Part 1: CTD Processing Notes for AU9101

D.J. Vaudrey
CSIRO Division of Oceanography
Hobart

General

Marine science cruise AU9101, the first completion of the WOCE SR3 transect, was conducted aboard the Australian icebreaker RSV Aurora Australis from September to October 1991. The original plan was to carry out the transect from south to north, however following a stop at Macquarie Island the ship had to return to Tasmania for major CTD winch repairs. The transect was then commenced from north to south, skipping some stations due to bad weather. These stations were occupied on the return passage north.

Table 1: **Summary of cruise itinerary.**

Expedition Designation
Cruise AU9101, encompassing WOCE section SR3

Chief Scientist
Steve Rintoul, CSIRO

Ship
RSV Aurora Australis

Ports of Call
Macquarie Island

Cruise Dates
September 25 to October 27 1991

Casts were carried out using the Australian Antarctic Division's NBIS Mark IIIB CTD serial 1193. The CTD was mounted in a 24 bottle rosette frame with 10 l Niskin bottles, all supplied by the CFC group from NOAA PMEL. A pre-cruise temperature sensor calibration, by the CSIRO Division of Oceanography Calibration Facility, was applied to the CTD temperature data. Pre-transect winch trails were carried out using other CTD units. Data from these casts, stations 1-5, were not processed due to unexplained hardware problems. Stations 6 and 7 were respectively the down and upcast of a shallow cast to 125 dbar; file problems occurred and these data were lost. Station 8 was the first full depth cast, carried out at the same site as station 6. One of the CTD's with hardware problems was trialed during station 21 with little success - temperature data only were processed for this station. No CTD dissolved oxygen data was obtained as the only working CTD could not be fitted with an oxygen sensor.

CTD data were logged on a single Hewlett Packard 286 PC using an early version of the NBIS Acquisition software. Neither audio nor direct digital recording were available for backup. Files were transferred to the ship's VAX, and archived daily to magnetic optical disk using VMS backup. The CTD PC had to be rebooted after each file transfer to the VAX, and the PC time was not always reset correctly. As a result incorrect times were often logged in the CTD file headers. These times were corrected later during data processing by checking the ship's underway data.

Two different NBIS rosette pylons were used throughout the cruise, both giving a variety of misfire problems. Various power failures, winch and trolley problems also caused delays.

Station List

1. Winch test station. Incorrect pressure factor applied to logging software and CTD hit the bottom. No apparent damage. Winch spooling problems. Not calibrated due to hardware problem with conductivity.
2. Winch trials. Appears to be a major problem with winch drum. Appears as if cheek plates cracked away from drum. Not calibrated due to hardware problem with conductivity.
3. Winch trials. Numerous stops on upcast in attempt to get wire spooled. Not calibrated due to hardware problem with conductivity.
4. Winch trials. Numerous stops on upcast in attempt to get wire spooled. Not calibrated due to hardware problem with conductivity.
5. New cable spooled onto drum prior to this cast. Spooling not perfect. Not calibrated due to hardware problem with conductivity.
6. Shallow biology cast. Files scrambled. Could not be deciphered. First cast with unit 1193. Not processed.
7. Logged upcast of station 6. Not processed.
8. First full station. Same site as station 6. Apparent misfire at position 1. Fired twice. Ramp indicated 25 successful fires. Vent on bottle #23 not tight.
9. Problem with deployment. Overhead gantry jammed. Logging stopped after 20 minutes and restarted 20 minutes later.
10. Bottles 5 and 6 indicated misfires but ramp position indicated successful firings. 200 metre biology cast.
11. Winch power lost at about 400 dbar on downcast. 50 minute delay. CTD raised to above failure depth before recommencing downcast. Bottle 24 did not close. Misfire at position 15.
12. Problem with winch at 757 dbar on downcast. About 10 minutes lost. No misfires.
13. Bottle #17 air vent not done up.
14. Misfire at bottle 5. Bottle 24 did not close.
15. No apparent problems.
16. No apparent problems. Bottom bottle fired 50 m above bottom due to very rugged bottom. Misfire on position 24. Refired and got confirmation.
17. Station not carried out fully as too rough. No bottles sampled.
18. "Short" misfire on #13, but appears to have fired.
19. CTD cable jumped off sheave. Station aborted. Retermination of CTD wire.
20. Retry of station 19. Some modifications to block to stop wire jumping out were carried out prior to this station.
21. Two misfires at position 9 and 11. Used CTD 1013 as trial but still problems with conductivity hysteresis.. Cause unknown. Able to calibrate temperature only. Not archived.
22. Niskins relablled to swap deep and shallow sets of 12. a number of misfires on position 6, 18, 19, 20, 21 and 22. Only one not closed on recovery. Most likely #6 from O/E returns.
23. Rosette pylon checked out before cast. Some changes made. Wire spooling problems on upcast. Misfire indicated on #19 and 20. All bottles closed. Heavy rolling during recovery. cTD most likely hit ship. Green water in CTD court. Bottle #9 leaking.
24. Misfires indicated on #15, 18, 19, 20 and 21. One bottle empty at the surface. Most likely #15.
25. Pylon changed prior to this cast. Spooling problems. a number of short stops and reversals to cure spooling problems on the upcast.
26. Misfire on #9. Bottle not closed at surface. Not fired.
27. No apparent problems.
28. Two halts during upcast for spooling problems (@3200 dbar and 1300 dbar).
29. Misfire at #1 (repeated fire), misfire at #23 and 24.
30. Sensor cover not filled prior to this station. Some spooling difficulties. Misfire on #16 and 23.
31. Misfires on #8, 9, 10, 11 and 23.

32. Rosette pylon changed prior to this cast. No apparent problems. #24 leaking through tap on recovery.
33. Misfire on #23. 1 bottle empty at surface.
34. Misfire indicated on #9. All bottles closed.
35. Misfire indicated on #1, 4, 6 and 7. One bottle open.
36. Test cast for CFC's.

Calibration Information

Temperature coefficients

CTD	calibration date	offset	slope
1193	September 1991	-1.0049e-03 ^{o}C	1.0004
1013 (stn 21 only)	September 1991	3.5007e-03 ^{o}C	0.99994

Conductivity cell factors

station grouping	offset term	slope term	station dependent slope correction	number of samples	standard deviation
8 to 15	-0.32931824e-01	0.10013949e-02	0.11493561e-07	169	0.32613e-02
16 to 22	-0.43591284e-01	0.10011636e-02	0.31668779e-07	85	0.28287e-02
(station 21 not calibrated for conductivity)					
23 to 35	0.42793579e-02	0.99997440e-03	0.67473564e-08	229	0.20476e-02

Standard deviation of salinity (bottle-CTD) residual after calibration=0.0031 (PSS78)

Surface pressure offset (individual stations)

station	pressure offset (dbar)	station	pressure offset (dbar)
8	-3.30	24	-2.90
9	-3.40	25	-2.60
10	-3.30	26	-2.60
11	-4.00	27	-2.30
12	-3.10	28	-2.50
13	-3.00	29	-2.30
14	-3.20	30	-2.90
15	-3.20	31	-2.80
16	-2.80	32	-2.90
17	-3.00	33	-2.80
18	-3.20	34	-2.60
20	-2.80	35	-2.80
22	-2.20		
23	-3.00		

Moorings and drifters

7 ALACE floats, 1 current meter mooring and 1 pressure gauge mooring were deployed during the cruise, as follows:

Current meter mooring deployment

site name	deployment time (UTC)	bottom depth (m)	latitude	longitude	current meter depths (m)	nearest CTD station no.
SO1	12 Oct 1991	3570	50° 42.90'S	143° 22.90'E	570	18
					820	
					1070	
					2070	
					3270	

Pressure gauge mooring deployment

site name	deployment time (UTC)	bottom depth (m)	latitude	longitude	nearest CTD station no.
Hobart91b	07:49, 08 Oct 1991	1043	44° 06.83'S	146° 14.03'E	35

ALACE float deployments

deployment number	serial number	deployment time (UTC)	latitude	longitude	nearest CTD station no.
1	89	19:59, 10 Oct 1991	48° 44.8'S	143° 55.9'E	14
2	25	22:25, 11 Oct 1991	50° 39.9'S	143° 17.0'E	18
3	93	10:45, 22 Oct 1991	56° 24.4'S	140° 39.4'E	22
4	91	19:53, 22 Oct 1991	54° 39.5'S	141° 29.7'E	21
5	90	23:07, 23 Oct 1991	52° 07.5'S	141° 38.5'E	20
6	88	18:05, 24 Oct 1991	49° 53.10'S	143° 23.49'E	16
7	94	21:38, 25 Oct 1991	44° 41.61'S	145° 55.75'E	34

References

Rintoul, S.R. and Bullister, J.L., 1999. A late winter hydrographic section from Tasmania to Antarctica. *Deep-Sea Research I*, Vol. 46, pp1417-1454.

Part 2: CFC-11 and CFC-12 Measurements on AU9101 (WOCE SR3)

(Following discussion provided by John Bullister)

John Bullister
NOAA-PMEL
Building #3
7600 Sand Point Way, NE
Seattle, WA 98115 USA
Telephone: 206-526-6741
FAX : 206-526-6744
Internet : bullister@pmel.noaa.gov

Cruise A9101 Chlorofluorocarbon (CFC) Measurements

Specially designed 10 liter water sample bottles were used on the cruise to reduce CFC contamination. These bottles have the same outer dimensions as standard 10 liter Niskin bottles, but use a modified end-cap design to minimize the contact of the water sample with the end-cap O-rings after closing. The O-rings used in these water sample bottles were vacuum-baked prior to the first station. Stainless steel springs covered with a nylon powder coat were substituted for the internal elastic tubing standardly used to close Niskin bottles.

Water samples for CFC analysis were usually the first samples collected from the 10 liter bottles. Care was taken to co-ordinate the sampling of CFCs with other samples to minimize the time between the initial opening of each bottle and the completion of sample drawing. In most cases, dissolved oxygen and total CO2 were collected within several minutes of the initial opening of each bottle. To minimize contact with air, the CFC samples were drawn directly through the stopcocks of the 10 liter bottles into 100 ml precision glass syringes equipped with 2-way metal stopcocks. The syringes were immersed in a holding tank of clean surface seawater until analyses.

To reduce the possibility of contamination from high levels of CFCs frequently present in the air inside research vessels, the CFC extraction/analysis system and syringe holding tank were housed in a modified 20' laboratory van on the deck of the ship.

For air sampling, a ~100 meter length of 3/8" OD Dekaron tubing was run from the CFC lab van to the bow of the ship. Air was sucked through this line into the CFC van using an Air Cadet pump. The air was compressed in the pump, with the downstream pressure held at about 1.5 atm using a back-pressure regulator. A tee allowed a flow (~100 cc/min) of the compressed air to be directed to the gas sample valves, while the bulk flow of the air (>7 liter/minute) was vented through the back pressure regulator.

Concentrations of CFC-11 and CFC-12 in air samples, seawater and gas standards on the cruise were measured by shipboard electron capture gas chromatography (EC-GC), using techniques similiar to those described by Bullister and Weiss (1988). For seawater analyses, a ~30-ml aliquot of seawater from the glass syringe was transferred into the glass sparging chamber. The dissolved CFCs in the seawater sample were extracted by passing a supply of CFC-free purge gas through the sparging chamber for a period of 4 minutes at ~70 cc/min. Water vapor was removed from the purge gas while passing through a short tube of magnesium perchlorate dessicant. The sample gases were concentrated on a cold-trap consisting of a 3-inch section of 1/8-inch stainless steel tubing packed with Porapak C and Porapak T (60-80 mesh) immersed in a bath of isopropanol held at -20 degrees C. After 4 minutes of purging the seawater sample, the sparging chamber was closed and the trap isolated. The trap was then heated to 100 degrees C. The sample gases held in the trap were then injected onto a precolumn (12 inches of 1/8-inch O.D. stainless steel tubing packed with 80-100 mesh Porasil C, held at 90 degrees C), for the initial separation of the CFCs and other rapidly eluting gases from more slowly eluting compounds. The CFCs then passed into the main analytical column (10 feet, 1/8-inch stainless steel tubing packed with Porasil C 80-100 mesh, held at 90 degrees C), and then into the EC detector.

The CFC analytical system was calibrated frequently using standard gas of known CFC composition. Gas sample loops of known volume were thoroughly flushed with standard gas and injected into the system. The temperature and pressure was recorded so that the amount of gas injected could be calculated. The procedures used to transfer the standard gas to the trap, precolumn, main chromatographic column and EC detector were similar to those used for analyzing water samples. Two sizes of gas sample loops were present in the analytical system. Multiple injections of these loop volumes could be done to allow the system to be calibrated over a relatively wide range of CFC concentrations. Air samples and system blanks (injections of loops of CFC-free gas) were injected and analyzed in a similar manner. The typical analysis time for a seawater, air, standard or blank sample was about 12 minutes.

Concentrations of CFC-11 and CFC-12 in air, seawater samples and gas standards are reported relative to the SIO93 calibration scale (Cunnold, et. al., 1994). CFC concentrations in air and standard gas are reported in units of mole fraction CFC in dry gas, and are typically in the parts-per trillion (ppt) range. Dissolved CFC concentrations are given in units of picomoles of CFC per kg seawater (pmol/kg). CFC concentrations in air and seawater samples were determined by fitting their chromatographic peak areas to multi-point calibration curves, generated by injecting multiple sample loops of gas from a CFC working standard (PMEL cylinder 71489) into the analytical instrument. The concentrations of CFC-11 and CFC-12 in this working standard were calibrated before and after the cruise versus a primary standard (36743) (Bullister, 1984). No measurable drift in the concentrations of CFC-11 and CFC-12 in the working standard could be detected during this interval. Full range calibration curves were run at intervals of ~3 days during the cruise. Single injections of a fixed volume of standard gas at one atmosphere were run much more frequently (at intervals of 1 to 2 hours) to monitor short term changes in detector sensitivity.

Dissolved CFCs were detected throughout the section. The lowest (<0.01 pmol/kg) CFC concentrations were measured in deep water (>2500 meters) on the northern end of the section, north of 47^{o}S near Tasmania. The low, but non-zero CFC-11 and CFC-12 concentrations observed in most of the samples from this region are generally consistent, with each other, and indicate very long time scales for ventialation of these waters. Because of the absence of CFC-free waters along the section, and the agreement of observed CFC-11 and CFC-12 concentrations at low levels, no blank corrections have been applied to the reported CFC-11 and CFC-12 data sets.

On this expedition, we estimate precisions (1 standard deviation) of about 1% or 0.005 pmol/kg (whichever is greater) for dissolved CFC-11 and 2% or 0.005 pmol/kg (whichever is greater) for dissolved CFC-12 measurements (see listing of replicate samples given at the end of this report).

A number of water samples had clearly anomolous CFC-11 and/or CFC-12 concentrations relative to adjacent samples. These anomolous samples appeared to occur more or less randomly during the cruise, and were not clearly associated with other features in the water column (eg. elevated oxygen concentrations, salinity or temperature features, etc.). This suggests that the high values were due to individual, isolated low-level CFC contamination events. Measured concentrations for these samples are included in this report, but are give a quality flag of either 3 (questionable measurement) or 4 (bad measurement). A total ~12 analyses of CFC-11 were assigned a flag of 3 and ~12 analyses of CFC-12 were assigned a flag of 3. A total of ~9 analyses of CFC-11 were assigned a flag of 4 and ~8 CFC-12 samples assigned a flag of 4.

CFC samples from test stations 1-7 are not included in this report.

In addition to the file of mean CFC concentrations, tables of the following are included in this report:

Table 1a. A9101 Replicate dissolved CFC-11 analyses
Table 1b. A9101 Replicate dissolved CFC-12 analyses
Table 2. A9101 CFC air measurements

Table 3. A9101 CFC air measurments interpolated to station locations

A value of -9.0 is used for missing values in the listings.

References

Bullister, J.L., 1984. *Anthropogenic Chlorofluoromethanes as Tracers of Ocean Circulation and Mixing Processes: Measurement and Calibration Techniques and Studies in the Greenland and Norwegian Seas*. Ph.D. dissertation, Univ. Calif. San Diego, 172 pp.

Bullister, J.L. and R.F. Weiss, 1988. Determination of CCl3F and CCl2F2 in seawater and air. *Deep-Sea Research*, 35 (5), 839-853.

Cunnold, D.M., P.J. Fraser, R.F. Weiss, R.G. Prinn, P.G. Simmonds, B.R. Miller,F.N. Alyea, and A.J.Crawford, 1994. Global trends and annual releases of CCl3F and CCl2F2 estimated from ALE/GAGE and other measurements from July 1978 to June 1991. *J. Geophys. Res*., 99, 1107-1126.

Table 1a: AU9101 Replicate dissolved CFC-11 analyses

STATION NUMBER	SAMP NO.	F11 pM/kg	F11 Stdev
15	1	0.019	0.001
15	4	0.031	0.004
18	2	0.023	0.001
20	21	5.114	0.019
20	23	4.978	0.191
23	10	0.048	0.002
24	20	6.490	0.034
27	23	5.930	0.008
29	10	0.047	0.002
29	23	5.715	0.007
31	14	1.117	0.028
33	23	4.233	0.033
35	5	2.047	0.049

Table 1b: A9101 Replicate dissolved CFC-12 analyses

STATION NUMBER	SAMP NO.	F12 pM/kg	F12 Stdev
15	1	0.008	0.001
15	4	0.015	0.001
18	2	0.013	0.004
20	21	2.453	0.006
20	23	2.462	0.031
23	10	0.032	0.000
24	20	2.955	0.021
27	23	2.767	0.004
29	10	0.025	0.000
29	23	2.725	0.013
31	14	0.550	0.018
33	23	2.086	0.021
35	5	1.031	0.037

Table 2: A9101 CFC Air Measurements

Leg 1

Date	Time (hhmm)	Latitude	Longitude	F11 PPT	F12 PPT
30 Sep 91	1016	53 12.5 S	157 04.6 E	252.7	490.4
30 Sep 91	1047	53 12.5 S	157 04.6 E	256.1	495.7
30 Sep 91	1059	53 12.5 S	157 04.6 E	255.2	487.5
30 Sep 91	1112	53 12.5 S	157 04.6 E	257.0	495.4
10 Oct 91	1851	48 44.0 S	143 55.0 E	256.4	491.2
10 Oct 91	1905	48 44.0 S	143 55.0 E	257.6	494.4
10 Oct 91	1919	48 44.0 S	143 55.0 E	255.7	495.4
14 Oct 91	1940	54 32.0 S	142 21.0 E	255.4	484.8
14 Oct 91	1953	54 32.0 S	142 21.0 E	255.7	492.0
14 Oct 91	2010	54 32.0 S	142 21.0 E	255.0	486.6
18 Oct 91	0026	63 25.0 S	137 49.0 E	257.4	494.8
18 Oct 91	0039	63 25.0 S	137 49.0 E	255.9	492.0
18 Oct 91	0051	63 25.0 S	137 49.0 E	256.6	494.4
18 Oct 91	0107	63 25.0 S	137 49.0 E	256.0	491.7
22 Oct 91	0350	57 15.0 S	140 17.0 E	254.5	490.4
22 Oct 91	0403	57 15.0 S	140 17.0 E	255.6	491.7
22 Oct 91	0416	57 15.0 S	140 17.0 E	255.3	488.6
22 Oct 91	0430	57 15.0 S	140 17.0 E	253.6	488.0
24 Oct 91	1828	49 51.0 S	143 24.0 E	256.6	492.9
24 Oct 91	1843	49 51.0 S	143 24.0 E	256.7	493.0
24 Oct 91	1857	49 51.0 S	143 24.0 E	255.4	488.5

Table 3: A9101 CFC Air values (interpolated to station locations)

STATION NUMBER	Latitude	Longitude	Date	F11 PPT	F12 PPT
1	44 54.5 S	149 15.0 E	26 Aug 91	262.0	485.0
2	48 14.4 S	152 34.7 E	27 Aug 91	262.0	485.0
3	44 17.6 S	148 26.5 E	4 Oct 91	255.8	491.9
4	44 18.0 S	148 26.1 E	4 Oct 91	255.8	491.9
5	44 08.1 S	148 12.9 E	7 Oct 91	255.8	492.9
6	45 11.0 S	145 42.2 E	8 Oct 91	255.9	490.7
7	45 11.0 S	145 42.2 E	8 Oct 91	255.9	490.7
8	45 11.1 S	145 43.8 E	8 Oct 91	255.9	490.7
9	45 49.7 S	145 25.6 E	9 Oct 91	255.9	490.7
10	46 28.1 S	145 05.1 E	9 Oct 91	255.9	490.7
11	46 27.3 S	145 04.9 E	9 Oct 91	255.9	490.7
12	47 14.4 S	144 45.6 E	9 Oct 91	255.9	490.7
13	47 59.4 S	144 22.0 E	10 Oct 91	255.9	490.7
14	48 44.8 S	143 55.6 E	10 Oct 91	255.9	490.7
15	49 12.8 S	143 38.9 E	10 Oct 91	255.9	490.7
16	49 44.5 S	143 26.8 E	11 Oct 91	255.9	490.7
17	50 12.9 S	143 11.2 E	11 Oct 91	255.9	490.7
18	50 39.7 S	143 16.2 E	11 Oct 91	255.9	490.7
19	50 39.7 S	143 16.2 E	12 Oct 91	255.9	490.7
20	51 51.4 S	142 36.5 E	13 Oct 91	255.9	490.7
21	54 39.8 S	141 22.9 E	15 Oct 91	255.7	490.7
22	56 27.8 S	140 37.7 E	15 Oct 91	256.0	491.6
23	58 08.2 S	139 50.7 E	16 Oct 91	255.0	488.9
24	59 37.1 S	139 09.9 E	16 Oct 91	255.6	491.5
25	61 46.9 S	138 07.2 E	17 Oct 91	255.6	491.5
26	64 53.3 S	136 23.4 E	19 Oct 91	255.6	491.5
27	63 36.1 S	137 00.3 E	20 Oct 91	255.6	491.5
28	60 40.7 S	138 40.5 E	21 Oct 91	255.6	491.5
29	57 15.3 S	140 16.8 E	22 Oct 91	255.6	491.5
30	54 06.3 S	141 40.2 E	22 Oct 91	255.4	490.5
31	53 25.2 S	141 56.9 E	23 Oct 91	255.4	490.5
32	51 14.2 S	142 55.9 E	24 Oct 91	255.4	490.5
33	50 12.1 S	143 12.1 E	24 Oct 91	255.4	490.5
34	44 42.3 S	145 55.9 E	25 Oct 91	255.4	490.5
35	44 05.9 S	146 14.8 E	26 Oct 91	255.4	490.5
36	43 54.5 S	148 03.4 E	26 Oct 91	255.4	490.5

Part 3: Conversion of data to WOCE format

Mark Rosenberg
Antarctic CRC
Hobart

CTD 2 dbar-averaged data files (*.ctd)

* CTD 2 dbar-averaged file format is as per the WOCE manual, except that measurements are centered on even pressure bins (with first value at 2 dbar).
* CTD temperature and salinity are reported to the third decimal place only.

Hydrology data file (a9101.sea)

**** CTD upcast burst data were only available for pressure. CTD temperature, salinity and theta values are from equivalent pressures in the downcast 2 dbar CTD data.***
* Hydrology data file format is as per the WOCE manual.
* The total value of nitrate+nitrite only is listed.
* Silicate and nitrate+nitrite are reported to the first decimal place only.
* CTD temperature (including theta), CTD salinity and bottle salinity are all reported to the third decimal place only.
* Raw CTD pressure values are not reported.
* SAMPNO is equal to the rosette position of the Niskin bottle.
* Bottle oxygen data where no equivalent CTD data were available for conversion of units are not reported.
* Salinity samples rejected for conductivity calibration are not flagged in the .sea file.

Conversion of units for bottle dissolved oxygen and nutrients

Dissolved oxygen

All Niskin bottle dissolved oxygen concentration values have been converted from volumetric units μmol/l to gravimetric units μmol/kg, as follows. Concentration C_k in μmol/kg is given by

$$C_k = 1000\, C_l / \rho(\theta,s,0)$$

where C_l is the concentration in μmol/l, 1000 is a conversion factor, and $\rho(\theta,s,0)$ is the potential density at zero pressure and at the potential temperature θ, where potential temperature is given by

$$\theta = \theta(T,s,p)$$

for the *in situ* temperature T, salinity s and pressure p values at which the Niskin bottle was fired. Note that T and s are from equivalent pressures in the downcast 2 dbar CTD data, as mentioned above.

Nutrients

For the WOCE format files, all Niskin bottle nutrient concentration values have been converted from volumetric units μmol/l to gravimetric units μmol/kg using

$$C_k = 1000\ C_l / \rho(T_l,s,0)$$

where 1000 is a conversion factor, and $\rho(T_l,s,0)$ is the water density in the hydrology laboratory at the laboratory temperature T_l and at zero pressure. No laboratory temperature values were recorded during the cruise - a estimated value $T_l = 22^oC$ has been used for all the data. CTD salinity values are used for s, as per the oxygen data. For samples where no CTD data were available, bottle salinities are used for s.

Station information files

* File format is as per the WOCE manual.
* All depths are calculated using a uniform speed of sound through the water column of 1498 ms^{-1}. Reported depths are as measured from the water surface
* An altimeter attached to the base of the rosette frame (approximately at the same vertical position as the CTD sensors) measures the elevation (or height above the bottom) in metres. The elevation value at each station is recorded manually from the CTD data stream display at the bottom of each CTD downcast. Motion of the ship due to waves can cause an error in these manually recorded values of up to $\pm$3 m.
* Lineout (i.e. meter wheel readings of the CTD winch) were unavailable.