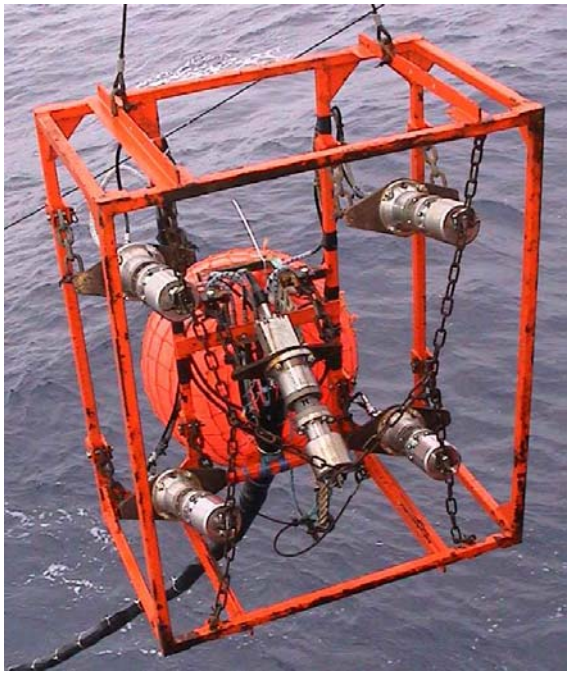
British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Rockall – Hatton 2002
BGS Project 02/02 Operations Report
RRS James Clark Ross Cruise JR76

Continental Shelf and Margins Programme

Internal Report IR/02/152



BRITISH GEOLOGICAL SURVEY

INTERNAL REPORT IR/02/152

Rockall – Hatton 2002
BGS Project 02/02 Operations Report
RRS James Clark Ross Cruise JR76

D. J. Smith

Contributions by: Colin Brett, Neil Campbell, Mick Mackey, David McInroy

Continental Shelf and Margins Programme

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Key words

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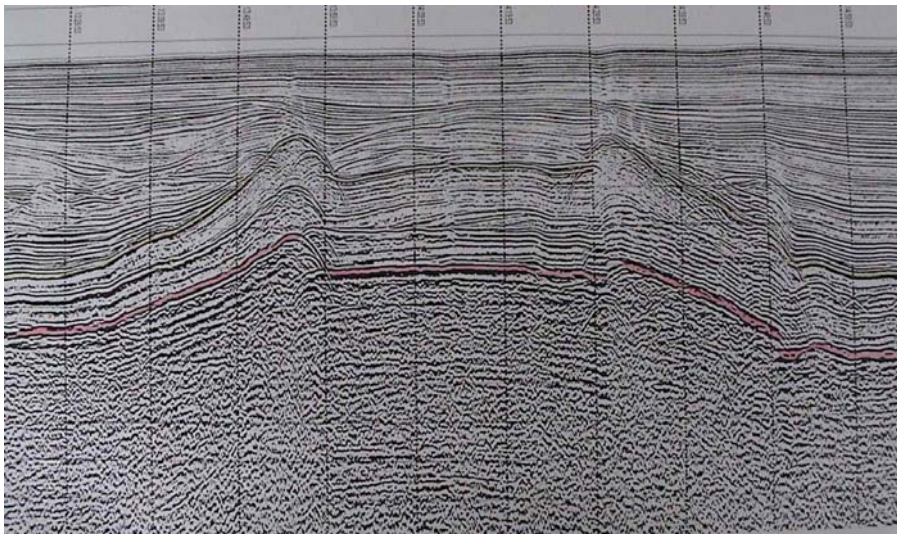
Front cover

5 x 40 cu in Bolt Airguns on frame.



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Foreword

This report covers the operation of RRS James Clark Ross (JCR) Cruise JR76, BGS Project 02/02, a regional marine geophysical survey west of Scotland, carried out from 11th July to 31st July 2002. This field operation continues the regional geological mapping in this area that was initiated 10 years ago as part of the BGS Rockall Continental Margin project. This cruise was funded by the BGS Science Budget.

Acknowledgements

As with any offshore work programme, this project was 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 operation is hereby acknowledged. Grateful thanks are also due to Captain Chris Elliott, the other officers and crew of the RRS James Clark Ross, the technical support provided by British Antarctic Survey (BAS) IT and ETS and the BAS logistical support provided by Chris Hindley, for their efforts and assistance to make this an efficient and smooth operation. Thanks also to Ken Hitchen and Howard Johnson for the report review.

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Summary

This report describes the operation for BGS Project 02/02, from the mobilisation on the 14th June to the regional marine geophysical survey west of Scotland carried out from 11th July to 31st July 2002. The main objective was to in fill gaps in the existing seismic data coverage, which is especially sparse over north Hatton Bank.

The operational aims of the survey project were:

- To carry out a planned programme of 2100 km of marine geophysical surveying to link into existing data
- Run additional lines if any of the lines showed any unexpected or interesting seismic reflectors
- Identify windows in the Palaeogene lavas

The order of priority of the survey areas were

- North Rockall Trough
- Northern Hatton Bank
- Additional lines

The geophysical techniques employed were high-resolution single channel seismic reflection, (Airgun and Sparker), gravitational field, magnetic field and swath bathymetry. All systems were digitally recorded and in addition both Airgun and Sparker were digitally processed on line.

The vessel used was the RRS James Clark Ross (JCR), Cruise JR76. This platform proved to be excellent for the work involved with excellent laboratory space, working deck space, general facilities, vessel stability and experienced officers and crew.

A cetacean observer from the Coastal Resources Centre, University of Cork was invited onboard the vessel to monitor the movements of whales, dolphins and sea birds.

The majority of equipment was loaded in Leith on the 14th June at the same time as the mobilisation for cruise JR75. The main mobilisation took place in Stornoway on the 11th July. Operations were conducted over the next 16 days and demobilisation took place in Portsmouth on the 31st July. Weather conditions varied but, in general, were better than expected for the area and no survey time was lost due to weather.

The survey was extremely productive with the entire planned programme of 2100 km being completed in 12 days. Additional lines were run for both in the North Rockall Trough and North Hatton Bank.

In total 2810 line km of generally very good quality data were collected.

1 Introduction

The British Geological Survey Project 02/02 was a marine geophysical survey (seismic reflection, gravitational field, magnetic field, bathymetry) over the North Rockall Trough and North Hatton Bank. The survey was designed to fill in gaps in the existing seismic data coverage, which is especially sparse over North Hatton Bank. There were essentially two scientific aims of the survey:

1) To map known seismic reflectors in the Cenozoic succession in the North Rockall Trough, with the ultimate aim of combining the interpretations with those from other seismic datasets and well data to produce a geological map of the North Rockall Trough. The production of this map forms part of the continuing mapping programme of the BGS Continental Shelf and Margins Programme, which is currently evaluating the offshore geology west of Scotland.
2) To map and date compressional structures on north Hatton Bank, with the ultimate aim of identifying the regional stress patterns that have affected the Atlantic margin offshore UK and Norway.

2 Narrative

All times are GMT.

2.1.1 Mobilisation

The mobilisation of cruise JR76 on board the RRS James Clark Ross (JCR) was split into two phases both were shared with cruise JR75. The first was in Leith on June 14th which was the starting piont for cruise JR75. Here BGS equipment from Antarctic cruise JR71 was sorted, equipment not required for JR75 or JR76 was returned to BGS Loanhead. Equipment for JR75 and JR76 was loaded onto the vessel and where possible commissioned.

The second mobilisation took place on July 11th in Stornoway at the same time that JR75 was demobilising, with extra equipment including the gravity meter, transported to Stornoway by van.

A gravity base tie was conducted at the 'Old Ferry Jetty' gravity base station shortly before departing for the survey area.

2.1.2 Survey

The vessel sailed from Stornoway at 05:44 on July 12th on passage to the survey area. A ship's safety briefing was carried out in the morning and the survey area was reached just after lunch. The vessel's hull cathodic protection system was switched off prior to the start of the survey and remained off for the entire survey period. The vessel's cathodic protection system pumps electrical energy in the form of dirty DC current, rectified from 50 Hz AC supply to reduce the effects of seawater corrosion on the hull. The resultant 100 Hz noise signal observed swamps the returned signals from the airgun and sparker hydrophones. Tests carried out during cruise JR71 confirmed that the vessel is unsuitable for BGS seismic reflection operations with the present system switched on. Agreement was made with BAS prior to the start of the project that the system would be switched off for this project. At 11:50 the vessel slowed to deploy over the side equipment 10 nm from the start of the first survey line. Problems were encountered with the airguns, one leaking and another gun's time break signal. By 14:15 all equipment had been deployed and all systems were operational.

Line 1 was started at 16:30 utilising the following systems, airgun, sparker, gravity, magnetometer and swath bathymetry. Lines 2 to 12 followed without interruption from weather or equipment down time, with sparker and airgun maintenance carried while transiting between survey lines. On Line 3 the seismic data quality suffered slightly due to poor weather but was within acceptable limits. The spare magnetometer was deployed before the start of line 8, due to increased noise on the record. The problem was traced to water ingress in the inboard connector. The repaired magnetometer was deployed prior to the start of line 18 and was used for the reminder of the survey. The first part of the survey, North Rockall Trough was completed at 02:06 on 19th July.

The second part of the survey around the northern part of Hatton Bank followed immediately with line 13 and was well ahead of schedule. Midway through line 13 the power supply within the gravity meter control computer catastrophically failed. This resulted in the meter becoming unstable with associated loss of data. The gravity meter was restored to a working condition with a spare computer with no apparent damage or tear in the data. The survey continued to experience no weather, vessel or equipment down time. Part way through the agreed line plan two additional lines, 20 and 23 were added to the survey. The remaining lines from the original line plan were completed in deteriorating weather conditions with line 25 completed at 17:31 on 25th July. Further additional lines followed, concluding with a long line linking the NE section

of the North Hatton Bank with the North Rockall Trough area, finishing at the edge of the Hebrides Shelf NW of St Kilda at 01:30 on the 28th July. Approximately 700 additional survey line kilometres were completed, bringing the total survey to over 2800 km in 15.4 survey days. During the period inside the survey area, 85% was spent online, 14% turning between lines and 1% steaming. No time was lost through weather, vessel or BGS equipment down time.

During the morning of 28th July a current meter mooring belonging to Southampton Oceanographic Centre (SOC), part of a Scottish Association for Marine Sciences (SAMS) project was reported to be drifting close to our passage to Portsmouth. The JCR diverted to pickup the remains of the mooring.

2.1.3 Demobilisation

The vessel tied up at the FSL dockyard, Portsmouth in dry dock No. 15 at 14:30 on the 31st July. The dock remained flooded for the period of unloading BGS survey and sampling equipment from the last two JR cruises. A gravity base tie was conducted at the 'West Harbour Wall' Ministry of Defence (MOD) gravity base station prior to decommissioning the marine gravity meter. All BGS staff left the vessel that day and returned to Edinburgh.

3 Equipment Used

3.1 AIRGUN SYSTEM

Source: An array of 5 x 40 cu inch Bolt 600B airguns with waveshape kits and time break solenoids was utilised as the airgun source. Routinely, up to four guns were fired simultaneously, keeping the fifth gun as a ready spare. The number of guns used varied with water depth, with a minimum of three being used in the shallower areas. The firing rate varied from 5 – 8 seconds depending on water depth. The airgun array firing synchronisation was achieved by monitoring the time break solenoids and manually adjusting each airgun's trigger as required. This introduces a short time delay into the system of between 25 and 38 milliseconds and thus the sea bed return time is not an absolute measurement of depth. Two of the four vessel's Hamworthy compressors had been commissioned for the project. Only the capacity of one compressor was required to power all five guns at the fastest firing rate required. The two compressors were used on an approximate 24 hourly rotation.

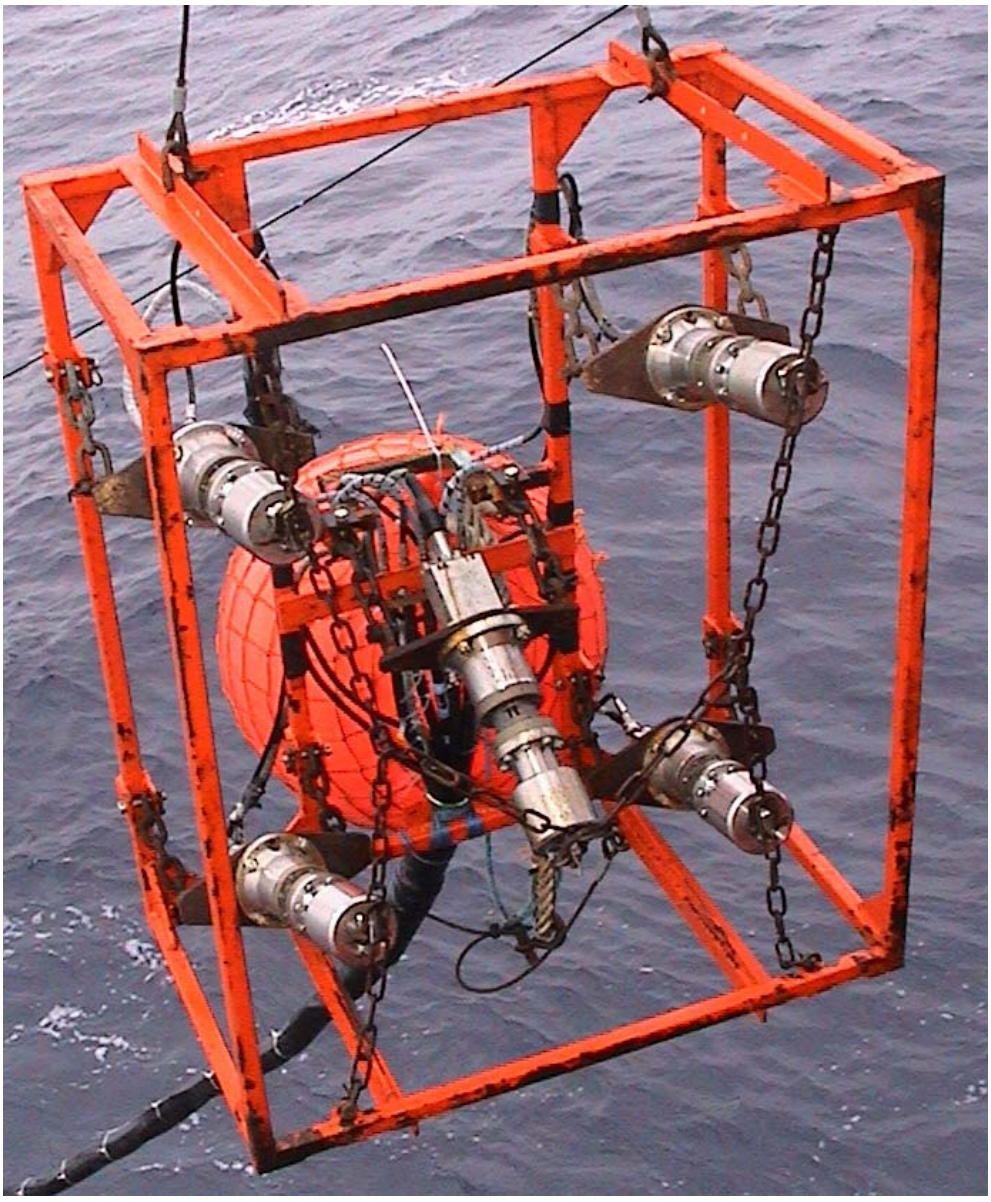


Plate 1 5 x 40 cu in airguns and frame

Plate 2 Airgun array firing and hydrophone on reel

Hydrophone: A two-channel Geomechanique hydrophone summed to give a single channel 30m active length was utilised as the receiver for the airgun source.

Recording: A CODA DA200, software version 2.2.16.4 (2002) four-channel digital recording and processing system was utilised to record the raw data. The data were recorded on Exabyte tape in CODA format with a sampling interval of 0.2 msec, record length of 4 seconds and bandpass filter of 25-500 Hz. The start of recording was delayed in deep water to permit a minimum of 2 seconds of data below the sea bed. The CODA system also received a navigation data string from the vessels navigation processor, and logged position, time and date on each shot.

Online processing: In addition to the recording described above, the CODA system was also used to process the data on-line and 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 and, in extremely large amplitude sea swell situations, a swell filter. Both TVG and TVF were applied from the sea bed, which was tracked automatically. A 1.4sec record length was used for the on-line hard copy, with a delay adjusted to give an optimum record for the water depth.

Plate 3 2 x seismic reflection recording systems

3.2 SPARKER SYSTEM

Source: EG&G, nine candle, multi-tip sparkarray with 135 tips was utilised as the sparker source.

High Voltage Power Supply: Applied Acoustic Engineering CSP3000 capacitor charging unit. This is a single unit, powered from the ship's 240VAC supply incorporating switchable output energy up to a maximum of 2200 J. Apart from the beginning of line 1 the whole survey was conducted at an output of 2200 J.

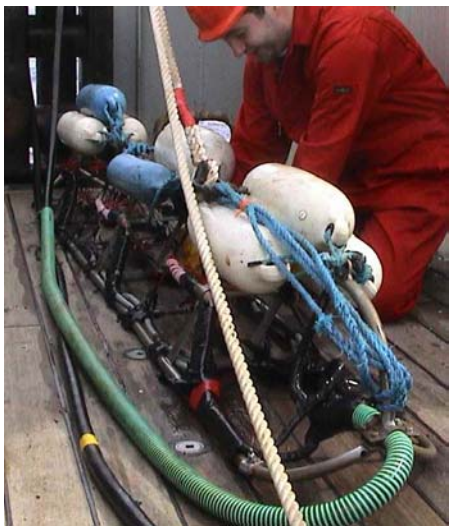


Plate 4 135 tip sparkarray

Hydrophone: A seven channel Teledyne 10m hydrophone, summing all channels to give a single output, was utilised as the receiver for the sparker source.

Recording: This utilised the same CODA DA200 four-channel digital recording and processing system as the airgun, with the data recorded on the same Exabyte tape in CODA format. The data were recorded with a sampling interval of 0.1msec, record length of 1.5 seconds and a bandpass filter of 130-2000 Hz. The start of recording was delayed in deep water to permit a minimum of 1 second of data below the seabed. As with the airgun, position, time and date were 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 (occasionally), and trace mixing. Both TVG and TVF were applied from the sea bed, which was tracked automatically. A 500msec record length was used for the online hard copy, with a delay adjusted to give an optimum record in the prevailing water depth. The performance of the CODA systems was the best that had been seen for the method that BGS uses to collect and processes data online.

Plate 5 Online processing

3.3 GRAVITY METER

The gravity meter used was a ZLS Corporation UltraSys controlled LaCoste and Romberg sensor serial No. S75 system. This consists of a highly damped, zero-length spring type gravity sensor mounted on a gyro-stabilised platform, together with associated control and recording electronics. The sensor and control electronics were located two decks below, and forward of, the main laboratory within the Gravity Room 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 logging and processing system and internally in the gravity control computer. Additional backup data storage were achieved through utilising the zip drive incorporated with the gravity control computer. Data were also output to a colour printer for QC purposes. No data processing was carried out on the vessel.

The gravity meter performed well, the only problems encountered being outdated manuals, which caused some confusion on mobilisation, and the failure of the gravity control computer resulting in a few hours loss of data. Preliminary calibration results indicate this failure did not affect the data collected.

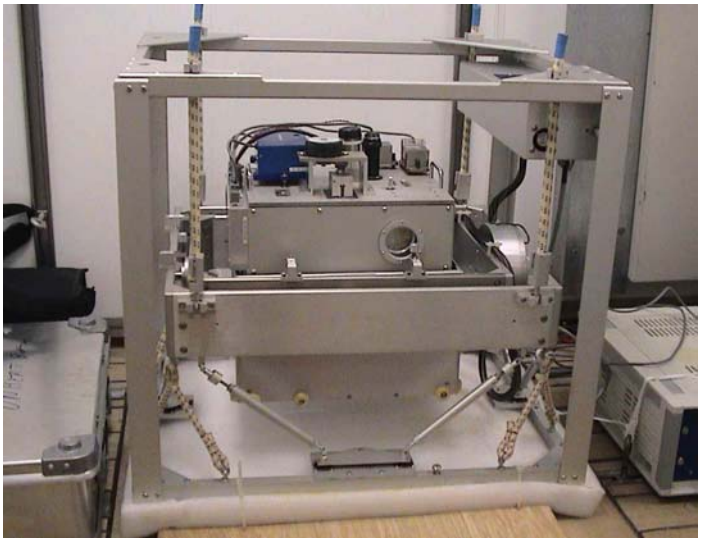


Plate 6 Marine gravity meter

3.4 MAGNETOMETER

The system used was a Barringer proton precession magnetometer with 1 gamma sensitivity. The sensor was towed 200 m astern to minimise the effects of the vessel's steel hull on the local magnetic field. 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. The data were converted from parallel Binary Coded Decimal (BCD) data to serial data within a BCD to serial converter before being logged onto the ship's logging and processing system.

The system performed well. The only problem encountered was that there was water ingress in the tow cable connector of one of the magnetometers sensors. This caused a deterioration in data quality on part of one line. Consideration should be given to the replacing the ageing ink pen chart recorder with a thermal recorder, or similar, as paper and pens are becoming expensive and difficult to source.

Plate 7 Magnetometer sensor on deck and deployment

3.5 SWATH BATHYMETRY

Bathymetry data were required for:

- Basic bathymetry mapping
- Gravity data reduction
- Magnetic data reduction

The minimum BGS requirement for water depth logging is point depth below vessel track. The shipboard Kongsberg-Simrad EM120 swath system was utilised for this purpose. Being a swath system it can obtain water depth information equalling up to 1.5 times the water depth port and starboard of the vessel's track. Three Expendable Bathythermographs (XBT) were launched during the survey to provide a sound/velocity profile through the water column to maintain the system in calibration.

Various problems were encountered with the system operating at the survey speed of 4.5 knots and in sea conditions greater than +/-2 degrees of roll. These are detailed in a separate BAS report, copies kept with the archive data, BAS and the vessel. The views expressed in that report are those of the BAS IT, ETS personnel and the captain and are not necessarily those of BGS. It was of joint opinion that the system did not provide quality data at survey speeds required for seismic reflection operations in anything other than calm conditions, more precisely a vessel roll of greater than +/- 2 degrees.

Swath data were lost on various lines and water depth below vessel track data was lost on parts of lines.

BGS personnel have been on several non BGS JCR cruises where the system has performed very well and it was disappointing to witness the poor performance on this BGS cruise.

Note: Information obtained post cruise on this system has put the poor performance of the swath system down to mud in the transducer space. This was found during the vessel's annual refit scheduled immediately after JR76.

Examples in Appendix 7 show quality data on line 10 (**Error! Reference source not found.**) and the ends of other lines (**Error! Reference source not found.**) where the vessel changes from a stable heading (< +/-2 degrees of roll) to a heading where the vessel experiences greater roll.

3.6 NAVIGATION, PROCESSING AND DATA LOGGING

The process of calculating the position of the ship track was carried out using a differential corrected Trimble GPS receiver and logged to the vessel's scientific logger. WGS 84 datum was used throughout the survey.

The vessel is steered using another differential corrected GPS receiver, the Ashtec.

Amongst the data logged to the vessels logger is time, date, water depth, the BGS raw gravity data set and the BGS magnetometer data.

Data was extracted onto CD in MGD77 format and the BGS specified format:

Project name, Line No., Date, Time, Lat, Long, Water depth, full raw gravity data string, Magnetometer

A track plot of each completed line was plotted to allow geological interpretation to be carried out on a daily basis. A completed line track chart was plotted at a 1:500,000 scale. A TIFF file image of the track chart was also provided.

Swath data were logged to the Kongberg Simrad EM120 logger. Digital Swath data were provided on one tape in Kongberg Simrad format. A TIFF file image of the track chart was also produced.

4 Initial Geological Findings

Contribution by D. McInroy

4.1 NORTH ROCKALL BASIN

The Rockall Basin is a NE-SW trending intra-continental basin and is located offshore northwest Britain and Ireland. In the north Rockall Basin where the seismic surveying was undertaken, the water depth reaches over 1500 metres. Further south, the water depth increases to 4 kilometres. The Rockall Basin is essentially a failed rift arm of the proto-North Atlantic Ocean. The Rockall area experienced continental rifting throughout the Late Mesozoic and Early Cenozoic (150 to 53 million years ago) as the North Atlantic Ocean attempted to open along the axis of the Rockall Basin. The rifting ceased before sea-floor spreading could begin, and instead ocean spreading commenced further west at the current spreading axis 53 million years ago. The Rockall Basin now remains as a failed rift preserved in the continental crust. The early stages of ocean-opening were accompanied by extensive igneous activity, and much of the Atlantic margin off northwest Britain is covered in thick lavas.

By mapping the sediments preserved in the Rockall Basin, we hope to better understand what has happened to the basin during the last 53 million years since the Atlantic Ocean opened. It is known that the Rockall Basin hasn't experienced tectonic quiescence during this time, rather it has experienced periods of subsidence, uplift and compression. These events affected the continental margin from offshore southwest Ireland to offshore Norway.

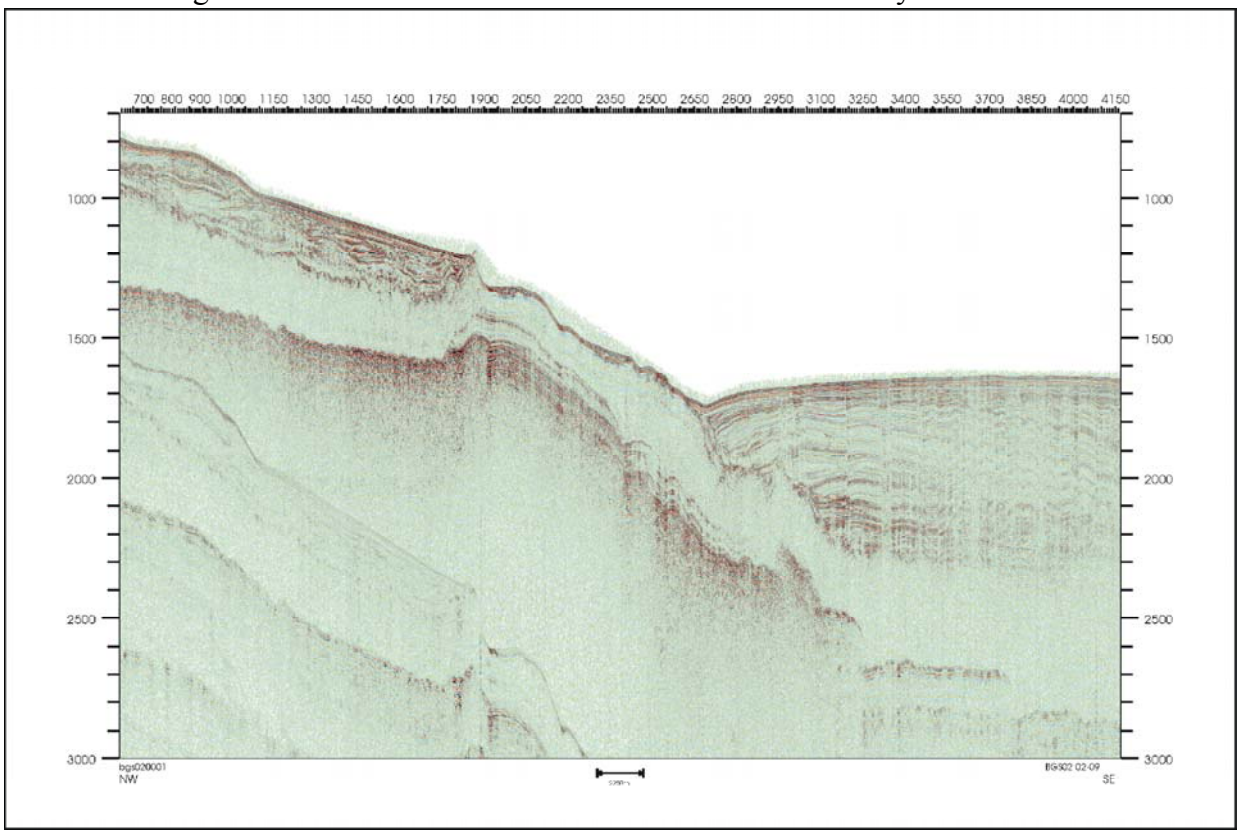


Plate 8 Shows interpreted airgun seismic line 9 (after post cruise processing using Promax and Landmark systems) across part the north Rockall Basin Southeast of Lousy Bank showing domed lavas and sediments.

4.2 NORTH HATTON BANK

North Hatton Bank, a submerged piece of continental crust, is situated approximately 600 km northwest of Britain and is the last piece of continental crust of significant thickness before the North Atlantic oceanic crust begins. 150 to 53 million years ago, rifting affected Hatton Bank, the adjacent Hatton Basin and the Rockall Basin. However, during the last 53 million years the UK and Norwegian Atlantic margin (including Hatton Bank) has experienced three or four compressional phases which have folded, domed and reverse faulted the Cenozoic sediments and underlying Palaeogene lavas. The 2002 BGS survey of Hatton Bank has revealed some interesting structures that affect these lavas and sediments. These strata have been folded and faulted on the southeast side of the bank. As is the case with other compressional structures along the UK and Norwegian Atlantic margin, there is debate over the driving mechanisms behind the compressional stress fields: are they effects from the opening of the nearby Atlantic Ocean, movement along large scale transfer faults, lithospheric drag associated with the Iceland Plume, the far-field Alpine Orogeny or due to a combination of these factors?

Appendix 1

BGS		**RRS James Ross Clark**	
Dave Smith	*Electronic Engineer-Principal Scientist*	Chris Elliott	*Master*
Davie Baxter	*Mechanical Engineer*	Robert Patterson	*Chief Officer*
Colin Brett	*Geophysicist*	Kim Cooling	*2nd Officer*
Neil Campbell	*Mechanical Engineer*	Michael Golding	*3rd Officer*
David McInroy	*Geologist*	John Summers	*Deck Officer (Science)*
Dave Wallis	*Electronic Engineer*	David Cutting	*Chief Engineer*
Michael Wilson	*Electronic Engineer*	Bill Kerswell	*2nd Engineer*
		Gerry Armour	*3rd Engineer*
		Steve Eadie	*4th Engineer*
		Simon Wright	*Deck Engineer*
University of Cork		Norman Thomas	*Senior Electrical Officer*
Mick Mackey	*Cetacean Observer*	Ken Olley	*Purser/Catering Officer*
		Charlie Waddicor	*Radio Officer*
		George Stewart	*Bosun*
		Dave Williams	*Bosun's Mate*
		Derek Jenkins	*Seaman*
		Marc Blaby	*Seaman*
		John McGowan	*Seaman*
		Dave Rees	*Seaman*
		Jim Baker	*Seaman*
		Mark Robinshaw	*Motorman*
		Charlie Smith	*Motorman*
		Richard Turner	*Chief Cook*
		Lawarence Baldwin-White	*2nd Cook*
		Cliff Pratley	*2nd Steward*
		Derek Lee	*Steward*
		Kenneth Weston	*Steward*
		Jimmy Newall	Steward

Appendix 2 Summary Daily Log

All Times quoted are GMT

Project 02/02 Summary Daily Log

Date: 11 July

Time

07:00 Join vessel in Stornoway and start mobilisation

Total km of completed lines: 0

	Today (hours)	Total (hours)
Mob/Demob, setting up	17.0	17.0
On line		0.0
Turning		0.0
Steaming		0.0
Weather downtime		0.0
Equipment downtime		0.0
Vessel downtime		0.0
Port		0.0

Project 02/02 Summary Daily Log

Date: 12 July

Time

05:00 Gravity base tie carried out

05:44 Vessel sailed Stornoway, on passage to survey area

07:00 Scientific cruise briefing

07:30 Ship's safety briefing

11:50 Slowed to deploy outboard equipment 10 nm from start of line 1,

12:30 Airguns deployed, problems with one airgun 3 leaking and airgun 1 time break signal

12:45 Airguns recovered for repair

13:59 Deploy Airguns, Gun 1 time break monitor poor

14:15 Magnetometer deployed

14:28 All equipment deployed and operational, turning towards line 1

16:30 SOL1 Airgun, Sparker, Gravity, Magnetometer, Swath Bathymetry, data quality good.

18:52 Sparker power increased to 2200 J

19:00 Adjust course to avoid fishing vessel/gear

22:00 Switched on gun 1, time break OK

22:30 XBT launched

24:00 Online 1

Total km of completed lines: 124

	Today (hours)	Total (hours)
Mob/Demob, setting up	9.6	26.6
On line	7.5	7.5
Turning		0.0
Steaming	6.2	6.2
Weather downtime		0.0
Equipment downtime		0.0
Vessel downtime		0.0
Port	0.7	0.7

Project 02/02 Summary Daily Log

Date: 13 July

Time

00:00 Online 1

06:56 EOL1, recover Sparker for trimming

07:10 Deploy Sparker, head for line 2

08:26 SOL2

15:47 Slowed slightly – gear at surface

16:00 Weather conditions deteriorating, force 5/6

17:25 Problems with Swath system, very poor data

17:55 Adjust course for fishing vessel

18:10 Swath problems continuing, under investigation

18:15 Returning to line course

19:45 Tried firing two Sparker cycles per Airgun cycle, bang box tripped, resume with one cycle

19:55 Sea state building, Sparker data poor

24:00 Online 2

Total km of completed lines: 274

	Today (hours)	Total (hours)
Mob/Demob, setting up		26.6
On line	22.5	30.0
Turning	1.5	1.5
Steaming		6.2
Weather downtime		0.0
Equipment downtime		0.0
Vessel downtime		0.0
Port		0.7

Project 02/02 Summary Daily Log

Date: 14 July

Time

00:00 Online 2

00:32 EOL 2

00:40 Sparker recovered for trimming

00:50 Sparker deployed, turning towards line 3

01:52 SOL 3

07:42 EOL 3

07:45 Sparker recovered for trimming

08:00 Sparker deployed, turning towards line 4, checked data on CODA tape 1

08:45 SOL 4

10:00 Adjust hydrophone (Sparker) – in 1m

14:00 Problems with fix mark on CODA – Sparker, trying to adjust the time of marks

15:00 Fix marks back on Sparker

15:36 Firing rate 7 seconds - all systems

20:00 EOL 4

20:17 Sparker recovered for trimming

20:40 Sparker deployed, heading for line 5 at increased speed of 5.5 knots

22:08 SOL 5

22:50 Magnetometer noisy, less noisy after isolated connector from deck

24:00 Online 5

Total km of completed lines: 428

	Today (hours)	Total (hours)
Mob/Demob, setting up		26.6
On line	20.5	50.5
Turning	3.5	5.0
Steaming		6.2
Weather downtime		0.0
Equipment downtime		0.0
Vessel downtime		0.0
Port		0.7

Project 02/02 Summary Daily Log

Date: 15 July

Time

00:00 Online 5
04:00 Increasing swell from SW
05:25 Magnetometer noisy
05:57 Magnetometer OK, deck cable connector on drum touching frame
07:45 Occasional leak on gun 3, switch out
09:55 Magnetometer still noisy, firing rate 6 sec
11:52 EOL 5
12:05 Recover Airguns and Sparker
12:15 Magnetometer inboard and replaced by spare, OK
12:25 Sparker deployed
12:40 Heading back towards aim point
12:50 Airguns deployed and tested
14:12 SOL 6
14:43 Cannot keep gun 3 in synchronisation with others
14:48 Airgun 3 back in
20:00 Problems synchronising gun 3, has reached limits of delay range
20:59 Airgun 3 off, timing erratic
22:22 EOL 6
22:31 Sparker recovered for trimming, hose broken on frame cable clamp, repair
23:43 SOL 7
24:00 Online 7

Total km of completed lines: 625

	Today (hours)	Total (hours)
Mob/Demob, setting up		26.6
On line	21.5	72.0
Turning	2.5	7.5
Steaming		6.2
Weather downtime		0.0
Equipment downtime		0.0
Vessel downtime		0.0
Port		0.7

Project 02/02 Summary Daily Log

Date: 16 July

Time

00:00 Online 7

09:42 EOL 7, recover Airguns and Sparker for servicing, new set of candles for Sparker and replace broken earth connection. Recover magnetometer and deploy other magnetometer

11:05 Broken off earth lug could have been the cause of noise and poor performance of Sparker. Repaired magnetometer still noisy, replace with other magnetometer

12:18 SOL 8

21:10 EOL 8

21:20 Airguns and Sparker recovered for maintenance

21:44 Sparker deployed

21:50 Airguns deployed, tested all OK

22:02 Head towards SOL

23:35 SOL 9

24:00 Online 9

Total km of completed lines: 791

	Today (hours)	Total (hours)
Mob/Demob, setting up		26.6
On line	19.4	91.4
Turning	4	11.5
Steaming		6.2
Weather downtime		0.0
Equipment downtime	0.6	0.6
Vessel downtime		0.0
Port		0.7

Project 02/02 Summary Daily Log

Date: 17 July

Time

00:00 Online 9

10:08 Dogleg start turn

10:35 Dogleg finish turn, heading 178 deg

16:37 EOL 9, guns off, Sparker recovered for trimming, earth lug come off

17:10 Sparker deployed, heading towards SOL

17:30 SOL 10

23:55 EOL 10

24:00 Heading towards line 11

Total km of completed lines: 998

	Today (hours)	Total (hours)
Mob/Demob, setting up		26.6
On line	23.0	114.4
Turning	1.0	12.5
Steaming		6.2
Weather downtime		0.0
Equipment downtime		0.6
Vessel downtime		0.0
Port		0.7

Project 02/02 Summary Daily Log

Date: 18 July

Time

00:00 Heading for line 11

00:05 Sparker recovered for trimming

00:15 Sparker deployed

01:15 SOL 11

01:55 Gun 1 not firing correctly, guns 2+3+4+5 on

16:26 EOL 11, guns of, Sparker recovered for trimming, new earth wire mounting attached to Sparker frame

17:20 SOL 12, Airguns 1+2+3+4, Firing rate 7 sec

18:30 Airgun 1 time break return intermittent

24:00 Online 12

Total km of completed lines: 1200

	Today (hours)	Total (hours)
Mob/Demob, setting up		26.6
On line	21.75	136.15
Turning	2.25	14.75
Steaming		6.2
Weather downtime		0.0
Equipment downtime		0.6
Vessel downtime		0.0
Port		0.7

Project 02/02 Summary Daily Log

Date: 19 July

Time

00:00 Online 12
02:06 EOL12
02:10 Sparker recovered for trimming
02:20 Sparker deployed
03:05 SOL13
11:15 Gravity data not updating, followed a bang as the control computer failed
12:41 Starting to alter course for dogleg
12:46 Course alteration for dogleg completed
12:55 Gravity meter settled and operational
20:13 EOL13
20:40 Sparker recovered for trimming
20:56 Sparker deployed
21:20 SOL14
24:00 Online 14

Total km of completed lines: 1409

	Today (hours)	Total (hours)
Mob/Demob, setting up		26.6
On line	22.0	158.15
Turning	2.0	16.75
Steaming		6.2
Weather downtime		0.0
Equipment downtime		0.6
Vessel downtime		0.0
Port		0.7

Project 02/02 Summary Daily Log

Date: 20 July

Time

00:00 Online 14
03:32 EOL14
03:50 Airguns recovered, replace gun 1, Sparker recovered for trimming
06:00 Sparker and Airguns deployed, gun 4 failed to fire
06:30 Airguns recovered
07:10 Airguns deployed, gun 3 leaking but cleared itself
07:38 SOL15
15:10 EOL15
15:17 Sparker recovered for trimming
15:25 Sparker deployed
15:35 Guns tests, gun 1 not working, recover airguns
16:30 Guns deployed
17:50 SOL16
24:00 Online 16

Total km of completed lines: 1532

	Today (hours)	Total (hours)
Mob/Demob, setting up		26.6
On line	19.5	158.15
Turning	4.5	21.25
Steaming		6.2
Weather downtime		0.0
Equipment downtime		0.6
Vessel downtime		0.0
Port		0.7

Project 02/02 Summary Daily Log

Date: 21 July

Time

00:00 Online 16
01:30 EOL16
01:35 Sparker recovered for trimming
01:45 Sparker deployed
04:06 SOL17
11:55 EOL17
12:02 Sparker recovered for trimming
12:22 Magnetometer recovered to test with repaired magnetometer, OK
12:25 Sparker deployed
14:30 SOL18
23:26 EOL18
23:35 Sparker recovered for trimming
23:45 Sparker deployed
24:00 Heading for SOL19

Total km of completed lines: 1685

	Today (hours)	Total (hours)
Mob/Demob, setting up		26.6
On line	18.75	176.9
Turning	5.25	26.5
Steaming		6.2
Weather downtime		0.0
Equipment downtime		0.6
Vessel downtime		0.0
Port		0.7

Project 02/02 Summary Daily Log

Date: 22 July

Time

00:00 Heading towards SOL19

02:07 SOL19

12:00 EOL19

12:15 Airguns recovered, Sparker recovered for trimming

12:47 Airguns and Sparker deployed

13:37 SOL20

24:00 Online 20

Total km of completed lines: 1872

	Today (hours)	Total (hours)
Mob/Demob, setting up		26.6
On line	19.25	196.15
Turning	4.75	31.25
Steaming		6.2
Weather downtime		0.0
Equipment downtime		0.6
Vessel downtime		0.0
Port		0.7

Project 02/02 Summary Daily Log

Date: 23 July

Time

00:00 Running line 20
01:16 EOL20
01:30 Sparker recovered for trimming, replaced 3 candles
03:50 Airguns recovered, replaced gun 3
04:30 Airguns deployed
04:35 Sparker deployed
05:30 SOL21
12:33 Guns finally failed after 122, 558 shots
16:30 EOL21
16:45 Airguns recovered, Sparker recovered for trimming
17:10 Airguns deployed
18:30 Sparker deployed
19:10 SOL22
24:00 Online 22

Total km of completed lines: 2062

	Today (hours)	Total (hours)
Mob/Demob, setting up		26.6
On line	19.75	215.9
Turning	4.25	35.5
Steaming		6.2
Weather downtime		0.0
Equipment downtime		0.6
Vessel downtime		0.0
Port		0.7

Project 02/02 Summary Daily Log

Date: 24 July

Time

00:00 Online 22
05:06 EOL22
05:15 Sparker recovered for trimming
05:25 Sparker deployed
05:30 Airguns recovered
06:15 Airguns deployed
07:34 SOL23
16:38 EOL23, Sparker recovered for trimming
16:55 Sparker deployed
17:50 SOL24
24:00 Online 24

Total km of completed lines: 2256

	Today (hours)	Total (hours)
Mob/Demob, setting up		26.6
On line	20.4	236.3
Turning	3.6	39.1
Steaming		6.2
Weather downtime		0.0
Equipment downtime		0.6
Vessel downtime		0.0
Port		0.7

Project 02/02 Summary Daily Log

Date: 25 July

Time

00:00 Online 24

05:55 EOL24, sea states moderate

05:56 Airguns, Sparker, 2 x hydrophones recovered,

06:16 Transit to next line at 12 knots, with magnetometer only deployed

09:03 Slowing down to deploy equipment in worsening sea conditions

09:30 Airguns and hydrophone deployed and tested

10:13 SOL25, Airgun, magnetometer, echosounder (EA500), gravity, no Sparker, or Swath.

15:06 Altered course for boat

16:03 Back on course

17:31 EOL25

19:30 SOL26, no Sparker, better data in this direction, swath giving depth readings

19:45 Sparker and hydrophone deployed

19:50 Sparker ON

20:10 Wind freshening, occasional 30 knots+

24:00 Online 26

Total km of completed lines: 2388

	Today (hours)	Total (hours)
Mob/Demob, setting up		26.6
On line	17.4	253.7
Turning	4.0	43.1
Steaming	2.6	8.8
Weather downtime		0.0
Equipment downtime		0.6
Vessel downtime		0.0
Port		0.7

Project 02/02 Summary Daily Log

Date: 26 July

Time

00:00 Online 26
02:35 EOL26
02:45 Sparker recovered for trimming
02:55 Sparker deployed
04:25 SOL27
08:25 Sparker OFF, data poor, weather deteriorating
12:07 Sparker recovered for trimming
12:11 EOL27
12:21 Sparker deployed
13:15 SOL28
16:12 Off track to port for fishing float
24:00 Online 28

Total km of completed lines: 2460

	Today (hours)	Total (hours)
Mob/Demob, setting up		26.6
On line	21.0	274.7
Turning	3.0	46.1
Steaming		6.2
Weather downtime		0.0
Equipment downtime		0.6
Vessel downtime		0.0
Port		0.7

Project 02/02 Summary Daily Log

Date: 27 July

Time

00:00 Online 28

24:00 Online 28

Total km of completed lines: 2700

	Today (hours)	Total (hours)
Mob/Demob, setting up		26.6
On line	24.0	298.7
Turning		46.1
Steaming		6.2
Weather downtime		0.0
Equipment downtime		0.6
Vessel downtime		0.0
Port		0.7

Project 02/02 Summary Daily Log

Date: 28 July

Time

00:00 Online 28

01:30 EOL28, end of survey

01:55 All over the side equipment recovered

02:00 Steaming to look for SAMS adrift mooring on passage to Portsmouth

07:30 Mooring spotted

09:10 Completed lifting of mooring string, only partially recovered

09:15 On passage to Portsmouth

24:00 On passage to Portsmouth

Total km of completed lines: 2810

	Today (hours)	Total (hours)
Mob/Demob, setting up		26.6
On line	1.5	300.2
Turning		46.1
Steaming	22.5	28.4
Weather downtime		0.0
Equipment downtime		0.6
Vessel downtime		0.0
Port		0.7

Project 02/02 Summary Daily Log

Date: 29 July

Time

00:00 On passage to Portsmouth

24:00 On passage to Portsmouth

Total km of completed lines: 2810

	Today (hours)	Total (hours)
Mob/Demob, setting up		26.6
On line		300.2
Turning		46.1
Steaming	24.0	52.4
Weather downtime		0.0
Equipment downtime		0.6
Vessel downtime		0.0
Port		0.7

Project 02/02 Summary Daily Log

Date: 30 July

Time

00:00 On passage to Portsmouth

24:00 On passage to Portsmouth

Total km of completed lines: 2810

	Today (hours)	Total (hours)
Mob/Demob, setting up		26.6
On line		300.2
Turning		46.1
Steaming	24.0	76.4
Weather downtime		0.0
Equipment downtime		0.6
Vessel downtime		0.0
Port		0.7

Project 02/02 Summary Daily Log

Date: 31 July

Time

00:00 On passage to Portsmouth

14:30 Arrive Portsmouth

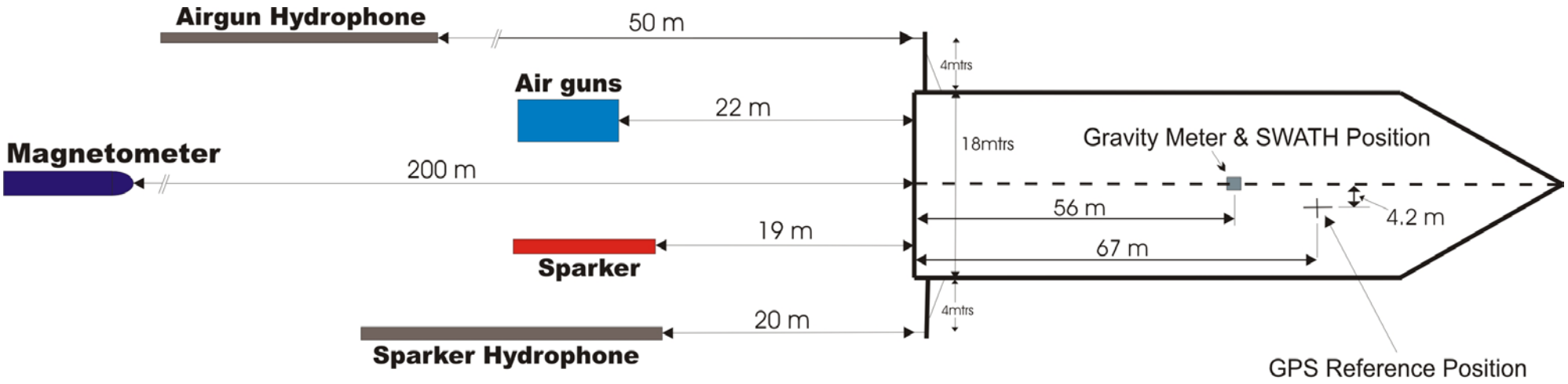
15:00 Demob BGS equipment from vessel

18:30 All BGS staff depart vessel

Total km of completed lines: 2810

	Today (hours)	Total (hours)
Mob/Demob, setting up	8.5	35.1
On line		300.2
Turning		46.1
Steaming	10.0	86.4
Weather downtime		0.0
Equipment downtime		0.6
Vessel downtime		0.0
Port		0.7

Appendix 3 Equipment Layback Diagram



RRS JAMES CLARK ROSS - PROJECT BGS02/02, CRUISE JR 76

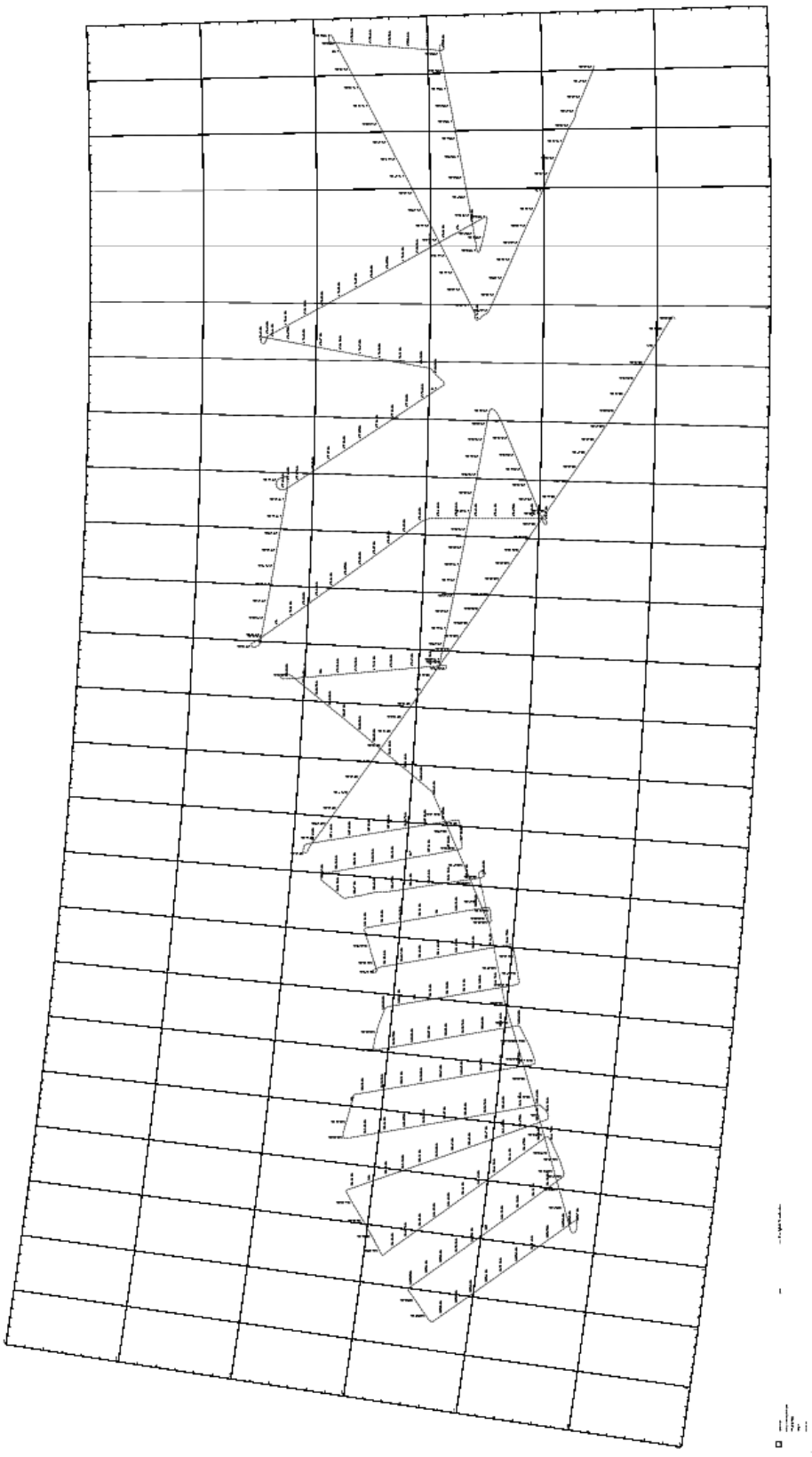
Appendix 4 Line Summary Sheet

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

PROJECT 02/02 ROCKALL-HATTON 2002 GEOPHYSICAL SURVEY **Vessel: RRS James Clark Ross**

Line	Start			End			Length	Total	Equipment Run						Comments
No.	Date	J. Day	Time	Date	J. Day	Time	(km)	(km)	Airgun	Sparker	Gravity	Magnetics	Swath		
1	12-Jul	193	16:30	13-Jul	194	6:56	124	124	x	x	x	x	x		sea state 3-5
2	13-Jul	194	8:26	14-Jul	195	0:32	150	274	x	x	x	x	x		sea state 6
3	14-Jul	195	1:52	14-Jul	195	7:42	52	326	x	x	x	x	x		sea state 6
4	14-Jul	195	8:43	14-Jul	195	20:00	102	428	x	x	x	x	x		sea state 3
5	14-Jul	195	22:08	15-Jul	196	11:52	121	549	x	x	x	x	x		sea state 3
6	15-Jul	196	14:12	15-Jul	196	22:22	76	625	x	x	x	x	x		sea state 3-4
7	15-Jul	196	23:43	16-Jul	197	9:42	91	716	x	x	x	x	x		sea state 3-4
8	16-Jul	197	12:18	16-Jul	197	21:10	75	791	x	x	x	x	x		sea state 3
9	16-Jul	197	23:35	17-Jul	198	16:37	157	948	x	x	x	x	x		sea state 3
10	17-Jul	198	17:30	17-Jul	198	23:55	50	998	x	x	x	x	x		sea state 3-4
11	18-Jul	199	1:15	18-Jul	199	16:26	126	1124	x	x	x	x	x		sea state 3
12	18-Jul	199	17:20	19-Jul	200	2:06	76	1200	x	x	x	x	x		sea state 3-5
13	19-Jul	200	03:05	19-Jul	200	20:13	152	1352	x	x	x	x	x		sea state 3
14	19-Jul	200	21:20	20-Jul	201	03:32	57	1409	x	x	x	x	x		sea state 3-4
15	20-Jul	201	07:38	20-Jul	201	15:10	62	1471	x	x	x	x	x		sea state 3
16	20-Jul	201	17:50	21-Jul	202	01:30	61	1532	x	x	x	x	x		sea state 1-2
17	21-Jul	202	04:06	21-Jul	202	11:55	68	1600	x	x	x	x	x		sea state 3-5
18	21-Jul	202	14:30	21-Jul	202	23:26	85	1685	x	x	x	x	x		sea state 4-5
19	22-Jul	203	02:07	22-Jul	203	12:00	94	1779	x	x	x	x	x		sea state 4-5
20	22-Jul	203	13:37	23-Jul	204	1:16	93	1872	x	x	x	x	x		sea state 4-5
21	23-Jul	204	5:20	23-Jul	204	16:30	100	1972	x	x	x	x	x		sea state 3
22	23-Jul	204	19:10	24-Jul	205	5:06	90	2062	x	x	x	x	x		sea state 3
23	24-Jul	205	7:34	24-Jul	205	16:38	81	2143	x	x	x	x	x		sea state 3-5
24	24-Jul	205	17:50	25-Jul	206	5:55	113	2256	x	x	x	x	x		sea state mod, following swell
25	25-Jul	206	10:13	25-Jul	206	17:31	66	2322	x		x	x			sea state poor, beam on to swell
26	25-Jul	206	19:30	26-Jul	207	2:35	66	2388	x	x	x	x	x		sea state poor, beam on to swell
27	26-Jul	207	4:25	26-Jul	207	12:11	72	2460	x	x	x	x			sea state poor, beam on to swell
28	26-Jul	207	13:15	28-Jul	209	1:30	350	2810	x	x	x	x	x		sea state mod, following swell

Appendix 5 Track Chart



Appendix 6 Gravity Base Ties

Date	Location	Corrected Ship Base (mgals)	Still Meter Reading	Corrected Meter Value (0.9911 x meter Reading, mgals)
12th July 2002	Stornoway, Old Ferry Berth	981815.63	12531.38	12419.85
31st July 2002	Portmouth, West Harbour Wall	981111.17	11814.8	11709.65

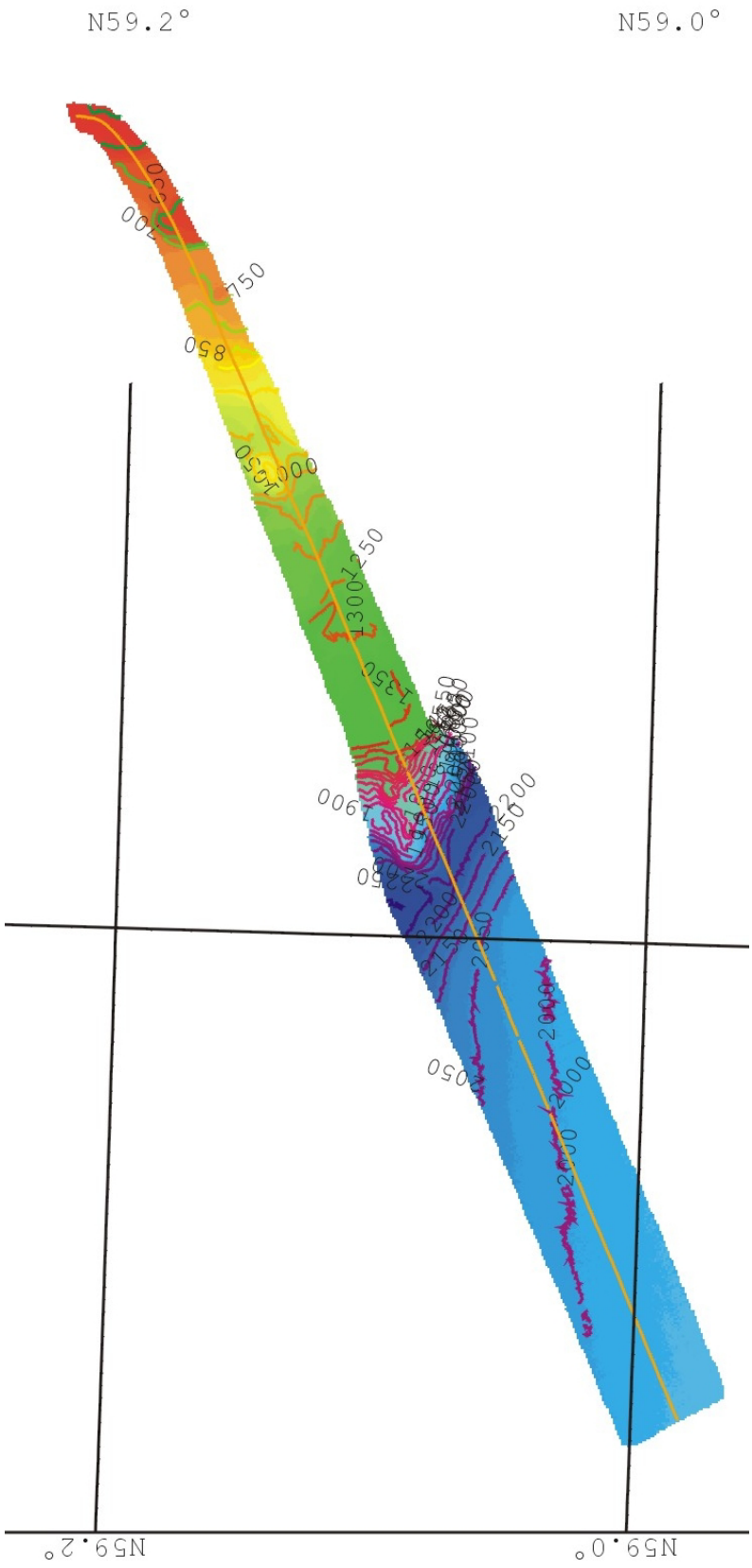
	Stornoway, Old Ferry Berth (mgals)	Portmouth, West Harbour Wall (mgals)	Difference between locations (mgals)
Corrected Ship Base	981815.63	981111.17	704.46
Corrected Meter Value	12419.85	11709.65	710.20
Calculated Drift			-5.74

Notes:

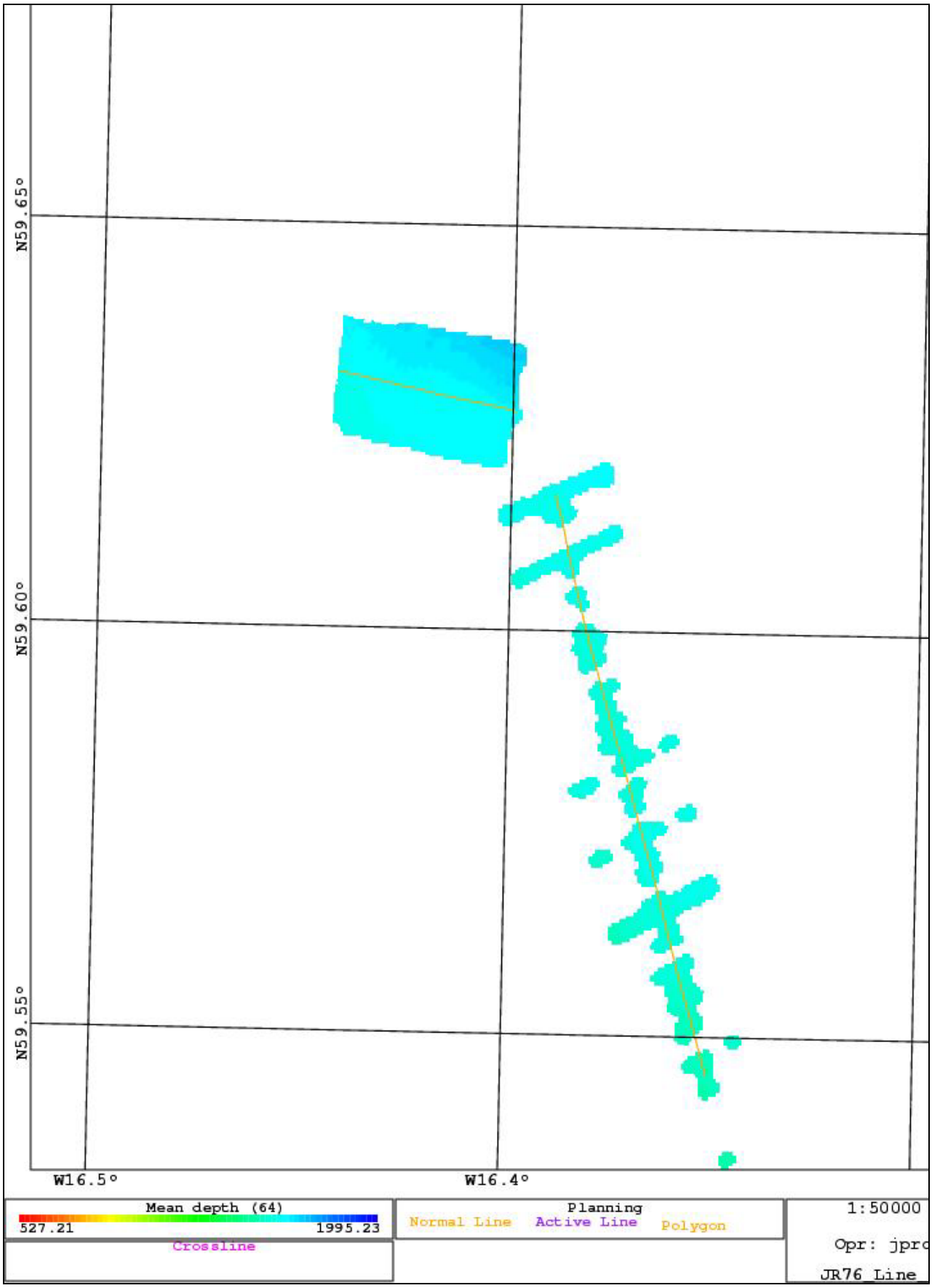
1. The gravity control computer failed during the operation. Observations at the time indicated that this did not affect the gravity readings and hence no 'tear' at this point.

2. The still meter reading at Portsmouth did not fully settle due to continuous crane work on the vessel resulting in vessel movement whilst tied up in the centre of a water filled dry dock. The most stable reading is at or about 1530 GMT and that value has been selected as the Base-tie reading. The final meter reading is thought to be within +/-0.5 mgal error.

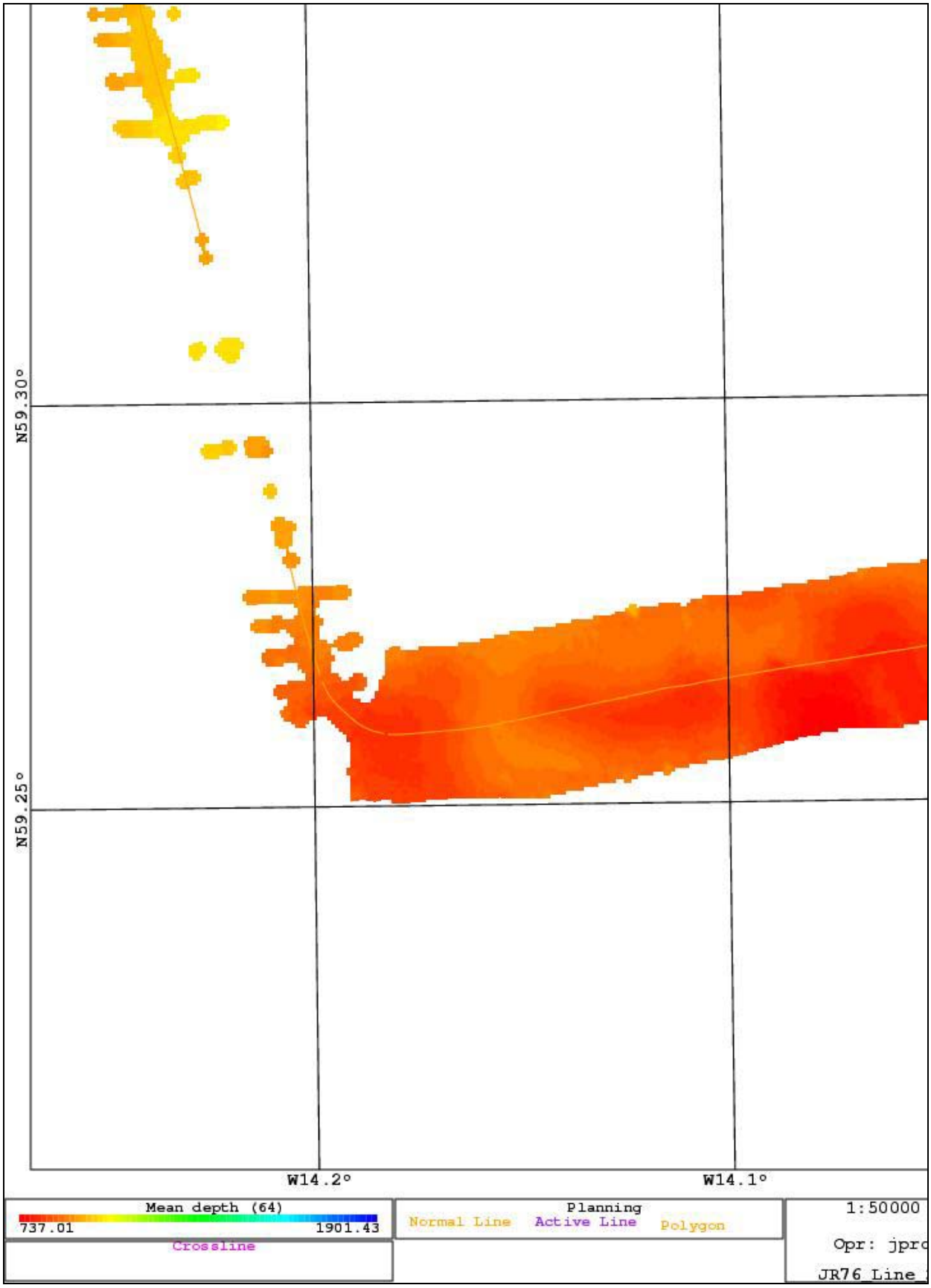
Appendix 7 Swath Images



Swath data of line 10



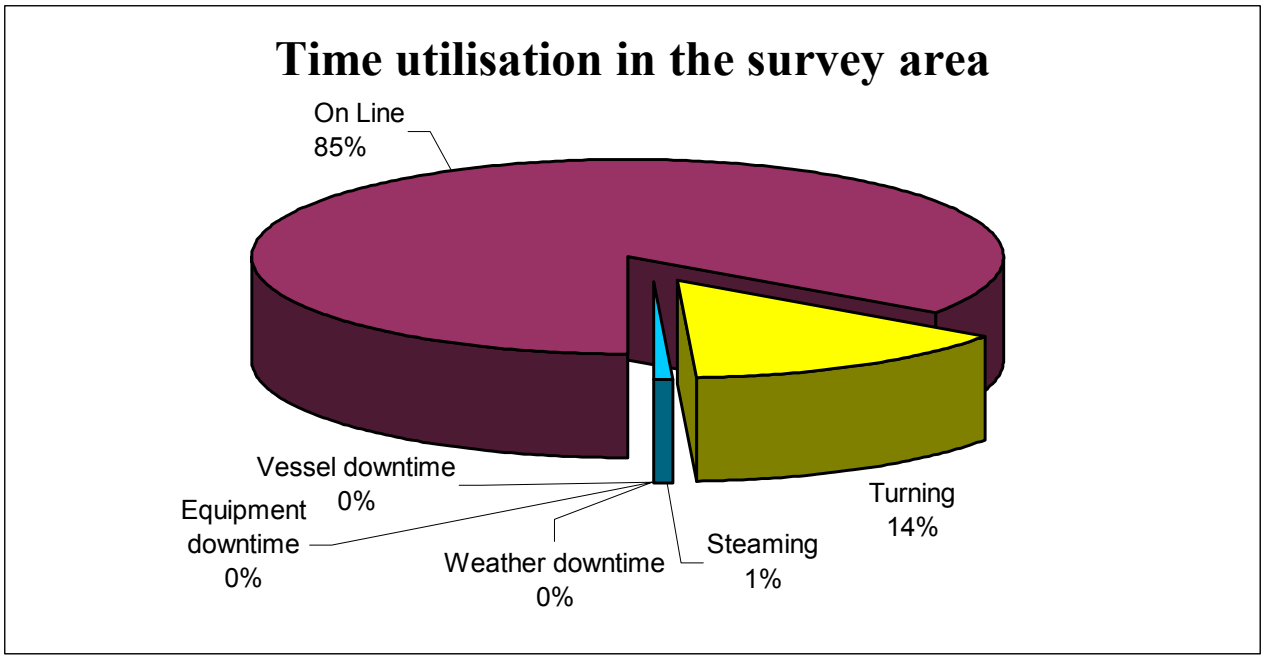
Example of swath data with change of course and vessel roll



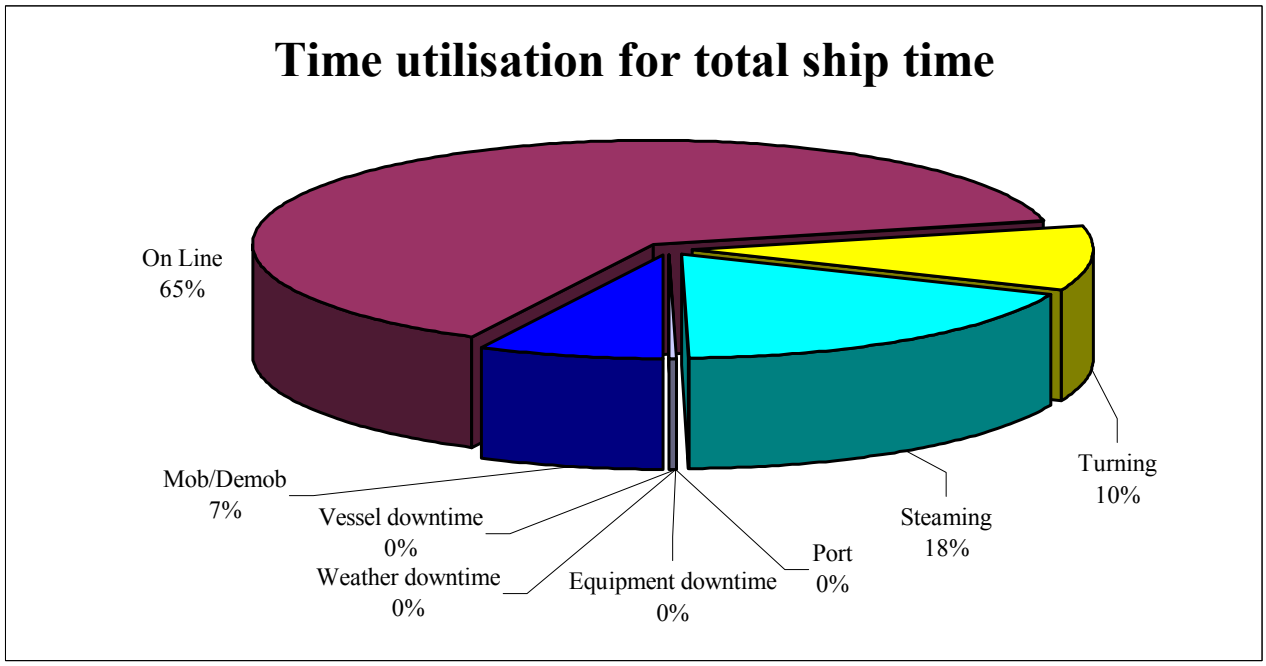
Example of swath data with change of course and vessel roll

Appendix 8 Time Utilisation Diagrams

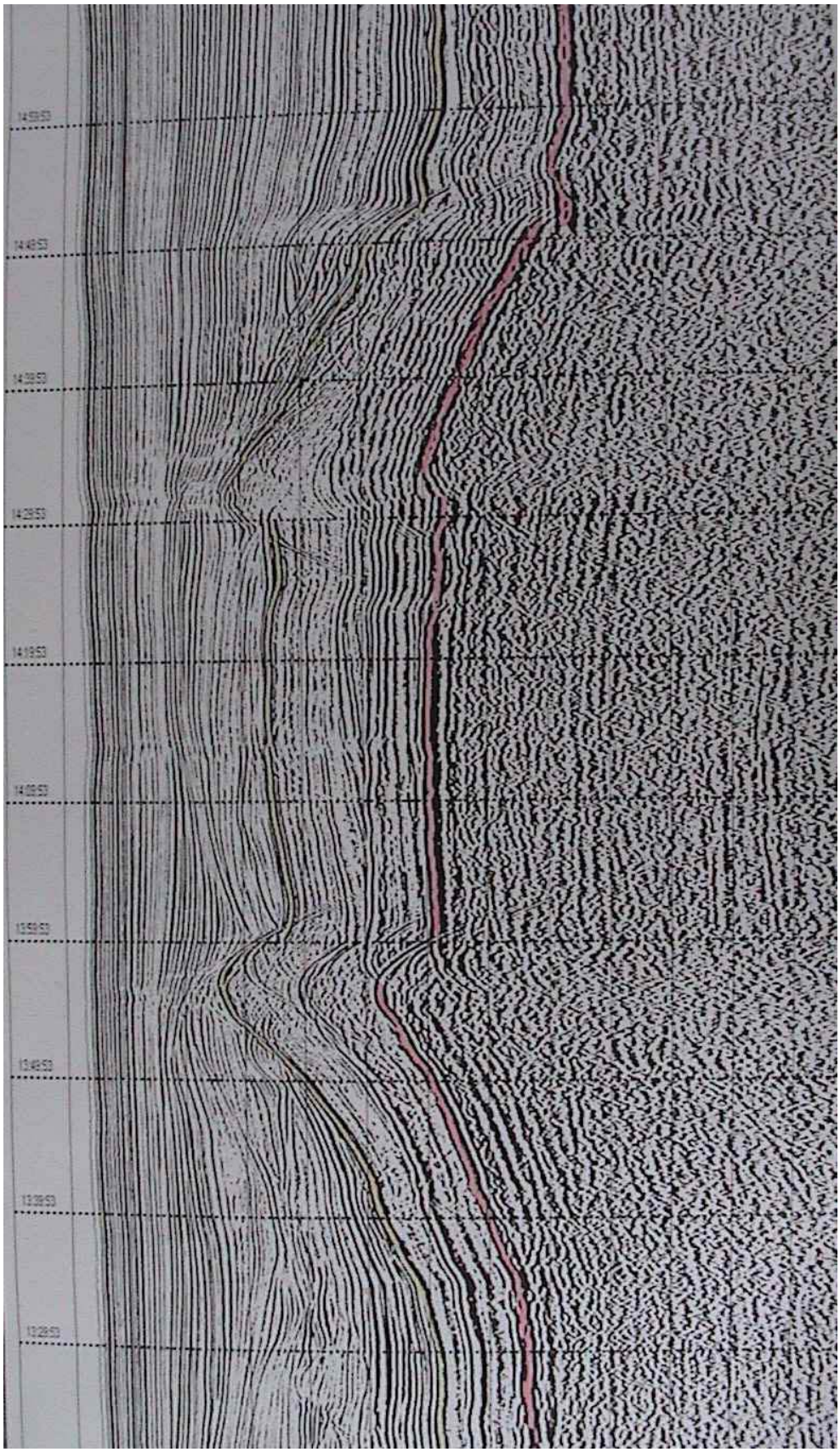
TIME UTILISATION IN THE SURVEY AREA



TIME UTILISATION FOR TOTAL SHIP TIME



Appendix 9 Example Of Online Processed Airgun Data



Appendix 10 Cetacean and Sea Bird Observation Summary

Contribution by M. Mackey

INTRODUCTION

As part of the BGS's regional geophysical survey in the Hatton-Rockall area, a cetacean and sea bird observer from the Coastal Resources Centre, University College, Cork, Ireland 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).

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 extended from the continental shelf edge, north-west of the Isle of Lewis, across the northern sector of the Rockall Trough, concentrating in the area around the Rosemary Bank, and westward to a region north of the George Bligh Bank and the Hatton Bank (Figure 1). Surveys were also conducted on the homeward leg, as the vessel

steamed south over the Anton Dohrn Seamount, through the Rockall Trough and over the continental shelf southwest of Ireland.

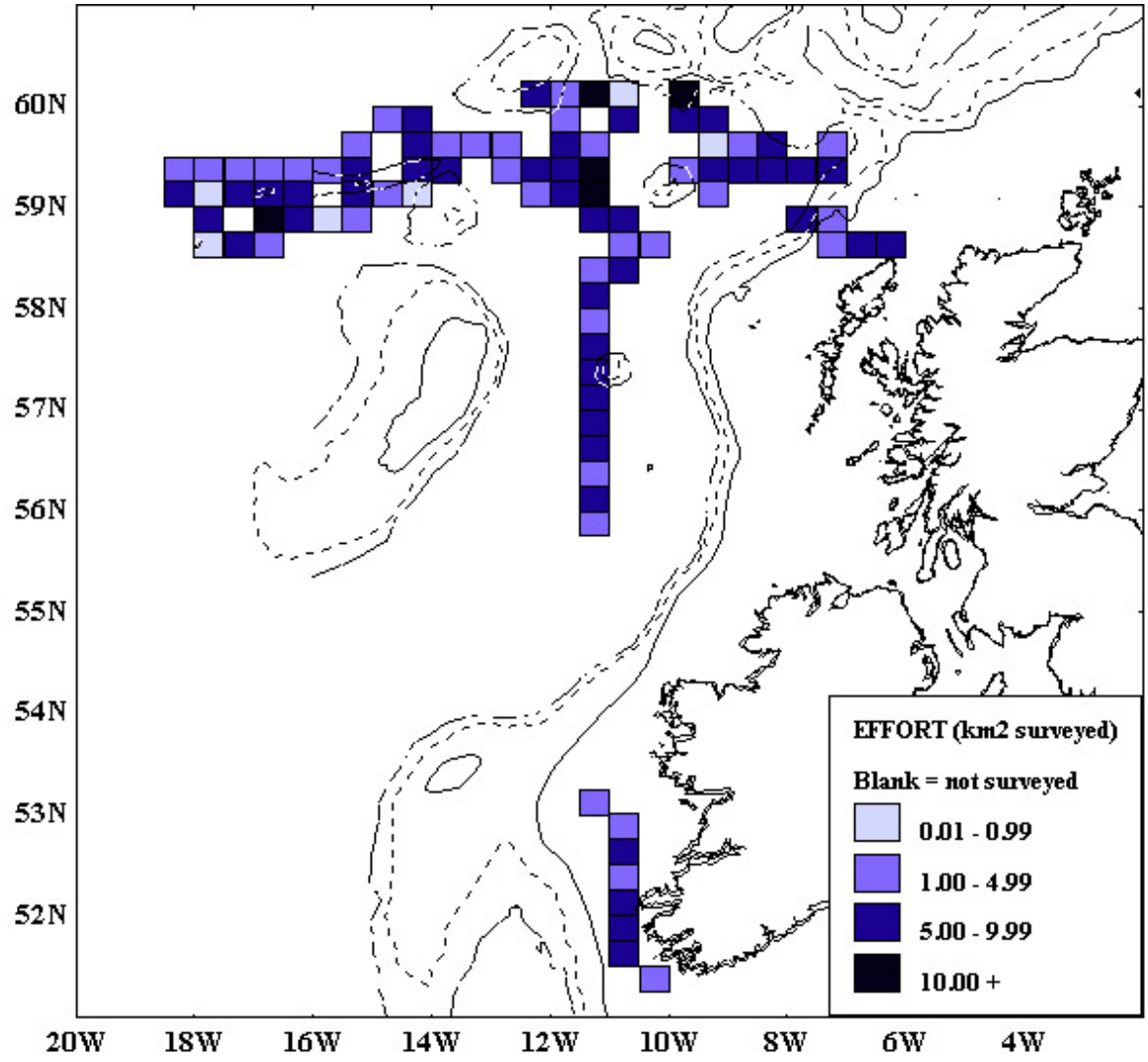


Figure 1 Full survey effort achieved for ¼ ICES square surveyed

RESULTS

Effort

Full surveys were conducted during each day of the 18-day cruise (12th July – 29th July 2002). The average working period for each day was restricted to 5.30am and 8.00pm GMT, although ship downtime, high wind conditions and severe sun glare limited available survey time further. Over 498 km^2 were surveyed during a total of 154 hours 20 minutes (average ~ 8.5 survey hours per day). The survey effort area (km^2) achieved for each ¼ ICES square, each measuring 15' latitude x 30' longitude, is highlighted in Figure 1.

Cetaceans

A total of nine cetacean species and five unidentified categories were recorded during the study, comprising a total of 262 animals that were recorded during 49 sighting events, including four multi-species encounters (Table 1). Seven toothed cetacean species (n=233 animals) and two species of baleen whales (n=13) were positively identified during 43 encounters. In addition to

those positively identified animals, 16 unidentified cetaceans were observed during six separate encounters, including the distant sighting of a breaching beaked whale, and the remains of a dead large whale species.

Toothed Whales

All but two of the toothed species were recorded within the survey area during seismic operations. The two exceptions, Risso's dolphin and white-beaked dolphin, were observed over the continental shelf, northwest of the Isle of Lewis. The harbour porpoise was represented by a single, dead individual during the initial stages of the first seismic line 1. The most numerous and frequently encountered species was the long-finned pilot whale, which was sighted on 23 separate occasions (47% of all encounters). This squid-eating species accounted for over 72% of all individuals recorded (n=189 animals). With the exception of a single encounter, all pilot whale sightings occurred at depths between 1100-2500m (Figure 2). 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 has been observed during previous surveys on seismic vessels, and may help to explain the relatively high encounter rate. On two occasions, immature pilot whales were observed swimming in close association (within 30m) of the sparkarray, in a similar manner to bow-riding dolphins. 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. Eighteen of the pilot whale encounters occurred during seismic operations. A single long-term close encounter occurred as the ship's crew retrieved current meters from the Rockall Trough. The animals displayed numerous forms of behaviour during this hour-long exhibition, including spy-hopping, logging, tail-slapping, milling and fluking. All multi-species encounters involved pilot whales and various dolphin species, including the rarely sighted common dolphin.

Table 1 Total numbers of individuals and encounters, and average group sizes for each cetacean species recorded

Cetacean Species	Total Number of Animals Recorded	Total Number of Encounters	Average Group Size
Toothed Cetaceans			
Harbour Porpoise*	1	1	1
Common Dolphin	16	3	5.3
White-side Dolphin	7	2	3.5
White-beaked Dolphin	3	1	3.0
Risso's Dolphin	5	1	5.0
Long-finned Pilot Whale	189	23	8.2
Sperm Whale	12	10	1.2
Baleen Whale			
Fin Whale	11	5	2.2
Minke Whale	2	1	2.0
Unidentified Cetaceans			
Cetacean sp	10	2	4.0
Large Whale sp*	1	1	1.0
Beaked Whale sp	1	1	1.0
Whale sp	3	1	3.0
Dolphin sp	1	1	1.0
TOTAL	**262**	**53**†	

* Dead Animal.

† Total includes 4 multi-species encounters

The second most frequently encountered toothed whale was the deep-diving sperm whale. Twelve sperm whales were recorded during ten sighting events, although nine animals were observed in close proximity to other individuals (i.e. with 1-2 km). Although most sperm whale sightings tend to occur in waters of great depth, three individuals observed during HB13 were recorded over a 4-5 mile course at a depth of ~590 m. All but one sperm whale encounter occurred during seismic operations, where they appeared to display total indifference to the acoustic activities. In most encounters, sperm whales were observed "fluking-up" indicative of a deep dive. The only species that showed possible signs of avoidance during seismic operations were the common dolphins and white-sided dolphins, which kept an unusually cautious distance from the vessel.

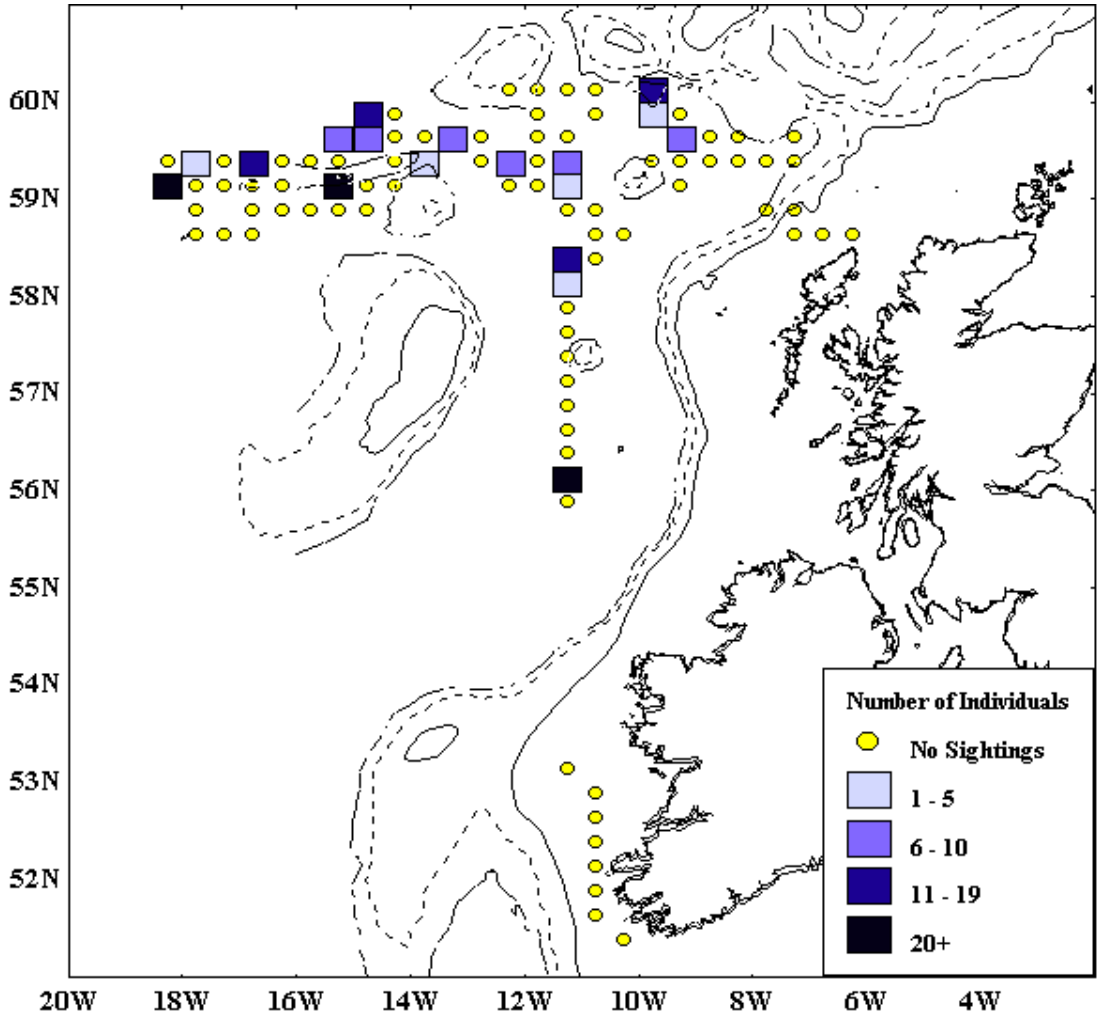


Figure 2 Pilot whale sighting locations

Baleen Whales

Only two species of the filter-feeding baleen whale, the fin and minke whales, were identified throughout the cruise, all of which occurred during seismic operations. Eleven fin whales were recorded during five encounters. Fin whales have a reputation for showing indifference to shipping traffic, and like the sperm whales mentioned previously, they displayed little to suggest that they were affected by the seismic activity. Although one large individual breached clear of the water in a very spectacular display, it cannot be said with any certainty that this behaviour was in response to the airguns and sparkarray. Three individuals observed well ahead of the ship's trackline, steadily swimming directly towards the vessel, moved past at a cautious distance (~400m) without breaking their "stride". The two minke whales observed during a single encounter, slipped across the ship's bow 800m ahead of the trackline.

Sea birds

Approximately 3300 seabirds, representing 19 species, were recorded during the 18-day survey Table 2). In addition, 32 waders were observed during the latter part of the survey. By far the most frequently encountered seabird species (~55% of total) was the northern fulmar, which was a constant companion throughout the survey period. Although low concentrations were recorded in most areas surveyed, large concentrations were periodically observed in association with fishing vessels. Northern gannet numbers were highest over the continental shelf region, where foraging adults dominated. The low concentrations of northern gannets recorded in the northern

regions of the Rockall Trough and Hatton Bank were generally dominated by, juveniles of varying age-classes. The low numbers of black-legged kittiwakes noted during this survey is in contrast to the moderate densities observed during a similar survey in the southern Hatton Bank region last May. Interesting observations of migratory species were also made during the study period. The sighting of eight individual sooty shearwaters and a single great shearwater marks the onset of the migration of these pelagic species across the North Atlantic. They will continue their migration down past Ireland and the British Isles during August and September, returning to their breeding colonies located on islands east of South America. The 22 small skuas (pomarine, arctic and long-tailed skuas) marks either the end of the northern migration to their northern breeding/feeding grounds or the early departure to the southern wintering grounds off Africa and South America. The latter scenario is indicative of poor "lemming years" in the breeding grounds of the Arctic tundra. Only two representatives of the auk group were recorded – the common guillemot and the Atlantic puffin. The Atlantic puffin was observed in low concentrations throughout the survey area, while occasional records of single common guillemots were made spasmodically. Records of storm petrels were restricted to waters east of the Rockall Trough, with the highest numbers recorded off the breeding colonies along the southwest Irish coastline.

Table 2 Total numbers of seabird and coastal bird species recorded

Species	Total Number Recorded
Northern Fulmar	1,814
Great Shearwater	1
Sooty Shearwater	8
Manx Shearwater	163
European Storm-petrel	47
Leach's Storm-petrel	18
Northern Gannet	853
European Shag	2
Dunlin	1
Whimbrel	17
Pomarine Skua	9
Arctic Skua	7
Long-tailed Skua	6
Great Skua	30
Lesser Black-backed Gull	61
Great Black-backed Gull	5
Black-legged Kittiwake	122
Common Tern	1
Arctic Tern	17
Common Guillemot	21
Atlantic Puffin	86

Appendix 11 Glossary

BAS	British Antarctic Survey
BCD	Binary Coded Decimal
EOL	End of line
ETS	Electronic and Technical Support
GMT	Greenwich Mean Time
ICES	International Council for the Exploration of the Sea
IT	Information Technology
JCR	RRS James Clark Ross
JNCC	Joint Nature Conservation Committee
MOD	Ministry of Defence
SOL	Start of line
SOC	Southampton Oceanographic Centre
SAMS	Scottish Association for Marine Science
TVF	Time Varied Filter
TVG	Time Varied Gain
XBT	Expendable Bathythermograph

Definitions

A quarter ICES square is equivalent to 15' latitude x 30' longitude

Full survey effort area (km2) for each ¼ ICES square was calculated by multiplying the total number of kilometres surveyed, using the standard JNCC full survey method, by 0.3 to account for the 300m transect strip width.