bed. The CODA system also received a navigation data string from the navigation processor, and logged position on each shot.

**On-line processing:** In addition to the recording described above, the CODA system was also used to process the data on-line and to produce a real-time hard copy output on a Waverley 3710 thermal printer. Processes applied were time varied gain (TVG), time varied filtering (TVF) and trace mixing. Both TVG and TVF were applied from the sea bed, which was tracked automatically. A 1.4 sec record length was used for the on-line hard copy, with a delay adjusted to give an optimum record in the prevailing water depth. Other records were replayed off-line at the request of the geologist.

### 2.2 SPARKER SYSTEM

**Source:** EG&G, nine candle, multi-tip array with 135 tips.

High Voltage Power Supply: 2 x Applied Acoustic Engineering CSP3000 capacitor charging units. Only one unit, powered from the ship's mains and with a switchable output up to a maximum of 2.2 KJ, was used at any one time, with the second as a back-up.

**Hydrophone:** Teledyne, 10 m, 7 channels with all summed to give a single output. The summing amplifier used was a newly developed BGS unit, which also included low pass and anti-alias filters. The new unit proved to be significantly less noisy than the previous version, a feature which was particularly noticeable in deep water when very high gain levels were required.

**Recording:** The same CODA DA200 four channel digital recording and processing system as for the airgun, with the data being recorded on the same Exabyte tape in CODA format. The data were recorded with a sampling interval of 0.1 msec, record length of 1.5 seconds and a bandpass filter of 103-1730 Hz. The start of recording was delayed in deep water to permit a minimum of 1 second of data below the sea bed. As with the airgun, position was recorded with every shot.

**On-line processing:** A second CODA system was used to process the data on-line and to produce a real time hard copy output on a Waverley 3710 thermal printer. Processes applied were time varied gain (TVG), time varied filtering (TVF), swell filter and trace mixing. Both TVG and TVF were applied from the sea bed, which was tracked automatically. A 500 msec record length was used for the on-line hard copy, with a delay adjusted to give an optimum record in the prevailing water depth. Other records were replayed off-line at the request of the geologist.

## 2.3 SUB- BOTTOM PROFILER

IOS 3.5kHz system: This was a high resolution, deep water (up to 6000m) swept or 'chirp' frequency profiling system consisting of 4 major components; the recorder, transceiver, correlator and towfish. The transceiver was a Raytheon PTR 105B producing 6 kWatts of acoustic power, the recorder was a Waverley 3710 Linescan recorder and was selected for a 480 msec sweep. A small programmer allowed the transceiver and recorder to be pulsed at an optimum repetition rate for a given depth range. The correlator is of IOS design and converts the 28 ms reflected swept pulse to a filtered 1.5 ms, 3.5 kHz output pulse for greater noise immunity. The towfish contained four TR109F Massa transducers wired in a parallel series combination.

## 2.4 GRAVITYMETER

The gravimeter was a LaCoste and Romberg AIR-SEA system. This consists of a highly damped, zero-length spring type gravity sensor (LaCoste and Romberg S84) mounted on a gyro-stabilised platform, together with associated control and recording electronics. The sensor and control electronics were located two decks below the main laboratory within the Stable Laboratory close to the centre of motion of the vessel.

Gravity was measured continuously and the gravity, spring tension and cross coupling correction values logged, at a one second interval in L&R Long Format, onto the ship's Level ABC logging and processing system. Data were also output to a colour printer for quality control purposes. Data were first processed to produce a Free Air anomaly, sub sampled to 10 seconds, edited to remove erroneous data (such as that obtained on turns) and smoothed using a Gaussian filter with a 20-sample window.

## **2.5 MAGNETOMETER**

The system used was a Direct Reading Barringer M123 marine proton precession magnetometer with 1 gamma sensitivity. The sensor was towed 200 m astern and the system was triggered by the seismic control system such that the sensor was polarising when the sparker fired. This eliminated electrical interference from the sparker discharge. Data was logged on the ship's ABC level logging and processing system.

For the most part the data was of good quality, but throughout the survey occasional periods of noisy data were observed. Various attempts were made to identify, and hence eliminate, the source of this noise but it proved impossible to identify the source. The system certainly operated much better than last year when several problems with the magnetometer electronics console were identified and successfully addressed.

## **2.6 VECTOR MAGNETOMETER**

A three-component vector magnetometer, supplied by the BGS Geomagnetism Programme was installed on the vessel. This was a self-contained unit mounted on a frame, complete with Ashtec differential GPS receivers to record the attitude of the sensors. The unit was pre-assembled and calibrated ashore and then the complete frame was mounted on the top of the spare seismic compressor container, which was located on the stern deck. Previously, the system had only been used on a fibreglass or 'non-magnetic' vessel, and was installed here as an experiment to investigate its performance in the very noisy magnetic environment of a steel ship. The data was logged on a dedicated data logger for future analysis by the staff from the Geomagnetism Programme.

## **2.7 ECHO SOUNDER**

This was a Simrad EA500 hydrographic echo sounder with a 9 element tow fish operating at 10 kHz. Serial data, showing depth in metres and reflected power, were logged on the ship's Level ABC system. Echograms were displayed onto colour monitors during operation and for QC purposes.

As observed in 2002 (Cruise D265) the performance of the echo sounder was somewhat poor compared with the operation in 2001 (Cruise D254) with problems tracking the seabed when using the towed fish transducer. However, on this cruise, it was possible to identify the problem as being due to interference from the pinger fish. Such interference had not occurred in 2001, despite the apparently similar set-up and therefore had not been considered as a potential problem in 2002. However, it had been observed that the pinger operation in 2002 was better than in 2001. By juggling the use of hull-mounted or towfish transducer it was possible to minimise the effects of the pinger interference.

Data were processed by editing out erroneous and null values (registered as a Zero depth) and converting to true depth by applying the appropriate Carter corrections to the 1500 m/second data.

## **2.8 NAVIGATION, PROCESSING AND DATA LOGGING**

The process of calculating the position of the ship, and thus the navigation of the ship, was carried out using a mixture of dead reckoning and GPS inputs. However, in practice the dead reckoning data is almost never used in the final navigation as GPS data is updated at a rate of once every second. Reliability problems were encountered with both the log and gyro, so it was decided to use GPS only.

The Bestnav program then takes the data from a primary fix file (data from a Trimble GPS 4000DL) and if this is not available from a secondary fix file (data from an Ashtech GG-24 (combined GPS + GLONASS)). The differential corrections for both of these files are fed from a Sea Star (3000L DGPS set to Eik EMS). On Day 235 it was found that the Sea Star was wrongly configured and that the Trimble was not receiving DGPS corrections. The Sea Star was reconfigured, but it must be assumed that prior to 0000 Day 236, positioning was GPS without differential corrections. Since the removal of selective availability in 2000, using DGPS makes the navigation data more reliable in that poorer quality satellites are dropped earlier. However, in practice, this makes little difference to the overall accuracy, with the corrections observed being the order of a few metres.

In addition to logging the routine parameters, the ship's Ashtec ADU-2 (ships attitude) multihead GPS was logged for the duration of the cruise to provide a data set to compare with the Ashtec system which was an integral part of the BGS vector magnetometer system.

All position data are referred to the WGS 84 datum.

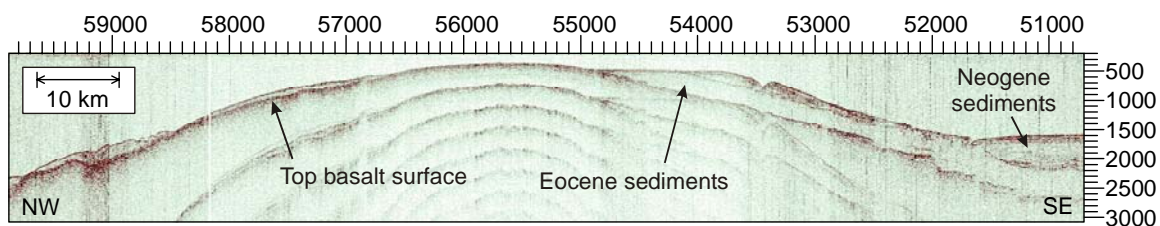
### 3 Preliminary Interpretation of Seismic Data

By D B McInroy

The BGS 2003 seismic survey was designed to investigate aspects of the geology of the northwest continental margin on the border between the UK and Faroe Islands offshore sectors. Areas that were specifically targeted were Lousy Bank, the bathymetric ‘neck’ between Lousy Bank and Hatton Bank, and the continental margin immediately north of Hatton Bank.

The first and longest seismic line, BGS03-01/01, was shot on route to the outer margin. The line is the first to give a continuous seismic profile from the Hebrides Shelf slope to the northwest side of Lousy Bank across the northern Rockall Basin, including the first continuous seismic coverage across Rosemary and Lousy Banks. The line provides linkage between the Hebrides Shelf and the Rockall Basin, crucial for stratigraphic correlation studies, and also adds coverage to the previously sparse area southeast of Rosemary Bank, an area crucial for stratigraphic correlation between the central and northeast regions of the basin.

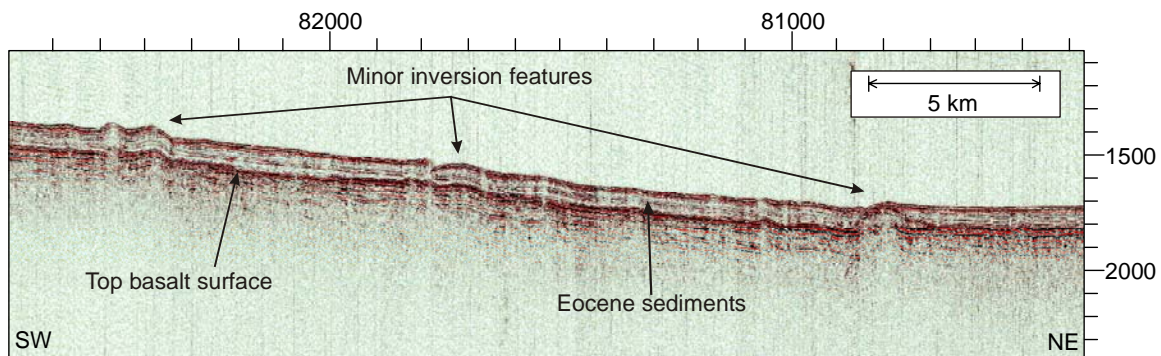
Lines BGS03-01/01 and BGS03-01/02 investigated Lousy Bank (Fig. 1). The BGS geophysical survey conducted in 2002 revealed north Hatton Bank to be underlain by a significant Eocene inversion feature (Johnson *et al.* in press), and the continuation of this inversion trend was tested by the seismic lines shot during the 2003 survey. Initial interpretations suggest that Lousy Bank is underlain by an inversion feature similar to that under north Hatton Bank, and that both probably formed contemporaneously by the same tectonic mechanism(s).



**Figure 1** Part of seismic line BGS03-01/01 across Lousy Bank. Horizontal scale: shotpoint number, vertical scale: TWTT (ms).

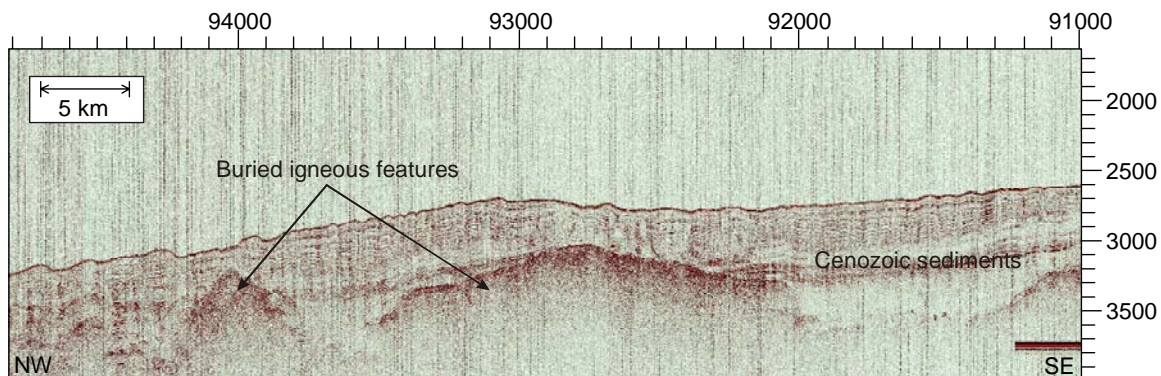
The semi-regular grid of lines between north Hatton Bank and Lousy Bank (lines BGS03-01/03 to BGS03-01/10) investigated the geology of the ‘neck’ between the two banks. The region in the neck was found to be entirely covered by basalt, overlain by a thin sedimentary cover of probable Eocene age, with internal reflections sub-parallel with the top basalt surface (Fig. 2). Minor inversion features or small ‘pop-up’ structures were imaged in this area, suggesting inversion affected this area to a lesser extent than at Hatton and Lousy Banks, which have significant present day bathymetric expressions. The seismic data suggests an Eocene age for

the minor inversion structures, proving a continuous, margin sub-parallel Eocene inversion trend extending from at least north Hatton Bank in the south to Lousy Bank in the north.



**Figure 2** Part of seismic line BGS03-01/10 between Hatton and Lousy banks. Horizontal scale: shotpoint number, vertical scale: TWTT (ms).

Lines BGS2003-01/11 to BGS2003-01/15 supplied new coverage over the continental margin north of Hatton Bank. The area is located north of a dextral offset in the north Hatton Bank Anticline (suggested to be associated with an extension of the Anton Dohrn Transfer Zone), and represents a region of magnetic anomaly ambiguity. The lines were positioned to investigate the nature of the crust north of the transfer zone. The geology in this region is typified by an uneven basalt surface overlain by relatively flat lying to mounded sediments. Two large basalt features (20 km and 6 km wide) were imaged on line BGS03-01/11, and have the appearance of igneous centres found elsewhere in the Hatton-Rockall region. Their significance is yet to be fully investigated, but one possibility is that they represent igneous activity in a region underlain by continental crust intruded with significant amounts of oceanic crustal material.



**Figure 3** Part of seismic line BGS03-01/11 across buried igneous features on the continental margin north of Hatton Bank. Horizontal scale: shotpoint number, vertical scale: TWTT (ms).

The seismic data collected in this survey contributes to the BGS seismic data set in the Hatton-Rockall area. The 2003 data has been incorporated into the current production of the 1:500,000 North Rockall solid geology map sheet, and will contribute to the ongoing study of Cenozoic inversion tectonics on the northwest European margin.

Reference:

Johnson H, Ritchie JD, Hitchen K, McInroy DB and Kimbell GS, (In Press). Aspects of the Cenozoic deformational history of the northeast Faroe-Shetland Basin, the Wyville Thomson Ridge and Hatton Bank areas. *In: Petroleum Geology of Northwest Europe: Proceedings of the 6<sup>th</sup> Conference.*



## 4 Personnel

### **BGS**

Colin Brett	Geophysicist, Principal Scientist
David Wallis	Electronics Engineer, 2 I/C
Davie Baxter	Mechanical Engineer
John Derrick	Mechanical Engineer
David McInroy	Geologist/Watchkeeper
Michael Wilson	Electronics Engineer

### **University College Cork**

Mick Mackey	Cetacean Observer
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### **SOC UKORS**

Dougal Mountifield	Computing
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### **RRS Discovery**

Robin Plumley	Master
Richard Warner	Ch. Officer
Andy Cope	2 <sup>nd</sup> Officer
Phil Oldfield	2 <sup>nd</sup> Officer
Bernie McDonald	Ch. Engineer
Ian Slater	2 <sup>nd</sup> Engineer
Tony Healy	3 <sup>rd</sup> Engineer
Chris Uttley	3 <sup>rd</sup> Engineer
Dean Hurren	ETO
Brian Wares	Cadet
Mick Drayton	Bosun
Greg Lewis	Bosun Mate
Stewart Barrett	Deck
Dave Buffery	Deck
Jerry Cooper	Deck
Steve Day	Deck
Mark Moore	Deck
John Smyth	Motorman
Eddie Staite	Catering Manager
Darren Caines	Chef
Jimmy Nugent	Steward

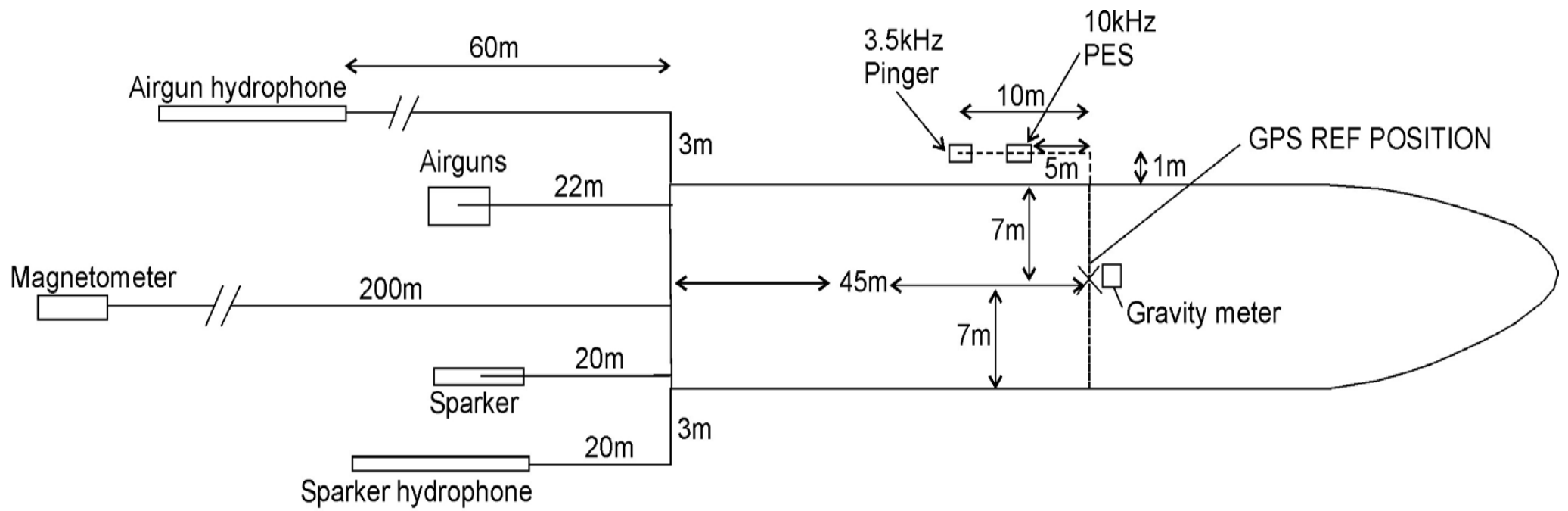
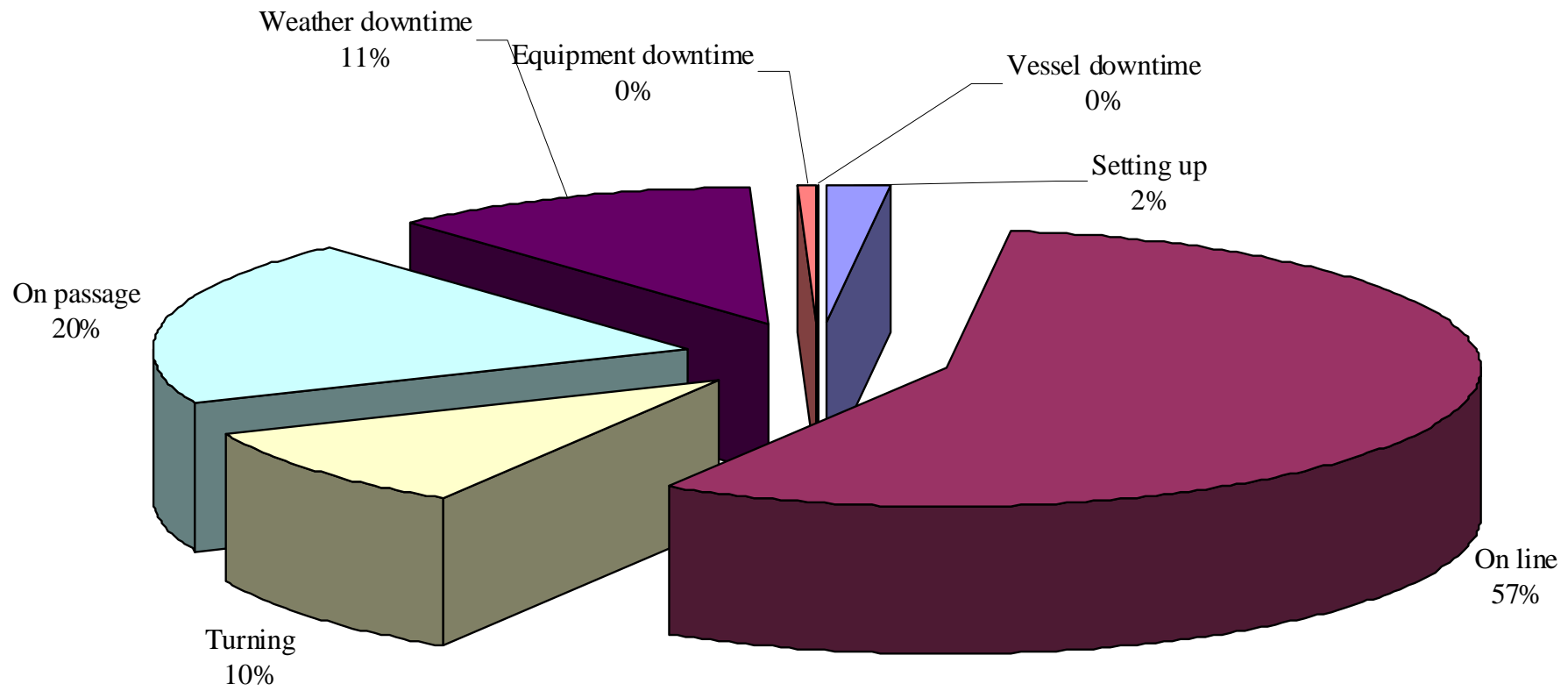


Figure 1. RRS DISCOVERY - LAYBACK DIAGRAM



**Figure 2. Time Utilisation Summary**

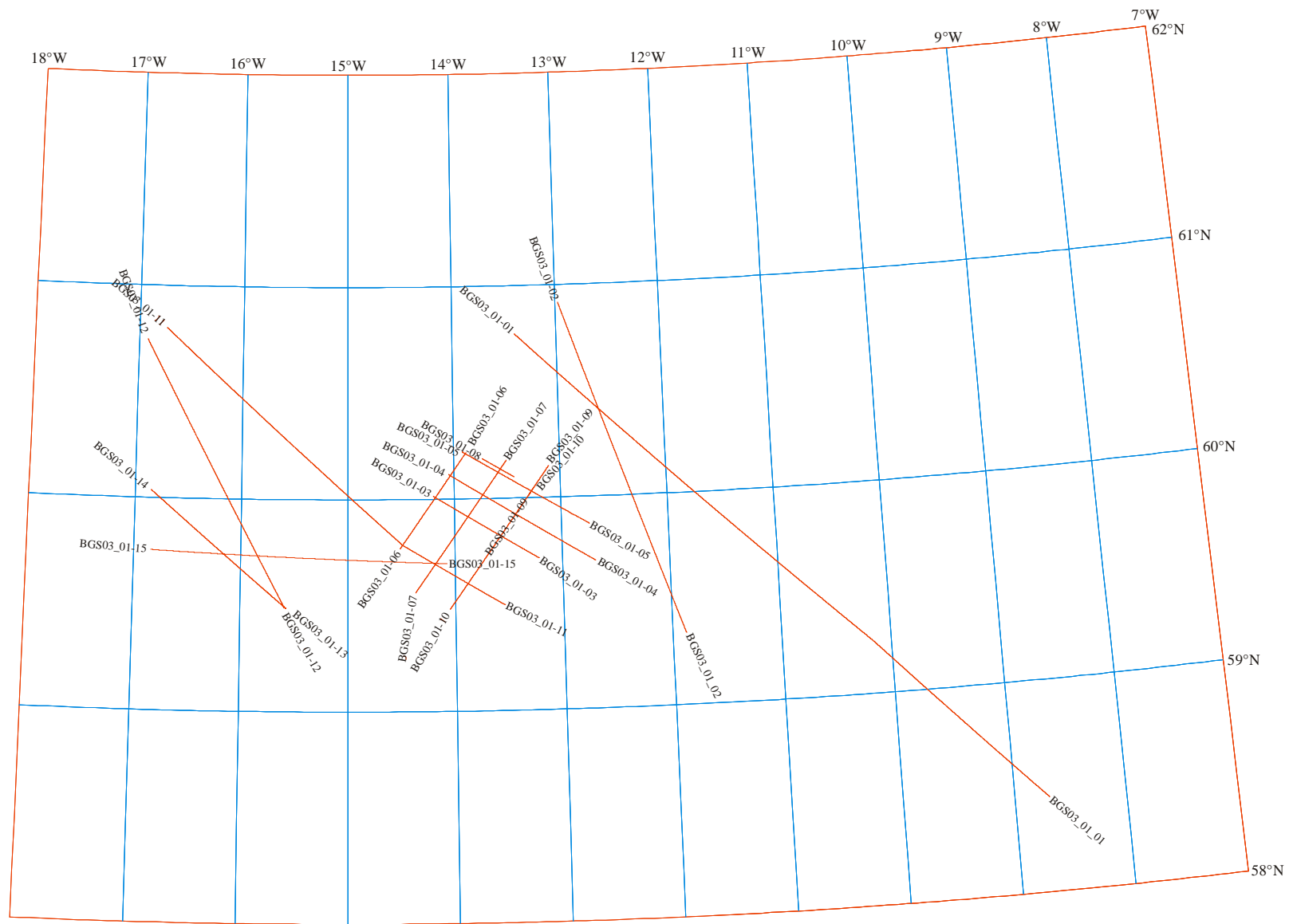


Figure 3. Discovery Cruise D273 Summary Track Chart



## Appendix I Summary Daily Log

## Daily Summary Log

**Date:** 11/08/03      **JD:** 223

Time	
0900	Commence mobilisation. All equipment transported to Govan and loaded on vessel.
	Containers fitted down, some cables run, lab layout arranged

### Total km of completed lines:

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

## Daily Summary Log

Date: 12/08/03 JD: 224

Time	
0900	Mobilisation continued throughout the day
	All cables run, lab fitted out
	Gravity base tie completed
	Personnel joined vessel

### Total km of completed lines:

	Today (hours)	Total (hours)
Setting up		
On Line		
Turning		
Steaming		
Weather downtime		
Vessel downtime		
Equipment downtime		



**Daily Summary Log**

**Date: 13/08/03 JD: 225**

Time	
0710	Vessel left berth – proceeding down river
1000	Conducting vessel compass corrections
1030	Dropped pilot – heading for survey area – calibrating ships speed log en route
1515	Boat drill carried out
2400	On passage in good conditions

**Total km of completed lines:**

	Today (hours)	Total (hours)
Setting up		
On Line		
Turning		
Steaming	14	
Weather Downtime		
Vessel Downtime		
Equipment Downtime		

## Daily Summary Log

Date: 14/08/03 JD: 226

Time	
0000	On passage to survey area
0726	Slowed to commence vector magnetometer calibration
	Completed 2 x 360 degs turns each to port and starboard.
0801	Resumed full speed passage
1300	Slowed to deploy gear starting with E/S and pinger towfish
1345	Airguns deployed – all firing, but air leak so guns recovered
1415	Airguns deployed – as above, guns recovered again
1445	Airguns deployed – now functioning correctly
1510	Sparker and both hydrophones deployed
1523	Increase to survey speed for final testing/tuning
1626	Magnetometer deployed
1750	SOL 1 – Airgun, sparker, gravity, magnetics, echo sounder, pinger, vector magnetometer
1807	Sparker stopped – reset
1845	Airgun record suddenly poor – Gun 4 not firing, leaking badly. Gun 4 closed off
2000	Sparker stopped again – reset
2200	Sparker stopped – reset. Start of a period of sparker interruptions – under investigation
2400	Running Line 1

### Total km of completed lines:

	Today (hours)	Total (hours)
Setting up	5.4	5.4
On Line	6.1	6.1
Turning		
Steaming	12.5	26.5
Weather Downtime		
Vessel Downtime		
Equipment Downtime		

## Daily Summary Log

**Date:** 15/08/03      **JD:** 227

Time	
0000	Running Line 1
0420	Sparker stopped as before. This problem continued intermittently throughout the night.
0550	Changed E/S to hull transducer – fish transducer performance poor
0615	Magnetometer suddenly very noisy – connector cleaned
0640	Magnetometer still noisy after cleaning but cleared some ten minutes later
0732	Sparker tripped again – effectively off for next few hours while fault investigated
1028	Sparker recovered to change for spare array
1230	Contact from fisherman regarding fixed nets. Too deep for our shallow towed gear
1605	Sparker back on – triggering with bnc cable direct from seismic control, not using the
	Applied Acoustics lead/remote box. Problem solved.
1711	Magnetometer off to re-route deck lead away from sparker trigger/remote
1720	Magnetometer on
1725	Sparker tried on trigger/remote – failed almost immediately, continuing with direct bnc.
2400	Running Line 1 in continuing good conditions

### Total km of completed lines:

	Today (hours)	Total (hours)
Setting up		5.4
On Line	24	30.1
Turning		
Steaming		26.5
Weather Downtime		
Vessel Downtime		
Equipment Downtime		

## Daily Summary Log

**Date:** 16/08/03      **JD:** 228

Time	
0000	Running Line 1
0319	Gun 5 failed – continuing with three guns only
0630	Reduced to two guns in shallow water
1038	Back to 3 guns
1550	EOL 1 – turning towards next line
1610	Airguns and sparker recovered for maintenance
1630	Increased speed for transit
1830	Slowed to deploy guns and sparker
1850	Guns and sparker redeployed and operating
1940	SOL 2
2100	Air pressure down – compressor #2 tripped out – reset
2140	Geomag vector magnetometer failed – under investigation
2400	Running Line 2

**Total km of completed lines: 371kms**

	Today (hours)	Total (hours)
Setting up		5.4
On Line	20.1	50.2
Turning	3.9	3.9
Steaming		26.5
Weather Downtime		
Vessel Downtime		
Equipment Downtime		

## Daily Summary Log

**Date:** 17/08/03      **JD:** 229

Time	
0000	Running Line 2
0030	Reduced to 3 guns in shallower water
0641	Increase to 4 guns
0745	Vector magnetometer restarted
0950	Weather deteriorating steadily
1155	E/S having difficulty tracking – changed to towed fish transducer – much better after changing to long pulse and considerable experimenting with gain settings
1252	Sparker switched off – weather conditions too poor
1300	Sparker and hydrophone recovered
1440	Wind now a steady 30 knots
1820	EOL 2
1855	All gear inboard except magnetometer – increase to full speed to next line
2230	Slowed to deploy equipment
2255	Airguns and hydrophone deployed – conditions improving but still too poor for sparker
2345	SOL 3
2400	Running Line 3

**Total km of completed lines: 556kms**

	Today (hours)	Total (hours)
Setting up		5.4
On Line	18.5	68.7
Turning	5.5	9.4
Steaming		26.5
Weather Downtime		
Vessel Downtime		
Equipment Downtime		

## Daily Summary Log

**Date:** 18/08/03      **JD:** 230

Time	
0000	Running Line 3
0310	Sparker and hydrophone deployed in improved sea conditions
0600	Magnetometer off to clean connector
0630	Magnetometer on but still noisy
0730	Magnetometer no longer noisy – no explanation for noise
0750	EOL 3 – turning to next line
0800	Sparker inboard for trimming and redeployed
0808	Increase speed to 5.5 knots for transit
0930	Slowed to survey speed
0950	SOL 4
1048	Unable to change delay on sparker trigger unit – changed for spare
2026	EOL 4 – turning to next line
2030	Sparker recovered for trimming and redeployed
2300	SOL 5
2400	Running Line 5

**Total km of completed lines: 707kms**

	Today (hours)	Total (hours)
Setting up		5.4
On Line	19.7	88.4
Turning	4.3	13.7
Steaming		26.5
Weather Downtime		
Vessel Downtime		
Equipment Downtime		

## Daily Summary Log

**Date:** 19/08/03      **JD:** 231

Time	
0000	Running Line 5
0020	A/C to avoid fishing vessel
0645	DGPS dropped out briefly
0850	EOL 5 – turning to next line
0855	Sparker inboard for trimming and redeployed
0940	SOL 6
1300	Wind now Force 5+ and conditions moderate
1650	EOL 6 – turning to next line
1700	Sparker inboard for trimming and redeployed
1735	Speed increased to 5.5 knots for transit
1943	SOL 7
2320	Magnetometer noisy
2400	Running Line 7

**Total km of completed lines: 844kms**

	Today (hours)	Total (hours)
Setting up		5.4
On Line	20.3	108.7
Turning	3.7	17.4
Steaming		26.5
Weather Downtime		
Vessel Downtime		
Equipment Downtime		

## Daily Summary Log

**Date:** 20/08/03      **JD:** 232

Time	
0000	Running Line 7
0100	Magnetometer still noisy
0440	Extending line – possible basalt window
0535	EOL 7 – turning to next line
0545	Sparker inboard for trimming and redeployed
0605	Increase speed for transit
0735	Trying 5 guns at 6 seconds – to improve image of sediments through basalt window
	Compressors working almost at full capacity but coping
0810	SOL 8    5 guns
1040	EOL 8 – turning to next line
1100	Magnetics no longer noisy
1320	SOL 9    Back to normal 4 guns
1550	Wind up to Gale 8 – rapid increase in the last hour
1600	EOL 9 – abandoned due to weather conditions which have deteriorated rapidly
1646	All towed gear recovered and secured for poor weather – Hove too
2400	Waiting on weather

**Total km of completed lines:      961kms**

	Today (hours)	Total (hours)
Setting up		5.4
On Line	10.7	119.4
Turning	5.3	22.7
Steaming		26.5
Weather Downtime	8.0	8.0
Vessel Downtime		
Equipment Downtime		



**Daily Summary Log**

**Date: 21/08/03 JD: 233**

Time	
0000	Waiting on weather
0945	Wind gale 8
1215	Wind severe gale 9
1400	Wind severe gale 9
1510	Altering course to retrieve loose life raft
1710	Turned back into sea – very heavy rolling (35deg) on turn
2400	Hove too waiting on weather

**Total km of completed lines: 961kms**

	Today (hours)	Total (hours)
Setting up		5.4
On Line		119.4
Turning		22.7
Steaming		26.5
Weather Downtime	24.0	32.0
Vessel Downtime		
Equipment Downtime		

## Daily Summary Log

**Date:** 22/08/03      **JD:** 234

Time	
0000	Hove to - waiting on weather
0600	Sea conditions moderating steadily overnight, heading back towards proposed restart
0650	Slowing and turning to deploy equipment
0720	Airguns deployed – data looks acceptable
0732	All gear deployed – heading for start of line
0810	SOL 10 – continuation of Line 9 with overlap
1200	Conditions improving steadily – now good
1615	Boat drill carried out
1743	EOL 10 – turning towards next line
1745	Sparker inboard for trimming and redeployed
1800	Speed increased to 5.5 knots for transit
2126	SOL 11
2300	Compressor #1 problem with fourth stage valve – pressure dropping
2310	Compressor #1 off to replace valve – continuing on one compressor
2320	Cycle reduced to 7 seconds to try to maintain pressure
2330	Reduced to 3 guns
2345	Compressor #1 back on line – return to 4 guns at 6 second firing
2400	Running Line 11

**Total km of completed lines: 1040kms**

	Today (hours)	Total (hours)
Setting up		5.4
On Line	12.0	131.4
Turning	3.9	26.6
Steaming		26.5
Weather Downtime	8.1	40.1
Vessel Downtime		
Equipment Downtime		

## Daily Summary Log

**Date:** 23/08/03      **JD:** 235

Time	
0000	Running Line 11
0830	Ongoing attempts to improve tracking for echo sounder towed fish digitisation
0845	Pinger off briefly – echo sounder tracks perfectly using towed fish
0853	Change to hull transducer for echo sounder
1110	Firing cycle to 8 seconds as water depth increased
1746	Sparker switched off – water depth too great – would have required a 10 second cycle
	In water depth of 2310 m
1750	Airgun only – back to 6 second firing
2400	Running Line 11

**Total km of completed lines: 1040kms**

	Today (hours)	Total (hours)
Setting up		5.4
On Line	24.0	155.4
Turning		26.6
Steaming		26.5
Weather Downtime		40.1
Vessel Downtime		
Equipment Downtime		

## Daily Summary Log

**Date:** 24/08/03      **JD:** 236

Time	
0000	Running Line 11
0110	EOL 11 – Turning to next line
0303	SOL 12
0515	Air pressure down – compressor tripped out – reset
1338	Sparker deployed
1350	Sparker on
1425	Large noise spikes on both sparker and airgun – caused by airgun not sealing
1426	Gun 3 shut off – Gun 5 on
2055	Compressor #2 burst air pipe – completing line (500m to go) on one compressor
2100	EOL 12 – turning to next line
2110	Airguns and sparker recovered – sparker trimmed, Gun 3 replaced with spare
2150	Spare compressor wired in – sparker redeployed
2230	Airguns deployed and tested
2320	SOL 13
2340	EOL 13 – Spare compressor wiring earth fault causing earth leakage alarm in engine room
2345	Vessel circling back to start of line while earth problem investigated
2400	Vessel circling
	Note: No useful data on Line 13 completely re-run as Line 14

**Total km of completed lines: 1427kms**

	Today (hours)	Total (hours)
Setting up		5.4
On Line	19.4	174.8
Turning	4.2	30.8
Steaming		26.5
Weather Downtime		40.1
Vessel Downtime		
Equipment Downtime	0.4	0.4

## Daily Summary Log

Date: 25/08/03 JD: 237

Time	
0000	Vessel circling to restart line – earth fault on compressor wiring solved
0120	SOL 14
0130	Magnetometer noisy
0300	Noise on magnetometer ceased
1250	EOL 14 – turning to next line – sparker recovered for trimming
1305	Speed increased for transit
1615	Sparker redeployed
1640	Slowed to survey speed
1700	SOL 15
2400	Running Line 15

**Total km of completed lines: 1521kms**

	Today (hours)	Total (hours)
Setting up		5.4
On Line	18.5	193.3
Turning	4.2	35.0
Steaming		26.5
Weather Downtime		40.1
Vessel Downtime		
Equipment Downtime	1.3	1.7

## Daily Summary Log

**Date:** 26/08/03 **JD:** 238

Time	
0000	Running Line 15
0600	Magnetometer noisy
1010	EOL 15 – end of survey operations
1045	All equipment inboard – starting turns to calibrate vector magnetometer
1115	Magnetometer calibration complete – commence passage to Govan
2400	On passage

**Total km of completed lines: 1677kms**

	Today (hours)	Total (hours)
Setting up	1.1	6.5
On Line	10.1	203.4
Turning		35.0
Steaming	12.8	39.3
Weather Downtime		40.1
Vessel Downtime		
Equipment Downtime		1.7

**Daily Summary Log**

**Date:** 27/08/03      **JD:** 239

Time	
	On passage to Govan throughout – packing en route

**Total km of completed lines: 1677kms**

	Today (hours)	Total (hours)
Setting up		6.5
On Line		203.4
Turning		35.0
Steaming	24.0	63.3
Weather Downtime		40.1
Vessel Downtime		
Equipment Downtime		1.7

# Daily Summary Log

**Date:**            **28/08/03**        **JD: 240**

Time	
0000	On Passage to Govan
0730	Alongside Govan - Demobilisation

**Total km of completed lines:        1677kms**

	Today (hours)	Total (hours)
Setting up		6.5
On Line		203.4
Turning		35.0
Steaming	7.5	70.8
Weather Downtime		40.1
Vessel Downtime		
Equipment Downtime		1.7



# Appendix II Line Summary

**British Geological Survey Marine Operations**

**Line Summary Log**

**PROJECT 03/01 Hatton-Rockall 2003**

**GEOPHYSICAL SURVEY Vessel: RRS Discovery**

Line	Start			End			Length	Total	Equipment Run							Comments
No.	Date	J. Day	Time	Date	J. Day	Time	(km)	(km)	Airgun	Sparker	Gravit y	Magnetics	Pinger	E/S	V Mag	
1	14-Aug	226	17:50	16-Aug	228	15:50	371	371	x	x	x	x	x	x	x	
2	16-Aug	228	19:40	17-Aug	229	18:20	185	556	x	Part	x	x	x	x	Part	Too rough for sparker near end
3	17-Aug	229	23:45	18-Aug	230	7:50	62	618	x	Part	x	x	x	x	x	Too rough for sparker at start
4	18-Aug	230	9:50	18-Aug	230	20:26	89	707	x	x	x	x	x	x	x	
5	18-Aug	230	23:00	19-Aug	231	8:50	76	783	x	x	x	x	x	x	x	
6	19-Aug	231	9:40	19-Aug	231	16:50	61	844	x	x	x	x	x	x	x	
7	19-Aug	231	19:43	20-Aug	232	5:45	80	924	x	x	x	x	x	x	x	
8	20-Aug	232	8:10	20-Aug	232	10:40	19	943	x	x	x	x	x	x	x	
9	20-Aug	232	13:20	20-Aug	232	16:00	18	961	x	x	x	x	x	x	x	Abandoned due to weather
10	22-Aug	234	8:10	22-Aug	234	17:43	79	1040	x	x	x	x	x	x	x	
11	22-Aug	234	21:26	24-Aug	236	1:10	229	1269	x	Part	x	x	x	x	x	Too deep for sparker towards end
12	24-Aug	236	3:03	24-Aug	236	21:00	158	1427	x	Part	x	x	x	x		Too deep for sparker at start
13	24-Aug	236	23:20	24-Aug	236	23:40	0	1427								Aborted due to electrical problem
14	25-Aug	237	1:20	25-Aug	237	12:50	94	1521	x	x	x	x	x	x	x	
15	25-Aug	237	17:00	26-Aug	238	10:10	156	1677	x	x	x	x	x	x	x	

## Appendix III Gravity Base Ties

Date	Location	Corrected ship base	Corrected meter reading	Drift mgal
12/08/03	Govan	981589.58	12823.50	0.0
28/08/03	Govan	981589.65	12815.81	-7.7

## Appendix IV Cetacean Observers Report

**R.R.S. *Discovery*: 14<sup>th</sup> August – 27<sup>th</sup> August 2003.**

## **Cetacean and Seabird Observation Summary**

**M. Mackey**

**Marine Mammals and Seabirds Group**

**Coastal and Marine Resources Centre, University College Cork**

As part of the BGS's regional geophysical survey in the Hatton-Rockall area, cetacean and seabird observer from the Coastal & Marine Resources Centre, University College, Cork, Ireland, I was invited to conduct general surveys of the offshore cetacean and seabird populations. The current survey is an extension of the Irish Cetaceans and Seabirds at Sea study, undertaken on behalf of the Rockall Studies Group and Porcupine Studies Group of the Petroleum Infrastructure Programme - a programme set up by Ireland's Department of the Marine and Natural Resources in 1997. The main aims of the research are:

- (1) to establish reliable baseline information on the distribution and abundance of seabirds and cetaceans off western Ireland throughout the year;
- (2) to identify critical habitats for these species; and
- (3) to provide independent scientific information essential for conservation and management purposes.

The observer also attempted to assess any behavioural responses of cetaceans to the seismic operations. The observer was also asked to inform BGS scientific staff of visual cetacean presence prior to activating seismic equipment (i.e. sparkarray and airguns).

This cruise was the second most productive survey for 2002, in terms of species encountered: 18 seabird species, three coastal bird species and nine cetacean species were recorded. The Manx Shearwater, Northern Fulmar and Northern Gannet were the three most numerous seabird species for the trip, while Black-legged Kittiwake was recorded in relatively low concentrations. The Long-finned Pilot Whale was comfortably the most frequently encountered cetacean species, although Sperm Whales and Fin Whales were also recorded in relatively high numbers.

### **Methods:**

Two observation methods were employed simultaneously throughout the survey. The standard method for recording all seabirds within 90° of the ship's trackline, devised by the Joint Nature Conservation

Committee (JNCC), was used when the vessel was travelling on a set course, at speeds greater than 4 knots and when climatic conditions allowed (i.e. less than wind force 7). Due to the extremely low concentrations of seabirds recorded within the study area, general scans for cetaceans were also conducted in the 180° area ahead of the ship, using waterproof 10x42 binoculars. The binocular scans allowed for early detection of cetaceans, in addition to clearer assessments of behavioural responses to seismic operations. General 360° cetacean scans were carried out prior to the initiation of seismic activity. Casual sightings recorded while the ship was stationary or during meal breaks have also been included in this brief analysis. All data collected during this survey will contribute to the Irish Cetacean and Seabirds at Sea study's database, and the central European cetacean and seabird databases maintained by the JNCC.

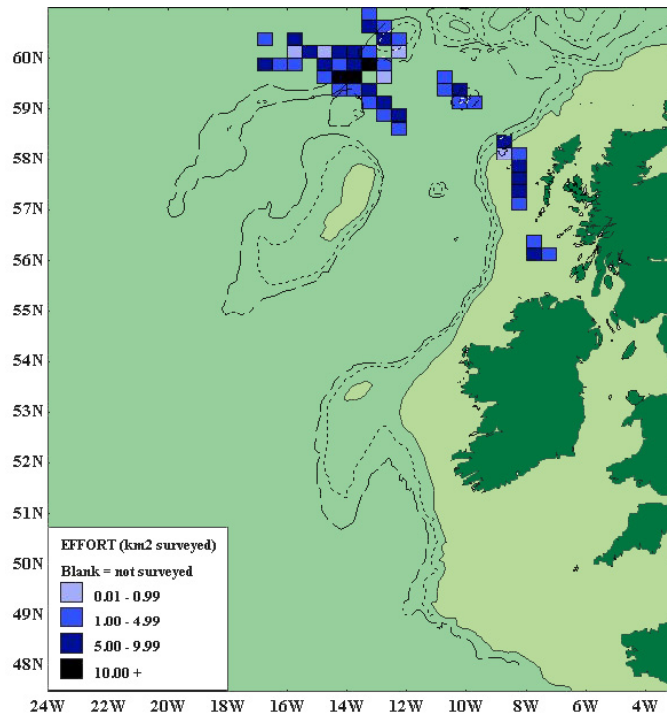
## **Study Area:**

The primary study area during the cruise was concentrated over the Lousy Bank and the northern sectors of the George Bligh Bank and the Hatton Bank (Figure 1). Surveys were also conducted on both the outward and homeward legs, as the vessel steamed over the Rosemary Bank, the continental shelf west of the Western Isles, in close proximity to St Kilda, and the waters northwest of Mull.

## **Results:**

### EFFORT

Full surveys were conducted on all but two days of the 14-day cruise (14<sup>th</sup> August – 27<sup>th</sup> August 2003). The average working period for each day was restricted to 6.30am and 9.00pm GMT, although ship downtime, high wind conditions and severe sun glare limited available survey time further. Approximately 815km<sup>2</sup> of trackline were surveyed during a total of 74 hours 40 minutes (average ~ 5.5 survey hours per day). The survey effort area (km<sup>2</sup>) achieved for each ¼ ICES square, each measuring 15' latitude x 30' longitude, is highlighted in Figure 1.



**Figure 1. Full survey effort achieved for ¼ ICES square surveyed during Discovery Cruise 273.**

## CETACEANS

A total of five cetacean species and two unidentified categories were recorded during the study, comprising a total of 148 animals that were recorded during 18 sighting events (Table 1). Five toothed cetacean species (n=147 animals) and one species of baleen whales (n=1) were positively identified during 16 encounters. In addition to those positively identified animals, 11 unidentified cetaceans were observed during two separate encounters.

### *Toothed Whales*

The most numerous and frequently encountered species was the long-finned pilot whale, which was sighted on 11 separate occasions (61% of all encounters). This squid-eating species accounted for over 82% of all individuals recorded (n=122 animals). With the exception of two encounters, all pilot whale sightings occurred at depths between 1000-2250m (Figure 2). The two exceptions occurred over the shallow region of the Lousy Bank (depth~600m). As was noted last year, the pilot whale was the only species that appeared to display a positive response to seismic operations (i.e. actively approached vessel and arrays). This investigative behaviour may help to explain the relatively high encounter rate. On two occasions, pilot whales were observed swimming above the airgun array. On most occasions however, pilot whales were observed swimming rapidly towards the ship until they get within 150-200m. At this point, they tended to slow to a cautious pace, swimming parallel and in the opposite direction to the vessel. Once level with the stern/array region, most groups milled about in the one position, sometimes quite actively, before moving off in various directions relative to the ship's course. Eight of the eleven pilot whale encounters occurred during seismic operations. A single long-term close encounter occurred as the ship's crew retrieved the air-gun array following the final seismic line (Plate 1). The animals displayed numerous forms of behaviour during this hour-long exhibition, including spy-hopping, logging, tail-slapping, milling and fluking.

**Table 1. Total numbers of individuals and encounters, and average group sizes for each cetacean species recorded during Discovery Cruise 273.**

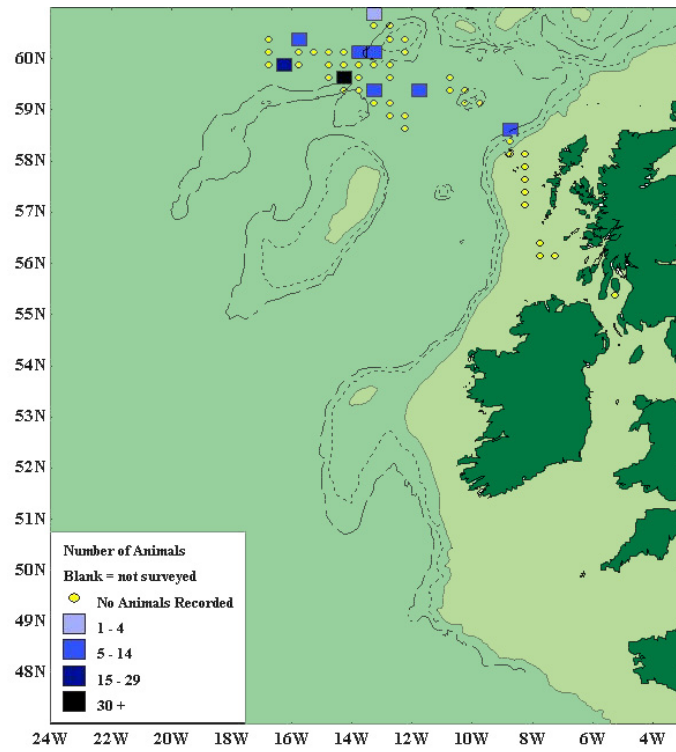
<b>Cetacean Species</b>	<b>Total Number of Animals Recorded</b>	<b>Total Number of Encounters</b>	<b>Average Group Size</b>
<b>Toothed Cetaceans</b>			
Harbour Porpoise	3	1	3
White-sided Dolphin	3	1	3
White-beaked Dolphin	6	1	6
Long-finned Pilot Whale	122	11	11
Sperm Whale	2	1	2
<b>Baleen Whale</b>			
Minke Whale	1	1	1
<b>Unidentified Cetaceans</b>			
Cetacean sp	8	1	8
Dolphin sp	3	1	3
<b>TOTAL</b>	<b>148</b>	<b>18</b>	

Two sperm whales were recorded during a single sighting, on August 26<sup>th</sup> as the ship steamed across the Rockall Trough, southwest of the Rosemary Bank (depth~1600m). The six white-beaked dolphins were recorded in association with a feeding flock of 200-300 northern gannets, within sight of St Kilda, while the three white-sided dolphins were recorded in association with a large male long-finned pilot whale as the vessel steamed between lines over the Lousy Bank. The three harbour porpoises were observed on the final evening of the cruise as the Discovery remained in the Mull of Kintyre. Of some surprise, was the complete lack of common dolphin sightings throughout the cruise.

#### **Baleen Whales**

Only a single sighting of one minke whale was identified throughout the cruise, which occurred during seismic operations. Although eleven fin whales were recorded during BGS cruise 02/02 in July 2002, no sightings were recorded during the current trip.





**Figure 2. Pilot whale sighting locations during Discovery Cruise 273.**



**Plate 1. A family group of long-finned pilot whales swim away from the R.R.S. *Discovery* after an hour-long encounter at the closure of seismic operations.**

## SEABIRDS

Approximately 4070 seabirds, representing 16 species, were recorded during the 14-day survey (Table 2). In addition, 2 waders were observed on August 18<sup>th</sup>. By far the most frequently encountered seabird species (~55% of total) was the northern gannet, with over 95% of sightings occurring close to St Kilda, the world's largest gannetry. Northern fulmars were the second most common species, however their distribution was far more widespread throughout the area surveyed. The low numbers of black-legged kittiwakes noted during this survey was also observed during 2002. This pattern may reflect a preference of this small gull species to waters south of the Hatton-Rockall region. A surprisingly low encounter rate with the migratory sooty shearwaters was recorded – only five birds were recorded during a time normally considered to be a peak period for this pelagic species. The other trans-equatorial migrant commonly observed in Irish waters, the great shearwater was not recorded during the current study, which was probably too early for this species north Atlantic migration. Both the sooty and great shearwaters will generally continue their migration down past Ireland and the British Isles during August and October, returning to their breeding colonies located on islands east of South America. The 31 small skuas (pomarine, arctic and long-tailed skuas) recorded during this trip were observed during their routine migration to their southern wintering grounds off Africa and South America. Only one representative of the auk group was recorded during Cruise 273 – the Atlantic puffin. Eight Atlantic puffins were observed in during three separate encounters. Records of European storm petrels were far more widespread than observed during Cruise 02/02, with limited numbers recorded over the slope waters associated with the continental shelf, the Rosemary, Lousy, George Bligh and Hatton Banks.

**Table 2. Total numbers of seabird and coastal bird species recorded during Discovery Cruise 273.**

<b>Species</b>	<i>Total Number Recorded</i>
Northern Fulmar	1,415
Cory's Shearwater	1
Sooty Shearwater	5
Manx Shearwater	54
European Storm-petrel	29
Leach's Storm-petrel	13
Northern Gannet	2,379
Ringed Plover	1
Ruddy Turnstone	1
Pomarine Skua	20
Arctic Skua	2
Long-tailed Skua	9
Great Skua	14
Sabine's Gull	2
Lesser Black-backed Gull	16
Black-legged Kittiwake	85
Arctic Tern	13
Atlantic Puffin	8

