PROUDMAN OCEANOGRAPHIC LABORATORY

CRUISE REPORT NO. 33

Sea Level Measurements in the Weddell Sea

As part of

FS POLARSTERN ANT XVI/2

JANUARY 9, 1999 – MARCH 16, 1999

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1999

DOCUMENT DATA SHEET

AUTHOR G.W. HARGREAVES	PUBLICATION DATE 1999
TITLE Sea Level Measurements in the Weddell Sea, as part of, FS Polarstern ANT XVI/2, January 9, 1999 – March 16, 1999	
REFERENCE Proudman Oceanographic Laboratory, Cruise Report, No 33, 18pp	

ABSTRACT

The Weddell Sea is a major source of bottom water, the production of which is contributed to by tidal action. Tidal models are available but there are very few data available to verify the model.

Bottom Pressure Recorders deployed along the Ronne Ice Shelf allow verification and modification of this tidal model.

Bottom Pressure Recorders deployed at similar depths across the Weddell Abyss also measure coherent signals.

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KEYWORDS Bottom Pressure Recorder Weddell Sea Ronne Ice Shelf ROPEX Sea Level British Antarctic Survey Polarstern	CONTRACT PROJECT 3310 MLL-15-5 PRICE £10

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CONTENTS

CRUISE PERSONNEL 4

ACKNOWLEDGEMENTS 4

OVERVIEW 4

POL CRUISE OBJECTIVES 5

BPR RECOVERIES 5
- Ship Preparation 5
- ATTEMPTED RECOVERY OF MS2 BPR, 25/1/99 6
- ATTEMPTED RECOVERY OF MS1 BPR, 2/2/99 6
- ATTEMPTED RECOVERY OF MS3 BPR, 4/2/99 6
- RECOVERY OF CH2 BPR, 17/2/99 7
  - CH2 Recovery Information 7
- RECOVERY OF MS2 BPR, 21/2/99 8
  - MS2 BPR Recovery Information 8
- CONCLUSION 8
- RECOMMENDATIONS 9

APPENDIX 1 - BPR TECHNICAL INFORMATION 10
- CH2 BPR RECOVERY INFORMATION 10
- RECOVERY OF MS2 BPR INFORMATION 11
- MAP OF BPR DEPLOYMENT POSITIONS 13
- CRUISE TRACK 14
- ICEBERG A38-B 15

GLOSSARY 17

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ACKNOWLEDGEMENTS

The author would like to thank the Captain, Officers and crew of FS Polarstern for their help in the recovery of sea level equipment in the Weddell Sea, and also Eberhard Fahrbach and Gerd Rohardt of the Alfred-Wegner-Institute for their knowledge of recovering moorings through sea ice.

OVERVIEW

The Weddell Sea is thought to be the most important source of bottom water in the Southern Ocean, accounting for about 80% of total production, and water modified by passage under the Filchner-Ronne Ice Shelf (FRIS) is a major constituent. Because there is no contact between the atmosphere and the ocean under the ice-shelf, sub ice-shelf circulation, mixing and heat transport are forced by tidal action. An understanding of the tides and the interaction of the tides with the ice shelf are therefore important.

A tidal model of the Weddell Sea has been developed but there are few reliable observations to validate the model. An amphidromic point in the principal semidiurnal tides is seen in the model, centred on the Ronne Ice Shelf. The position of this amphidrome is sensitive to the model parameters, in particular the bottom friction coefficient. However, the available data, although indicating that such a feature may exist, are insufficient to fix its location. Thus the data from Bottom Pressure Recorders at either end of the ice shelf should help to pinpoint the amphidrome position and fix some of the model parameters. In addition, a third BPR off the Filchner Ice Shelf should enable an estimate of the tidal energy dissipated under FRIS to be made. These measurements will complement current meter, CTD and bathymetry measurements made as part of the Ronne Polynya Experiment (ROPEX).

Two further BPRs, one at the southern end of the South Sandwich Islands, the other on the Weddell Sea shelf break, form part of a continuing programme investigating large-scale coherence of sea-level signals in the Southern Ocean. In addition, the BPR on the shelf break complements current meter measurements from nearby moorings and will provide additional ground truth data for validation of the Weddell Sea tide model.

POL CRUISE OBJECTIVES

1) To recover one Bottom Pressure Recorder from the base of the Antarctic continental shelf slope.

2) To recover three Bottom Pressure Recorders near the Filchner-Ronne Ice Shelf on the Antarctic continental shelf.

In October 1998, it was discovered that a large iceberg measuring 150km by 40km had broken away from the Ronne Ice Shelf, eventually splitting into two icebergs. Iceberg A38-B, as it is called, was carrying with it the German summer only base of Filchner. As a result of this, the entire oceanographic work section of the cruise was given a lower priority rating than the logistical requirement to remove the base from the iceberg. Thus the cruise was undertaken with the understanding that it might not be possible to visit the Bottom Pressure Recorder deployment sites.

BPR RECOVERIES

Ship Preparation

Geoff Hargreaves joined FS Polarstern at Cape Town, South Africa on January 9, 1999 and the ship departed later that evening. All of the equipment had been transported in containers and access to these was not possible until January 10. The equipment was unloaded from the container and then unpacked and safely stowed ready for use. The crossing to the Weddell Sea work area involved a couple of short stops at SANAE (South African Antarctic Expedition) base, Neumeyer base and Drescher Inlet.

ATTEMPTED RECOVERY OF MS2 BPR, 25/1/99

The ship arrived at an area of open water six miles East of the BPR site in order to transfer four Norwegian scientists to a summer station at Blåenga. The ship's helicopter flew over the mooring site to assess the possibility of attempting a recovery and reported that the whole area between the ship and the location was 90% covered by ice of varying thickness. It was thus decided that an attempt to recover at this stage would not prove to be successful.

ATTEMPTED RECOVERY OF MS1 BPR, 2/2/99

The ship arrived at the intersection of the Ronne Ice Shelf and the Larsen Ice Shelf, where the MS1 BPR was deployed, during the morning of the 2nd February. When the ship was forty nautical miles from the mooring position a helicopter was despatched to survey the site. Unfortunately, with the exception of a small polyna near the Ronne Ice Shelf, the whole area was covered with tightly packed flows of ice and a particularly large ice flow was situated directly above the BPR deployment site. Once again it would not be possible to recover in these conditions so the ship stopped twenty miles short of the site in open water near the Ronne Ice Shelf to perform a CTD.

The ship stayed in the area all day since other scientific work was being undertaken on fast ice near the Ronne Ice Shelf. During the afternoon, a southerly wind started to blow the sea ice away from the ice shelf and a large polyna started forming. That evening the ship headed towards the mooring site to investigate whether the ice had retreated sufficiently far to be able to attempt a recovery. Unfortunately the BPR area was still covered by two miles of thick sea ice and the wind had once again changed direction, causing the ice to start returning to the shelf edge.

ATTEMPTED RECOVERY OF MS3 BPR, 4/2/99

The deployment location of MS3 BPR coincided with the area of the Ronne Ice Shelf from which iceberg A38-B had calved. Shortly after breaking from the ice shelf the giant iceberg split in half, creating in the process a number of a much smaller icebergs. As the ship headed towards the mooring site from the East along the Ronne Ice Shelf front, the smaller icebergs had not drifted very far away and were causing the sea ice behind them to become tightly packed. The Captain was worried about the ship becoming trapped between the icebergs and the shelf ice, since there was now a Force 8 wind blowing from the Northeast. An ARGOS tracking beacon had been installed on iceberg A38-B and this was showing that it was heading in a southwesterly direction. The ship was also finding it difficult to break through the tightly packed ice, so the decision was taken to return to more open water and the mooring site was never reached.

RECOVERY OF CH2 BPR, 17/2/99

EVENTS

13.30 GMT	Vessel on station.
16.50 GMT, 17.03 GMT, 17.20 GMT	Released command transmitted.
18.30 GMT	On the surface.

Total time on station: 5 hours

<u>CH2 Recovery Information</u>

Upon arrival at the mooring site the ice cover was assessed to determine the probability of a successful recovery. The mooring site was covered by a fairly tightly packed ice flow, however two hundred meters to the West there was quite a bit of open water with only small flows. It was necessary to determine whether the BPR, on its ascent, would be likely to drift with the deep currents into the open water. The conclusion was that this was unlikely and the probability of the BPR surfacing in open water was only 30%. A CTD was performed on the mooring site and then a biological trawl was undertaken nearby. After this the ship returned to the position above the mooring and another assessment was undertaken. This time the decision was even more difficult to make since the ship was now in open water, but immediately to the East was tightly packed ice and 600m to the West was more tightly packed ice. The decision was eventually reached that an attempt would be made.

The ship turned off its engines to make the acoustic conditions as quiet as possible and acoustic contact was successfully made. The first release command was transmitted at 16.50 and the acoustic unit was monitored for any signs of it coming to the surface. The release was fitted with a burnwire, which usually takes about 10 minutes to burn through. During this time, the ship was drifting and the slant range displayed by the acoustic deck unit was increasing. The release command was transmitted again at 17.03 and 17.20, but it was not possible to determine whether the BPR had successfully released. The ship was now approximately half a mile from the site and the decision was made to return to the original site. The ascent time of the BPR, once released, would be about 90 minutes. At 18.25 GMT, another attempt was made to contact the BPR to determine if it had released. This time range readings showing 1000m were achieved, but there were also readings showing about 3000m. It was still difficult to decide whether the unit had released from the seabed. Five minutes later the ship's direction finder radio receiver detected the signal from the BPR transmitter. The BPR had surface in open water about 350m from the ship and 250m from thick ice.

RECOVERY OF MS2 BPR, 21/2/99

EVENTS

15.20 GMT	Vessel on station.
15.20, 15.30, 15.42 , 16.02 and 16.13 GMT	Released command transmitted.
16.18 GMT	Released at.
16.30 GMT	On the surface.

Total time on station: 1 hour 10 minutes

<u>MS2 BPR Recovery Information</u>

The whole mooring site was covered with a thin layer of new ice between 5-10 cm thick which was still transparent and the sea beneath could be seen. There were also a few small flows of ice up to 1.8m thick. The ship manoeuvred over the site and started to break the thin ice into small flows to create a bit of open water. The first release command was transmitted at 15.20 and the acoustic interrogated for an indication of the BPR having released. However the unit was not releasing. Release commands were transmitted at the other times indicated above and it was not until 16.18 that the unit showed signs of coming to the surface. The BPR surfaced about 300m ahead of the ship under the thin ice. It could not be seen visibly from the ship but the unit's radio transmitter was received by the ship and guided it in the direction of the signal. The ship actually passed the BPR without realising it until the radio receiver indicated a change of direction in the signal. At this point the ship hove-to and eventually the BPR was spotted under a small mound of ice about 1m from the open water created by the ship passing through. The ship was then manoeuvred to break the ice surrounding the BPR in order to recover it.

CONCLUSION

Due to very heavy ice conditions throughout the entire Weddell Sea, it was not possible to attempt a recovery on all of the Bottom Pressure Recorders. Due to the nature and small size of the BPRs deployed in the Weddell Sea, if there is not open water over the deployment site then a recovery attempt is unlikely to be successful. However if a different design is used for future under ice measurements then recovery is possible even with thick ice cover, as was demonstrated by AWI personnel who successfully recovered four current meter moorings from underneath thick ice cover.

RECOMMENDATIONS

When trying to recover moorings from underneath ice, especially deep moorings, it is desirable that the release works quickly. The burnwire system is slow and as a result can mean that the open water that was available has drifted past by the time the release has activated and the unit surfaced. It also can cause confusion as to whether the acoustic unit has actually received the release command successfully. Currently the acoustic release units are configured so that the burnwire can be deactivated should the release command be transmitted by accident. This can result in the burning being switched on and off at regular intervals, the probable cause of the MS2 BPR taking 70 minutes to surface. The ideal solution is to have a faster alternative to the burnwire. This exists as the pyrolease, but is difficult to transport abroad by commercial carriers due to its Health and Safety Executive (HSE) explosive classification. Other commercial acoustic release mechanisms use a mechanical hook driven by a motor housed in a waterproof case. This acts almost instantaneously but may not be available outside of the specific acoustic units to which it is currently fitted. If burnwire releases are to remain, then a re-design of the firing circuit is needed such that it has a positive on action; thus every release command transmitted acts to turn the burnwire on.

A mooring can be given a better chance of successful recovery by having multiple sets of buoyancy. This enables any one of the sets of buoyancy to surface in open water, or through brash ice and allow the recovery to commence, even though the rest of the mooring is hidden under thick ice. If the mooring also has buoyancy within 300m of the surface, then the floats are likely to surface quickly in any open water that is above the mooring position, making recovery simpler. To aid the recovery of a mooring which surfaces under ice, an acoustic transponder has to be used to locate it, but the transponder must be at a suitable depth below the water surface to be able to communicate with the ship transducer. The current range of Bottom Pressure Recorders deployed by POL do not allow communication with the acoustics once the unit has surfaced. In normal open water deployments this is not a problem since the BPR is usually quickly spotted.

APPENDIX 1 - BPR TECHNICAL INFORMATION

CH2 BPR RECOVERY INFORMATION

Location details	**-**	***Latitude 73°41.523' S*** ***Longitude 034°36.594' W*** ***Depth 2836m***
On station	-	13.30 GMT on 16/2/99
Released command transmitted		- 16.50, 17.03 and 17.20 GMT
On surface	-	18.30 GMT
Acoustic Information	-	TR 7000 Acoustics ID 02, Rx 11.0 kHz, Tx 12.0 kHz, Enable A Disable B, Release C, Pinger D
Radio Beacon	-	Benthos 154.585 MHz Channel A
Logger	-	C2

Logger Information

Sensor	-	DQ 68482

Timebase Channels

1	-	Temperature
2	-	Pressure

Timebase scan

Expected	Actual
16.00.0 GMT on 18/2/99	16.01.46 GMT

Timebase is 1 minute 46 seconds slow.

Data Arrangement

Channel 1	-	Scan number
Channel 2	-	Time
Channel 3	-	Pressure
Channel 4	-	Temperature

Data downloaded to ch2.raw and converted to ch2.dat. Conversion process splits data into separate columns and adds leading 1 to temperature data.

Battery Voltages

Logger	-	14.68 V
Burnwire	-	26.6 V
Acoustic	-	12.14 V

MS2 BPR RECOVERY INFORMATION

Location details	-	***Latitude*** ***76°35.09' S*** ***Longitude*** ***032°00.4' W*** ***Depth 389m***
On station	-	15.20 GMT on 21/2/99
Released command transmitted		- 15.20, 15.30, 15.42, 16.02 and16.13 GMT
Released from seabed	-	16.18 GMT
On surface	-	16.30 GMT

Given the shallow depth of this deployment, there was very good communication with the acoustic release on the seabed. However there was uncertainty whether the release command had been received properly. Since the release toggles the burning action with every command received, it is probable that all commands were received since the burnwire was active when recovered. This would mean that the total time taken to burn the wire was in excess of 30 minutes.

Acoustic Information	-	XT 6000 Acoustics Rx 11.0 kHz, Tx 12.0 kHz, Release A
Radio Beacon	-	Novatek 160.725 MHz Channel C
Logger	-	M2

Logger Information

Sensors		- DQ 41086 Temp sensor QT1

Timebase Channels

1	-	Temperature
2	-	Pressure
3	-	Temperature

Timebase

Expected scan	Actual scan
11.30.00 GMT on 22/2/99	11.30.19 GMT

Timebase is 19 seconds slow.

Data Arrangement

Channel 1	-	Time
Channel 2	-	Date
Channel 3	-	Temperature

Channel 4	-	Pressure
Channel 5	-	Temperature

Data downloaded to ms2.raw.

Battery Voltages

Logger	-	8.70 V
Burnwire	-	28.16 V
Temp Sensor	-	9.49 V

MAP OF BPR DEPLOYMENT POSITIONS

CRUISE TRACK

ICEBERG A38-B

GLOSSARY

AWI	-	Alfred-Wegener Institute
BAS	-	British Antarctic Survey
BPR	-	Bottom Pressure Recorder
CTD	-	Conductivity, Temperature and Depth Profiler
FRIS	-	Filchner-Ronne Ice Shelf
HSE	-	Health & Safety Executive
ROPEX	-	Ronne Polynya Experiment
SANAE	-	South African National Antarctic Expedition
UEA	-	University of East Anglia