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Sea Level Measurements in the Drake Passage

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ABSTRACT

Bottom Pressure Recorders have been used for making measurements of the Antarctic Circumpolar Current (ACC) since 1988, initially in the Scotia Sea and then later across the Drake Passage between the Falkland Islands and the Antarctic peninsula. Some of the Bottom Pressure Recorders (BPRs) are combined with Inverted Echo Sounders (IES).

During this cruise, one BPR and one BPR/IES were recovered and re-deployed in the Drake Passage. An additional BPR was deployed and a data pod was also recovered from MYRTLE.

The Sea Level Recorders at Stanley, Falkland Islands, Vernadsky and Rothera Research Stations in Antarctica, were serviced.

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CRUISE PERSONNEL

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The author would also like to thank the base personnel of the Ukrainian Antarctic Research Station at Vernadsky for their continued help in the operation and maintenance of sea level equipment.

OVERVIEW

The remote island sea level stations in the South Atlantic and Southern Ocean provide valuable data which is supplemented by Bottom Pressure Record (BPR) measurements.

The principal objective is to study variations in the flow of the Antarctic Circumpolar Current (ACC) on large time and space scales; however the sea level station network is also a component of GLOSS (Global Sea Level Observing System). The Bottom Pressure Recorders have supplied sea level data that has provided knowledge of tidal behaviour in this remote area.

Bottom Pressure Recorders have been deployed since 1988, initially in the Scotia Sea and

then later in the Drake Passage. The data is made available to the international research community through the Permanent Service for Mean Sea Level (PSMSL).

POL CRUISE OBJECTIVES

1) To service the Sea Level Recorder at Port Stanley, Falkland Islands.
2) To recover a BPR and BPR/IES from the Drake Passage.
3) To deploy two BPRs and a BPR/IES in the Drake Passage.
4) To recover a data pod from MYRTLE.
5) To service the Sea Level Recorder at Vernadsky Antarctic Research Station.
6) To service the Sea Level Recorder at Rothera Antarctic Research Station.

SHIP PREPARATION

POL personnel, Geoff Hargreaves and Steve Mack, joined RRS James Clark Ross at Stanley, Falkland Islands, on 10/12/2008. The equipment was quickly located and arranged in the lab. The Bottom Pressure Recorder loggers, the Inverted Echo Sounder and the SeaBird Microcat loggers were all started. The acoustic releases were tested and the external battery packs assembled. The ship sailed on the morning of 12/12/2008, heading for Rothera.

STANLEY SEA LEVEL RECORDER 9/12/2008

The system was monitored and the time of the last scan was noted. The data were downloaded and the system then restarted. A new iModem was installed to replace the existing one. The email function of the system was not working properly. The local service provider had changed it's login procedure, so a configuration file was modified to reflect the new changes.

RECOVERY OF DRAKE PASSAGE NORTH BPR (POL 8) 13/12/2008

EVENTS

17.40 GMT	Vessel on station
17.53 GMT	Release command transmitted
18.08 GMT	Released from seabed
18.30 GMT	On the surface

Total time on station: 50 minutes

Drake Passage North BPR (POL 8) Recovery Summary

The recovery went very smoothly. Communication was poor with acoustic release 63801 11.5/B. Acoustic release 69675 performed well. Both releases were fired.

DEPLOYMENT OF DRAKE PASSAGE NORTH BPR (POL 8) 13/12/2008

EVENTS

19.05 GMT	-	Vessel on station
19.07 GMT	-	Released into the water
19.31 GMT	-	On the seabed

Total time on station: 26 minutes

Drake Passage North BPR Deployment Summary

The sea conditions were very good. Communication was achieved with both of the acoustic releases to the seabed.

DEPLOYMENT OF DRAKE PASSAGE MIDDLE (POL 9) 16/12/2008

EVENTS

07.58 GMT	-	Vessel on station
08.04 GMT	-	Released into the water
09.32 GMT	-	On the seabed

Total time on station: 1 hour 34 minutes

Drake Passage Middle BPR Deployment Summary

The deployment went smoothly with both acoustic releases responding all the way to the seabed.

RECOVERY OF MYRTLE POD (M3) 18/12/2008

EVENTS

06.02 GMT	Vessel on station
06.15, 07.05 GMT	Release command transmitted
07.17 GMT	Released from the seabed
08.26 GMT	On the surface

Total time on station: 2 hours 24 minutes

MYRTLE Pod (M3) Recovery Summary

Acoustic conditions were very good. The acoustic release for the pod was enabled and slant range readings obtained. The release command was transmitted and the four ping reply was observed. Acoustic signals were transmitted to the pod, which would become active upon releasing from the frame. The release acoustic 'timed out' after 45 minutes and was re-enabled again. The confirmation of release of the pod was eventually observed and once on the surface, it was tracked using the radio beacon. The pod surface about 1Km from the ship.

RECOVERY OF DRAKE PASSAGE SOUTH (POL 6) 18/12/2008

EVENTS

17.24 GMT	Vessel on station
17.26, 17.27 GMT	Release command transmitted
17.36 GMT	Released from the seabed
18.09 GMT	On the surface

Total time on station: 45 minutes

Drake Passage South (POL 6) Recovery Summary

The recovery went smoothly. Acoustic release 63803 was responding with 4 ping after receiving the release command. Acoustic release 70772 was not giving 4 ping replies that could be detected at the ship.

DEPLOYMENT OF DRAKE PASSAGE SOUTH (POL 6) 18/12/2008

EVENTS

18.47 GMT	Vessel on station
18.51 GMT	Released into the water
19.11 GMT	On the seabed

Total time on station: 24 minutes

Drake Passage South (POL 6) Deployment Summary

Everything went very smoothly and both of the acoustics were monitored to the seabed.

VERNADSKY 20/12/2008

POL personnel were transported to the base in a RHIB (Rigid Hulled Inflatable Boat) and took with them a set of spare parts for the OTT Tide Gauge system. There is a problem with the retrieval of data from the tide gauge via satellite and it is hoped that replacing modules within the system will rectify this. There was not enough time to perform these tasks during the visit, so the spares were left with the base personnel, so that they can undertake the work.

ROTHERA 21/12/2008

The ship arrived at Rothera on 21/12/2008. Once permission was obtained, POL personnel visited the tide gauge logger which is sited in the sea water pump house. The pump house contains three data logging systems. Logger one and logger two record the signal from the sensors independently of each other, while the third system receives data output from logger one and sends it to POL via the internet.

When the cabinet door of logger one was opened, the scan LED indicator was lit constantly indicating that the timebase for the system had been reset. This means that the system was not logging any data. The embedded controller was tested and it was not responding to requests indicating that the program was still running. Further testing of the system involved resetting the embedded controller and trying to download the data. The system was not responding to requests but was outputting information when the reset button was pressed. It was finally determined that there is a problem with the serial connection being used. Fortunately, there was a second serial connection and lead available. This was used and the system responded normally. Probably the program had stopped, but the faulty serial port masked this error. The data were then recovered.

The cabinet of logger two was opened and the scan time noted. The data were then downloaded. It was at this point that it was noted that a vast chunk of data had not been

recorded to the memory card.

Both loggers were restarted. Logger two was using the same memory card since there were no replacements available.

CONCLUSIONS

The scientific objectives were met.

APPENDIX 1 - BPR TECHNICAL INFORMATION

STANLEY SEA LEVEL RECORDER INFORMATION

The Sea Level Recorder at Stanley consists of three independent logging systems. The first two systems use high precision pressure sensors to measure pressure and temperature of the sea water, whilst the third system uses radar technology to measure water height.

The logging systems using pressure sensors have three installed for each system; the 'full tide' sensor, a 'half tide' sensor and a barometric sensor. The full tide sensor is mounted such that it is permanently below the water level, even at the extreme low tide event. The half tide sensor is mounted alongside the full tide sensor and is fitted with a feed pipe to the pressure inlet port that is taken from a point at the middle of the tidal range. Thus as the tide falls below this point, the pressure being measured by the sensor should remain constant, with a value equal to the head of water retained in the feed pipe. This then provides a datum level for determining the full tide level. The barometric sensor is used to measure air pressure and temperature. This information is used to correct the full and half tide pressure measurements, removing the barometric influences.

The output from these six sensors is fed into two independent logging systems. The first system (TDS Logger) continuously integrates the frequency output of the sensors and stores this information every fifteen minutes to a Static RAM (SRAM) card. The second logging system (CF1 Logger) works in a similar way, except the information is stored every second, thus allowing wave data to be collected and analysed. This second logger also sends data back to the UK in quasi real time, via the telephone network, in the form of an email. This system can also be dialled-up and data be collected manually.

The third measuring system uses radar which bounces electromagnetic waves off the sea surface. The radar is positioned so that it points vertically downwards and several readings are taken, with the average of these being logged. These measurements are then transmitted via the Orbcomm satellite communication network in the form of an email.

<u>TDS Logger</u>
Timebase scan

Expected	Actual
14.00.00 GMT on 9/12/2008	13.59.05 GMT on 9/12/2008

The calibrated and raw data were downloaded from the memory card and stored as stan0708.cal and stan0708.raw respectively.

Sensors fitted.

Full Tide	DQ 47594
Half Tide	DQ 47598
Barometer	DQ 39239

The timebase was restarted at 18.30.00 GMT on 9/12/2008
The battery in the SRAM card was replaced with a new one.

CF1 Logger

The iModem was replaced with a new one as the system had stopped sending out emails. The modem would attempt to make a connection but then hang up without sending any emails. It was thought that changing the modem might help.

Sensors fitted

Full Tide	QX 99099
Half Tide	QX 99450
Barometer	QX 97890

On 11/12/2008, the modem setup parameters were changed. It had been determined that the internet service provider had changed their email settings, requiring all users to authenticate themselves before allowing the transmission of emails. The necessary modifications were made to the modem configuration file and the system tested. Everything worked well.

DRAKE PASSAGE NORTH BPR (POL 8) RECOVERY INFORMATION

Location details	**-**	***Latitude 54° 56.59' S***
		Longitude 058° 21.41' W
		Depth 1218m
On station	-	17.40 GMT on 13/12/2008
Release command transmitted	-	17.53 GMT
On the surface	-	18.30 GMT

Acoustic Information

Benthos XT6001 (69675)	-	Tx 12.0 kHz, Rx 13.5 kHz, Release D, Enable F
Benthos XT6000 (63801)	-	Tx 12.0 kHz, Rx 11.0 kHz, Release B

Logger

Logger P3 with sensor DQ 68485

Timebase scan

Expected	Actual
12.00.00 GMT	11.59.00 GMT on 14/12/2008

The timebase is 60 seconds slow.

Data were downloaded to dpn0608.raw.

Data Arrangement
The raw data are made up of six columns

Column	Data
1	Scan number
2	Time
3	Pressure (DQ 68485)
4	Temperature (DQ 68485)
5	Blank
6	Blank

SeaBird Microcat
37SMP34870-3023 had recorded 70750 samples. Data stored in dpn0608sbe37.asc.

Recovery Equipment
Benthos radio beacon - 154.585MHz Channel A

DRAKE PASSAGE NORTH DEPLOYMENT (POL 8) INFORMATION

Location details - ***Latitude 54° 56.59' S***
Longitude 058° 21.41' W
Depth 1227m

On station - 19.07 GMT on 13/12/2008
Release into the water - 19.10 GMT
On the seabed - 19.31 GMT

Acoustic Information
Benthos XT6000 (63965) - Rx 11.0kHz, Tx 12.0kHz, Release B
Benthos XT6000 (46421) - Rx 14.0kHz, Tx 12.0kHz, Release D

63965 is using burnwire cable BW005, 46421 is using burnwire cable BW006. No external battery pack is fitted to either acoustic release.

Logger
Logger SSDL2 with sensors DQ 44935, DQ 46267
Timebase started at 19.30.00 GMT on 11/12/2008
First scan at 19.45.00 GMT on 11/12/2008

CTD Equipment
SeaBird Microcat - Serial number 37SMP45824-4583
First sample at 12.00.00 GMT on 14/12/2008
Sampling interval – 3600 seconds
Number of samples to average – 1
Transmit Real Time Data - N

Recovery Equipment

Benthos radio beacon	-	Nominal frequency - 154.585 MHz, Channel A. S/N W03-076

New Battery Information

Logger	-	14.69V

DRAKE PASSAGE MIDDLE DEPLOYMENT (POL 9) INFORMATION

Location details	**-**	***Latitude***	***57° 53.817' S***
		Longitude	***056° 32.666' W***
		Depth	***4007m***

On station	-	07.58 GMT on 16/12/2008
Release into the water	-	08.04 GMT
On the seabed	-	09.32 GMT

Acoustic Information

CROCUS XT6000 (69304)	-	Rx 10.5kHz, Tx 12.0kHz, Release C
Benthos XT6001 (44084)	-	Rx 11.5kHz, Tx 12.0kHz, Enable F, Release D

S/N 69304 is a 17" CROCUS BPR with XT6000 acoustic release fitted with burnwire module number BM010, the burnwire lead is not numbered. The logger is fitted inside this sphere. S/N 44084 is fitted with burnwire lead BW001 and burnwire module BM005

Logger

CROCUS Logger with sensors DQ 87193 and bluetooth serial connection. DQ 87194 is fitted but not used.
Timebase started at 18.15.00 GMT on 11/12/2008
First scan at 18.30.00 GMT on 11/12/2008

CTD Equipment

SeaBird Microcat	-	Serial number 37SM32218-2991 Started at 12.00.00 GMT on 16/12/2008 Sampling interval - 900 seconds

This is a coastal observatory Microcat without a pressure sensor. It also uses a RS485 serial port.

RBR Temperature Logger

RBR TR1050Ti	-	Serial Number 15568 Started at 15.00.00 GMT on 14/12/2008 Sampling interval - 60 seconds Will stop sampling at 15.00.00 GMT on 25/12/09

Recovery Equipment

Benthos radio beacon	-	Nominal frequency - 154.585 MHz, Channel A. S/N W06-166

New Battery Information

Logger	-	14.69V

MYRTLE POD RECOVERY (M3) INFORMATION

Location details	**-**	***Latitude 60° 37.197*** ***Longitude 053° 50.9286'W*** ***Depth 2793m***
On station	-	06.02 GMT on 18/12/2008
Release command transmitted	-	06.15, 07.05 GMT
Released from seabed	-	07.17 GMT
On the surface	-	08.26 GMT

Acoustic Information

Main Frame

Benthos XT6001 (73870)	-	Tx 12.0 kHz, Rx 11.0 kHz, Release B, Enable A
Benthos XT6000 (63783)	-	Tx 12.0 kHz, Rx 13.5 kHz, Release C

Data Pod Releases

Benthos XT6001 (72380)	-	Tx 12.0 kHz, Rx 11.5 kHz, Release D, Enable A
Benthos XT6001 (71913)	-	Tx 12.0 kHz, Rx 12.5 kHz, Release B, Enable A

Data Pod Transponders

Pod 3	-	Tx 12.0 kHz, Rx 11.5 kHz
Pod 4	-	Tx 12.0 kHz, Rx 10.5 kHz

Logger

Logger MLOG1 with sensor DQ 96819, DQ 96820, FSI OEM CTD

The data were recovered from the pod and stored as myrtle_pod3_0508.hex. The data is in hexadecimal format. There is no timing information since the main logger is still deployed.

Recovery Details

MYRTLE was deployed in 2005, fitted with four data recovery pods so that data may be recovered during the five year deployment. Each data pod receives the same data as the main logger. Pods numbered 3 and 4 are released via a command to an acoustic release, whilst pods numbered 1 and 2 are released via an automatic timed release. Pods 1 and 2 should already have released, leaving pods 3 and 4 attached to the main frame.

It was decided to attempt a recovery of pod 4.

Acoustic release S/N 72380 was enabled; range readings were then obtained and the release command transmitted. The acoustic transponder of pod number 4 was interrogated regularly for a response. The pod transponder is kept in an inactive state and will only become active once the pod has released from the main frame.

The data pods are held in place using burnwire modules manufactured by TT Engineering. These burnwires consist of a loop of 0.9mm solid Inconel wire, which is partially sheathed, leaving the tip of the wire loop open to the seawater. This acts to focus the 'burning' of the wire at that point to make it work quicker. After MYRTLE was deployed, it was noticed that the amount of sheathed wire was a little longer than required, thus making the unsheathed section slightly smaller than the opening needed to allow the release arm to pass through unhindered. This was first been spotted after the recovery of Drake South in 2006, when it took a lot longer for the frame to release from the seabed than usual.

During the recovery of the pod, the same reluctance to release was experienced. After forty five minutes, the acoustic release timed-out and was re-enabled again. Eventually, the pod released and this was shown to have occurred due to communication with the pod transponder being achieved.

The pod was ascending at a rate of approximately 40m/min. When it surfaced, the pod was not visible from the ship, but the radio beacon activated and we could locate onto it. The pod was approximately 1Km from the ship.

DRAKE PASSAGE SOUTH BPR/IES (POL 6) RECOVERY INFORMATION

Location details	**-**	***Latitude***	***60° 51.03' S***
		Longitude	***054° 42.81' W***
		Depth	***999m***
On station	-	17.24 GMT on 18/12/2008	
Release command transmitted	-	17.26 GMT	
Released from seabed	-	17.36 GMT	
On the surface	-	18.09 GMT	

Acoustic Information

Benthos XT6001 (70772)	-	Tx 12.0 kHz, Rx 11.0 kHz, Release D, Enable F
Benthos XT6000 (63803)	-	Tx 12.0 kHz, Rx 10.5 kHz, Release A

Logger

Logger P1 with sensor DQ 68489

Timebase scan

Expected	Actual

22.15.00 GMT on 18/12/2008 22.21.17 GMT on 18/12/2008

Timebase was 377 seconds fast.

The data were downloaded to dps0608.raw.

Data Arrangement
The raw data are made up of six columns

Column	**Data**
1	Scan Number
2	Time
3	Pressure (DQ 68489)
4	Temperature (DQ 68489)
5	blank
6	blank

Inverted Echo Sounder
IES chirped at 01.14.05 GMT on 19/12/2008.
The data were recovered and stored in the file dps0608ies.v12
Number of datafiles recorded to disk is 4461.

Recovery Equipment
Benthos radio beacon - 154.585MHz Channel A

DRAKE PASSAGE SOUTH DEPLOYMENT (POL 6) INFORMATION

Location details - ***Latitude 60° 51.03' S***
Longitude 054° 42.81' W
Depth 999m

On station - 18.41 GMT on 12/12/2006
Release into the water - 18.43 GMT
On the seabed - 19.03 GMT

Acoustic Information
Benthos XT6000 (51314) - Rx 14.5kHz, Tx 12.0kHz, Release A
Benthos XT6000 (51329) - Rx 10.0kHz, Tx 12.0kHz, Release D
Release 51314 is using release cable S/N BW003 and release 51329 is using release cable BW004.

Logger
Logger SSDL3 with sensors QD 49187, DQ 46251
Timebase started at 23.15.00 GMT on 11/12/2008

First scan at 23.45.00 GMT on 11/12/2008

CTD Equipment

SeaBird Microcat	-	Serial number 37SMP49454-5600 Started at 12.00.00 GMT on 19/12/2008 Sampling interval - 900 seconds Number of samples to average – 1 Transmit Real Time Data - N

Inverted Echo Sounder

IES started at 13.59.40 GMT on 12/12/2008
First Chirp at 15.59.58 GMT on 12/12/2008

Set-up parameters

Chirp interval	120 minutes
Samples per datafile	2
Sample rate	Fast
Lockout time (1/100 s)	0
Start file number	1
Serial number	8
Deployment number	3
Comment	Drake South 2008-2010

Recovery Equipment

Benthos radio beacon	-	Nominal frequency - 154.585 MHz, Channel A. Serial No W06-167
Release gate serial number	-	073

New Battery Information

Logger	-	14.69V

VERNADSKY

POL personnel travelled to Vernadsky via a rigid hulled inflatable boat (RHIB). Upon arriving at the base, we were escorted to the ozone loft where the OTT HDR unit is located. This was inspected and then we were escorted to the tide gauge hut. The OTT system there was checked.

Spares for the OTT tide gauge system were handed over to the base personnel to allow them to perform an upgrade and subsequent system test of the data collection and satellite transmission components of the tide gauge system.

ROTHERA

The tide gauge at Rothera consists of three pressure sensors, a full tide sensor, a half tide sensor and a barometer. The full tide sensor is positioned to be submerged at all times, whilst the half tide sensor is positioned above the full tide sensor at the middle of the tidal range. The half tide sensor act as a reference point for the full tide sensor and allows accurate surveying of the installation to be undertaken.

The output signals from these sensors are fed into two independent logging systems. Logger 1 is the main logging system. It is this system that the base meteorologists interact with to recover the tide data and email it back to POL. Logger 2 is a backup system recording the same information as Logger 1. Both systems use a TDS logger and store data to a SRAM card.

Sensors fitted	
Full tide	DQ 47942
Half tide	DQ 47452
Barometer	DQ 65487

When Logger 1 was opened up it was discovered that the scan LED was permanently lit, indicating that timebase had been reset. Therefore it was not possible to make a measurement of the time drift. When trying to communicate to logger 1 via the three pin serial port it was discovered that data was not being transferred to the TDS controller, although the laptop could receive data from the TDS controller. Fortunately, there was a second serial connector available which worked properly.

The data were downloaded to ro1_07344.raw

The timebase was restarted at 18.00.00 GMT on 21/12/2008
The first scan was at 18.15.00 GMT on 21/12/2008

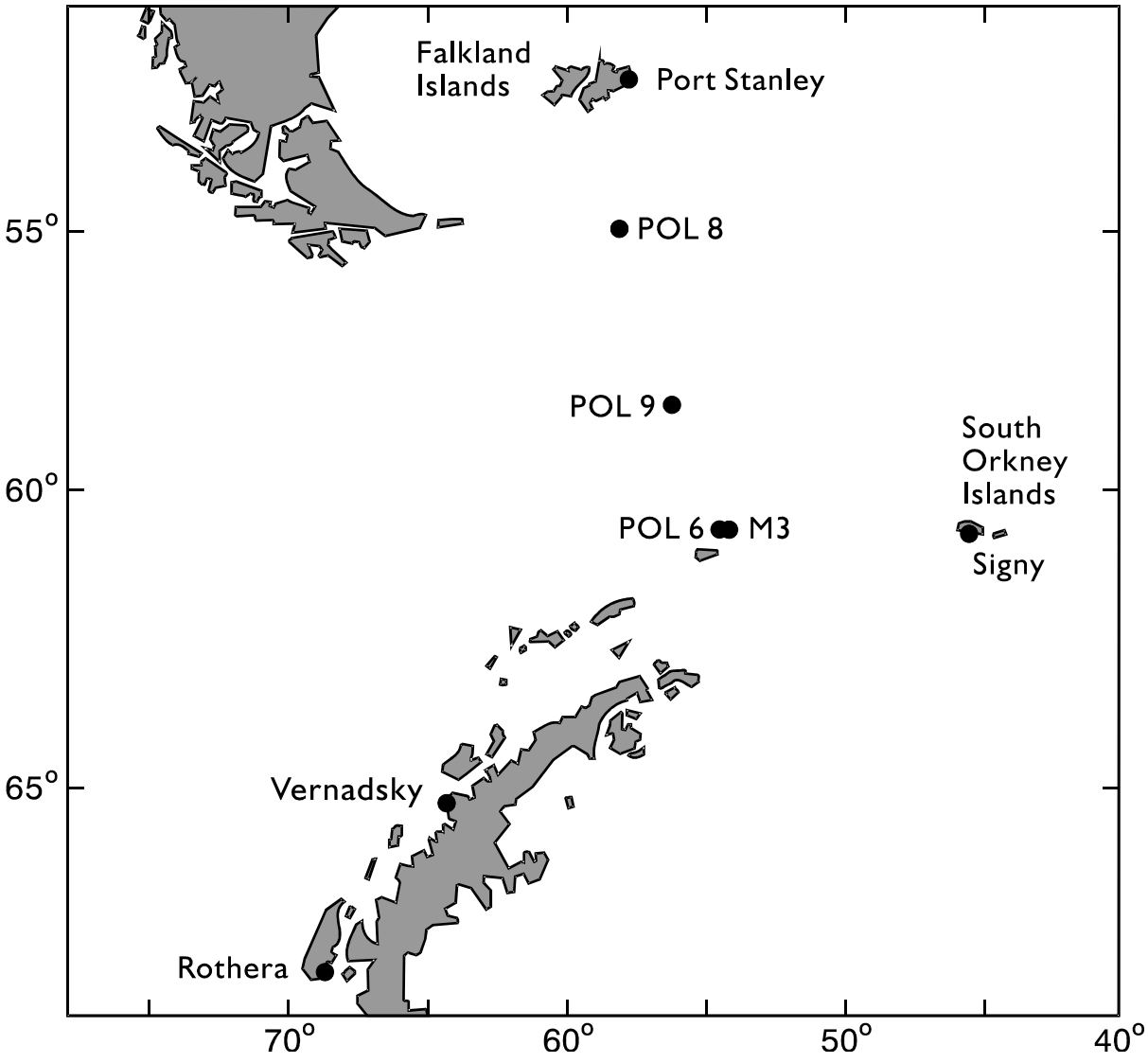
Logger 2 timebase scan

Expected	Actual
15.15.00 GMT on 21/12/2008	15.08.21 GMT on 21/12/2008

Data were downloaded to ro2_07344.raw
The data started at day number 353 but at day 32 it stopped. It then restarted on day 356 and recorded two scans at 15.00 and 15.15, which is the day the data was downloaded.

Logger 2 timebase started at 17.15.00 GMT on 21/12/2008
First scan at 17.30.00 GMT

MAP OF DEPLOYMENT POSITIONS



GLOSSARY

ACCLAIM	-	Antarctic Circumpolar Current levels from Altimeter and Island Measurements
ADC	-	Analogue to Digital Converter
BPR	-	Bottom Pressure Recorder
EPROM	-	Erasable Programmable Memory
GMT	-	Greenwich Mean Time
GPS	-	Global Positioning System
HDR	-	High Data Rate Satellite Transmitter (OTT)
IES	-	Inverted Echo Sounder
Logosens	-	OTT sensor logger
POL	-	Proudman Oceanographic Laboratory
SLR	-	Sea Level Recorder
SRAM	-	Static Random Access Memory
TDS	-	Triangle Digital Services