Cruise Report

JR151 – Long-Term Monitoring and Survey

26-27 December 2005

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Summary

The purpose of cruise JR151 was to deploy three moorings across Orkney Passage, to monitor the outflow of Weddell Sea Deep Water from the Weddell Sea into the Scotia Sea. BAS had entered an agreement with Lamont-Doherty Earth Observatory of Columbia University to cooperate on these moorings, in which we were to retrieve an LDEO mooring, M4, from Orkney Passage, refurbish the instruments, download the data, and then redeploy the instruments on the new moorings, extending from the middle of Orkney Passage and onto the slope towards the west. One day of ship time was allocated to this work.

This planning was all made under the assumption that Orkney Passage would be ice free. However, at the time of the cruise, late December 2005, the whole area south and east of the South Orkneys was filled with ice, largely multiyear, that had blown up from the Weddell Sea, making Orkney Passage inaccessible within the allocated time for the cruise. A decision was therefore made to go to the area north of Coronation Island instead, and to do a CTD survey of the slope here, and, if moorings were deemed useful in this location, two moorings could be deployed here. The ship entered a lead around 7:00 on 26/12/2005, and was able to proceed to the first CTD station at around 4000 m depth at 08:37. Three more CTDs were taken at around 3500, 3000, and 2500 m depth along a course of 200°. Based on the preliminary processing of these CTDs, two moorings were deployed at approx. 4000 and 3500 m depth. These moorings are referred to as CI1 and CI2, respectively. The mooring deployments were completed at midnight on 27/12/2005, and after verifying that the mooring had landed on the seabed and the acoustic release was communicating with the deck unit, the ship proceeded toward Bird Island to commence JR140.

Instruments & methods

CTD

The ship's Seabird Electronics 9/11+ CTD system was used on the cruise. The sensors installed are listed in appendix 2. Note that this configuration does not correspond to the .CON file provided by AME and used during data acquisition. The new file has been named JR151_postproc.CON. The calibration supplied by NOC for the primary temperature sensor was invalid, therefore new coefficients were calculated; these are also given in appendix 2. A total of 20 salinity samples were taken; 17 of these were used for calibration. In addition, a Seabird Electronics 35 deep sea standards thermometer was installed, and took readings when bottles were fired. The data have been processed using a combination of Seabird Electronics' "SBE Data Processing" software version 5.37b and Matlab scripts primarily written by Karen

Heywood/Mike Meredith and modified for use on JR097 and JR139. Further modifications were made on this cruise:

- All use of the functions ds_ptemp and ds_salt have been removed. No use has been made of IPTS-68 temperatures, instead all calculations are done using version 3.0 of the seawater toolbox using ITS-90 temperatures.
- A bug was identified in "botlsal.m", in which only half of the conductivity offset from the standard seawater calibrations was used to correct the other samples. This is because of the confusion caused by using the double conductivities given by the salinometer.
- Spike2.m was modified to remove large jumps adjacent to NaN values on the second pass. This improved despiking.
- Other minor modifications were made to programs loading files, e.g. ctdcal and sb35read, and changes were made to pathnames.
- Samplsal.m was modified to work with Matlab 6.5.

The programs were run in this sequence:

1. datcnv: apply sensor calibrations and convert to engineering units
2. alignctd: forward the oxygen measurements by 5 seconds
3. celltm: correct conductivities for cell thermal mass effects
4. asciiout: export processed data into .hdr and .asc files
5. a manual edit was made to ensure that positions and station numbers were correct in the file headers at this point.
6. ctdcal.m: load raw data from the .hdr and .asc files
7. offpress.m: manually identify pressure offsets based on deck pressure. This step was only done once, and future runs were done using offpress2.m, which is non-interactive.
8. spike2.m: Despike measurements.
9. interpol.m: Interpolate over removed values.
10. makebot.m: Load rosette information from .BL files and save CTD measurements from the identified scan range in a "botNNN.1st" file.
11. samplsal.m: Load salinometer measurements from the Excel spreadsheet containing conductivity ratio readings.
12. sb35read.m: Load SBE 35 measurements
13. addsal.m: Add conductivities from the salinometer to the file with CTD measurements
14. setsalflag.m: Update salinity flags (flag out bottles with high conductivity std. dev.
15. sb35comp.m: Merge SBE35 measurements with CTD measurements from the corresponding salinity bottle file.
16. jr151_cal.m:
    - Load all SB35 and salinometer measurements
    - Computer mean and std. dev. values between calibration instruments and CTD sensors, computing the calibration conductivity using the SB35 temperature, salinometer-derived salinity, and CTD pressure
    - As the temperature differences were not statistically significant, no temperature calibration was performed. The salinity/conductivity offsets are significant, and all sensor offsets were saved to calvalues.mat
17. salcalapp.m: Apply the calibration offsets to measurements and save to .var file. Sensor 1 is used for the variables "potemp" and "salin".

18. splitcast.m: Split into upcast and downcast
19. ctd2db.m: Bin downcast into 2db pressure bins and save to .2db file.
20. ctd1hz.m: Save 1-second averages to .1hz Matlab file
21. make_ladcp_1hz.m: Save 1-second data in ascii file for LADCP processing

The mean and std. dev. calibration offsets found in step 16 are given in the following table:

	Sensor 1	(std. dev.)	Sensor 2	(std. dev.)
SBE35-SBE9+ Temperature	3.067e-4	6.980e-4	-7.933e-4	7.878e-4
Bottle-SBE9+ Salinity	1.7819e-2	1.311e-3	2.0945e-2	1.268e-3
Bottle-SBE9+ Conductivity	1.4016e-2	1.129e-3	1.5412e-2	1.121e-3

LADCP

The University of Hawaii LADCP processing software was run on JRUA using the same software as on cruise JR139, following the instructions from the JR139 cruise report by Nuno Nunes. The magnetic field values used to perform magnetic deviation corrections were updated to the newest IGRF10 model output, as the previous version gave invalid output after Jan. 1 2005.
A large difference was found between the upcast and downcast on station 1; on the remaining stations the processing appears to have been more successful.

Multibeam sonar

The Simrad/Kongsberg EM120 multibeam sonar was used from 12:34 on 25/12/2005 until 18:11 on 28/12/2005. Logging was stopped when the ship was stopped for CTD stations and mooring deployments, and pinging was disabled when attempting to communicate with the acoustic releases following mooring deployments, as the EM120 interferes with communication.
The raw data was collected into ".all" files in Simrad's proprietary format, with a new file ("line") started every hour, or whenever logging was stopped and restarted. Not all the data collected have been processed; only lines 16-30 have been fully cleaned. Five lines at a time were selected in Simrad's Neptune software, and then processed in "BinStat" *without* using any statistical rules. Then invalid beams were flagged using the correlation plot. After each five-line block was cleaned, the beam flagging information was saved, creating a file named "Binstat_1.rules". This file was renamed "Binstat_NN-NN.rules" with NN replaced by the line numbers contained in the file. The corresponding ".all" files were then compressed and copied to the central UNIX/Solaris server BSUCENA at BAS HQ, where they were converted to "mb57" format for use with the LDEO/MBARI MBtools package. The ".rules" files were then converted to ".esf" format using mbneptune2esf, processed using mbprocess, and finally gridded on a 100*100 m grid using mbgrid.
The results for lines 16-30 are plotted in figure 1.

Moorings

Two moorings were deployed, CI1 and CI2. The instruments were set up as follows:

RCM11 sn 517
DSU sn 14742
Started at 03:00 UTC on 24/12/2005
Sampling interval: 1 hour
Temperature range: Arctic
Conductivity range: 28.5-31.5 mS/cm
with rollover
Tilt on channel 6
Signal strength on channel 7
Lithium battery

RCM11 sn 521
DSU sn 14743
Started at 13:00 UTC on 24/12/2005
As sn 517, but with alkaline battery

RCM11 sn 532
DSU sn 14744
Started at 13:00 UTC on 24/12/2005
As sn 517, but with alkaline battery

RCM8 sn 12669
DSU sn 11121
Started at 03:00 UTC on 24/12/2005
Sampling interval: 1 hour
Low & Arctic temperature range

RCM8 sn 12677
DSU sn 11533
Started at 03:00 UTC on 24/12/2005
Sampling interval: 1 hour
Arctic temperature range
Pressure sensor (0-6000 dbar)

SBE39 sn 0110
Started at 18:00 UTC on 25/12/2005
Sampling interval: 5 minutes

SBE39 sn 1311
Started at 18:00 UTC on 25/12/2005
Sampling interval: 5 minutes
With pressure sensor

All RCMs were initially started at 03:00 UTC on 24/12/2005 to check that they were working correctly. However, after a few measurement cycles it was apparent that sn 521 and 532 were not working correctly: sn 521 was sampling 30 seconds before the other current meters after 8 hours, while sn 532 had an incorrect word count and had written invalid data to its DSU. These were the two current meters fitted with lithium batteries supplied by A1, and when measured, the voltage on these batteries was 6.75 V, while the Aanderaa lithium battery in sn 517 had a voltage of 7.18 V (both measured while connected, with the current meter switched on but not sampling). The open circuit voltage of the A1 batteries was found to be 7.04 V, significantly below Aanderaa's specification of 7.33 V for new batteries. After the batteries were replaced with the alkaline batteries supplied with the instruments, all instruments functioned correctly.

The RCM11's have new conductivity cells, where the range is programmed before deployment using Aanderaa's "4040 conductivity setup program". Here the range was set to 28.5-31.5 mS/cm, yielding a resolution of 0.0029 mS/cm. The rollover feature is enabled, so if values fall outside the measured range, the values will over- or underflow. However, in the deployment area it seems unlikely that measured values will fall outside this range. Two "DCS multiplexing cables" were installed to supply tilt on channel 6 and signal strength on channel 7.

The moorings were deployed without any problems, at uncorrected depths of 3872 m and 3410 m depth, respectively (from the EA600 echosounder, using 1500 m/s speed of sound). Corrected depths from the center beam of the EM120 swath are 3912 m and 3463-3485 m depth, respectively. The range of values for CI2 may indicate that the small-scale topography is rough in this area.

All instruments have sufficient battery power and memory for more than one year's operation. The mooring diagrams are shown in figure 2.

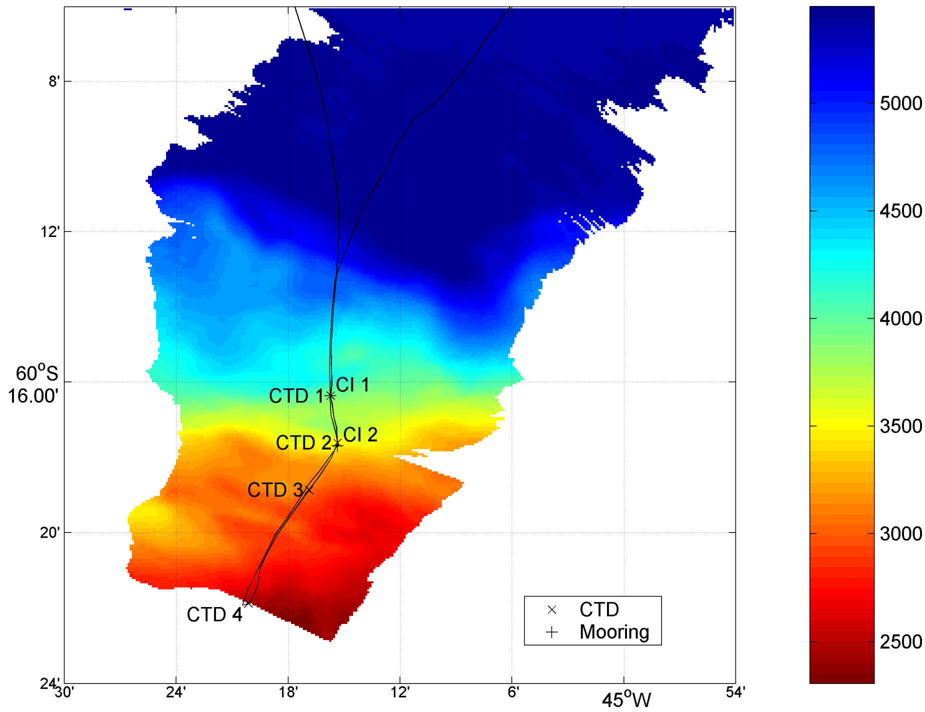

Fig. 1a. Bathymetry around the CTD and mooring sites, from multi-beam sonar.

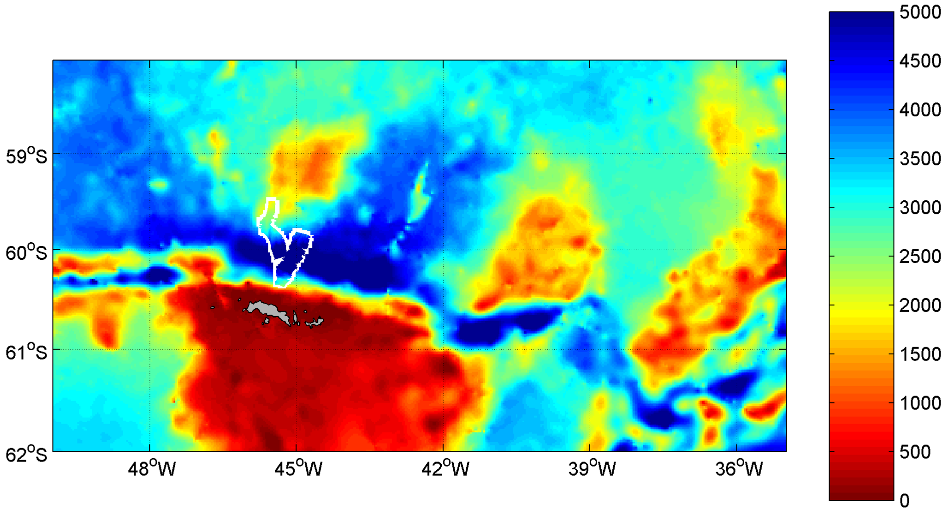

Fig. 1b. Swath bathymetry from JR151 with surrounding bathymetry from Smith & Sandwell version 8.2.

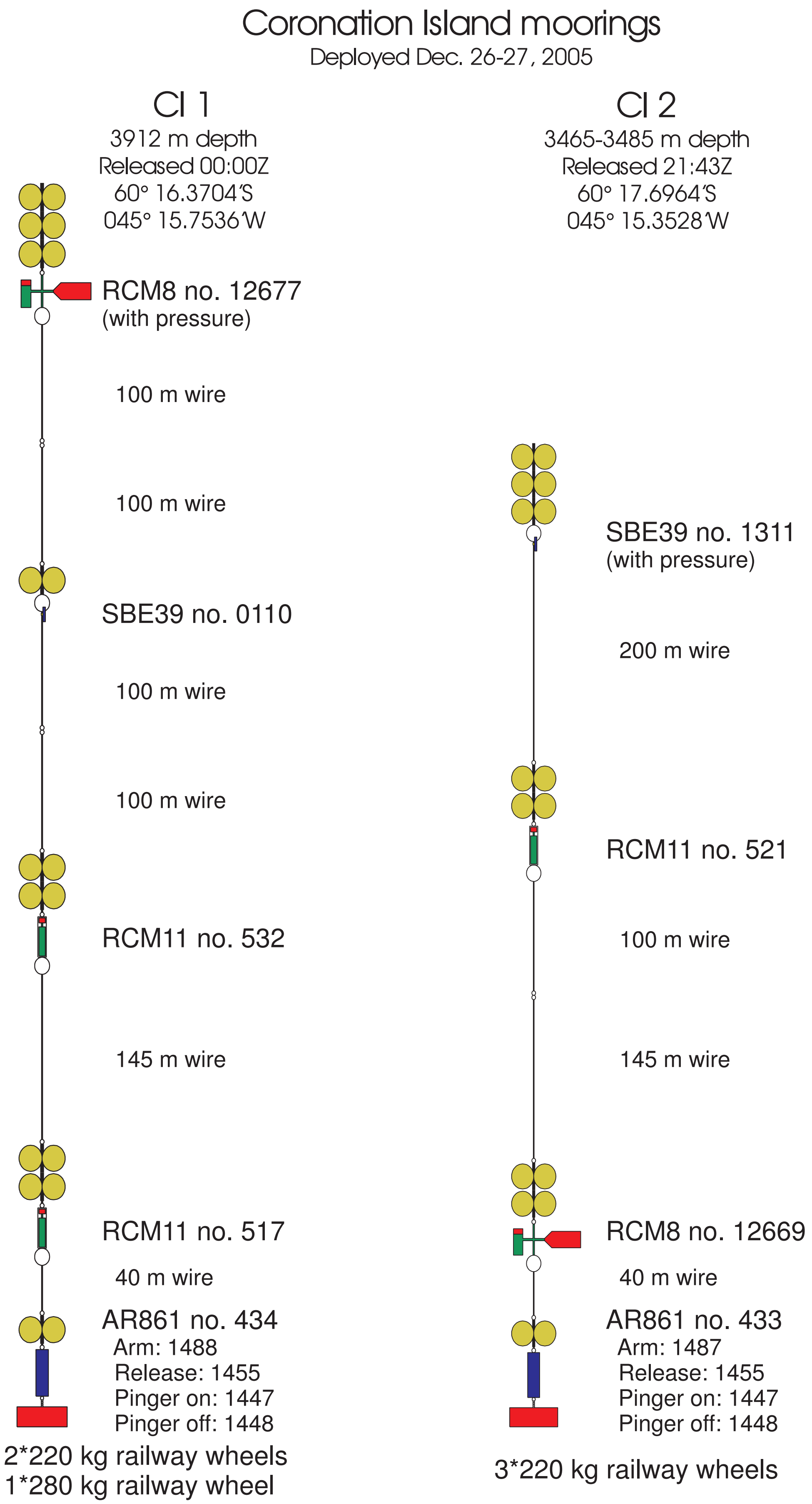

Fig. 2. Diagram of the two moorings deployed north of Coronation Island.

Preliminary Results

Potential temperatures, salinities, and oxygen concentrations from the four CTD casts are plotted in figure 3:

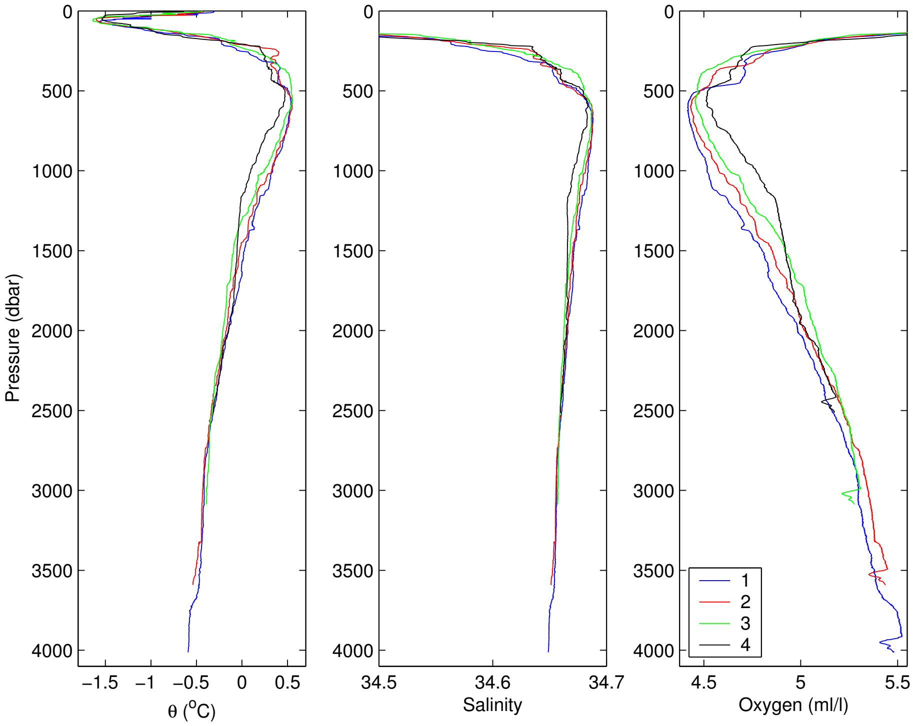

Figure 3. Potential temperature, salinity, and oxygen concentration from stations 1-4.

The lowest 1000 m are plotted in figure 4:

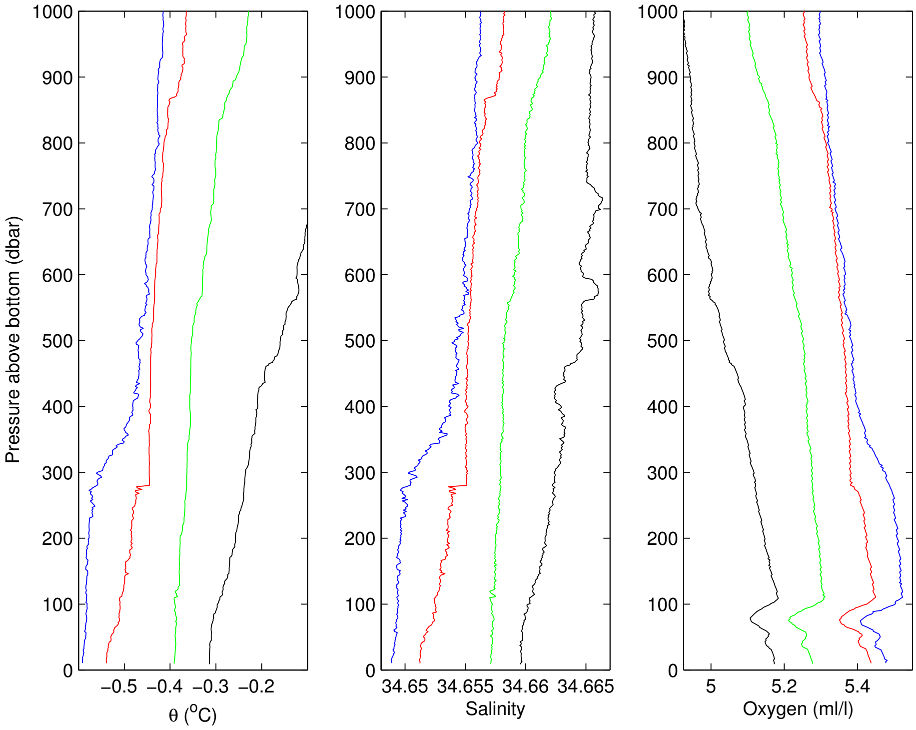

Figure 4. Potential temperature, salinity, and oxygen concentration near the bottom from stations 1-4. The same colors have been used as in figure 3.

The oxygen concentration profiles in the lowest 100 m are rather unusual, and all four stations exhibit the same behaviour. The oxygen sensor and altimeter were connected to the main CTD unit using a y-cable. On a later cruise, the connector on the main unit was found to have corroded, leading to interference between the two instruments. Unfortunately this does cast doubt as to the value of all the oxygen measurements, as no independent calibration was performed. However, the measurements do give an indication of the relative oxygen concentrations.

Towards the bottom, stations 1 and 2 display a drop in temperature and salinity, along with an increase in oxygen.

All of the water at pressures greater than 1600 dbar falls under the definition of WSDW from Gordon et al., 2001. This paper shows that the water in the South Orkney Trough flows over the South Scotia Ridge around 38 °W and through Orkney Passage, and has a higher temperature and salinity and lower oxygen concentration than the bottom water of the Weddell Sea. The increased oxygen concentration and the general bathymetry of the region (see fig. 1b) indicate that the water has passed through Orkney Passage.

Appendix 1: Bridge science log

Note: all of the echo depths are uncorrected values from the EA600 (using 1500 m/s as the speed of sound)

Time (UTC)	Lat	Lon	Comment
26/12/2005 08:37	60° 16.3656'S	45° 15.7308'W	On station for CTD 1 depth 3875m
26/12/2005 08:45	60° 16.3692'S	45° 15.7380'W	CTD deployed
26/12/2005 08:49	60° 16.3668'S	45° 15.7368'W	CTD being lowered to 3800m
26/12/2005 09:56	60° 16.3662'S	45° 15.7560'W	CTD held at 3930m wire out. Commence recovery.
26/12/2005 11:12	60° 16.3674'S	45° 15.7506'W	CTD recovered.
26/12/2005 11:38	60° 17.6184'S	45° 15.3816'W	V/L on station
26/12/2005 11:45	60° 17.6214'S	45° 15.3894'W	CTD Deployed to 3468m
26/12/2005 12:52	60° 17.6226'S	45° 15.3780'W	ctd @ 3523m
26/12/2005 14:05	60° 18.8676'S	45° 16.8930'W	CTD Recovered to deck.
26/12/2005 14:23	60° 18.8682'S	45° 16.8954'W	V/L on station 3000m
26/12/2005 14:32	60° 18.8658'S	45° 16.9008'W	CTD deployed
26/12/2005 15:27	60° 18.9096'S	45° 16.9560'W	PO Held at 3031- Commence recovery
26/12/2005 16:26	60° 18.9120'S	45° 16.9662'W	CTD Recovered to deck.
26/12/2005 17:05	60° 21.8814'S	45° 20.1348'W	Vessel On Station for CTD 4, depth 2500m
26/12/2005 17:13	60° 21.8808'S	45° 20.1498'W	CTD deployed to approx 2500m
26/12/2005 17:57	60° 21.8838'S	45° 20.1354'W	CTD at 2467m, commence recovery
26/12/2005 18:44	60° 21.8826'S	45° 20.1270'W	CTD on deck, vessel moving to moorings station.
26/12/2005 19:52	60° 17.6268'S	45° 15.4080'W	Commence deployment of mooring. Depth on EA 600 3437mts
26/12/2005 21:43	60° 17.6964'S	45° 15.3528'W	Mooring released. Depth on EA 600 3410mts
26/12/2005 22:51	60° 16.3758'S	45° 15.7596'W	Commence deployment of mooring. Depth on EA 600 3980mts
27/12/2005 00:00	60° 16.3704'S	45° 15.7536'W	Mooring released. Depth on EA 600 3872mts
27/12/2005 00:33	60° 16.3710'S	45° 15.7542'W	Mooring landed on seabed. Hydrophone recovered. Clear to depart.

Appendix 2: CTD configuration

The CTD was configured with the following sensors:

Frequency 0	Temperature, SBE3+ 2705	23 June 2005
Frequency 1	Conductivity, SBE4C 2248	23 June 2005
Frequency 2	Pressure, Paroscientific, 89973-0707	03 June 2005
Frequency 3	Temperature, SBE3+ 2709	23 June 2005
Frequency 4	Conductivity, SBE4C 2255	23 June 2005
Voltage 2	Fluorometer, Chelsea Mk III Aquatracka 88216	21 June 2004
Voltage 4	Transmissometer, Wet-Labs C-Star CST-846DR	29 March 2005
Voltage 6	Altimeter, PA200/20-6K8 2130.26993	28 Jan. 2000
Voltage 7	Oxygen, SBE43 0245	31 May 2005

Problem with calibration of primary temperature sensor, s/n 2705.

The coefficients on the first page of the PDF "T Primary – SBE3 Plus – 2705.pdf" do not match the calibration points below.
Using the coefficients as they are written in the document, residuals are of order 0.3 deg. C, which, needless to say, is unacceptably high, and must be due either to a typo or to a mistake in the calculations.
Based on the calibration points, I have calculated a correct set of coefficients, given below:

g = 4.3911657e-003 i = 2.6675626e-005
h = 6.5518078e-004 j = 2.7979928e-006
where

$$Temp(ITS-90) = \left\{ \frac{1}{g + h(\ln(f_0/f) + i(\ln^2(f_0/f) + j(\ln^3(f_0/f)))} \right\} - 273.15$$

and f_0 is 1000 Hz

The residuals are given below:

Temperature (ITS-90)	SBE Freq. (Hz)	Fitted temp. (new)	Residual (new)	Temp. from coeffs in PDF
-0.1185	3190.47	-0.1185	0.0000	-0.3497
3.1406	3427.30	3.1407	-0.0001	2.8932
6.2711	3666.47	6.2711	-0.0000	6.0081
10.3251	3993.68	10.3250	0.0001	10.0421
14.2855	4332.94	14.2857	-0.0002	13.9836
17.7206	4643.21	17.7205	0.0001	17.4019
20.1623	4873.03	20.1621	0.0002	19.8319
23.0997	5159.92	23.0997	-0.0000	22.7558
26.0386	5458.49	26.0390	-0.0004	25.6815
29.0058	5771.72	29.0056	0.0002	28.6346