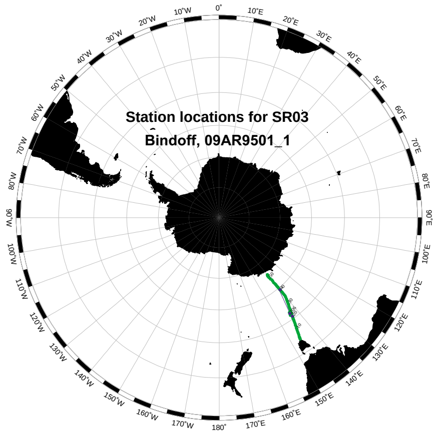

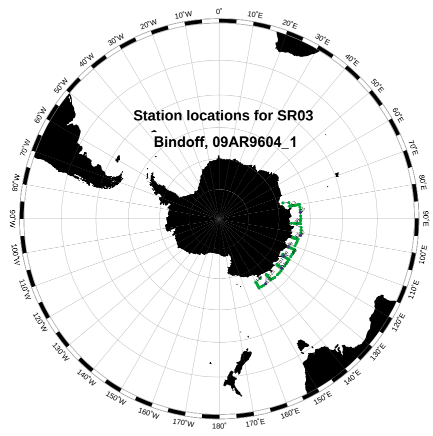

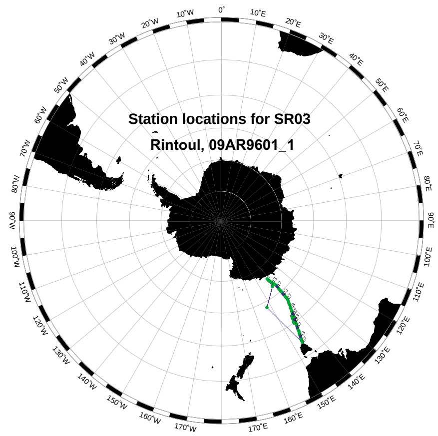

WHP Cruise Summary Information

WOCE section designation	**SR03**
Expedition designation (EXPOCODE)	**09AR9501_1; 09AR9604_1 ; 09AR9601_1**
Chief Scientist(s) and their affiliation	**Nathan Bindoff**, Antarctic CRC (9501) **Nathan Bindoff**, Antarctic CRC (9604) **Stephen Rintoul**, CSIRO (9601)
Dates	1995.07.17 - 1995.09.02 (9501) 1996.01.19 - 1996.03.31 (9604) 1996.08.22 - 1996.09.22 (9601)
Ship	AURORA AUSTRALIS
Ports of call	Davis; Casey; Macquarie Island (9604)
	Macquarie Island (9601)
Number of stations	208 (9501); 147 (9604); 71 (9601)
Geographic boundaries of the stations 09AR9501_1	43°59.86 S 139°44.93 E 146°20.32 E 65°30.64 S
09AR9601_1	44°00.01 S 139°49.38 E 152°18.29 E 65°44.59 S
09AR9604_1	44°7.02 S 76°1.96 E 150°1.03 E 68°8.43 S
Floats and drifters deployed	8 deployed (9604)
Moorings deployed or recovered	1 recovered (9604)
Contributing Authors	M. Rosenberg
	S. Bray
	N. Bindoff
	S. Rintoul
	N. Johnston
	S. Bell
	P. Towler

COOPERATIVE RESEARCH CENTRE FOR THE ANTARCTIC AND SOUTHERN OCEAN ENVIRONMENT (ANTARCTIC CRC)

Aurora Australis Marine Science Cruises AU9501, AU9604 and AU9601 - Oceanographic Field Measurements and Analysis, Inter-cruise Comparisons and Data Quality Notes

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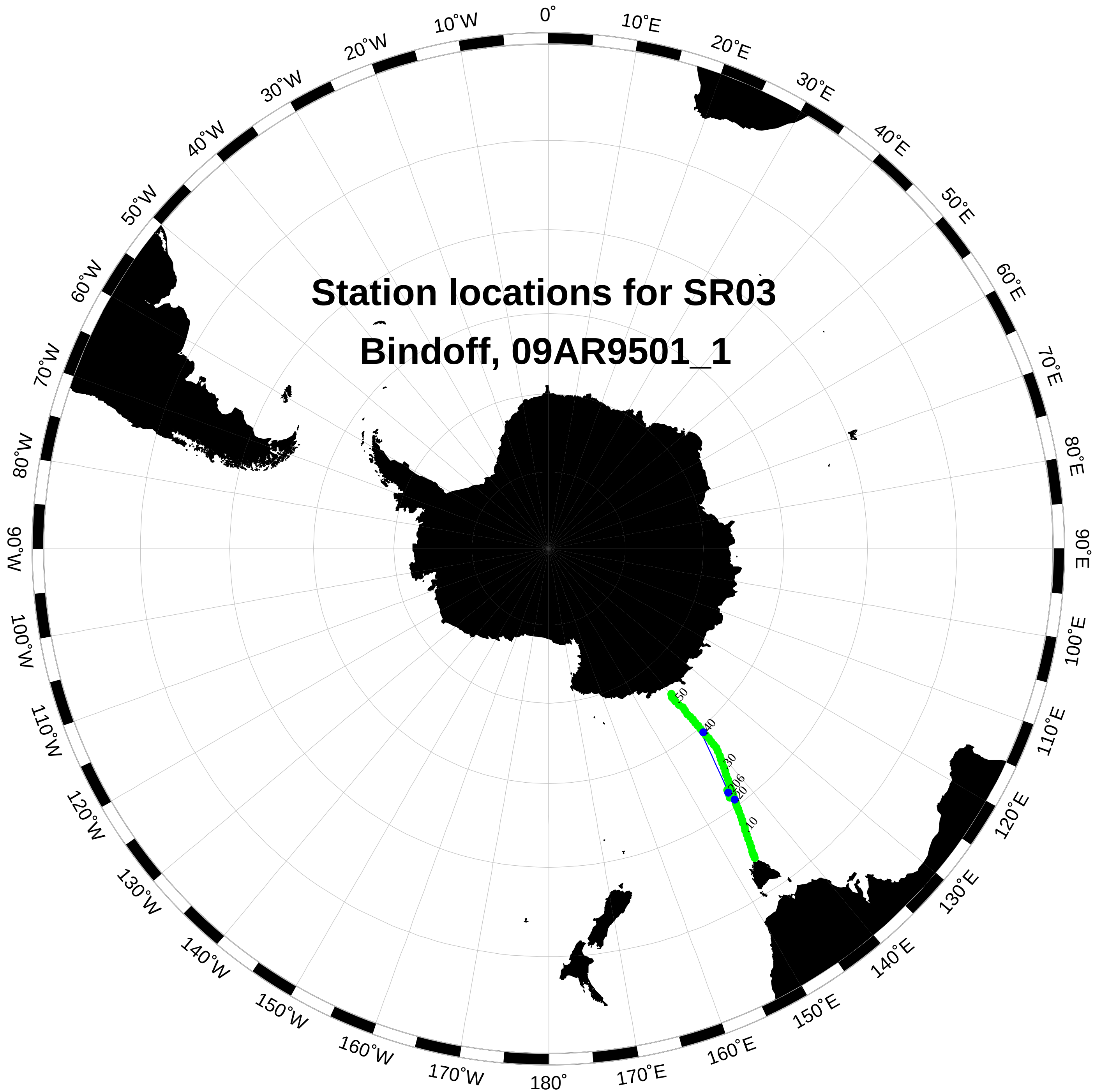
PART 4

LIST OF TABLES (continued)

PART 5


Station locations for SR03
Bindoff, 09AR9501_1
0°
10°E
20°E
30°E
40°E
50°E
60°E
70°E
80°E
90°E
100°E
110°E
120°E
130°E
140°E
150°E
160°E
170°E
180°
170°W
160°W
150°W
140°W
130°W
120°W
110°W
100°W
90°W
80°W
70°W
60°W
50°W
40°W
30°W
20°W
10°W
10
20
30
40
50

Part 1
Aurora Australis Marine Science Cruise AU9501 - Oceanographic Field Measurements and Analysis

ABSTRACT

Oceanographic measurements were conducted along WOCE Southern Ocean meridional section SR3 between Tasmania and Antarctica, and around the boundary of a square-plan test volume south of the Antarctic Divergence, from July to September 1995. A total of 208 CTD vertical profile stations were taken, 64 of those to near bottom, and the remaining 144 to a depth of 500 m. Over 2300 Niskin bottle water samples were collected for the measurement of salinity, dissolved oxygen, nutrients, dissolved organic and inorganic carbon, iodate/iodide, primary productivity, and biological parameters, using both a 24 and 12 bottle rosette sampler. Near surface current data were collected using a ship mounted ADCP. Measurement and data processing techniques are summarised, and a summary of the data is presented in graphical and tabular form.

1.1 INTRODUCTION

Marine science cruise AU9501, the fourth oceanographic cruise of the Cooperative Research Centre for the Antarctic and Southern Ocean Environment (Antarctic CRC), was conducted aboard the Australian Antarctic Division vessel RSV Aurora Australis from July to September 1995. The first major constituent of the cruise was the collection of oceanographic data relevant to the Australian Southern Ocean WOCE Hydrographic Program, along WOCE section SR3 (Figure 1.1a). The primary scientific objectives of this program are summarised in Rosenberg et al. (1995a). This was the sixth occupation of section SR3, and the first during a southern winter. Previous occupations of SR3 by the Aurora Australis were in the spring of 1991 (Rintoul and Bullister, submitted), in the autumn of 1993 (Rosenberg et al., 1995a), and in the summers of 1993/94 and 1994/95 (Rosenberg et al., 1995b and 1996). The northern half of the SR3 section was occupied by the SCRIPPS ship R.V. Melville in the autumn of 1994 (principal investigators R.Watts, S. Rintoul, J. Richman, B. Petit, D. Luther, J. Filloux, J. Church, A. Chave).

The second major constituent of the cruise was the dual oceanographic and sea ice experiments FORMEX (Formation Experiment: water mass formation near the Antarctic Continental slope) and HIHO-HIHO (Harmonious Ice and Hydrographic Observations - Halide In, Heat Out: sea ice formation processes; Worby et al., 1996). The primary objectives of FORMEX are:

1. to obtain quantitative estimates of the rate of formation of Antarctic surface waters in the ice pack during winter;

2. to obtain quantitative estimates of the transfer of heat between the ocean and atmosphere and the role of advection of surface and circumpolar deep water on these transfers;

3. to investigate processes and mechanisms involved in the mixing of Polar Zone waters with “Complex Zone” waters near the Antarctic shelf.

FORMEX CTD measurements were collected to a depth of 500 m every 5 nautical miles around the perimeter of a closed 60x60 nautical mile area within the pack ice (Figure 1.1b). The closed volume was sampled clockwise 3 times over a 21 day period, with 48 CTD/ADCP profile stations sampled on each of the 3 completed circuits.

This report describes the collection of oceanographic data from the SR3 transect and FORMEX, and summarises the chemical analysis and data processing methods employed. All information required for use of the data set is presented in tabular and graphical form.

1.2 CRUISE ITINERARY

The cruise commenced with a north to south traverse of section SR3, with a typical station spacing of 30 nautical miles. Station spacing between 49.5°S and 52°S was decreased to less than 20 nautical miles (Table 1.2) to include CTD casts over current meter and inverted echo sounder moorings (Table 1.4), thereby increasing meridional resolution in the vicinity of the Subantarctic Front. The mooring array had been deployed in the autumn of 1995 by the R.V. Melville (principal investigators R.Watts, S. Rintoul, J. Richman, B. Petit, D. Luther, J. Filloux, J. Church, A. Chave). South of ~55°S, periods of very calm conditions were encountered, with winds close to zero and the ocean surface glassy. ADCP measurements from this period will be useful for an examination of ADCP data in the absence of noise created by rolling and pitching of the ship. CTD data from this period will allow closer examination of CTD data quality in the absence of pressure reversals caused by a heaving vessel. The section was interrupted at ~65.1°S, due to thick sea ice and rising northerly winds.

The first lap around the FORMEX area was commenced 3 days after the interruption of the SR3 transect, and took 4 days to complete. The ship then travelled south as far as ~65.5°S, with further progress prevented by sea ice conditions. The SR3 section was recommenced at the southernmost latitude, and 3 stations were completed from south to north (Table 1.2). Note that the southermost station was over the continental slope, in a water depth of 1761 m.

Back at the FORMEX site, 2 test casts were taken inside the FORMEX area, both to trial a protective cover against cold air for the CTD sensors, and to investigate sensor performance on CTD serial 1193. FORMEX lap 2 then commenced, 6 days after the completion of lap 1, and taking 4.5 days to complete. Lap 3 commenced 1.5 days after the completion of lap 2, and took 3.5 days to complete. The time before and after each FORMEX lap was dedicated to sea ice experiments.

The ship then returned to the SR3 section, and CTD measurements at stations 44, 43 and 42 were repeated, owing to conductivity sensor malfunction during the earlier occupation. Before returning to Hobart, a further 4 stations were completed over inverted echo sounder moorings along the SR3 transect in the vicinity of the Subantarctic Front (Table 1.4). No measurements could be taken at the remaining 3 inverted echo sounder locations (mooring numbers I3, I5 and I7) due to rough weather conditions encountered on the northward leg.

Table 1.1: Summary of cruise itinerary.

Expedition Designation
Cruise AU9501 (cruise acronym ABSTAIN), encompassing WOCE section SR3, and FORMEX

Chief Scientists
Nathan Bindoff, Antarctic CRC
Ian Allison, Antarctic Division

Ship
RSV Aurora Australis

Ports of Call
-

Cruise Dates
July 17 to September 2 1995

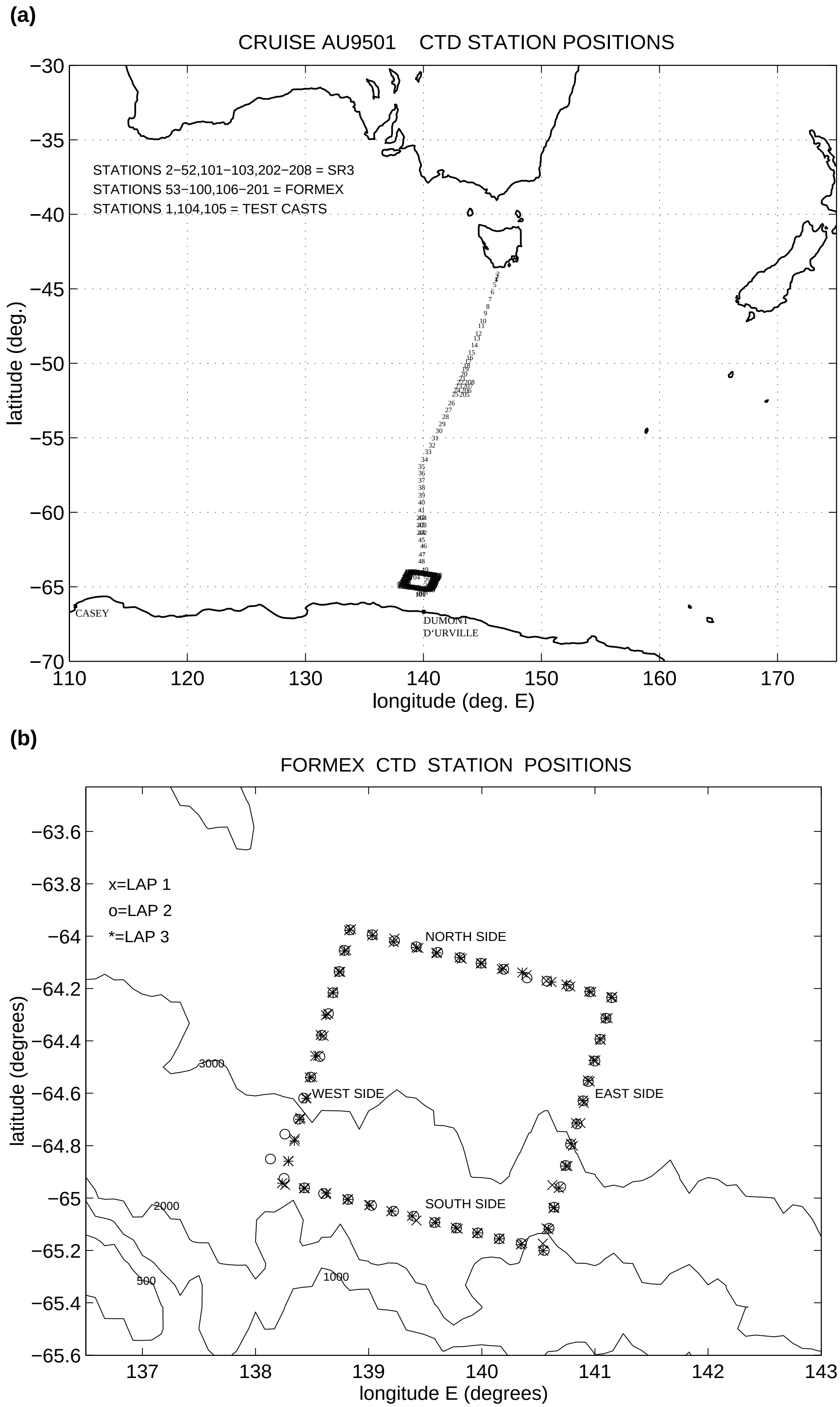


Figure 1.1a and b: **CTD station positions for RSV Aurora Australis cruise AU9501 along WOCE transect SR3, and around FORMEX area.**

1.3 CRUISE SUMMARY

1.3.1 CTD casts and water samples

In the course of the cruise, 61 CTD casts were completed along the SR3 section (Figure 1.1a), with most casts reaching to within 17 m of the sea floor (Table 1.2); 144 CTD casts to a depth of 500 m were completed on the 3 FORMEX laps; and 3 additional full depth test casts were completed at various locations. Over 2300 Niskin bottle water samples were collected for the measurement of salinity, dissolved oxygen, nutrients (orthophosphate, nitrate plus nitrite, and reactive silicate), dissolved organic and inorganic carbon, iodate/iodide, primary productivity, and biological parameters, using a 24 bottle rosette sampler for the SR3 section, and a 12 bottle system (with 6 bottles mounted) for FORMEX. Table 1.3 provides a summary of samples drawn at each station. Principal investigators for the various water sampling programmes are listed in Table 1.5a. For all stations, the different samples were drawn in a fixed sequence (see Rosenberg et al., 1996, for more details, including descriptions of methods for drawing samples).

1.3.2 Principal investigators

The principal investigators for the CTD and water sample measurements are listed in Table 1.5a. Cruise participants are listed in Table 1.5b.

<u>Table 1.2 (following 6 pages):</u> Summary of station information for RSV Aurora Australis cruise AU9501. The information shown includes time, date, position and ocean depth for the start of the cast, at the bottom of the cast, and for the end of the cast. The maximum pressure reached for each cast, and the altimeter reading at the bottom of each SR3 cast (i.e. elevation above the sea bed) are also included. Missing ocean depth values are due to noise from the ship's bow thrusters interfering with the echo sounder. For casts which do not reach to within 100 m of the bed (i.e. the altimeter range), or for which the altimeter was not functioning, there is no altimeter value. For station names, TEST is a test cast, and Fx.y is cast number y on FORMEX lap x (Figure 1.1b). Note that all times are UTC (i.e. GMT). CTD unit 7 (serial no. 1103) was used for stations 1 to 29, 45 to 103, and 106 to 208; CTD unit 5 (serial no. 1193) was used for stations 30 to 44, and 104 to 105.

station	START					maxP	BOTTOM					END			
number	time	date	latitude	longitude	depth(m)	(dbar)	time	latitude	longitude	depth(m)	altimeter	time	latitude	longitude	depth(m)
1 TEST	2227	17-JUL-95	44:22.85S	146:10.75E	2387	2306	2345	44:22.66S	146:11.34E	2392	58.4	0046	44:22.50S	146:11.50E	2393
2 SR3	0315	18-JUL-95	43:59.86S	146:19.20E	240	174	0330	43:59.88S	146:19.62E	-	14.0	0358	43:59.97S	146:20.32E	210
3 SR3	0538	18-JUL-95	44:07.38S	146:13.72E	1076	1106	0612	44:07.59S	146:14.85E	-	16.0	0658	44:07.59S	146:15.67E	-
4 SR3	1000	18-JUL-95	44:22.72S	146:10.59E	2407	2348	1103	44:22.65S	146:10.77E	-	15.6	1224	44:22.62S	146:10.90E	-
5 SR3	1610	18-JUL-95	44:43.18S	146:02.80E	3225	3230	1736	44:43.24S	146:03.31E	3225	17.6	1916	44:43.30S	146:03.67E	3123
6 SR3	0020	19-JUL-95	45:12.82S	145:51.22E	2866	2890	0155	45:12.72S	145:51.11E	-	18.0	0317	45:12.66S	145:52.36E	2764
7 SR3	1729	19-JUL-95	45:41.88S	145:39.45E	2017	2056	1838	45:41.88S	145:38.57E	2068	17.6	2005	45:41.66S	145:37.75E	2068
8 SR3	0027	20-JUL-95	46:10.36S	145:27.57E	2744	2748	0148	46:10.18S	145:27.58E	2740	18.1	0311	46:09.89S	145:27.63E	2764
9 SR3	0710	20-JUL-95	46:39.14S	145:15.03E	3348	3392	0835	46:38.93S	145:14.68E	-	16.8	1019	46:38.40S	145:14.63E	3368
10 SR3	1413	20-JUL-95	47:08.72S	145:03.10E	3593	3910	1545	47:08.28S	145:04.02E	-	15.1	1721	47:07.67S	145:04.28E	-
11 SR3	2001	20-JUL-95	47:28.20S	144:54.33E	4300	4344	2145	47:27.01S	144:55.48E	-	17.9	2336	47:26.85S	144:56.04E	4068
12 SR3	0318	21-JUL-95	47:59.90S	144:40.57E	4064	4144	0458	47:59.08S	144:40.79E	-	5.0	0633	47:58.53S	144:40.99E	-
13 SR3	0852	21-JUL-95	48:19.03S	144:31.56E	4003	4170	1040	48:18.35S	144:31.13E	-	15.0	1242	48:18.12S	144:31.58E	3936
14 SR3	1525	21-JUL-95	48:46.60S	144:18.95E	4177	4134	1706	48:45.73S	144:19.15E	-	16.5	1850	48:44.91S	144:19.14E	4045
15 SR3	2152	21-JUL-95	49:16.19S	144:05.63E	4218	4254	2341	49:15.28S	144:05.86E	4350	11.1	0133	49:14.49S	144:06.13E	-
16 SR3	0338	22-JUL-95	49:36.61S	143:56.13E	3686	3836	0518	49:35.98S	143:57.07E	-	-	0659	49:35.37S	143:57.97E	-
17 SR3	0849	22-JUL-95	49:53.24S	143:48.21E	3788	3864	1037	49:52.30S	143:49.92E	-	16.0	1215	49:52.06S	143:50.73E	-
18 SR3	1414	22-JUL-95	50:09.62S	143:40.72E	3711	3818	1555	50:09.45S	143:41.91E	-	17.3	1724	50:09.34S	143:42.88E	3813
19 SR3	1908	22-JUL-95	50:23.92S	143:33.66E	3583	3656	2056	50:24.03S	143:35.08E	-	16.7	2241	50:23.60S	143:36.13E	3573
20 SR3	0031	23-JUL-95	50:42.52S	143:26.96E	3655	3556	0157	50:42.42S	143:27.26E	-	19.9	0321	50:42.55S	143:27.22E	-
21 SR3	0503	23-JUL-95	51:00.00S	143:17.77E	3808	3880	0634	51:00.18S	143:17.62E	-	19.8	0811	51:00.12S	143:17.39E	-
22 SR3	0952	23-JUL-95	51:15.68S	143:07.69E	3706	3876	1114	51:15.54S	143:08.06E	-	15.0	1302	51:14.88S	143:08.68E	-
23 SR3	1451	23-JUL-95	51:32.20S	142:59.21E	3778	3788	1624	51:32.31S	143:00.10E	3778	17.0	1810	51:32.00S	143:00.77E	3778
24 SR3	2004	23-JUL-95	51:48.51S	142:50.80E	3757	3674	2127	51:48.64S	142:52.80E	3686	17.4	2307	51:48.61S	142:53.60E	3722
25 SR3	0055	24-JUL-95	52:04.88S	142:42.01E	3512	3514	0243	52:04.80S	142:44.15E	-	19.5	0421	52:04.65S	142:45.42E	-
26 SR3	0735	24-JUL-95	52:39.55S	142:22.85E	3348	3470	0903	52:39.82S	142:23.97E	-	12.0	1025	52:40.05S	142:24.57E	-
27 SR3	1301	24-JUL-95	53:07.40S	142:08.25E	3133	3134	1432	53:07.75S	142:08.16E	3133	15.0	1601	53:07.71S	142:07.92E	3113
28 SR3	1936	24-JUL-95	53:34.80S	141:51.81E	2508	2508	2053	53:34.84S	141:52.23E	2508	13.0	2215	53:35.28S	141:52.65E	2661
29 SR3	0107	25-JUL-95	54:03.97S	141:35.63E	2662	2656	0220	54:03.69S	141:35.57E	-	15.6	0347	54:03.40S	141:35.70E	-
30 SR3	0620	25-JUL-95	54:31.72S	141:19.42E	2815	2844	0730	54:31.48S	141:19.86E	-	12.0	0843	54:31.12S	141:19.75E	-
31 SR3	1303	25-JUL-95	55:01.23S	141:00.79E	3348	3300	1430	55:01.04S	141:00.34E	3328	15.2	1613	55:01.25S	141:00.74E	3328
32 SR3	2034	25-JUL-95	55:29.86S	140:43.48E	3993	4140	2223	55:29.22S	140:43.15E	-	15.0	0010	55:28.78S	140:43.08E	-
33 SR3	0258	26-JUL-95	55:55.54S	140:23.88E	3583	3638	0440	55:55.57S	140:24.37E	-	15.5	0619	55:55.26S	140:25.04E	-
34 SR3	0918	26-JUL-95	56:26.28S	140:06.09E	3890	4162	1115	56:26.41S	140:06.07E	-	15.0	1258	56:26.73S	140:05.98E	-
35 SR3	1822	26-JUL-95	56:55.51S	139:50.88E	4075	4180	2031	56:55.45S	139:51.85E	-	14.3	2208	56:55.60S	139:52.18E	4157
36 SR3	0024	27-JUL-95	57:22.25S	139:51.04E	4075	4058	0212	57:22.17S	139:49.72E	-	11.4	0404	57:22.58S	139:48.79E	-

station	START					maxP	BOTTOM					END			
number	time	date	latitude	longitude	depth(m)	(dbar)	time	latitude	longitude	depth(m)	altimeter	time	latitude	longitude	depth(m)
37 SR3	0650	27-JUL-95	57:51.42S	139:51.42E	4095	4182	0831	57:51.31S	139:51.89E	-	15.0	1000	57:51.39S	139:52.72E	-
38 SR3	1524	27-JUL-95	58:20.62S	139:51.08E	3993	4044	1703	58:20.59S	139:51.57E	-	12.8	1846	58:20.96S	139:51.62E	3993
39 SR3	2236	27-JUL-95	58:51.45S	139:50.49E	3942	4046	0031	58:51.76S	139:50.71E	-	15.9	0215	58:51.72S	139:50.53E	-
40 SR3	0539	28-JUL-95	59:21.04S	139:50.89E	4218	4220	0720	59:21.33S	139:51.23E	-	15.8	0850	59:21.64S	139:51.76E	-
41 SR3	1428	28-JUL-95	59:51.30S	139:50.94E	4587	4540	1632	59:50.24S	139:51.31E	-	13.8	1829	59:49.57S	139:52.13E	4587
42 SR3	2320	28-JUL-95	60:21.27S	139:50.24E	4443	4506	0128	60:21.54S	139:49.95E	4443	9.9	0328	60:21.87S	139:49.61E	-
43 SR3	0611	29-JUL-95	60:51.27S	139:50.17E	4402	4466	0747	60:51.80S	139:49.52E	-	11.3	0928	60:52.30S	139:49.72E	-
44 SR3	1431	29-JUL-95	61:21.06S	139:51.01E	4351	4410	1649	61:22.09S	139:50.41E	4351	13.6	1847	61:22.39S	139:50.64E	4351
45 SR3	2326	29-JUL-95	61:50.05S	139:51.60E	4300	3348	0125	61:49.87S	139:54.95E	4300	-	0255	61:50.58S	139:57.90E	-
46 SR3	0622	30-JUL-95	62:15.68S	140:00.46E	4054	4082	0758	62:15.84S	140:01.21E	4054	16.4	0936	62:16.32S	140:02.14E	-
47 SR3	1424	30-JUL-95	62:49.70S	139:53.68E	3235	3262	1601	62:50.56S	139:54.91E	3275	13.5	1728	62:51.63S	139:55.29E	3255
48 SR3	2112	30-JUL-95	63:17.16S	139:50.37E	3819	3830	2241	63:18.37S	139:49.53E	3819	25.5	0036	63:20.65S	139:47.19E	3819
49 SR3	0450	31-JUL-95	63:49.89S	140:07.79E	3716	3746	0625	63:49.72S	140:11.10E	3716	16.0	0751	63:49.80S	140:14.37E	3716
50 SR3	1733	31-JUL-95	64:26.58S	140:20.49E	3481	3476	1908	64:26.59S	140:20.04E	3471	13.7	2027	64:26.46S	140:19.64E	3471
51 SR3	0318	1-AUG-95	64:46.74S	140:20.35E	3327	3274	0441	64:47.33S	140:18.40E	-	16.2	0614	64:48.17S	140:16.84E	-
52 SR3	1046	1-AUG-95	65:07.28S	140:19.45E	2583	2582	1201	65:07.55S	140:18.91E	-	14.9	1321	65:07.96S	140:18.24E	2563
53 F1.1	1706	4-AUG-95	64:57.01S	140:37.39E	2701	496	1726	64:56.98S	140:36.97E	2713	-	1739	64:56.96S	140:36.63E	2723
54 F1.2	1939	4-AUG-95	65:02.29S	140:37.98E	2598	496	1952	65:02.26S	140:37.62E	2608	-	2011	65:02.22S	140:37.09E	2518
55 F1.3	2213	4-AUG-95	65:06.95S	140:34.41E	2471	500	2231	65:06.91S	140:34.00E	2471	-	2248	65:06.90S	140:33.66E	2501
56 F1.4	0021	5-AUG-95	65:10.43S	140:32.34E	2217	496	0042	65:10.40S	140:31.93E	2232	-	0056	65:10.41S	140:31.67E	2252
57 F1.5	0250	5-AUG-95	65:10.33S	140:21.43E	2383	496	0306	65:10.33S	140:21.26E	-	-	0318	65:10.33S	140:20.98E	2406
58 F1.6	0454	5-AUG-95	65:09.28S	140:09.12E	2569	496	0510	65:09.30S	140:08.93E	-	-	0523	65:09.29S	140:08.75E	2569
59 F1.7	0638	5-AUG-95	65:08.05S	139:57.79E	2746	498	0651	65:08.03S	139:57.66E	-	-	0707	65:07.99S	139:57.50E	2774
60 F1.8	0757	5-AUG-95	65:07.04S	139:47.20E	2538	496	0814	65:06.98S	139:47.10E	2544	-	0830	65:06.95S	139:46.83E	2508
61 F1.9	0953	5-AUG-95	65:05.44S	139:34.91E	2537	496	1008	65:05.45S	139:34.86E	-	-	1018	65:05.44S	139:34.83E	2539
62 F1.10	1159	5-AUG-95	65:05.16S	139:25.27E	2688	498	1212	65:05.15S	139:25.16E	2703	-	1227	65:05.14S	139:25.13E	2698
63 F1.11	1508	5-AUG-95	65:03.01S	139:12.11E	2911	496	1523	65:03.02S	139:12.06E	2911	-	1534	65:03.00S	139:12.03E	2911
64 F1.12	1733	5-AUG-95	65:01.59S	139:00.64E	2595	496	1748	65:01.59S	139:00.56E	2595	-	1802	65:01.58S	139:00.52E	2589
65 F1.13	1934	5-AUG-95	65:00.31S	138:48.70E	2314	498	1948	65:00.30S	138:48.65E	2314	-	2002	65:00.27S	138:48.67E	2314
66 F1.14	2255	5-AUG-95	64:59.08S	138:37.25E	2524	496	2311	64:59.10S	138:37.16E	-	-	2331	64:59.09S	138:37.09E	2524
67 F1.15	0348	6-AUG-95	64:57.75S	138:26.05E	2205	498	0402	64:57.75S	138:25.99E	2201	-	0423	64:57.77S	138:25.92E	2201
68 F1.16	0620	6-AUG-95	64:57.01S	138:15.69E	2498	498	0632	64:57.03S	138:15.69E	2500	-	0646	64:57.06S	138:15.60E	2500
69 F1.17	1058	6-AUG-95	64:51.54S	138:17.32E	2630	498	1110	64:51.54S	138:17.57E	2683	-	1128	64:51.53S	138:17.68E	2611
70 F1.18	1500	6-AUG-95	64:46.44S	138:20.80E	2858	498	1512	64:46.41S	138:21.00E	2838	-	1528	64:46.30S	138:21.08E	-
71 F1.19	1634	6-AUG-95	64:41.61S	138:23.81E	2858	496	1651	64:41.52S	138:23.88E	2867	-	1708	64:41.41S	138:24.18E	2867
72 F1.20	1805	6-AUG-95	64:37.03S	138:26.85E	2853	496	1820	64:36.98S	138:26.97E	2843	-	1838	64:36.89S	138:27.03E	2843

station	START					maxP	BOTTOM					END			
number	time	date	latitude	longitude	depth(m)	(dbar)	time	latitude	longitude	depth(m)	altimeter	time	latitude	longitude	depth(m)
73 F1.21	1925	6-AUG-95	64:32.33S	138:30.00E	3086	498	1940	64:32.25S	138:30.00E	3096	-	1959	64:32.22S	138:30.05E	3096
74 F1.22	2107	6-AUG-95	64:27.42S	138:33.24E	3188	498	2123	64:27.42S	138:33.27E	3183	-	2139	64:27.35S	138:33.25E	3183
75 F1.23	2235	6-AUG-95	64:22.86S	138:36.08E	3287	496	2252	64:22.85S	138:36.13E	3287	-	2306	64:22.83S	138:36.24E	3287
76 F1.24	0002	7-AUG-95	64:17.79S	138:38.57E	3392	496	0015	64:17.82S	138:38.79E	3402	-	0028	64:17.82S	138:38.98E	3402
77 F1.25	0121	7-AUG-95	64:12.81S	138:40.75E	3480	500	0132	64:12.83S	138:40.83E	3480	-	0151	64:12.79S	138:41.23E	3480
78 F1.26	0322	7-AUG-95	64:08.17S	138:44.91E	3564	498	0337	64:08.13S	138:45.25E	3564	-	0358	64:08.04S	138:45.64E	3571
79 F1.27	0446	7-AUG-95	64:03.24S	138:48.02E	3677	498	0458	64:03.20S	138:48.31E	-	-	0516	64:03.21S	138:48.61E	-
80 F1.28	0553	7-AUG-95	63:58.39S	138:50.63E	3706	500	0610	63:58.50S	138:51.34E	-	-	0627	63:58.34S	138:52.12E	3737
81 F1.29	0715	7-AUG-95	63:59.61S	139:02.32E	3699	498	0727	63:59.59S	139:02.66E	3700	-	0746	63:59.52S	139:03.19E	3700
82 F1.30	0847	7-AUG-95	64:00.56S	139:13.69E	3618	496	0900	64:00.48S	139:13.91E	3620	-	0915	64:00.54S	139:14.46E	3621
83 F1.31	1027	7-AUG-95	64:02.70S	139:26.35E	3629	498	1038	64:02.67S	139:26.59E	3629	-	1057	64:02.74S	139:26.97E	-
84 F1.32	1147	7-AUG-95	64:03.85S	139:36.33E	3614	498	1158	64:03.76S	139:36.71E	-	-	1209	64:03.67S	139:37.09E	3604
85 F1.33	1306	7-AUG-95	64:05.16S	139:49.29E	3631	498	1319	64:05.06S	139:49.57E	-	-	1335	64:04.90S	139:49.94E	3635
86 F1.34	1431	7-AUG-95	64:06.24S	139:59.92E	3655	498	1445	64:06.07S	140:00.27E	-	-	1503	64:05.97S	140:00.56E	-
87 F1.35	1539	7-AUG-95	64:07.34S	140:11.71E	3610	500	1552	64:07.24S	140:12.03E	-	-	1611	64:07.13S	140:12.49E	-
88 F1.36	1649	7-AUG-95	64:08.93S	140:23.59E	3612	496	1659	64:08.89S	140:23.77E	-	-	1712	64:08.76S	140:24.00E	3612
89 F1.37	1740	7-AUG-95	64:10.22S	140:34.32E	3610	496	1753	64:10.21S	140:34.24E	3610	-	1808	64:10.06S	140:34.20E	3610
90 F1.38	1900	7-AUG-95	64:11.54S	140:46.92E	3594	496	1915	64:11.59S	140:46.86E	-	-	1929	64:11.67S	140:46.75E	3589
91 F1.39	2009	7-AUG-95	64:12.76S	140:58.08E	3597	498	2022	64:12.82S	140:58.11E	3597	-	2042	64:12.93S	140:58.41E	3592
92 F1.40	2117	7-AUG-95	64:13.92S	141:09.21E	3623	498	2130	64:13.87S	141:09.42E	3518	-	2147	64:13.93S	141:09.47E	3518
93 F1.41	2312	7-AUG-95	64:18.78S	141:06.73E	3550	498	2324	64:18.78S	141:06.79E	3550	-	2338	64:18.70S	141:06.75E	3550
94 F1.42	0120	8-AUG-95	64:23.78S	141:03.08E	3467	498	0133	64:23.74S	141:03.34E	3472	-	0145	64:23.71S	141:03.51E	3472
95 F1.43	0236	8-AUG-95	64:28.47S	141:00.15E	3365	496	0246	64:28.43S	141:00.26E	-	-	0304	64:28.37S	141:00.56E	3369
96 F1.44	0536	8-AUG-95	64:33.28S	140:57.15E	3264	508	0548	64:33.28S	140:57.25E	-	-	0606	64:33.25S	140:57.55E	3268
97 F1.45	0827	8-AUG-95	64:38.23S	140:54.08E	3100	498	0839	64:38.20S	140:54.09E	-	-	0902	64:38.18S	140:54.19E	3106
98 F1.46	0957	8-AUG-95	64:42.84S	140:52.30E	2881	496	1008	64:42.83S	140:52.24E	2881	-	1021	64:42.84S	140:52.17E	2880
99 F1.47	1153	8-AUG-95	64:48.04S	140:48.28E	2699	498	1203	64:48.00S	140:48.15E	2696	-	1220	64:47.97S	140:47.96E	2700
100 F1.48	1308	8-AUG-95	64:52.68S	140:45.46E	2602	498	1317	64:52.59S	140:45.33E	2611	-	1332	64:52.57S	140:45.07E	2620
101 SR3	1709	9-AUG-95	65:30.64S	139:44.93E	1761	1736	1757	65:30.63S	139:45.07E	1761	10.7	1850	65:30.64S	139:45.07E	1759
102 SR3	2015	9-AUG-95	65:27.61S	139:47.82E	2074	2072	2114	65:27.66S	139:47.67E	2069	11.6	2213	65:27.71S	139:47.62E	2069
103 SR3	2318	9-AUG-95	65:21.79S	139:56.58E	2551	2538	0010	65:21.80S	139:56.44E	2561	12.8	0104	65:21.80S	139:56.31E	2561
104 TEST	1041	12-AUG-95	64:21.32S	139:16.75E	3583	3582	1154	64:21.39S	139:15.34E	-	16.7	1259	64:21.58S	139:13.36E	-
105 TEST	1726	12-AUG-95	64:40.88S	138:31.57E	2701	2706	1848	64:40.68S	138:30.29E	2721	11.1	2001	64:40.48S	138:29.10E	2721
106 F2.19	1734	14-AUG-95	64:41.95S	138:22.80E	2767	500	1752	64:41.91S	138:22.49E	2780	-	1811	64:41.88S	138:22.18E	2780
107 F2.20	1945	14-AUG-95	64:37.11S	138:25.50E	2865	496	2005	64:37.08S	138:25.29E	-	-	2021	64:37.03S	138:25.01E	2870
108 F2.21	2217	14-AUG-95	64:32.28S	138:29.28E	3043	498	2230	64:32.23S	138:29.10E	3037	-	2244	64:32.20S	138:28.95E	3036

station	START					maxP	BOTTOM					END			
number	time	date	latitude	longitude	depth(m)	(dbar)	time	latitude	longitude	depth(m)	altimeter	time	latitude	longitude	depth(m)
109 F2.22	2346	14-AUG-95	64:27.59S	138:34.14E	3225	498	2357	64:27.60S	138:34.00E	3225	-	0019	64:27.59S	138:33.54E	3225
110 F2.23	0320	15-AUG-95	64:22.69S	138:35.08E	3276	498	0337	64:22.67S	138:34.84E	3297	-	0402	64:22.61S	138:34.21E	3328
111 F2.24	0458	15-AUG-95	64:17.74S	138:38.63E	3419	498	0525	64:17.62S	138:37.98E	3409	-	0541	64:17.54S	138:37.54E	3429
112 F2.25	0705	15-AUG-95	64:12.96S	138:41.11E	3471	498	0717	64:12.91S	138:40.82E	-	-	0734	64:12.87S	138:40.31E	-
113 F2.26	0830	15-AUG-95	64:08.07S	138:44.31E	3583	498	0843	64:08.04S	138:44.04E	-	-	0903	64:07.96S	138:43.53E	3573
114 F2.27	1016	15-AUG-95	64:03.25S	138:47.02E	3686	498	1027	64:03.22S	138:46.87E	-	-	1041	64:03.21S	138:46.49E	3676
115 F2.28	1151	15-AUG-95	63:58.55S	138:50.14E	3716	498	1201	63:58.54S	138:49.92E	-	-	1219	63:58.54S	138:49.50E	3706
116 F2.29	1328	15-AUG-95	63:59.70S	139:01.86E	3706	498	1338	63:59.70S	139:01.62E	3696	-	1352	63:59.68S	139:01.36E	3706
117 F2.30	1458	15-AUG-95	64:01.04S	139:13.75E	3634	498	1510	64:01.07S	139:13.54E	3634	-	1528	64:01.04S	139:13.17E	3634
118 F2.31	1626	15-AUG-95	64:02.41S	139:25.20E	3604	498	1638	64:02.43S	139:24.99E	3604	-	1652	64:02.44S	139:24.70E	3604
119 F2.32	1739	15-AUG-95	64:03.69S	139:36.59E	3609	498	1754	64:03.60S	139:36.21E	3635	-	1809	64:03.57S	139:35.86E	3635
120 F2.33	1924	15-AUG-95	64:04.91S	139:48.41E	3634	498	1939	64:04.86S	139:48.09E	3639	-	2002	64:04.77S	139:47.47E	3634
121 F2.34	2106	15-AUG-95	64:06.19S	139:59.58E	3634	498	2122	64:06.10S	139:59.20E	3654	-	2136	64:06.01S	139:58.77E	3654
122 F2.35	2236	15-AUG-95	64:07.57S	140:11.61E	3645	498	2249	64:07.50S	140:11.22E	3634	-	2303	64:07.47S	140:10.84E	3634
123 F2.36	0006	16-AUG-95	64:09.56S	140:23.98E	3614	498	0020	64:09.49S	140:23.39E	3614	-	0033	64:09.42S	140:23.01E	3634
124 F2.37	0127	16-AUG-95	64:10.30S	140:34.55E	3593	504	0140	64:10.26S	140:34.16E	3634	-	0156	64:10.29S	140:33.84E	3634
125 F2.38	0257	16-AUG-95	64:11.44S	140:46.03E	3645	500	0310	64:11.47S	140:45.61E	-	-	0328	64:11.52S	140:45.10E	3604
126 F2.39	0436	16-AUG-95	64:12.75S	140:57.40E	3604	498	0450	64:12.73S	140:57.12E	3604	-	0511	64:12.81S	140:56.59E	3604
127 F2.40	0621	16-AUG-95	64:14.12S	141:08.89E	3604	498	0634	64:14.13S	141:08.59E	3604	-	0650	64:14.19S	141:08.18E	3604
128 F2.41	0757	16-AUG-95	64:18.81S	141:05.85E	3553	498	0809	64:18.85S	141:05.73E	-	-	0825	64:18.90S	141:05.50E	3553
129 F2.42	0929	16-AUG-95	64:23.62S	141:02.69E	3450	498	0941	64:23.64S	141:02.61E	3450	-	1000	64:23.61S	141:02.33E	3440
130 F2.43	1108	16-AUG-95	64:28.61S	141:00.02E	3389	498	1117	64:28.58S	141:00.00E	3368	-	1129	64:28.56S	140:59.83E	3358
131 F2.44	1341	16-AUG-95	64:33.27S	140:56.42E	3276	498	1352	64:33.27S	140:56.30E	-	-	1405	64:33.23S	140:56.08E	3256
132 F2.45	1606	16-AUG-95	64:37.72S	140:53.68E	3092	498	1617	64:37.70S	140:53.42E	3092	-	1631	64:37.63S	140:53.06E	3092
133 F2.46	1750	16-AUG-95	64:43.02S	140:50.58E	2856	498	1806	64:42.99S	140:50.31E	2851	-	1825	64:42.94S	140:49.86E	2851
134 F2.47	2119	16-AUG-95	64:47.72S	140:47.04E	2725	498	2133	64:47.69S	140:46.89E	2719	-	2145	64:47.65S	140:46.58E	2719
135 F2.48	2342	16-AUG-95	64:52.54S	140:44.37E	2600	498	2357	64:52.47S	140:44.16E	2616	-	0012	64:52.45S	140:43.98E	2642
136 F2.1	0337	17-AUG-95	64:57.43S	140:41.82E	2518	498	0347	64:57.28S	140:41.07E	2535	-	0413	64:57.20S	140:40.50E	2550
137 F2.2	0845	17-AUG-95	65:02.08S	140:38.31E	2559	500	0859	65:02.08S	140:38.28E	2580	-	0913	65:02.06S	140:38.18E	2580
138 F2.3	1032	17-AUG-95	65:06.96S	140:35.71E	2406	498	1042	65:06.94S	140:35.59E	2385	-	1054	65:06.87S	140:35.56E	2365
139 F2.4	1209	17-AUG-95	65:12.00S	140:33.18E	2252	500	1219	65:11.94S	140:33.16E	2242	-	1237	65:11.90S	140:33.15E	2232
140 F2.5	1350	17-AUG-95	65:10.41S	140:20.97E	2395	498	1400	65:10.41S	140:20.96E	2395	-	1412	65:10.35S	140:20.92E	2395
141 F2.6	1552	17-AUG-95	65:09.35S	140:09.27E	2559	498	1607	65:09.34S	140:09.33E	2567	-	1626	65:09.27S	140:09.32E	2569
142 F2.7	1754	17-AUG-95	65:08.01S	139:57.91E	2744	498	1808	65:07.98S	139:57.96E	2739	-	1823	65:07.97S	139:58.02E	2739
143 F2.8	2020	17-AUG-95	65:06.90S	139:46.59E	2514	498	2033	65:06.88S	139:46.73E	2529	-	2049	65:06.91S	139:46.81E	2534
144 F2.9	2220	17-AUG-95	65:05.61S	139:34.99E	2511	498	2234	65:05.61S	139:35.08E	2526	-	2249	65:05.56S	139:35.34E	2531

station	START					maxP	BOTTOM					END			
number	time	date	latitude	longitude	depth(m)	(dbar)	time	latitude	longitude	depth(m)	altimeter	time	latitude	longitude	depth(m)
145 F2.10	0505	18-AUG-95	65:04.17S	139:24.01E	3010	498	0517	65:04.14S	139:24.13E	-	-	0538	65:04.10S	139:24.33E	3030
146 F2.11	0802	18-AUG-95	65:03.01S	139:13.23E	2907	498	0814	65:02.98S	139:13.32E	2917	-	0832	65:02.95S	139:13.38E	2917
147 F2.12	1033	18-AUG-95	65:01.70S	139:01.50E	2617	498	1045	65:01.69S	139:01.57E	2627	-	1058	65:01.65S	139:01.64E	2627
148 F2.13	1432	18-AUG-95	65:00.33S	138:49.09E	2319	500	1446	65:00.31S	138:49.12E	2315	-	1508	65:00.27S	138:49.23E	2313
149 F2.14	1959	18-AUG-95	64:58.96S	138:36.09E	2445	498	2012	64:58.94S	138:36.14E	2440	-	2024	64:58.90S	138:36.12E	2440
150 F2.15	2127	18-AUG-95	64:57.67S	138:25.90E	2215	496	2141	64:57.63S	138:25.88E	2230	-	2154	64:57.63S	138:25.91E	2230
151 F2.16	2254	18-AUG-95	64:55.47S	138:15.13E	2588	498	2307	64:55.52S	138:15.13E	2593	-	2318	64:55.40S	138:15.18E	2598
152 F2.17	0054	19-AUG-95	64:51.06S	138:07.90E	3034	498	0106	64:51.03S	138:07.93E	3034	-	0124	64:50.99S	138:07.99E	3028
153 F2.18	0429	19-AUG-95	64:45.37S	138:15.57E	3163	498	0439	64:45.37S	138:15.67E	-	-	0453	64:45.33S	138:15.70E	3173
154 F3.18	1501	20-AUG-95	64:46.93S	138:20.56E	2877	500	1512	64:46.96S	138:20.45E	2908	-	1526	64:46.99S	138:20.19E	2918
155 F3.19	1652	20-AUG-95	64:41.94S	138:23.50E	2810	498	1705	64:41.98S	138:23.25E	2805	-	1723	64:42.02S	138:22.93E	2805
156 F3.20	1850	20-AUG-95	64:37.18S	138:26.85E	2851	498	1907	64:37.21S	138:26.52E	2856	-	1923	64:37.24S	138:26.20E	2851
157 F3.21	2024	20-AUG-95	64:32.38S	138:28.80E	3023	498	2039	64:32.41S	138:28.43E	3028	-	2055	64:32.50S	138:28.00E	3033
158 F3.22	2201	20-AUG-95	64:27.46S	138:31.82E	3174	498	2215	64:27.48S	138:31.52E	3174	-	2229	64:27.52S	138:31.06E	3174
159 F3.23	2352	20-AUG-95	64:22.65S	138:34.54E	3297	498	0006	64:22.69S	138:34.00E	3317	-	0025	64:22.74S	138:33.16E	3327
160 F3.24	0136	21-AUG-95	64:18.09S	138:37.29E	3389	498	0148	64:18.15S	138:36.75E	3389	-	0201	64:18.16S	138:36.14E	3389
161 F3.25	0314	21-AUG-95	64:12.97S	138:41.14E	3460	498	0327	64:12.96S	138:40.58E	3450	-	0343	64:13.04S	138:39.84E	3450
162 F3.26	0444	21-AUG-95	64:08.16S	138:44.28E	3573	498	0455	64:08.18S	138:43.86E	3573	-	0514	64:08.22S	138:42.99E	3563
163 F3.27	0622	21-AUG-95	64:03.40S	138:47.13E	3686	498	0632	64:03.43S	138:46.71E	3676	-	0650	64:03.51S	138:46.03E	3676
164 F3.28	0755	21-AUG-95	63:58.65S	138:49.66E	3696	498	0808	63:58.72S	138:49.24E	3696	-	0823	63:58.78S	138:48.69E	3711
165 F3.29	0946	21-AUG-95	63:59.85S	139:01.84E	3696	498	1000	63:59.94S	139:01.39E	-	-	1019	64:00.03S	139:00.64E	3717
166 F3.30	1129	21-AUG-95	64:01.35S	139:13.29E	3604	498	1143	64:01.46S	139:12.67E	3604	-	1158	64:01.56S	139:12.21E	3604
167 F3.31	1250	21-AUG-95	64:02.61S	139:25.30E	3614	498	1306	64:02.68S	139:24.56E	3604	-	1318	64:02.74S	139:24.17E	3604
168 F3.32	1436	21-AUG-95	64:03.81S	139:35.83E	3634	502	1457	64:03.91S	139:35.43E	3634	-	1510	64:03.99S	139:35.27E	3634
169 F3.33	1625	21-AUG-95	64:04.89S	139:48.28E	3634	498	1637	64:04.90S	139:47.80E	3634	-	1656	64:04.89S	139:47.16E	3634
170 F3.34	1801	21-AUG-95	64:06.24S	139:59.51E	3645	498	1813	64:06.25S	139:59.04E	3645	-	1828	64:06.25S	139:58.43E	3645
171 F3.35	1938	21-AUG-95	64:07.55S	140:10.68E	3604	498	1953	64:07.50S	140:09.96E	3604	-	2007	64:07.42S	140:09.20E	3604
172 F3.36	2130	21-AUG-95	64:08.32S	140:21.48E	3634	500	2144	64:08.25S	140:21.21E	3634	-	2155	64:08.32S	140:20.45E	3604
173 F3.37	2316	21-AUG-95	64:10.53S	140:36.97E	3634	498	2331	64:10.32S	140:36.00E	3604	-	2350	64:10.10S	140:34.58E	3604
174 F3.38	0041	22-AUG-95	64:11.08S	140:44.86E	3604	498	0054	64:10.93S	140:44.11E	3604	-	0115	64:10.78S	140:42.87E	3604
175 F3.39	0305	22-AUG-95	64:12.69S	140:56.98E	3604	498	0316	64:12.61S	140:56.53E	3604	-	0331	64:12.54S	140:55.72E	3604
176 F3.40	0436	22-AUG-95	64:14.02S	141:08.70E	3604	498	0447	64:13.98S	141:08.26E	3604	-	0506	64:13.91S	141:07.60E	3604
177 F3.41	0552	22-AUG-95	64:18.81S	141:05.60E	3563	504	0603	64:18.74S	141:05.35E	3563	-	0622	64:18.64S	141:04.87E	3563
178 F3.42	0719	22-AUG-95	64:23.56S	141:02.71E	3471	496	0730	64:23.49S	141:02.50E	3440	-	0742	64:23.40S	141:02.27E	3405
179 F3.43	0849	22-AUG-95	64:28.42S	140:59.28E	3348	498	0905	64:28.32S	140:59.02E	3348	-	0920	64:28.19S	140:58.74E	3348
180 F3.44	1030	22-AUG-95	64:33.06S	140:56.27E	3286	498	1044	64:32.98S	140:55.99E	3276	-	1057	64:32.84S	140:55.83E	3276

station	START					maxP	BOTTOM					END			
number	time	date	latitude	longitude	depth(m)	(dbar)	time	latitude	longitude	depth(m)	altimeter	time	latitude	longitude	depth(m)
181 F3.45	1210	22-AUG-95	64:37.66S	140:53.70E	3102	498	1222	64:37.61S	140:53.56E	3102	-	1237	64:37.53S	140:53.31E	3092
182 F3.46	1348	22-AUG-95	64:42.79S	140:50.07E	2860	498	1359	64:42.75S	140:49.98E	2860	-	1416	64:42.66S	140:49.72E	2860
183 F3.47	1555	22-AUG-95	64:47.51S	140:47.36E	2741	498	1608	64:47.47S	140:47.24E	2741	-	1621	64:47.43S	140:47.11E	2741
184 F3.48	1728	22-AUG-95	64:52.67S	140:44.57E	2613	498	1740	64:52.62S	140:44.44E	2593	-	1753	64:52.58S	140:44.32E	2603
185 F3.1	1905	22-AUG-95	64:57.69S	140:40.87E	2540	498	1917	64:57.64S	140:40.77E	2545	-	1931	64:57.62S	140:40.68E	2545
186 F3.2	2053	22-AUG-95	65:02.19S	140:38.50E	2581	500	2106	65:02.18S	140:38.36E	2581	-	2122	65:02.14S	140:38.31E	2581
187 F3.3	2244	22-AUG-95	65:07.15S	140:35.33E	2448	498	2257	65:07.12S	140:35.29E	2453	-	2312	65:07.08S	140:35.24E	2458
188 F3.4	0050	23-AUG-95	65:12.06S	140:32.47E	2227	498	0104	65:12.03S	140:32.37E	2227	-	0118	65:11.98S	140:32.27E	2227
189 F3.5	0258	23-AUG-95	65:10.69S	140:20.81E	2387	500	0309	65:10.67S	140:20.67E	2387	-	0327	65:10.61S	140:20.58E	2387
190 F3.6	0434	23-AUG-95	65:09.34S	140:09.38E	2566	498	0444	65:09.32S	140:09.29E	2566	-	0457	65:09.30S	140:09.22E	2564
191 F3.7	0652	23-AUG-95	65:08.00S	139:57.58E	2764	498	0702	65:07.99S	139:57.57E	2764	-	0714	65:07.98S	139:57.51E	2764
192 F3.8	0825	23-AUG-95	65:06.84S	139:46.30E	2493	498	0837	65:06.81S	139:46.23E	2473	-	0855	65:06.81S	139:46.20E	2473
193 F3.9	1003	23-AUG-95	65:05.61S	139:35.49E	2520	532	1017	65:05.60S	139:35.47E	2510	-	1032	65:05.56S	139:35.41E	2510
194 F3.10	1155	23-AUG-95	65:04.12S	139:23.08E	3000	498	1212	65:04.09S	139:23.07E	3009	-	1226	65:04.07S	139:23.03E	3010
195 F3.11	1331	23-AUG-95	65:03.00S	139:12.16E	2915	498	1346	65:02.98S	139:12.27E	2915	-	1402	65:02.92S	139:12.18E	2915
196 F3.12	1512	23-AUG-95	65:01.65S	139:00.33E	2617	498	1526	65:01.62S	139:00.37E	2622	-	1538	65:01.59S	139:00.33E	2622
197 F3.13	1655	23-AUG-95	65:00.33S	138:49.08E	2317	498	1706	65:00.30S	138:49.08E	2312	-	1718	65:00.25S	138:49.05E	2312
198 F3.14	1902	23-AUG-95	64:58.87S	138:37.50E	2522	498	1916	64:58.86S	138:37.47E	2517	-	1930	64:58.86S	138:37.50E	2522
199 F3.15	2110	23-AUG-95	64:57.75S	138:25.71E	2211	498	2120	64:57.77S	138:25.69E	-	-	2137	64:57.71S	138:25.77E	-
200 F3.16	0022	24-AUG-95	64:56.60S	138:14.10E	2576	500	0035	64:56.58S	138:14.09E	2566	-	0050	64:56.55S	138:14.04E	2573
201 F3.17	0254	24-AUG-95	64:51.57S	138:17.44E	2626	500	0305	64:51.58S	138:17.37E	2633	-	0323	64:51.55S	138:17.37E	2640
202 SR3	1840	26-AUG-95	61:20.97S	139:52.00E	4402	4394	2046	61:19.93S	139:53.78E	4402	20.1	2230	61:19.68S	139:54.45E	4402
203 SR3	0253	27-AUG-95	60:51.05S	139:50.80E	4491	4462	0438	60:52.41S	139:49.81E	-	-	0616	60:53.09S	139:49.96E	-
204 SR3	0934	27-AUG-95	60:21.52S	139:50.65E	4505	4502	1112	60:21.24S	139:51.14E	-	16.1	1305	60:21.52S	139:51.40E	-
205 SR3	1532	29-AUG-95	52:05.57S	143:29.56E	3563	3584	1703	52:06.93S	143:30.40E	3543	15.1	1831	52:08.37S	143:31.36E	3533
206 SR3	2101	29-AUG-95	51:48.87S	143:38.08E	3450	3696	2240	51:48.99S	143:39.64E	-	23.1	0027	51:48.67S	143:40.63E	-
207 SR3	0257	30-AUG-95	51:32.13S	143:46.77E	3757	3796	0435	51:31.89S	143:47.71E	-	15.3	0554	51:31.35S	143:48.27E	-
208 SR3	1020	30-AUG-95	51:16.18S	143:54.75E	3757	3828	1206	51:16.51S	143:55.39E	-	25.0	1326	51:16.62S	143:56.33E	-

<u>Table 1.3:</u> Summary of samples drawn from Niskin bottles at each station, including salinity (sal), dissolved oxygen (do), nutrients (nut), dissolved inorganic carbon (dic), dissolved organic carbon (doc), iodate/iodide (i), primary productivity (pp), and the following biological samples: pigments (pig), microscopial protist examination (pro), cyanobacteria counts (cya), lugols iodine fixed plankton counts (lug), scanning and transmission electron microscopy (te), subsample of protist concentrate preserved (vir), and samples for culturing (cul). Note that 1=samples taken, 0=no samples taken, 2=surface sample only (i.e. from shallowest Niskin bottle).

									biology						
station		sal	do	nut	dic	doc	i	pp	pig	pro	cya	lug	te	vir	cul
1	TEST	1	1	1	0	0	0	0	0	0	0	0	0	0	0
2	SR3	1	1	1	2	0	1	1	1	0	1	0	0	0	0
3	SR3	1	1	1	0	0	1	0	0	0	0	0	0	0	0
4	SR3	1	1	1	0	0	1	0	1	1	1	0	0	0	0
5	SR3	1	1	1	2	0	1	0	0	0	0	0	0	0	0
6	SR3	1	1	1	0	1	1	1	1	0	1	0	0	0	0
7	SR3	1	1	1	0	0	0	0	1	1	1	1	0	0	0
8	SR3	1	1	1	2	0	1	1	0	0	0	0	0	0	0
9	SR3	1	1	1	0	1	1	0	1	1	1	0	0	0	0
10	SR3	1	1	1	2	0	1	0	0	0	0	0	0	0	0
11	SR3	1	1	1	0	0	1	0	1	1	1	1	0	0	0
12	SR3	1	1	1	0	0	1	1	0	0	0	0	0	0	0
13	SR3	1	1	1	2	0	1	0	1	1	1	0	0	0	0
14	SR3	1	1	1	0	0	1	0	0	0	0	0	0	0	0
15	SR3	1	1	1	2	1	1	0	1	1	1	1	1	1	1
16	SR3	1	1	1	0	0	0	0	0	0	0	0	0	0	0
17	SR3	1	1	1	0	0	0	0	1	1	1	1	0	0	0
18	SR3	1	1	1	2	0	1	0	0	0	0	0	0	0	0
19	SR3	1	1	1	0	0	1	0	1	1	1	0	0	0	0
20	SR3	1	1	1	0	0	0	1	1	1	1	1	0	0	0
21	SR3	1	1	1	2	1	1	0	0	0	0	0	0	0	0
22	SR3	1	1	1	0	0	0	0	0	0	0	0	0	0	0
23	SR3	1	1	1	0	0	0	0	0	0	0	0	0	0	0
24	SR3	1	1	1	0	0	1	1	1	1	1	0	1	1	1
25	SR3	1	1	1	2	0	0	0	0	0	0	0	0	0	0
26	SR3	1	1	1	0	1	1	0	1	1	1	0	0	0	0
27	SR3	1	1	1	2	0	0	0	0	0	0	0	0	0	0
28	SR3	1	1	1	0	0	1	0	0	0	0	0	0	0	0
29	SR3	1	1	1	0	0	1	1	1	1	1	0	1	1	0
30	SR3	1	1	1	2	0	1	0	1	1	1	0	1	0	0
31	SR3	1	1	1	2	1	0	0	0	0	0	0	0	0	0
32	SR3	1	1	1	0	0	1	1	1	1	1	0	1	1	1
33	SR3	1	1	1	0	0	0	0	0	0	0	0	0	0	0
34	SR3	1	1	1	2	1	1	0	1	1	0	0	0	1	0
35	SR3	1	1	1	0	0	0	0	0	0	0	0	0	0	0
36	SR3	1	1	1	2	0	1	1	1	1	1	0	0	1	0
37	SR3	1	1	1	0	0	0	0	1	1	1	0	0	1	0
38	SR3	1	1	1	2	0	0	0	0	0	0	0	0	0	0
39	SR3	1	1	1	2	1	1	1	1	1	1	1	0	1	0
40	SR3	1	1	1	0	0	0	0	1	1	0	0	0	1	0
41	SR3	1	1	1	2	0	1	0	0	0	0	0	0	0	0
42	SR3	1	1	1	0	1	1	1	1	1	1	0	0	1	0

									biology						
station		sal	do	nut	dic	doc	i	pp	pig	pro	cya	lug	te	vir	cul
43	SR3	1	1	1	0	0	0	0	1	0	0	0	0	0	0
44	SR3	1	1	1	2	0	0	0	0	0	0	0	0	0	0
45	SR3	1	1	1	2	0	0	1	1	1	1	0	0	1	0
46	SR3	1	1	1	0	1	1	0	1	1	0	1	0	1	0
47	SR3	1	1	1	0	0	0	0	0	0	0	0	0	0	0
48	SR3	1	1	1	1	0	1	1	1	1	1	0	1	1	0
49	SR3	1	1	1	0	0	0	0	1	1	0	0	0	1	0
50	SR3	1	1	1	2	1	0	0	0	0	0	0	0	0	0
51	SR3	1	1	1	2	0	1	0	1	1	1	0	0	1	0
52	SR3	1	1	1	0	0	0	0	0	0	0	0	0	0	0
53-56	F1.1-F1.5	1	1	1	0	0	0	0	0	0	0	0	0	0	0
57	F1.5	1	1	1	0	0	0	1	1	0	0	0	0	0	0
58-66	F1.6-1.14	1	1	1	0	0	0	0	0	0	0	0	0	0	0
67	F1.15	1	1	1	0	0	0	1	1	1	1	0	0	1	0
68-77	F1.16-1.25	1	1	1	0	0	0	0	0	0	0	0	0	0	0
78	F1.26	1	1	1	0	0	0	1	1	1	1	0	0	0	0
79-94	F1.27-1.42	1	1	1	0	0	0	0	0	0	0	0	0	0	0
95	F1.43	1	1	1	0	0	0	1	1	1	1	0	0	1	0
96-100	F1.44-1.48	1	1	1	0	0	0	0	0	0	0	0	0	0	0
101	SR3	1	1	1	2	1	1	0	1	1	1	0	0	1	0
102	SR3	1	1	1	2	0	0	0	0	0	0	0	0	0	0
103	SR3	1	1	1	0	0	1	0	1	1	0	0	0	1	0
104	TEST	1	0	1	0	0	0	0	0	0	0	0	0	0	0
105	TEST	1	0	0	0	0	0	0	0	0	0	0	0	0	0
106-109	F2.19-2.22	1	1	1	0	0	0	0	0	0	0	0	0	0	0
110	F2.23	1	1	1	0	0	0	0	1	1	0	1	0	0	0
111-113	F2.24-2.26	1	1	1	0	0	0	0	0	0	0	0	0	0	0
114	F2.27	1	1	1	0	2	0	0	0	0	0	0	0	0	0
115-124	F2.28-2.37	1	1	1	0	0	0	0	0	0	0	0	0	0	0
125	F2.38	1	1	1	0	2	0	1	1	1	0	1	0	0	0
126	F2.39	1	1	1	0	2	0	0	0	0	0	0	0	0	0
127-128	F2.40-2.41	1	1	1	0	0	0	0	0	0	0	0	0	0	0
129	F2.42	1	1	1	0	2	0	0	0	0	0	0	0	0	0
130	F2.43	1	1	1	0	0	0	0	0	0	0	0	0	0	0
131	F2.44	1	1	1	0	2	0	0	0	0	0	0	0	0	0
132-135	F2.45-2.48	1	1	1	0	0	0	0	0	0	0	0	0	0	0
136	F2.1	1	1	1	0	0	0	1	1	1	0	1	0	1	0
137	F2.2	1	1	1	0	0	0	0	0	0	0	0	0	0	0
138	F2.3	1	1	1	0	2	0	0	0	0	0	0	0	0	0
139-144	F2.4-2.9	1	1	1	0	0	0	0	0	0	0	0	0	0	0
145	F2.10	1	1	1	0	2	0	0	1	1	0	1	0	1	0
146-151	F2.11-2.16	1	1	1	0	0	0	0	0	0	0	0	0	0	0
152	F2.17	1	1	1	0	2	0	0	0	0	0	0	0	0	0
153	F2.18	1	1	1	0	2	0	0	1	0	0	0	0	0	0
154-159	F3.18-3.23	1	1	1	0	0	0	0	0	0	0	0	0	0	0
160	F3.24	1	1	1	0	2	0	0	0	0	0	0	0	0	0
161	F3.25	1	1	1	0	2	0	0	1	0	0	0	0	0	0
162	F3.26	1	1	1	0	2	0	0	0	0	0	0	0	0	0
163	F3.27	1	1	1	0	2	0	0	0	0	0	0	0	0	0
164-173	F3.28-3.37	1	1	1	0	0	0	0	0	0	0	0	0	0	0
174	F3.38	1	1	1	0	2	0	0	0	0	0	0	0	0	0

									biology						
station		sal	do	nut	dic	doc	i	pp	pig	pro	cya	lug	te	vir	cul
175	F3.39	1	1	1	0	2	0	0	1	0	0	0	0	0	0
176	F3.40	1	1	1	0	0	0	0	0	0	0	0	0	0	0
177	F3.41	1	1	1	0	2	0	0	0	0	0	0	0	0	0
178	F3.42	1	1	1	0	0	0	0	0	0	0	0	0	0	0
179	F3.43	1	1	1	0	2	0	0	0	0	0	0	0	0	0
180-181	F3.44-3.45	1	1	1	0	0	0	0	0	0	0	0	0	0	0
182	F3.46	1	1	1	0	2	0	0	0	0	0	0	0	0	0
183-187	F3.47-3.3	1	1	1	0	0	0	0	0	0	0	0	0	0	0
188-189	F3.4-F3.5	1	1	1	0	2	0	0	0	0	0	0	0	0	0
190	F3.6	1	1	1	0	2	0	0	1	1	0	1	0	1	0
191	F3.7	1	1	1	0	0	0	0	0	0	0	0	0	0	0
192	F3.8	1	1	1	0	2	0	0	0	0	0	0	0	0	0
193-200	F3.9-F3.16	1	1	1	0	0	0	0	0	0	0	0	0	0	0
201	F3.17	1	1	1	0	0	0	0	1	0	0	1	0	0	0
202	SR3	1	1	1	0	0	0	0	1	0	0	0	0	0	0
203	SR3	1	1	1	0	0	0	0	0	0	0	0	0	0	0
204	SR3	1	1	1	0	0	0	0	0	0	0	0	0	0	0
205	SR3	1	1	1	2	0	0	0	1	1	1	1	0	1	0
206	SR3	1	1	1	0	0	0	0	0	0	0	0	0	0	0
207	SR3	1	1	1	0	0	0	1	1	1	1	1	0	1	0
208	SR3	1	1	1	2	0	0	0	0	0	0	0	0	0	0

Table 1.4: CTD stations over current meter (CM) and inverted echo sounder (IES) moorings along SR3 transect in the vicinity of the Subantarctic Front. Note that bottom depths are calculated using a sound speed of 1498 ms^{-1}. For CTD station positions, see Table 1.2.

CTD station no.	start time	bottom depth (m)	mooring number
12	03:18, 21/07/95	4064	I1 (IES)
16	03:38, 22/07/95	3686	I2 (IES)
17	08:49, 22/07/95	3788	I4 (IES)
18	14:14, 22/07/95	3711	I6 (IES)
19	19:08, 22/07/95	3583	I8 (CM+IES)
20	00:31, 23/07/95	3655	I9 (CM+IES)
21	05:03, 23/07/95	3808	I10 (CM+IES)
22	09:52, 23/07/95	3706	I12 (IES)
23	14:51, 23/07/95	3778	I14 (IES)
24	20:04, 23/07/95	3757	I16 (IES)
25	00:55, 24/07/95	3512	I18 (IES)
205	15:32, 29/08/95	3563	I17 (IES)
206	21:01, 29/08/95	3450	I15 (IES)
207	02:57, 30/08/95	3757	I13 (IES)
208	10:20, 30/08/95	3757	I11 (IES)

Table 1.5a: Principal investigators (*=cruise participant) for water sampling programmes.

measurement	name	affiliation
CTD, salinity, O_2, nutrients (SR3)	Steve Rintoul/*Nathan Bindoff	CSIRO/Antarctc CRC
CTD, salinity, O_2 (FORMEX)	*Nathan Bindoff/*Ian Allison	Antarctic CRC/Antarctic Division
D.O.C.	Tom Trull	Antarctic CRC
iodate/iodide	Ed Butler	CSIRO
primary productivity	John Parslow	CSIRO
biological sampling	Harvey Marchant	Antarctic Division
D.I.C.	Bronte Tilbrook	CSIRO

Table 1.5b: Scientific personnel (cruise participants).

name	measurement	affiliation
Nathan Bindoff	CTD	Antarctic CRC
Ross Edwards	CTD, trace metals	Antarctic CRC
Brett Goldsworthy	CTD	Antarctic CRC
Phil Reid	CTD	Antarctic CRC
Mark Rosenberg	CTD, moorings	Antarctic CRC
Chris Zweck	CTD	Antarctic CRC
Steve Bell	salinity, oxygen, nutrients	Antarctic CRC
Stephen Bray	salinity, oxygen, nutrients	Antarctic CRC
Martina Doblin	oxygen	Antarctic CRC
Mick Mackey	primary productivity	Antarctic CRC
Rick van den Enden	biological sampling	Antarctic Division
Ian Jameson	biological sampling	Antarctic Division
Ian Allison	voyage leader, sea ice	Antarctic Division
Petra Heil	sea ice	Antarctic CRC
Ian Knott	sea ice, electronics	Antarctic CRC
Vicky Lytle	sea ice	Antarctic CRC
Rob Massom	sea ice	Antarctic CRC
Anton Rada	sea ice	Antarctic Division
Tony Worby	deputy voyage leader, sea ice	Antarctic Division
Greg Bush	upward looking sonar	Curtin University
Alec Duncan	upward looking sonar	Curtin University
Kevin Bartram	ornithology	Royal Australasian Ornithologists Union
Dion Hobcroft	ornithology	Royal Australasian Ornithologists Union
Peter Gill	whale observations	Ocean Research Foundation
Debbie Thiele	whale observations	Ocean Research Foundation
Pamela Brodie	computing	Antarctic Division
Andrew Climie	doctor	Antarctic Division
Vera Hansper	computing	Antarctic Division
Graham Hosie	sea ice biology	Antarctic Division
Andrew McEldowney	gear officer	Antarctic Division
Tim Pauly	hydroacoustics	Antarctic Division
Tim Ryan	underway measurements	Antarctic Division
Hyong-chul Shin	sea ice biology	Antarctic Division
Wojciech Wierzbicki	electronics	Antarctic Division

Peter Colpo	helicopters	Helicopter Resources
Adrian Pate	helicopters	Helicopter Resources
Rick Piacenza	helicopters	Helicopter Resources
Ian McCarthy	weather forecaster	Bureau of Meteorology

1.4 FIELD DATA COLLECTION METHODS

1.4.1 CTD and hydrology measurements

In this section, CTD and hydrology data collection and processing methods are discussed. Preliminary results of the CTD data calibration, along with data quality information, are presented in Section 1.6. CTD instrumentation and CTD and hydrology data collection techniques are described in detail in Rosenberg et al. (1995b). Water sampling methods are also detailed in previous data reports.

1.4.1.1 CTD Instrumentation

Briefly, General Oceanics Mark IIIC (i.e. WOCE upgraded) CTD units were used, with General Oceanics model 1015 pylons, and 10 litre General Oceanics Niskin bottles. A 24 position rosette package was deployed for stations 1 to 52 and 202 to 208 along the SR3 transect, with deep sea reversing thermometers (Gohla-Precision) mounted at rosette positions 2, 12 and 24. A Li-Cor photosynthetically active radiation sensor and Sea-Tech fluorometer were also attached to the package for some casts (Table 1.20). For stations 53 to 201, a 12 position rosette package was deployed. For most FORMEX stations, 6 bottles only were mounted, at alternate rosette positions, and with reversing thermometers at rosette position 2. Extra bottles were mounted for some FORMEX stations for the collection of biological samples (Table 1.3). For stations 101 to 105, 12 Niskin bottles were mounted.

1.4.1.2 CTD instrument and data calibration

Complete calibration information for the CTD pressure, platinum temperature and pressure temperature sensors are presented in Table 1.22. Post cruise pressure, platinum temperature and pressure temperature calibrations, performed at the CSIRO Division of Marine Research Calibration Facility, were available for all CTD units. The complete CTD conductivity and the limited CTD dissolved oxygen calibrations, derived respectively from the in situ Niskin bottle salinity and dissolved oxygen samples, are presented in a later section.

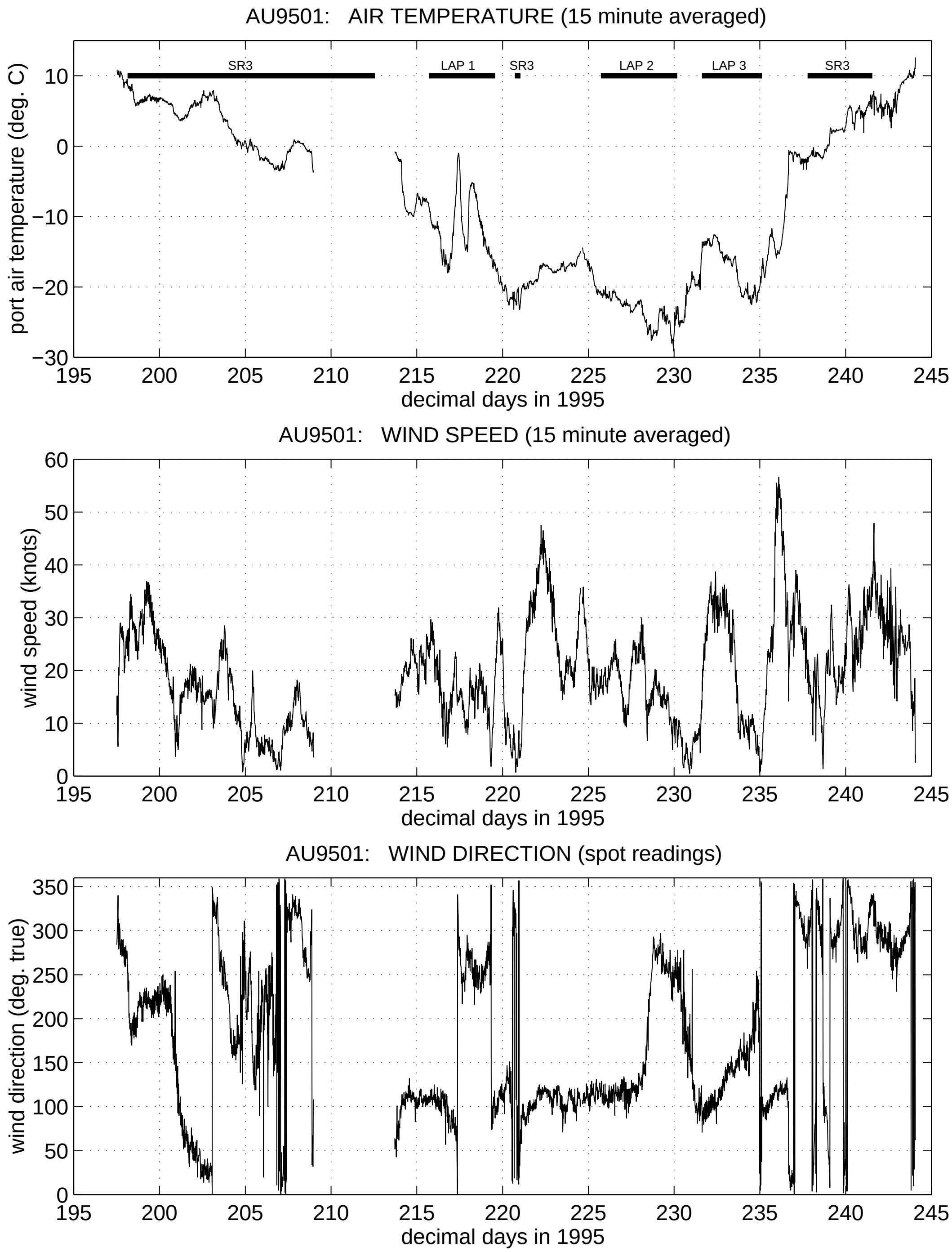
Manufacturer supplied calibrations were applied to the p.a.r. data, while fluorometer calibrations were performed at the Antarctic Division (Table 1.22). These calibrations are not expected to be correct - correct scaling of fluorescence data requires linkage with primary productivity data, while p.a.r. data requires recalculation using extinction coefficients for the signal strength (B. Griffiths, pers. comm.).

The CTD and hydrology data processing and calibration techniques are described in detail in Appendix 2 of Rosenberg et al. (1995b) (referred to as “CTD methodology” for the remainder of the report), with the following updates to the methodology:

(i) the 10 seconds of CTD data prior to each bottle firing are averaged to form the CTD upcast for use in calibration (5 seconds was used previously);

(ii) for stations 30 to 44, the minimum number of data points required in a 2 dbar bin to form an average was set to 6 (i.e. jmin=6; for other stations, jmin=10);

(iii) in the conductivity calibration for stations 30 to 44, an additional term was applied to remove the pressure dependent conductivity residual;
(iv) CTD raw data obtained from the CTD logging PC's no longer contain end of record characters after every 128 bytes.



<u>Figure 1.2:</u> Air temperature and wind speed and direction for cruise AU9501 from ship's underway data, including times of various cruise components (SR3 and FORMEX laps 1, 2 and 3). Note that decimal time = 0.0 at midnight of 31st December (so, e.g., midday on 2nd January = 1.5).

1.4.1.3 CTD/hydrology data collection techniques in cold conditions

Extreme cold was experienced for much of the cruise (Figure 1.2), and most of the time during FORMEX the oceanographic operations were conducted in consolidated sea ice. As a result, new methods had to be developed for deployment of the rosette package. In particular, great care had to be taken to minimize freezing of the CTD sensors. After arriving on station, the ship had to first clear a hole in the sea ice (in thicker ice, this operation took up to 1 hour). During the CTD cast, stern thrusters were used to keep ice clear of the CTD wire. Bow thruster usage was minimized during FORMEX, to ensure good ADCP data whilst on station.

CTD sensor caps were filled with hypersaline water to depress the freezing point of water on the sensors. To minimize exposure of the sensors to the cold air, the caps were not drained until the package was about to be lowered into the water; and the package was lowered promptly, and while still moving out towards the end of the gantry. Adherence to these steps minimized sensor freezing, however near surface downcast conductivity data were still affected by a thin film of frozen water remaining on the conductivity cell. Upcast data were therefore used for stations 53 to 201.

When the package was retrieved, water was often frozen in the Niskin bottle spiggots, and sampling was delayed by approximately 10 to 15 minutes to allow thawing of the spiggots. On several occasions, the flow during sampling for dissolved oxygen was interrupted due to incomplete thawing, causing a long delay between opening of the Niskin bottle vent valve and taking of the sample. Dissolved oxygen samples thus affected were not analysed.

1.4.1.4 Hydrology analytical methods

The analytical techniques and data processing routines employed in the Hydrographic Laboratory onboard the ship are discussed in Appendix 3 of Rosenberg et al. (1995b). Note the following changes to the methodology:

(i) 150 ml sample bottles were used, and 1.0 ml of reagents 1, 2 and 3 were used; the corresponding calculated value for the total amount of oxygen added with the reagents = 0.017 ml;

(ii) a mean volume of 147.00 ml for oxygen sample bottles was applied in the calculation of dissolved oxygen concentration.

1.4.2 Underway measurements

Underway data collection is as described in previous data reports; data files are described in Part 5. Note that a sound speed of 1498 ms^{-1} is used for all depth calculations, and the ship's draught of 7.3 m has been accounted for in final depth values (i.e. depths are values from the surface).

Table 1.6: ADCP logging parameters.

ping parameters		*bottom track ping parameters*	
no. of bins:	60	no. of bins:	128
bin length:	8 m	bin length:	4 m
pulse length:	8 m	pulse length:	32 m
delay:	4 m		
ping interval:	minimum	ping interval:	same as profiling pings

reference layer averaging:	bins 3 to 6
ensemble averaging duration:	3 min.

1.4.3 ADCP

The acoustic Doppler current profiler (ADCP) instrumentation is described in Rosenberg et al. (1996). GPS data was collected by a Lowrance receiver for the first half of the cruise, and a Koden receiver for the second half. Note that the Lowrance unit received GPS positions every 2 seconds, and GPS velocities every 2 seconds, with positions and velocities received on alternate seconds; the Koden unit received both GPS positions and velocities every 1 second. ADCP data processing is discussed in more detail in Dunn (a and b, unpublished reports). Logging parameters are summarised in Table 1.6, while data results for this cruise will be discussed in a future report.

1.5 MAJOR PROBLEMS ENCOUNTERED

1.5.1 Logistics

Rough weather on the return northward leg prevented CTD measurements being taken at 3 of the inverted echo sounder mooring locations (mooring numbers I3, I5 and I7). Time was not available to wait for calmer conditions.

1.5.2 CTD sensors

No good CTD dissolved oxygen data was obtained from CTD 1103. The problem, not diagnosed until after the cruise, was traced to an incorrectly wired oxygen sensor bulkhead connector (a factory fault). As a result, usable CTD dissolved oxygen data was only obtained from the limited number of stations where CTD 1193 was used.

The conductivity cell for CTD 1193 was faulty, displaying a large transient error when first entering the water (requiring several minutes to drift to a stable value), large hysteresis between the down and upcasts, and significant pressure dependent residuals. Conductivity data was recoverable for stations 30 to 41 (see section 1.6), but was unusable for stations 42 to 44 and 104 to 105.

Following station 50, a crack was discovered in the housing window for the photosynthetically active radiation sensor. The sensor was not used for the remainder of the cruise.

1.5.3 Other equipment

Very cold conditions were experienced during the cruise (Figure 1.2). When the air temperature dropped below -20^{o}C, icing of the CTD wire became a problem, causing jamming of the wire in the spooling sheath. On the worst occasion, several turns came off the winch drum, and several hundred metres of wire were badly kinked.

The Lowrance GPS receiver, accessed by the ADCP logging system, failed on 13/07/95. The replacement Koden unit came on line on 16/07/95. The missing 3 days of GPS data for the ADCP were obtained from data logged by the Magnavox GPS unit.

1.6 CTD RESULTS

This section details information relevant to the creation and quality of the final CTD and hydrology data set. For actual use of the data, the following is important:

CTD data - Tables 1.14 and 1.15, and Table 1.7;
hydrology data - Table 1.19.

Historical data comparisons are made in Part 4 of this report. Data file formats are described in Part 5.

1.6.1 CTD measurements - data creation and quality

CTD data calibration and processing methods are described in detail in the CTD methodology (i.e. Appendix 2 of Rosenberg et al., 1995b, with the additions listed in section 1.4.1.2 of this report). Cases for cruise au9501 which vary from this methodology are detailed in this section. CTD data quality is also discussed. For conversion to WOCE data file formats, see Part 5 of this report.

The final calibration results for conductivity/salinity and dissolved oxygen, along with the performance check for temperature, are plotted in Figures 1.3 to 1.6. For temperature, salinity and dissolved oxygen, the respective residuals (T_{therm} - T_{cal}), (s_{btl} - s_{cal}) and (o_{btl} - o_{cal}) are plotted. For conductivity, the ratio c_{btl}/c_{cal} is plotted. T_{therm} and T_{cal} are respectively the protected thermometer and calibrated upcast CTD burst temperature values; s_{btl}, s_{cal}, o_{btl}, o_{cal}, c_{btl} and c_{cal} , and the mean and standard deviation values in Figures 1.3 to 1.6, are as defined in the CTD methodology (with additional definitions described below for cases where a pressure dependent residual is removed from conductivity data).

1.6.1.1 Conductivity/salinity

An excellent conductivity calibration was obtained for CTD 1103 (stations 1-29, 45-103 and 106-208) - after calibrating against bottle data, low residuals were obtained between CTD and bottle values (Figures 1.4a and 1.5a). Note that a new conductivity cell was installed on this CTD at the start of the cruise. Upcast CTD data was used for stations 53 to 103 and 106-201, owing to sensor freezing (as described in section 1.4.1.3).

The conductivity cell for CTD 1193 (stations 30-44 and 104-105) was faulty, as described in section 1.5.2. Upcast CTD data were used for these stations, due to the large transient error in conductivity when entering the water, and the significant hysteresis between downcast and upcast conductivity data. The pressure dependent conductivity residual for this cell was removed by the following steps:

(a) CTD conductivity was initially calibrated to derive conductivity residuals (c_{btl} - c_{cal}), where c_{btl} and c_{cal} are as defined in the CTD methodology, noting that c_{cal} is the conductivity value after the initial calibration only i.e. prior to any pressure dependent correction.

(b) Next, for each station grouping (Table 1.9), a linear pressure dependent fit was found for the conductivity residuals i.e. for station grouping i, fit parameters α_i (Table 1.9) and β_i were found from

$$(c_{btl} - c_{cal})_n = \alpha_i \, p_n + \beta_i \qquad \text{(eqn 1.1)}$$

where the residuals $(c_{btl} - c_{cal})_n$ and corresponding pressures p_n (i.e. pressures where Niskin bottles fired) are all the values accepted for conductivity calibration in the station grouping.

(c) Lastly, the conductivity calibration was repeated, this time fitting ($c_{ctd} + \alpha_i$ p) to the bottle values c_{btl} in order to remove the linear pressure dependence for each station grouping i (for uncalibrated conductivity c_{ctd} as defined in the CTD methodology; and note that the offsets β_i were not applied).

A good conductivity calibration was obtained for stations 30 to 41 using this method (Figures 1.4b and 1.5b). However for stations 42 to 44 and 104 to 105, the conductivity data was not recoverable, owing to rapid deterioration of the cell.

The final standard deviation values for the salinity residuals (Figure 1.5) indicate the CTD salinity data over the whole cruise is accurate to within ±0.002 (PSS78).

1.6.1.2 Temperature

The comparison of CTD and thermometer temperatures is shown in Figure 1.3. The thermometer value used in each case is the mean of the two protected thermometer readings (protected thermometers used are listed in Table 1.21). Note that in the figures, the “dubious” and “rejected” categories refer to corresponding bottle samples and upcast CTD bursts in the conductivity calibration, rather than to CTD/thermometer temperature values.

Platinum temperature sensor performance of CTD’s 1103 and 1193 is not consistent, as shown by the different offsets in Figures 1.3a and b. For CTD 1193 (Figure 1.3b), the offset is small (~+0.001^{o}C), indicating a reliable laboratory calibration of the platinum temperature sensor. The offset for CTD 1103 of ~-0.007^{o}C (Figure 1.3a), using the post cruise temperature calibration, is large. If the pre cruise temperature calibration (September 1994) is applied, the offset is ~+0.007^{o}C, thus a significant calibration drift occurred for this CTD between the two laboratory calibrations. No attempt has been made to correct for this calibration drift, and the post cruise calibration is maintained. Note that over the actual period of the cruise, there was little calibration drift for CTD 1103, other than a possible small drift for stations 202-208 (although these stations were too few in number to confirm the trend).

1.6.1.3 Pressure

As described in previous data reports, noise in the pressure signal for CTD 1193 (used for stations 30 to 44 and 104 to 105) was high, with spikes of up to 1 dbar amplitude occurring, and with a large number of missing 2 dbar bins resulting. The number of missing bins was reduced by setting to 6 the minimum number of data points required in a 2 dbar bin to form an average (i.e. jmin=6; for CTD 1103 stations, jmin=10). For remaining missing bins, values were linearly interpolated between surrounding bins, except where the local temperature gradient exceeded 0.005^{o}C between the surrounding bins i.e. temperature gradient > 0.00125 degrees/dbar.

For stations 22, 128 and 190, data logging commenced when the CTD was already in the water, so surface pressure offset values were estimated from surrounding stations. For stations 144 and 168, conductivity cell freezing interfered with the automatic estimation of surface pressure offsets (see CTD methodology), so surface pressure offset values were estimated from a manual inspection of the pressure data. Note that for all these stations, any resulting additional error in the CTD pressure data is judged to be small (no more than 0.2 dbar).

1.6.1.4 Dissolved oxygen

Usable CTD dissolved oxygen data was only obtained from CTD 1193, stations 30 to 41, as discussed in section 1.5.2. For these stations, downcast oxygen temperature and oxygen current data were merged with the upcast pressure, temperature and conductivity data (upcast dissolved oxygen data is in general not reliable). With this data set, calibration of the dissolved oxygen data then followed the usual methodology. Note that for many of these stations, near surface CTD dissolved oxygen data were bad (Table 1.12).

A small additional error in CTD dissolved oxygen data is expected to occur from the merging of downcast oxygen data with upcast pressure, temperature and conductivity data - where horizontal gradients occur, there will be some mismatch of downcast and upcast data as the ship drifts during a CTD cast. At most, this error is not expected to exceed ~3%.

The dissolved oxygen residuals are plotted in Figure 1.6. The final standard deviation values are within ~1.2% of full scale values (where full scale is approximately equal to 250 μmol/l for pressure > 750 dbar, and 350 μmol/l for pressure < 750 dbar). Note that the standard deviation values are a little larger than for previous cruises, indicating a larger spread in the residuals for each station (Figure 1.6). The best calibration was achieved using large values of the order 13.0 for the coefficient K_1 (i.e. oxygen current slope), and large negative values of the order -2.0 for the coefficient K_3 (i.e. oxygen current bias) (Table 1.16). This, however, is not considered relevant to actual data quality.

1.6.1.5 Fluorescence and P.A.R. data

As discussed in section 1.4 above, fluorescence and p.a.r. are effectively uncalibrated. These data should not be used quantitatively other than for linkage with primary productivity data.

Table 1.7: Summary of cautions to CTD data quality.

station no.	CTD parameter	caution
1	salinity	test cast - all bottles fired at same depth; salinity accuracy reduced
22	pressure	surface pressure offset estimated from surrounding stations
31	oxygen	dissolved oxygen data could not be calibrated due to bad bottle data
42-44	oxygen	no CTD dissolved oxygen data due to bad conductivity data
45	salinity	most bottles tripped on the fly, which may introduce small inaccuracy into the conductivity calibration
104-105	all parameters	data not used for these stations (test casts only)
128	pressure	surface pressure offset estimated from surrounding stations
144	pressure	surface pressure offset estimated manually
168	pressure	surface pressure offset estimated manually
190	pressure	surface pressure offset estimated from surrounding stations
1-29, 45-208	oxygen	no CTD dissolved oxygen data due to faulty hardware
30-41	salinity	additional correction applied for pressure dependent conductivity residual
all CTD1103 stns	temperature	offset between CTD and reversing thermometer data
all stns	fluorescence/p.a.r.	fluorescence and p.a.r. sensors (where active) are uncalibrated

1.6.1.6 Summary of CTD data creation

stations 1-29 and 42-208: no CTD dissolved oxygen data;

stations 30-44: all CTD data from upcast (except dissolved oxygen); pressure dependent conductivity residual removed;

stations 53-103 and 106-201: all CTD data from upcast;

Further information relevant to the creation of the calibrated CTD data is tabulated, as follows:

* Surface pressure offsets calculated for each station are listed in Table 1.8.

* CTD conductivity calibration coefficients, including the station groupings used for the conductivity calibration, are listed in Tables 1.9 and 1.10.

* CTD raw data scans flagged for special treatment are listed in Table 1.11.

* Missing 2 dbar data averages are listed in Table 1.12.

* 2 dbar bins which are linearly interpolated from surrounding bins are listed in Table 1.13.

* Suspect 2 dbar averages are listed in Tables 1.14 and 1.15.

* CTD dissolved oxygen calibration coefficients are listed in Table 1.16. The starting values used for the coefficients prior to iteration, and the coefficients varied during the iteration, are listed in Table 1.17.

* Stations containing fluorescence and photosynthetically active radiation data are listed in Table 1.20.

* The different protected and unprotected thermometers used for the stations are listed in Table 1.21.

* Laboratory calibration coefficients for the CTD's are listed in Table 1.22.

1.6.1.7 Summary of CTD data quality

CTD data quality cautions for the various parameters are summarised in Table 1.7.

1.6.2 Hydrology data

Quality control information relevant to the hydrology data is tabulated, as follows:

* Dissolved oxygen Niskin bottle samples flagged with the code -9 (rejected for CTD dissolved oxygen calibration) are listed in Table 1.18.

* Questionable nutrient Niskin bottle sample values are listed in Table 1.19. Note that questionable values are included in the hydrology data file, whereas bad values have been removed. Also note that there are no questionable dissolved oxygen bottle samples.

For station 45, the cast was abandoned at ~1000 m above the bottom on the downcast, due to ice bearing down on the ship. During retrieval, bottles at rosette positions 2 to 19 were tripped while the instrument package was still moving.

1.6.2.1 Nutrients

As discussed in previous data reports, additional "dummy" samples drawn from the Niskin bottles were inserted in autoanalyser runs immediately following wash solution vials to artificially mask the suppression effect on subsequent phosphate samples (see section 6.2.1 in Rosenberg et al., 1995b). As a result, no phosphate data was lost.

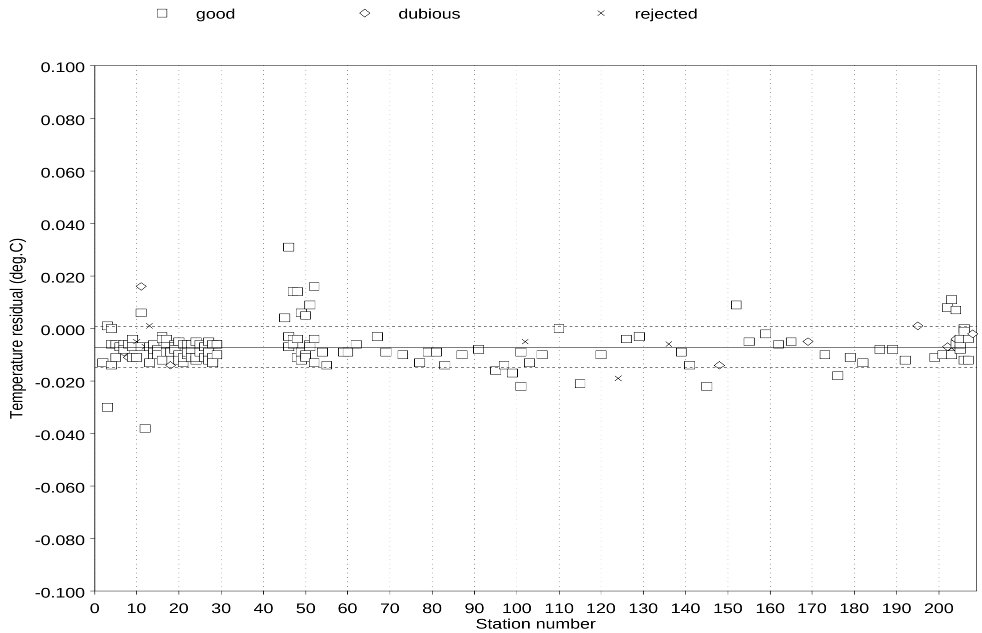
Laboratory temperature on the ship was stable, with lab temperatures at the times of nutrient analyses having a most common value of 18^{o}C.

1.6.2.2 Dissolved oxygen

Dissolved oxygen bottle data for stations 14, 23, 31 and 44 were unusable, as the bottles had not been adequately shaken following the addition of reagents during sampling.

Dissolved oxygen bottle values for stations 1 to 21 are ~6μmol/l smaller than for the remaining stations, due to drift of the laboratory standardisation values for the first 21 stations. See Part 4 of this report for a more detailed discussion.

(a)



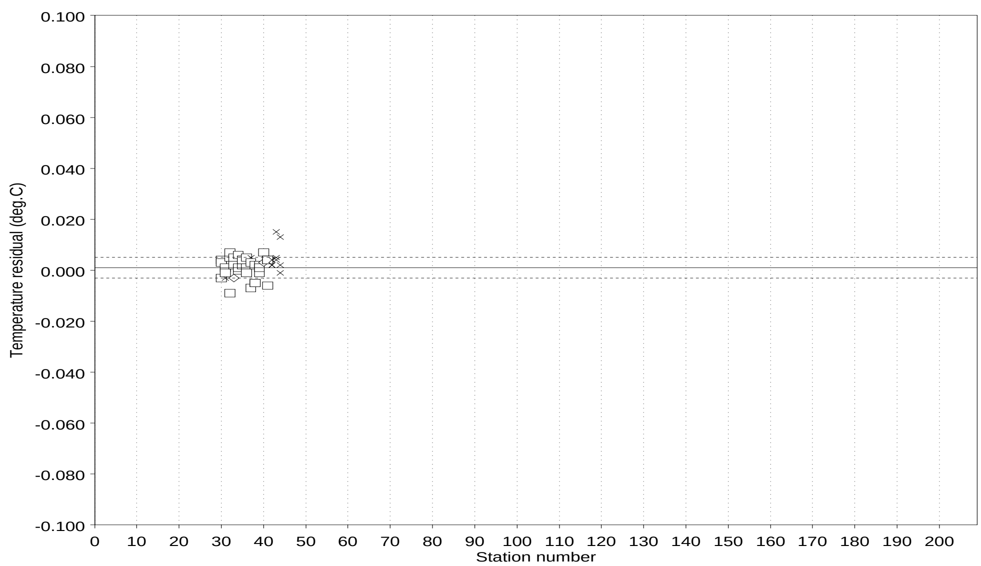
Calibration data for cruise : Au9501

Calibration file : CTD1103.lis

Mean offset Temperature = -.00709312c (s.d. = 0.0078 ˚c)

Number of samples used = 155 out of 161

(b)



Calibration data for cruise : Au9501

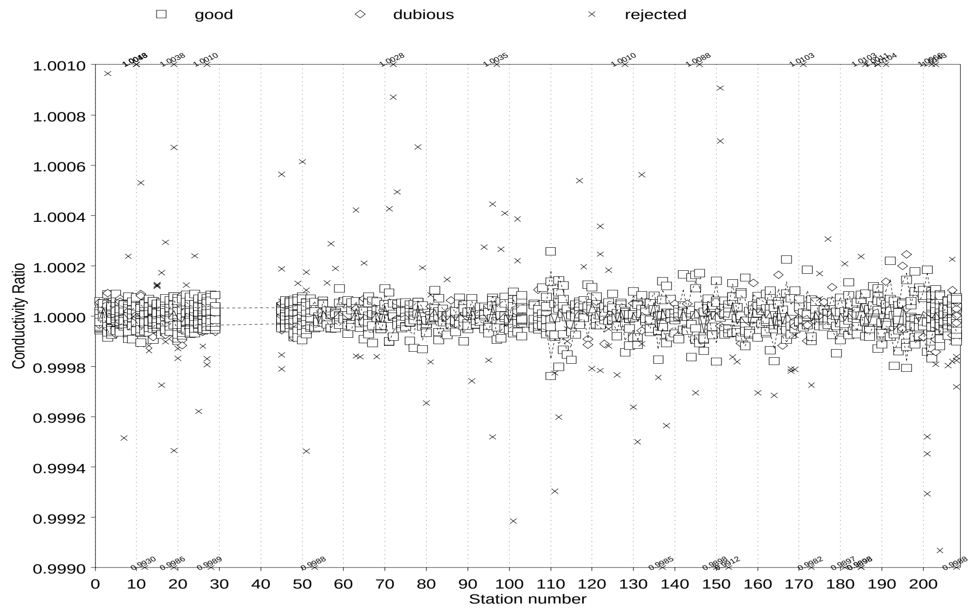
Calibration file : CTD1193.lis

Mean offset Temperature = 0.00106312c (s.d. = 0.0041 ˚c)

Number of samples used = 33 out of 44

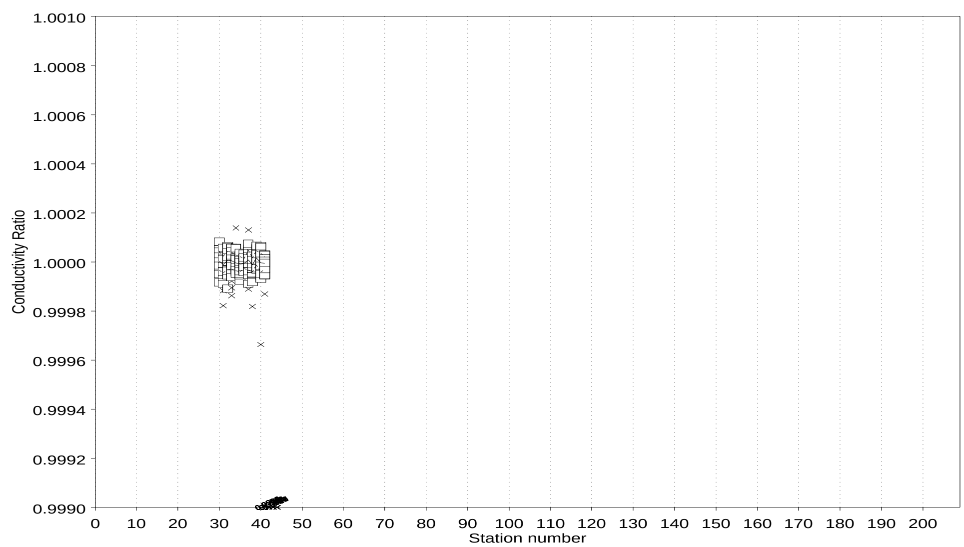
Figure 1.3: Temperature residual (T_{therm} - T_{cal}) versus station number for cruise au9501 for stations using (a) CTD1103, and (b) CTD 1193. The solid line is the mean of all the residuals; the broken lines are ± the standard deviation of all the residuals (see CTD methodology). Note that the "dubious" and "rejected" categories refer to the conductivity calibration.

(a)



Calibration data for cruise : Au9501
Calibration file : CTD1103.lis
Conductivity s.d. = 0.00005
Number of bottles used = 1731 out of 1911 Mean ratio for all bottles = 1.00000

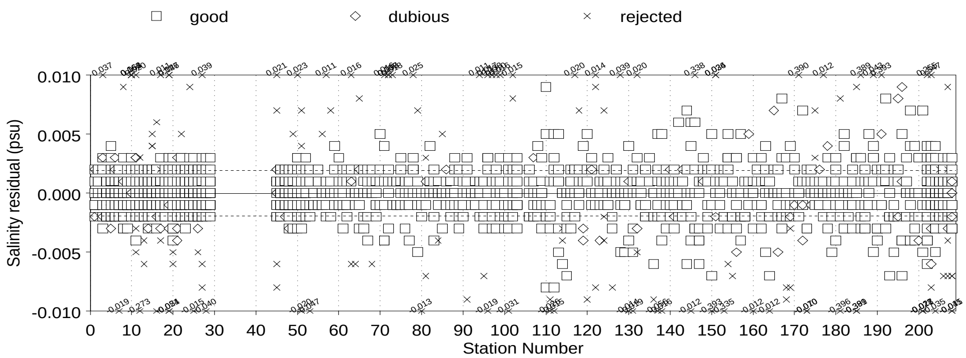
(b)



Calibration data for cruise : Au9501
Calibration file : CTD1193.lis
Conductivity s.d. = 0.00003
Number of bottles used =   275 out of   359 Mean ratio for all bottles = 1.00000
Comment:

Figure 1.4: **Conductivity ratio c_{btl}/c_{cal} versus station number for cruise au9501 for stations using (a) CTD1103, and (b) CTD1193. The solid line follows the mean of the residuals for each station; the broken lines are ± the standard deviation of the residuals for each station (see CTD methodology).**

(a)



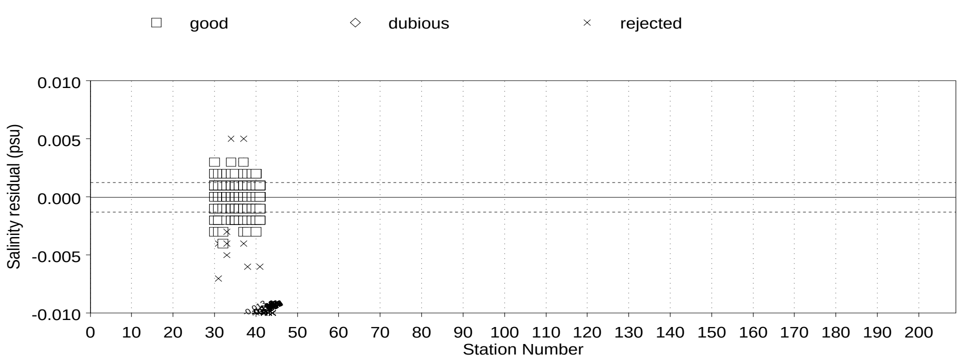
Calibration data for cruise : Au9501

Calibration file : CTD1103.lis

Mean offset salinity = 0.0000psu (s.d. = 0.0019 psu)

Number of bottles used = 1731 out of 1911

(b)



Calibration data for cruise : Au9501

Calibration file : CTD1193.lis

Mean offset salinity = 0.0000psu (s.d. = 0.0013 psu)

Number of bottles used = 275 out of 359

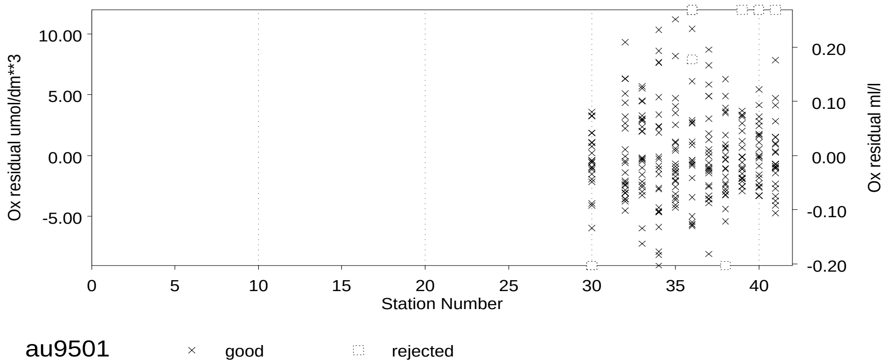
Figure 1.5: Salinity residual (s_{btl} - s_{cal}) versus station number for cruise au9501 for stations using (a) CTD1103, and (b) CTD1193. The solid line is the mean of all the residuals; the broken lines are ± the standard deviation of all the residuals (see CTD methodology).

Mean of Residual = -0.023umol/dm**3

S.D. of residual = 3.591umol/dm**3 (Equiv to 0.080ml/l)

Used 252 bottles out of total 358

S.D. deep (>750m) 2.977umol/dm**3 (equiv to 0.067ml/l)



<u>Figure 1.6:</u> Dissolved oxygen residual (o_{btl} - o_{cal}) versus station number for cruise au9501 (CTD1193 stations only).

Table 1.8: **Surface pressure offsets (as defined in the CTD methodology). ** indicates that value is estimated from surrounding stations, or else determined from manual inspection of pressure data.**

station number	surface p offset (dbar)	station number	surface p offset (dbar)	station number	surface p offset (dbar)	station number	surface p offset (dbar)
1	0.99	53	0.13	105	-	157	1.04
2	0.63	54	0.33	106	0.23	158	1.14
3	0.49	55	0.21	107	0.78	159	1.26
4	0.46	56	0.14	108	1.21	160	0.95
5	0.50	57	-0.23	109	1.13	161	0.85
6	0.28	58	-0.24	110	0.78	162	1.04
7	0.18	59	0.05	111	1.08	163	0.97
8	0.45	60	-0.16	112	1.12	164	0.97
9	0.17	61	0.25	113	0.86	165	0.59
10	0.42	62	0.29	114	0.65	166	1.15
11	-0.23	63	0.13	115	1.04	167	0.78
12	0.22	64	-0.14	116	0.97	168	0.78**
13	0.13	65	0.27	117	0.95	169	1.29
14	0.13	66	0.23	118	0.61	170	1.04
15	-0.11	67	-0.06	119	0.77	171	1.21
16	0.14	68	0.35	120	1.17	172	0.97
17	-0.01	69	0.13	121	1.17	173	1.14
18	-0.19	70	0.05	122	1.19	174	0.96
19	0.00	71	-0.11	123	1.12	175	0.96
20	-0.22	72	0.26	124	1.09	176	0.71
21	0.00	73	0.33	125	1.06	177	0.98
22	0.00**	74	0.44	126	0.98	178	0.91
23	-0.57	75	0.12	127	1.13	179	0.78
24	0.05	76	0.23	128	1.00**	180	1.17
25	-0.28	77	0.26	129	0.88	181	0.71
26	-0.45	78	0.57	130	0.66	182	0.70
27	-0.29	79	0.48	131	1.03	183	0.87
28	-0.40	80	0.46	132	0.68	184	0.51
29	-0.47	81	0.32	133	0.98	185	0.86
30	-0.69	82	0.31	134	0.67	186	1.40
31	-0.66	83	0.36	135	1.01	187	0.86
32	-1.26	84	0.26	136	0.82	188	0.73
33	-2.29	85	0.09	137	0.98	189	0.69
34	-1.90	86	0.28	138	0.82	190	0.66**
35	-1.30	87	0.12	139	1.03	191	0.63
36	-0.79	88	0.30	140	0.74	192	0.82
37	-1.15	89	0.29	141	0.96	193	0.81
38	-1.21	90	0.12	142	0.99	194	0.93
39	-1.73	91	0.80	143	0.55	195	1.10
40	-0.98	92	0.18	144	0.45**	196	0.65
41	-0.71	93	0.62	145	0.41	197	1.00
42	-1.08	94	0.40	146	0.72	198	0.70
43	-1.26	95	0.26	147	0.53	199	0.60
44	-0.80	96	0.46	148	0.56	200	0.79
45	0.65	97	0.14	149	0.56	201	0.82
46	0.23	98	0.29	150	0.36	202	0.68
47	-0.06	99	0.73	151	0.82	203	0.70
48	0.19	100	0.26	152	1.16	204	0.27
49	0.09	101	0.29	153	0.69	205	0.60
50	-0.02	102	0.46	154	0.56	206	0.70
51	-0.01	103	0.64	155	0.91	207	0.65
52	-0.30	104	-	156	0.94	208	0.52

Table 1.9: CTD conductivity calibration coefficients. F_1, F_2 and F_3 are respectively conductivity bias, slope and station-dependent correction calibration terms. n is the number of samples retained for calibration in each station grouping; σ is the standard deviation of the conductivity residual for the n samples in the station grouping (see CTD methodology); α is the correction applied to CTD conductivities due to pressure dependence of the conductivity residuals for stations 30 to 41 (eqn 1.1).

stn grouping	F_1	F_2	F_3	n	σ	α
001 to 003	-.15532800	0.10106622E-02	-.11470793E-08	43	0.001506	
004 to 006	-.12422183	0.10097721E-02	-.22838255E-07	66	0.001231	
007 to 011	-.11687464	0.10094945E-02	-.12108803E-07	108	0.001224	
012 to 013	-.10839249	0.10098253E-02	-.56286375E-07	43	0.001083	
014 to 017	-.10910666	0.10089800E-02	0.85821839E-08	85	0.001106	
018 to 024	-.10605356	0.10089344E-02	0.58253139E-08	152	0.001306	
025 to 026	-.11794039	0.10094659E-02	-.15959792E-08	43	0.001174	
027 to 029	-.11923390	0.10095053E-02	-.73952908E-09	65	0.000989	
030 to 032	-.84092238E-01	0.94275256E-03	0.65573267E-08	70	0.001063	1.207501E-06
033 to 037	-.83614084E-01	0.94281093E-03	0.34424272E-08	114	0.000946	1.239768E-06
038 to 041	-.84436830E-01	0.94285378E-03	0.28708290E-08	91	0.000948	1.321621E-06
042 to 044	-	-	-	-	-	-
045 to 047	-.50710766E-01	0.10080721E-02	-.17528905E-07	66	0.000900	
048 to 050	-.55259689E-01	0.10074674E-02	-.12693342E-09	69	0.001153	
051 to 052	-.51316066E-01	0.10065250E-02	0.14941010E-07	45	0.000960	
053 to 056	-.42571330E-01	0.10096393E-02	-.47862704E-07	22	0.000847	
057 to 061	-.46105712E-01	0.10066443E-02	0.76930518E-08	28	0.001093	
062 to 068	-.36372532E-01	0.10063733E-02	0.69886140E-08	37	0.001138	
069 to 071	-.56595171E-01	0.10105745E-02	-.42261552E-07	17	0.001753	
072 to 074	-.43002639E-01	0.10087385E-02	-.23044300E-07	15	0.000988	
075 to 083	-.46658731E-01	0.10068495E-02	0.30955746E-08	48	0.001327	
084 to 086	-.42416890E-01	0.10070047E-02	-.50938148E-09	15	0.000828	
087 to 089	-.31545437E-01	0.10082777E-02	-.19533903E-07	17	0.001211	
090 to 092	-.28704235E-01	0.10077391E-02	-.13458843E-07	17	0.000965	
093 to 094	-.49118959E-01	0.10094562E-02	-.23536990E-07	11	0.000925	
095 to 097	-.62152866E-01	0.10025474E-02	0.53099831E-07	14	0.001575	
098 to 101	-.14314088E-01	0.10047888E-02	0.12315666E-07	27	0.001345	
102 to 103	-.34956256E-01	0.10099761E-02	-.31950269E-07	22	0.001035	
104 to 105	-	-	-	-	-	
106 to 107	-.23593039E-01	0.10371770E-02	-.28856875E-06	11	0.001335	
108 to 109	-.19791365E-01	0.10130541E-02	-.63060262E-07	12	0.001446	
110 to 112	-.49023601E-01	0.10131578E-02	-.53759663E-07	15	0.003549	
113 to 129	-.40135147E-01	0.10069183E-02	-.85806002E-09	86	0.001647	
130 to 132	-.85296545E-02	0.10054166E-02	0.27726516E-08	14	0.001904	
133 to 134	-.25781684E-01	0.10052848E-02	0.71546988E-08	12	0.001136	
135 to 137	-.42318480E-01	0.10019220E-02	0.34902679E-07	12	0.002036	
138 to 140	-.14699730E-01	0.10035095E-02	0.14410654E-07	17	0.001514	
141 to 144	-.19358440E-01	0.10084928E-02	-.19248580E-07	24	0.001984	
145 to 148	-.28011470E-01	0.10051157E-02	0.68803976E-08	22	0.002432	
149 to 151	0.25657995E-01	0.10022988E-02	0.11828427E-07	14	0.002039	
152 to 153	-.45270083E-01	0.98897546E-03	0.11541208E-06	11	0.001242	
154 to 162	-.31067531E-01	0.10055354E-02	0.36686988E-10	51	0.001819	
163 to 167	-.34521659E-01	0.10018974E-02	0.23188345E-07	29	0.002383	
168 to 171	-.38682948E-01	0.10051592E-02	0.46065747E-08	19	0.001338	
172 to 174	-.38558169E-01	0.10161118E-02	-.58916707E-07	14	0.002094	
175 to 177	-.38509621E-01	0.10074843E-02	-.87849944E-08	14	0.000734	
178 to 180	-.55547340E-01	0.10069200E-02	-.19492192E-08	18	0.001820	
181 to 183	-.33533182E-01	0.99319718E-03	0.69701424E-07	16	0.001522	
184 to 188	-.30982703E-01	0.10032052E-02	0.14044956E-07	26	0.001601	
189 to 191	-.15491941E-01	0.99199340E-03	0.69487626E-07	16	0.002096	
192 to 195	-.28909825E-01	0.10034465E-02	0.11624303E-07	24	0.002599	
196 to 197	0.21113085E-01	0.99194842E-03	0.61703687E-07	12	0.003203	
198 to 201	-.28802603E-01	0.10147873E-02	-.44840249E-07	21	0.002606	
202 to 204	-.73871355E-01	0.10032132E-02	0.20954622E-07	68	0.001897	
205 to 208	-.10645228	0.10152894E-02	-.31595576E-07	78	0.001305	

<u>Table 1.10:</u> Station-dependent-corrected conductivity slope term ($F_2 + F_3 . N$), for station number N, and F_2 and F_3 the conductivity slope and station-dependent correction calibration terms respectively.

stn no.	($F_2 + F_3 . N$)	stn no.	($F_2 + F_3 . N$)	stn no.	($F_2 + F_3 . N$)	stn no.	($F_2 + F_3 . N$)
1	0.10106610E-02	53	0.10071026E-02	105	-	157	0.10055412E-02
2	0.10106599E-02	54	0.10070547E-02	106	0.10065887E-02	158	0.10055412E-02
3	0.10106587E-02	55	0.10070069E-02	107	0.10063001E-02	159	0.10055412E-02
4	0.10096808E-02	56	0.10069590E-02	108	0.10062436E-02	160	0.10055413E-02
5	0.10096579E-02	57	0.10070828E-02	109	0.10061805E-02	161	0.10055413E-02
6	0.10096351E-02	58	0.10070905E-02	110	0.10072443E-02	162	0.10055413E-02
7	0.10094098E-02	59	0.10070982E-02	111	0.10071905E-02	163	0.10056771E-02
8	0.10093977E-02	60	0.10071059E-02	112	0.10071368E-02	164	0.10057003E-02
9	0.10093856E-02	61	0.10071136E-02	113	0.10068213E-02	165	0.10057235E-02
10	0.10093735E-02	62	0.10068066E-02	114	0.10068205E-02	166	0.10057467E-02
11	0.10093613E-02	63	0.10068135E-02	115	0.10068196E-02	167	0.10057699E-02
12	0.10091499E-02	64	0.10068205E-02	116	0.10068188E-02	168	0.10059331E-02
13	0.10090936E-02	65	0.10068275E-02	117	0.10068179E-02	169	0.10059377E-02
14	0.10091001E-02	66	0.10068345E-02	118	0.10068170E-02	170	0.10059423E-02
15	0.10091087E-02	67	0.10068415E-02	119	0.10068162E-02	171	0.10059469E-02
16	0.10091173E-02	68	0.10068485E-02	120	0.10068153E-02	172	0.10059781E-02
17	0.10091259E-02	69	0.10076584E-02	121	0.10068145E-02	173	0.10059192E-02
18	0.10090393E-02	70	0.10076162E-02	122	0.10068136E-02	174	0.10058603E-02
19	0.10090451E-02	71	0.10075739E-02	123	0.10068127E-02	175	0.10059469E-02
20	0.10090510E-02	72	0.10070793E-02	124	0.10068119E-02	176	0.10059381E-02
21	0.10090568E-02	73	0.10070563E-02	125	0.10068110E-02	177	0.10059294E-02
22	0.10090626E-02	74	0.10070333E-02	126	0.10068102E-02	178	0.10065731E-02
23	0.10090684E-02	75	0.10070817E-02	127	0.10068093E-02	179	0.10065711E-02
24	0.10090743E-02	76	0.10070848E-02	128	0.10068085E-02	180	0.10065692E-02
25	0.10094260E-02	77	0.10070879E-02	129	0.10068076E-02	181	0.10058131E-02
26	0.10094244E-02	78	0.10070910E-02	130	0.10057770E-02	182	0.10058828E-02
27	0.10094854E-02	79	0.10070941E-02	131	0.10057798E-02	183	0.10059525E-02
28	0.10094846E-02	80	0.10070972E-02	132	0.10057826E-02	184	0.10057895E-02
29	0.10094839E-02	81	0.10071003E-02	133	0.10062364E-02	185	0.10058036E-02
30	0.94294928E-03	82	0.10071034E-02	134	0.10062436E-02	186	0.10058176E-02
31	0.94295584E-03	83	0.10071065E-02	135	0.10066339E-02	187	0.10058317E-02
32	0.94296239E-03	84	0.10069620E-02	136	0.10066688E-02	188	0.10058457E-02
33	0.94292453E-03	85	0.10069614E-02	137	0.10067037E-02	189	0.10051266E-02
34	0.94292798E-03	86	0.10069609E-02	138	0.10054981E-02	190	0.10051960E-02
35	0.94293142E-03	87	0.10065783E-02	139	0.10055126E-02	191	0.10052655E-02
36	0.94293486E-03	88	0.10065588E-02	140	0.10055270E-02	192	0.10056784E-02
37	0.94293830E-03	89	0.10065392E-02	141	0.10057787E-02	193	0.10056900E-02
38	0.94296287E-03	90	0.10065278E-02	142	0.10057595E-02	194	0.10057016E-02
39	0.94296574E-03	91	0.10065143E-02	143	0.10057402E-02	195	0.10057133E-02
40	0.94296861E-03	92	0.10065008E-02	144	0.10057210E-02	196	0.10040423E-02
41	0.94297148E-03	93	0.10072673E-02	145	0.10061134E-02	197	0.10041040E-02
42	-	94	0.10072437E-02	146	0.10061203E-02	198	0.10059090E-02
43	-	95	0.10075919E-02	147	0.10061271E-02	199	0.10058641E-02
44	-	96	0.10076450E-02	148	0.10061340E-02	200	0.10058193E-02
45	0.10072833E-02	97	0.10076981E-02	149	0.10040612E-02	201	0.10057744E-02
46	0.10072658E-02	98	0.10059957E-02	150	0.10040730E-02	202	0.10074460E-02
47	0.10072483E-02	99	0.10060080E-02	151	0.10040849E-02	203	0.10074670E-02
48	0.10074613E-02	100	0.10060203E-02	152	0.10065181E-02	204	0.10074879E-02
49	0.10074612E-02	101	0.10060327E-02	153	0.10066335E-02	205	0.10088123E-02
50	0.10074611E-02	102	0.10067172E-02	154	0.10055411E-02	206	0.10087808E-02
51	0.10072870E-02	103	0.10066853E-02	155	0.10055411E-02	207	0.10087492E-02
52	0.10073019E-02	104	-	156	0.10055411E-02	208	0.10087176E-02

Table 1.11: **CTD raw data scans, mostly in the vicinity of artificial density inversions, flagged for special treatment. Note that the pressure listed is approximate only; possible actions taken are either to ignore the raw data scans for all further calculations, or to apply a linear interpolation over the region of the bad data scans. Causes of bad data, listed in the last column, are detailed in the CTD methodology. For the raw scan number ranges, the lowest and highest scan numbers are not included in the ignore or interpolate actions.**

station number	approximate pressure (dbar)	raw scan numbers	action taken	reason
11	829	48358-48395	ignore	fouling of cond. cell
16	612	47637-47757	ignore	fouling of cond. cell
19	1850	75468-75585	ignore	fouling of cond. cell
23	206	16580-16738	ignore	wake effect
27	3030	126764-126858	ignore	fouling of cond. cell
49	234	21892-21901	ignore	fouling of cond. cell
68	458	19625-19640	ignore	fouling of cond. cell
81	20	43646-43867	ignore	fouling of cond. cell
100	12	33403-33449	ignore	fouling of cond. cell
204	186	13007-13104	ignore	wake effect
208	2468	100929-100979	ignore	fouling of cond. cell

Table 1.12: **Missing data points in 2 dbar-averaged files. "1" indicates missing data for the indicated parameters: T=temperature; S=salinity, σ_T, specific volume anomaly and geopotential anomaly; O=dissolved oxygen; PAR=photosynthetically active radiation; F=fluorescence. Note that jmin is the minimum number of data points required in a 2 dbar bin to form the 2 dbar average (see CTD methodology).**

station number	pressures (dbar) where data missing	T	S	O	PAR	F	reason
7	1202	1	1		1		no. of data pts in 2 dbar bin < jmin
16	612	1	1		1		fouling of cond. cell
16	804	1	1		1		no. of data pts in 2 dbar bin < jmin
22	2-26	1	1		1		CTD data logging started at 27 dbar
30	2022, 2844	1	1		1		no. of data pts in 2 dbar bin < jmin
30	2-68			1			bad oxygen data
31	entire profile			1			no bottle data for calibration
32	310	1	1		1		no. of data pts in 2 dbar bin < jmin
33	3638	1	1		1		no. of data pts in 2 dbar bin < jmin
34	322	1	1		1		no. of data pts in 2 dbar bin < jmin
35	14-48			1			bad oxygen data
36	2-26			1			bad oxygen data
37	2324,2686,2974,4182	1	1		1		no. of data pts in 2 dbar bin < jmin
37	2-22,76			1			bad oxygen data
38	2-28			1			bad oxygen data
39	130, 1934	1	1		1		no. of data pts in 2 dbar bin < jmin
39	12-28			1			bad oxygen data
40	244	1	1		1		no. of data pts in 2 dbar bin < jmin
40	18-34			1			bad oxygen data
41	10-28			1			bad oxygen data
42-44	entire profile		1	1			bad conductivity data
43	4466	1	1		1		no. of data pts in 2 dbar bin < jmin
104	entire profile	1	1	1			data not used
105	entire profile	1	1	1			data not used
206	672	1	1				no. of data pts in 2 dbar bin < jmin
1-29	entire profile			1			faulty oxygen sensor hardware
45-103	entire profile			1			faulty oxygen sensor hardware
106-208	entire profile			1			faulty oxygen sensor hardware
51-208	entire profile				1		PAR sensor not installed
5-208	entire profile					1	fluorometer not installed

Table 1.13: **2 dbar averages interpolated from surrounding 2 dbar values, for the indicated paramaters: T=temperature; S=salinity, σ_T, specific volume anomaly and geopotential anomaly; O=dissolved oxygen; PAR=photosynthetically active radiation.**

station number	interpolated 2 dbar values	parameters interpolated
19	1782, 1850	T, S, PAR
27	3032	T, S, PAR
30	560,608,1122	T, S, PAR
31	3076	T, S, PAR
32	300,440,882,902,2260,2454,3064	T, S, PAR
33	666,856,900	T, S, PAR
34	544	T, S, PAR
35	1466,2072,2960	T, S, PAR
36	1672, 4048	T, S, PAR
37	570,1774,2164	T, S, PAR
38	1428	T, S, PAR
39	948,1380,1526,1566	T, S, PAR
40	676,1926,3196	T, S, PAR
41	4036	T, S, PAR
81	18, 20	T, S
204	2042	T, S
205	1784	T, S

Table 1.14a: **Suspect 2 dbar averages. Note: for suspect salinity values, the following are also suspect: σ_T, specific volume anomaly, and geopotential anomaly.**

station number	suspect 2 dbar values (dbar) bad	questionable	reason
Suspect salinity values			
2	142	-	salinity spike due to wake effect
13	-	304	salinity spike in steep local gradient
14	-	328-330	salinity spike in steep local gradient
16	-	386-388	salinity spike in steep local gradient
19	-	266-268	salinity spike in steep local gradient

Table 1.14b: **Suspect 2 dbar-averaged data from near the surface (applies to all parameters other than dissolved oxygen, except where noted).**

stn no.	suspect 2dbar values(dbar) bad	questionable	comment	stn no.	suspect 2dbar values(dbar) bad	questionable	comment
1	2,4	-	-	48-49	2,4,6	-	-
2	2	-	-	50-52	2,4	-	-
3-7	2,4	-	-	72	-	2	temperature ok
8	2,4,6	-	-	84	-	2	temperature ok
9-12	2,4	-	-	85	-	6	temperature ok
13	2	-	-	100	6-12	-	temperature ok
14-15	2,4	-	-	115	-	2,4	temperature ok
16-19	2	-	-	116	-	2	temperature ok
20	2,4	-	-	123	-	2,4,8	temperature ok
21	2	-	-	153	-	18	temperature ok
23	2,4,6	-	-	172	-	10	temperature ok
24	2,4	-	-	200	-	2	temperature ok
25	2	-	-	201	-	2	temperature ok
26	2,4	-	-	202	2	4	-
27-28	2	-	-	203	2,4	6,8	-
29	2,4	-	-	204	2	4	-
45	2,4,6	-	-	205	2	-	-
46-47	2,4	-	-	206-207	2	4	-

Table 1.15: **Suspect 2 dbar-averaged dissolved oxygen data.**

stn no.	suspect 2dbar values(dbar) bad	questionable
32	-	2, 14-28
34	-	2-22
38	-	3906-4044

Table 1.16: **CTD dissolved oxygen calibration coefficients. K_1, K_2, K_3, K_4, K_5 and K_6 are respectively oxygen current slope, oxygen sensor time constant, oxygen current bias, temperature correction term, weighting factor, and pressure correction term. dox is equal to 2.8σ (for σ as defined by eqn A2.24 in the CTD methodology); n is the number of samples retained for calibration in each station or station grouping.**

station number	K_1	K_2	K_3	K_4	K_5	K_6	dox	n
30	12.057	5.0000	-1.570	-0.16340	0.67515	0.16214E-03	0.15525	22
32	13.933	5.0000	-1.999	-0.19355	0.78517	0.93553E-04	0.24321	24
33	10.938	5.0000	-1.510	-0.14316	0.12891	0.33452E-04	0.21989	24
34	13.713	5.0000	-2.051	-0.14829	0.91995	0.11928E-03	0.34838	24
35	14.503	5.0000	-1.990	-0.24202	0.69512	0.74484E-04	0.24419	24
36	24.416	5.0000	-3.394	-0.42081	0.81637	0.75967E-04	0.28902	20
37	12.645	5.0000	-1.703	-0.20725	0.56959	0.58486E-04	0.25036	24
38	12.389	5.0000	-1.872	-0.11335	0.60504	0.11011E-03	0.19553	23
39	12.977	8.0000	-1.700	-0.23495	0.69338	0.64992E-04	0.13824	22
40	16.556	5.0000	-2.359	-0.26428	0.82111	0.92212E-04	0.16173	22
41	12.979	5.0000	-1.746	-0.21918	0.71336	0.97135E-04	0.18931	23

Table 1.17: **Starting values for CTD dissolved oxygen calibration coefficients prior to iteration, and coefficients varied during iteration (see CTD methodology). Note that coefficients not varied during iteration are held constant at the starting value.**

station number	K_1	K_2	K_3	K_4	K_5	K_6	coefficients varied
30	12.0500	5.0000	-1.300	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
32	11.5000	5.0000	-1.440	-0.500E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
33	11.6000	5.0000	-1.600	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
34	12.4000	5.0000	-1.450	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
35	12.7000	5.0000	-1.650	-0.400E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
36	10.8000	5.0000	-0.400	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
37	12.7500	5.0000	-1.650	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
38	12.6500	5.0000	-1.700	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
39	12.4300	8.0000	-1.650	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
40	14.1000	5.0000	-1.650	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
41	12.6000	5.0000	-1.650	-0.500E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6

Table 1.18: **Dissolved oxygen Niskin bottle samples flagged as -9 for dissolved oxygen calibration. Note that this does not necessarily indicate a bad bottle sample - in many cases, flagging is due to bad CTD dissolved oxygen data.**

station number	rosette position
30	24,23
36	23,19,18,17
38	24
39	20
40	23,20
41	21

Table 1.19: Questionable nutrient sample values (not deleted from hydrology data file).

PHOSPHATE		NITRATE		SILICATE	
station number	rosette position	station number	rosette position	station number	rosette position
5	13	5	13		
8	1,2				
9	1,5,7	9	1,5,7		
27	11,13				
29	2,17	29	2,17	29	2
		44	13		
45	whole stn				
46	whole stn				

Table 1.20: Stations containing fluorescence (fl) and photosynthetically active radiation (par) 2 dbar-averaged data.

stations with fl data	stations with par data
1 to 4	1 to 50

Table 1.21: Protected and unprotected reversing thermometers used (serial numbers are listed).

protected thermometers

station numbers	rosette position 24 thermometers	rosette position 12 thermometers	rosette position 2 thermometers
1 to 52	12095,12096	12094	12119,12120
53 to 100	-	-	12119,12120
101-105	-	12095,12096	12119,12120
100 to 128	-	-	12119,12120
129 to 201	-	-	12119,12094
202 to 208	12095,12096	12094	12119,12120

unprotected thermometers

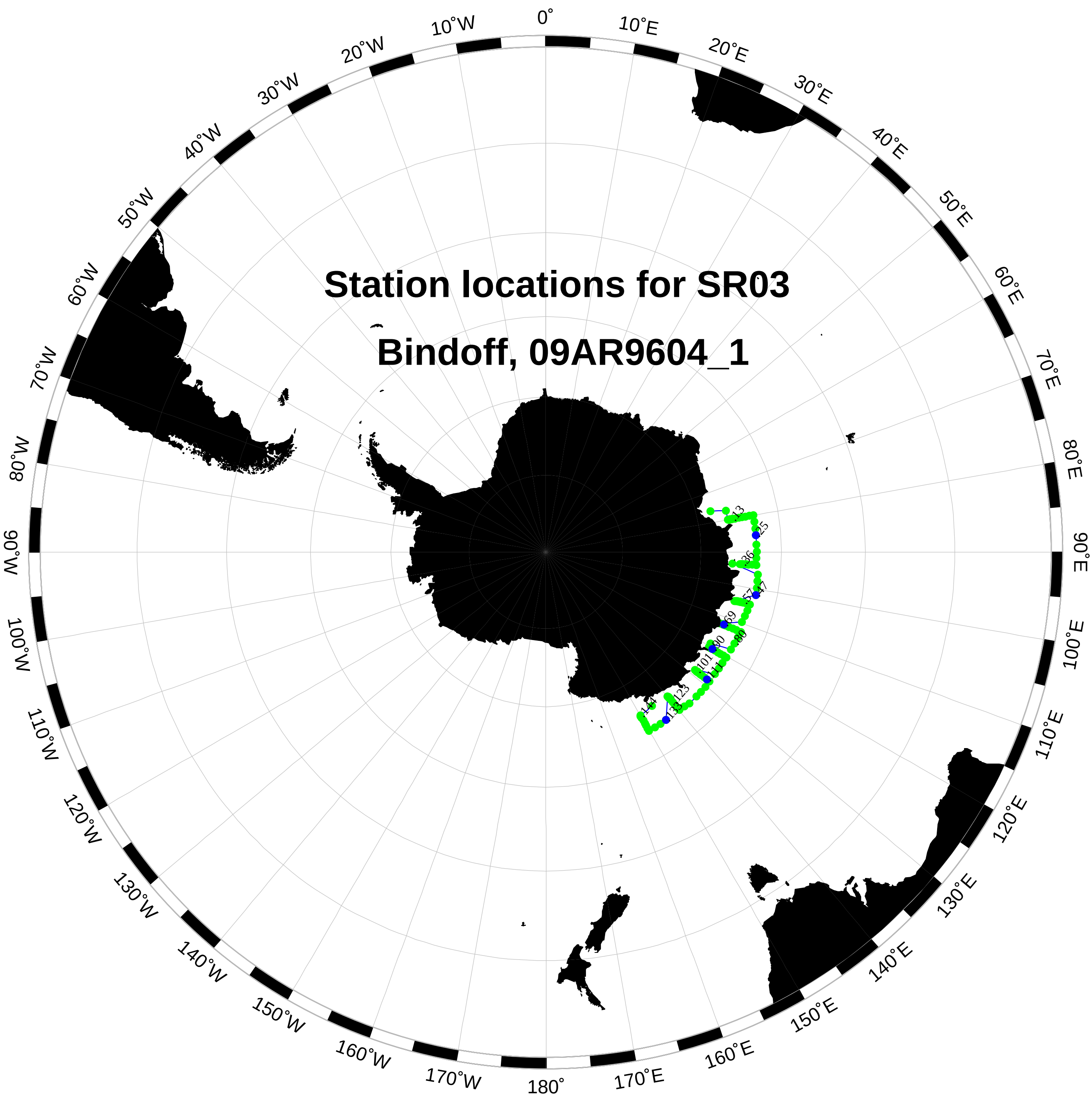
station numbers	rosette position 12 thermometers	rosette position 2 thermometers
1 to 52	11992	11993
53 to 100	-	11993
101-105	-	11993
100 to 128	-	11993
129 to 201	-	11993
202 to 208	11992	11993

Table 1.22: Calibration coefficients and calibration dates for CTD serial numbers 1103 and 1193 (unit nos 7 and 5 respectively) used during RSV Aurora Australis cruise AU9501. Note that an additional pressure bias term due to the station dependent surface pressure offset exists for each station (eqn A2.1 in the CTD methodology). Also note that platinum temperature calibrations are for the ITS-90 scale.

CTD serial 1103 (unit no. 7)		CTD serial 1193 (unit no. 5)	
coefficient	value of coefficient	coefficient	value of coefficient
pressure calibration coefficients		*pressure calibration coefficients*	
CSIRO Calibration Facility - 08/11/1995		*CSIRO Calibration Facility - 09/11/1995*	
pcal0	-2.065725e+01	pcal0	-8.810839
pcal1	1.002878e-01	pcal1	1.007713e-01
pcal2	4.951104e-09	pcal2	1.985674e-09
pcal3	4.500981e-14	pcal3	-1.521121e-14
pcal4	-4.514384e-19	pcal4	0.0
platinum temperature calibration coefficients		*platinum temperature calibration coefficients*	
CSIRO Calibration Facility - 26/09/1995		*CSIRO Calibration Facility - 26/09/1995*	
Tcal0	0.23396e-01	Tcal0	-0.20560e-01
Tcal1	0.49983e-03	Tcal1	0.49936e-03
Tcal2	0.35049e-11	Tcal2	0.27541e-11
pressure temperature calibration coefficients		*pressure temperature calibration coefficients*	
CSIRO Calibration Facility - 08/11/1995		*CSIRO Calibration Facility - 09/11/1995*	
Tpcal0	1.695615e+02	Tpcal0	1.167581e+02
Tpcal1	-3.240390e-03	Tpcal1	-2.450758e-03
Tpcal2	0.0	Tpcal2	0.0
Tpcal3	0.0	Tpcal3	0.0
coefficients for temperature correction to pressure		*coefficients for temperature correction to pressure*	
CSIRO Calibration Facility - 08/11/1995		*CSIRO Calibration Facility - 09/11/1995*	
T_0	20.00	T_0	20.00
S_1	-1.319844e-05	S_1	-1.474830e-05
S_2	-3.465273e-02	S_2	-7.847037e-02

preliminary polynomial coefficients applied to fluorescence (fl) (Antarctic Division, January 1996) and photosynthetically active radiation (par) (supplied by manufacturer) raw digitiser counts

f0	-1.115084e+01
f1	3.402400e-04
f2	0.0
par0	-4.499860
par1	1.373290e-04
par2	-3.452156e-23


Station locations for SR03
Bindoff, 09AR9604_1
0°
10°E
20°E
30°E
40°E
50°E
60°E
70°E
80°E
90°E
100°E
110°E
120°E
130°E
140°E
150°E
160°E
170°E
180°
170°W
160°W
150°W
140°W
130°W
120°W
110°W
100°W
90°W
80°W
70°W
60°W
50°W
40°W
30°W
20°W
10°W
13
25
36
47
57
69
80
90
101
111
123
133
144

Part 2
Aurora Australis Marine Science Cruise AU9604 - Oceanographic Field Measurements and Analysis

ABSTRACT

Oceanographic measurements were conducted along a series of meridional and zonal sections along the Antarctic continental shelf and slope region between 80 and 150°E, from January to March 1996. A total of 147 CTD vertical profile stations were taken, most to near bottom. Over 2450 Niskin bottle water samples were collected for the measurement of salinity, dissolved oxygen, nutrients, chlorofluorocarbons, oxygen 18, primary productivity, and biological parameters, using a 24 bottle rosette sampler. Near surface current data were collected using a ship mounted ADCP. Measurement and data processing techniques are summarised, and a summary of the data is presented in graphical and tabular form.

2.1 INTRODUCTION

Marine science cruise AU9604, the fifth oceanographic cruise of the Cooperative Research Centre for the Antarctic and Southern Ocean Environment (Antarctic CRC), was conducted aboard the Australian Antarctic Division vessel RSV Aurora Australis from January to March 1996. The major constituent of the cruise was a joint oceanographic and biological survey along the continental shelf and slope region of Antarctica between 80 and 150°E (Figure 2.1). The primary objectives of the oceanographic survey, named MARGINEX (Antarctic Margin Experiment), were:

1. to estimate the rate of formation of surface and Antarctic Bottom Water masses;

2. to define the evolution and modification of Antarctic water masses along the shelf and slope in the experimental region;

3. to estimate the relative importance of air-sea interaction and advection of surface and deep waters on property changes in the major water masses.

The biology program comprised of a hydroacoustic survey of krill population in the region, to enable setting of catch limits (principal investigator Steve Nicol, Australian Antarctic Division). The linked oceanography-biology objective was to determine the relationship between the distribution and production of marine biota and the physical and biogeochemical conditions along the Antarctic shelf break.

Two bottom-mounted pressure recorders (principal investigators Tom Whitworth, University of Texas A&M, and Dale Pillsbury, Oregon State University) were successfully recovered from the northern and southern ends of the WOCE SR3 meridional section. A current meter mooring (principal investigator Ted Foster, University of Delaware) was also recovered from the eastern end of the MARGINEX study region. Two upward looking sonar moorings (principal investigator Ian Allison, Australian Antarctic Division) were deployed in the vicinity of Davis (Figure 2.1). Eight drifting buoys were also deployed throughout the voyage.

This report describes the collection of oceanographic data from MARGINEX, and summarises the chemical analysis and data processing methods employed. All information required for use of the data set is presented in tabular and graphical form.

2.2 CRUISE ITINERARY

In early January 1996, prior to the cruise proper, marine trials were conducted from the Aurora Australis at Port Arthur, and south of Maatsuyker Island. A shallow CTD cast was taken at Port Arthur for calibration of the hydroacoustic equipment, and a deep cast was taken south of Tasmania for testing of CTD instrumentation. At the northern end of the SR3 section, an unsuccessful attempt was made to recover the pressure recorder mooring designated Hobart91b (Table 2.4). The pressure recorder mooring designated Hobart94 was successfully recovered from the same approximate location, and the mooring Hobart96 was deployed as a replacement.

The first CTD cast on the cruise proper was taken en route to Davis, to test CTD equipment and measure Niskin bottle CFC blank levels. Following cargo operations at Davis, the two upward looking sonar moorings were deployed, with a CTD cast taken at both mooring locations. CTD legs 1 and 4 were completed, with leg 4 finishing at station 42 near the edge of the Shackleton Ice Shelf. A speculative CTD cast was taken at station 43 to investigate possible ice crystal formation in water flowing over a sill (T. Pauly, pers. comm.). CTD legs 6 and 7 were then completed. After leg 7, a search was made of the old ULS mooring site SONEAR (Bush, 1994). Note that this was the third and final search for SONEAR. The mooring could not be located, so the ship proceeded to Casey for cargo operations.

At Casey, a shallow CTD cast (station 65) was taken for calibration of the hydroacoustic equipment in cold water. After Casey, the remaining CTD legs 9, 11, 13, 16 and 18 were completed. Leg 16 was interrupted briefly for pressure recorder mooring work: the mooring Dumont94 was successfully recovered, and the mooring Dumont96 was deployed as a replacement (Table 2.4).

Note that the southern end of all the meridional CTD sections were closed on the shelf or at the shelf break, with the exception of leg 18 - this leg had to be terminated early at a depth of ~2100 m on the continental slope, due to thickening sea ice conditions.

After completion of MARGINEX, grappling operations commenced to attempt recovery of 3 current meter moorings (Table 2.4). The mooring CM2 was recovered, and a CTD cast (station 145) was taken at the mooring location. Moorings CM1 and CM3 were not found. Two final shallow CTD casts were taken to attempt to sample shuga ice for biological analysis. The ship then proceeded to Macquarie Island for cargo operations, then returned to Hobart.

Table 2.1: Summary of cruise itinerary.

Expedition Designation
Cruise AU9604 (cruise acronym BROKE), encompassing MARGINEX

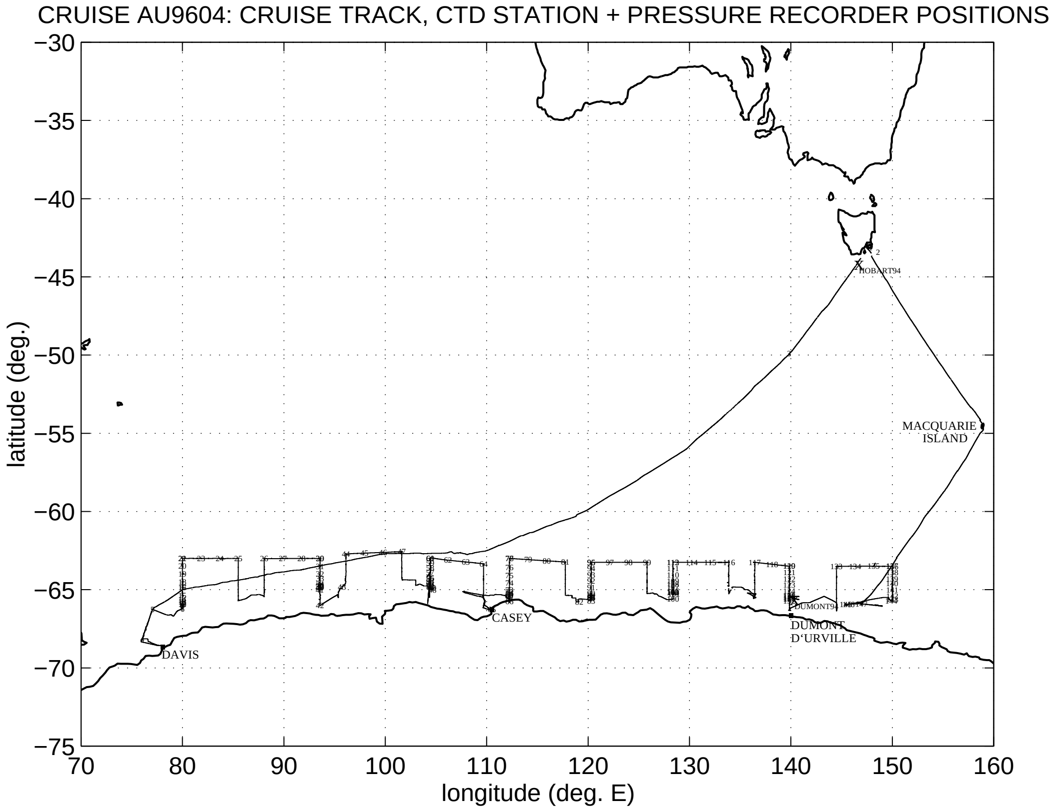
Chief Scientists
Nathan Bindoff, Antarctic CRC
Steve Nicol, Antarctic Division

Ship
RSV Aurora Australis

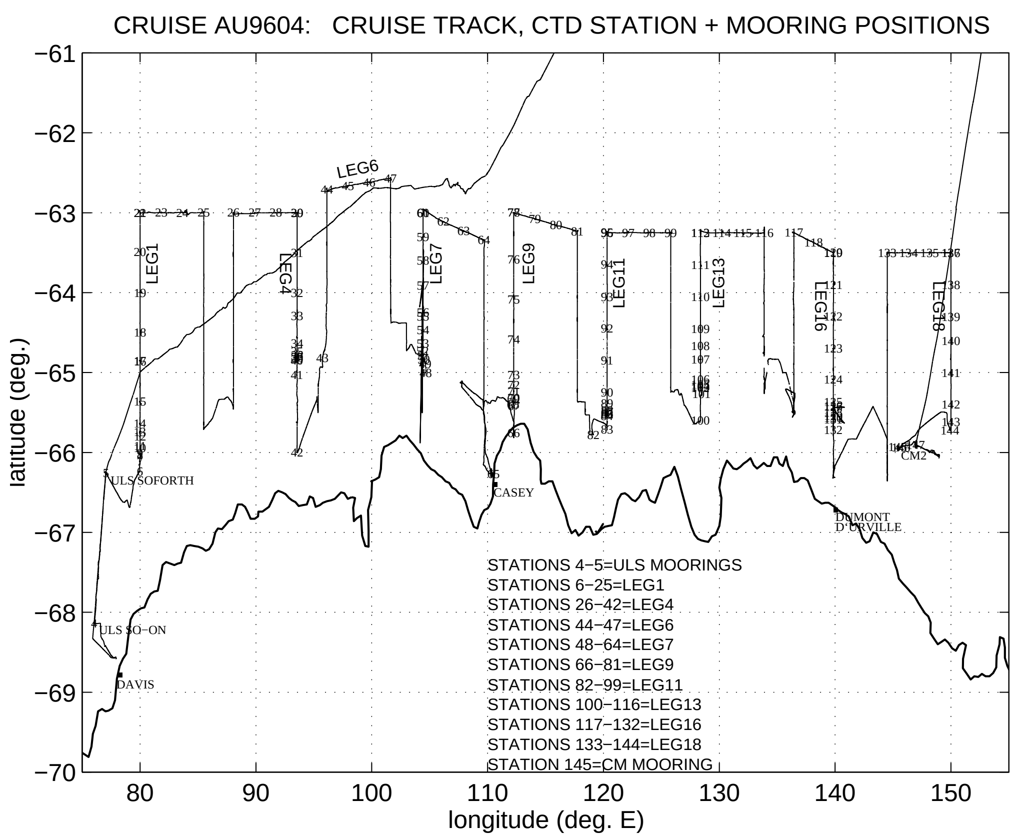
Ports of Call
Davis
Casey
Macquarie Island

Cruise Dates
January 19 to March 31 1996

(a)



(b)



<u>Figure 2.1a and b:</u> Cruise track, CTD station and mooring positions for RSV Aurora Australis cruise AU9604. Note that positions for pressure recorders are for recovered moorings only.

2.3 CRUISE SUMMARY

2.3.1 CTD casts and water samples

In the course of the cruise, 147 CTD casts were completed, 138 of which were along the MARGINEX study region (Figures 2.1a and b), with most casts reaching to within 20 m of the sea floor (Table 2.2). 8 meridional CTD sections and 9 shorter approximately zonal CTD sections were completed, providing closure for 7 different study areas (Figure 2.1b). Over 2450 Niskin bottle water samples were collected for the measurement of salinity, dissolved oxygen, nutrients (orthophosphate, nitrate plus nitrite, and reactive silicate), chlorofluorocarbons, oxygen 18, primary productivity, and biological parameters, using a 24 bottle rosette sampler. Table 2.3 provides a summary of samples drawn at each station. Principal investigators for the various water sampling programmes are listed in Table 2.6a. For all stations, the different samples were drawn in a fixed sequence (see previous data reports).

Table 2.2 (following 5 pages): Summary of station information for RSV Aurora Australis cruise AU9604. The information shown includes time, date, position and ocean depth for the start of the cast, at the bottom of the cast, and for the end of the cast. The maximum pressure reached for each cast, and the altimeter reading at the bottom of each cast (i.e. elevation above the sea bed) are also included. Missing ocean depth values are due to noise from the ship's bow thrusters interfering with the echo sounder. For casts which do not reach to within 100 m of the bed (i.e. the altimeter range), or for which the altimeter was not functioning, there is no altimeter value. For station names, LEGx is the MARGINEX CTD leg number (Figure 2.1b), TEST is a test cast, CAL is a cast for calibration of the hydroacoustic equipment, ULS is an upward looking sonar mooring site, CM is a current meter mooring site, and BIO is a speculative dip for biological analyses. Note that all times are UTC (i.e. GMT). CTD unit 7 (serial no. 1103) was used for stations 3 to 144; CTD unit 5 (serial no. 1193) was used for stations 1 to 2, and 145 to 147.

station			START			maxP		BOTTOM					END		
number	time	date	latitude	longitude	depth(m)	(dbar)	time	latitude	longitude	depth(m)	altimeter	time	latitude	longitude	depth(m)
1 CAL	0604	5-JAN-96	43:08.34S	147:52.26E	27	26	0610	43:08.34S	147:52.26E	-	8.1	0619	43:08.34S	147:52.26E	-
2 TEST	1436	5-JAN-96	43:26.20S	148:35.20E	3635	3552	1605	43:27.10S	148:34.75E	-	21.9	1711	43:28.00S	148:34.23E	3604
3 TEST	2112	20-JAN-96	49:54.55S	139:49.87E	3737	3924	2252	49:55.30S	139:50.70E	-	32.9	0006	49:55.74S	139:51.17E	-
4 ULS	2002	28-JAN-96	68:08.32S	76:02.67E	484	472	2014	68:08.38S	76:02.51E	479	12.6	2037	68:08.43S	76:01.96E	483
5 ULS	1059	29-JAN-96	66:15.50S	77:03.37E	2918	404	1118	66:15.51S	77:03.40E	-	-	1137	66:15.51S	77:03.41E	-
6 LEG1	0331	30-JAN-96	66:14.12S	80:00.21E	396	382	0400	66:14.21S	79:59.71E	-	9.5	0444	66:14.33S	79:58.92E	398
7 LEG1	0624	30-JAN-96	66:06.79S	79:59.50E	644	624	0653	66:06.89S	79:58.81E	638	9.7	0737	66:06.87S	79:57.87E	638
8 LEG1	1024	30-JAN-96	66:01.90S	79:59.94E	890	874	1058	66:01.98S	80:00.29E	870	2.5	1147	66:01.86S	80:00.16E	900
9 LEG1	1316	30-JAN-96	66:00.86S	79:59.92E	1208	1206	1407	66:00.60S	79:59.82E	1249	14.7	1516	66:00.25S	79:58.89E	1229
10 LEG1	1640	30-JAN-96	65:56.72S	79:59.60E	1668	1656	1731	65:56.69S	79:59.73E	-	11.2	1838	65:56.72S	79:59.11E	-
11 LEG1	2018	30-JAN-96	65:55.24S	80:00.29E	2099	2046	2115	65:55.26S	80:00.34E	2089	8.7	2232	65:55.33S	80:00.10E	-
12 LEG1	0000	31-JAN-96	65:47.99S	80:00.09E	2457	2522	0108	65:47.99S	79:59.64E	-	10.5	0229	65:48.29S	79:59.29E	2457
13 LEG1	0534	31-JAN-96	65:44.55S	79:59.65E	2866	2782	0701	65:44.74S	79:57.14E	2816	14.7	0841	65:45.34S	79:57.48E	-
14 LEG1	1153	31-JAN-96	65:38.11S	79:58.89E	3174	3144	1319	65:38.52S	79:58.60E	-	24.5	1436	65:39.05S	79:58.41E	-
15 LEG1	1701	31-JAN-96	65:21.56S	79:59.92E	3384	3396	1829	65:21.81S	79:58.52E	-	13.8	1958	65:21.99S	79:57.64E	-
16 LEG1	0255	1-FEB-96	64:51.51S	80:00.14E	3634	168	0309	64:51.45S	79:59.86E	-	-	0329	64:51.36S	79:59.62E	-
17 LEG1	0359	1-FEB-96	64:51.36S	79:59.68E	3634	3640	0526	64:51.10S	79:58.72E	-	20.4	0703	64:50.88S	79:57.35E	-
18 LEG1	1124	1-FEB-96	64:29.91S	79:59.89E	3634	3668	1303	64:29.12S	80:00.52E	-	15.0	1422	64:28.86S	80:00.75E	-
19 LEG1	1852	1-FEB-96	64:00.00S	79:59.82E	3686	3706	2020	63:59.68S	79:59.42E	-	18.3	2157	63:59.22S	79:59.40E	-
20 LEG1	0317	2-FEB-96	63:29.26S	79:59.21E	3737	3756	0447	63:29.22S	79:58.85E	-	13.2	0637	63:29.35S	79:58.61E	-
21 LEG1	1121	2-FEB-96	63:00.08S	80:00.01E	3583	166	1127	63:00.16S	80:00.18E	-	-	1146	63:00.09S	80:00.09E	-
22 LEG1	1226	2-FEB-96	63:00.13S	79:59.83E	3583	3574	1347	63:00.37S	79:59.83E	-	12.0	1508	63:00.79S	80:00.58E	-
23 LEG1	2159	2-FEB-96	62:59.97S	81:50.12E	2866	2862	2304	62:59.76S	81:49.48E	-	15.1	0023	62:59.42S	81:49.30E	-
24 LEG1	0526	3-FEB-96	62:59.98S	83:39.99E	2508	2490	0628	62:59.78S	83:40.09E	-	14.4	0754	62:59.65S	83:39.98E	-
25 LEG1	1531	3-FEB-96	62:59.92S	85:30.09E	3757	3784	1705	62:59.52S	85:30.42E	-	14.5	1901	62:58.98S	85:29.65E	3757
26 LEG4	2009	5-FEB-96	62:59.87S	88:03.66E	3788	3800	2137	63:00.64S	88:02.91E	-	13.7	2306	63:01.20S	88:02.52E	3840
27 LEG4	0318	6-FEB-96	62:59.92S	89:54.00E	3931	4008	0457	63:00.26S	89:53.45E	-	17.1	0647	63:00.63S	89:52.68E	4044
28 LEG4	1114	6-FEB-96	62:59.86S	91:43.78E	4095	3714	1247	63:00.04S	91:44.01E	-	13.9	1425	62:59.82S	91:43.32E	-
29 LEG4	1909	6-FEB-96	63:00.01S	93:34.02E	3327	170	1917	63:00.00S	93:33.83E	-	-	1933	62:59.98S	93:33.43E	-
30 LEG4	2010	6-FEB-96	62:59.98S	93:33.81E	3327	3318	2134	63:00.34S	93:32.97E	-	14.1	2305	63:00.23S	93:31.72E	3327
31 LEG4	0327	7-FEB-96	63:30.10S	93:33.70E	3194	3182	0436	63:30.16S	93:34.06E	-	14.3	0604	63:30.25S	93:33.00E	-
32 LEG4	1103	7-FEB-96	64:00.01S	93:33.79E	3297	3262	1218	64:00.07S	93:33.86E	-	10.9	1350	64:00.30S	93:33.61E	-
33 LEG4	1645	7-FEB-96	64:17.45S	93:33.59E	3051	3034	1804	64:17.82S	93:34.18E	3051	15.3	1941	64:17.98S	93:33.30E	-
34 LEG4	0058	8-FEB-96	64:38.25S	93:33.84E	2651	2638	0159	64:38.16S	93:33.78E	2651	13.0	0317	64:37.96S	93:33.16E	2651
35 LEG4	0435	8-FEB-96	64:43.97S	93:33.81E	2260	2252	0537	64:43.93S	93:32.61E	-	14.0	0655	64:44.03S	93:31.82E	2268
36 LEG4	0812	8-FEB-96	64:46.98S	93:33.22E	1791	1730	0905	64:47.22S	93:32.90E	1730	14.4	1006	64:47.54S	93:31.79E	1669

station	START					maxP	BOTTOM					END			
number	time	date	latitude	longitude	depth(m)	(dbar)	time	latitude	longitude	depth(m)	altimeter	time	latitude	longitude	depth(m)
37 LEG4	1137	8-FEB-96	64:48.06S	93:33.22E	1492	1440	1227	64:48.44S	93:31.62E	1413	17.9	1320	64:48.98S	93:30.22E	-
38 LEG4	1427	8-FEB-96	64:48.75S	93:33.40E	1278	1210	1506	64:49.20S	93:32.41E	1229	11.5	1545	64:49.73S	93:31.74E	-
39 LEG4	1651	8-FEB-96	64:50.05S	93:32.25E	925	888	1728	64:50.43S	93:30.77E	870	6.6	1815	64:50.91S	93:28.89E	772
40 LEG4	2027	8-FEB-96	64:51.05S	93:32.73E	593	522	2059	64:51.34S	93:32.08E	532	14.3	2136	64:51.59S	93:31.30E	512
41 LEG4	0109	9-FEB-96	65:01.62S	93:32.63E	467	450	0128	65:01.62S	93:32.32E	463	13.6	0156	65:01.71S	93:31.90E	463
42 LEG4	1210	9-FEB-96	66:00.04S	93:33.62E	1228	1198	1253	65:59.88S	93:32.80E	1228	13.6	1341	65:59.85S	93:32.06E	1228
43 CAL	0454	10-FEB-96	64:48.96S	95:44.40E	108	100	0458	64:48.97S	95:44.45E	-	13.4	0509	64:48.93S	95:44.20E	112
44 LEG6	0026	11-FEB-96	62:42.58S	96:07.38E	3583	3622	0142	62:42.13S	96:07.42E	3614	14.4	0304	62:41.68S	96:07.15E	3635
45 LEG6	0823	11-FEB-96	62:39.84S	97:56.92E	3839	3886	0955	62:40.34S	97:55.12E	-	17.2	1118	62:40.83S	97:53.93E	-
46 LEG6	1623	11-FEB-96	62:37.06S	99:47.17E	4095	4124	1805	62:37.32S	99:47.70E	4095	13.2	2000	62:37.45S	99:48.79E	4095
47 LEG6	0021	12-FEB-96	62:34.16S	101:37.59E	4761	4244	0150	62:33.61S	101:37.62E	4761	16.2	0353	62:33.70S	101:36.99E	4761
48 LEG7	0841	13-FEB-96	65:00.15S	104:39.62E	356	344	0857	65:00.19S	104:39.90E	-	11.4	0926	65:00.31S	104:39.71E	359
49 LEG7	1102	13-FEB-96	64:53.41S	104:37.66E	630	618	1125	64:53.38S	104:37.53E	635	15.8	1159	64:53.35S	104:37.23E	644
50 LEG7	1256	13-FEB-96	64:50.03S	104:29.44E	955	942	1328	64:49.91S	104:29.16E	955	14.2	1405	64:49.74S	104:28.92E	981
51 LEG7	1608	13-FEB-96	64:47.13S	104:27.18E	1251	1238	1658	64:46.89S	104:26.63E	1251	14.1	1759	64:46.62S	104:25.98E	1254
52 LEG7	1924	13-FEB-96	64:43.78S	104:24.01E	1561	1556	2017	64:43.66S	104:23.76E	1561	13.9	2112	64:43.59S	104:23.76E	1575
53 LEG7	2229	13-FEB-96	64:38.27S	104:25.09E	1817	1786	2315	64:38.24S	104:24.51E	1761	15.0	0015	64:38.16S	104:23.74E	1704
54 LEG7	0241	14-FEB-96	64:27.87S	104:26.01E	2129	2114	0334	64:27.83S	104:25.60E	2109	15.6	0452	64:28.00S	104:24.45E	2048
55 LEG7	0729	14-FEB-96	64:17.68S	104:25.51E	2570	2572	0835	64:17.62S	104:25.69E	-	14.4	0953	64:17.68S	104:25.29E	2549
56 LEG7	1106	14-FEB-96	64:15.02S	104:25.76E	2774	2806	1217	64:14.53S	104:26.20E	-	18.7	1349	64:13.68S	104:26.68E	-
57 LEG7	1926	14-FEB-96	63:54.68S	104:26.00E	3337	3334	2053	63:54.49S	104:25.53E	3327	14.3	2221	63:54.25S	104:25.69E	3357
58 LEG7	0203	15-FEB-96	63:35.75S	104:25.77E	3634	3646	0331	63:35.74S	104:26.06E	3707	14.7	0514	63:35.37S	104:26.14E	-
59 LEG7	0940	15-FEB-96	63:17.89S	104:26.05E	3942	3986	1111	63:18.20S	104:26.79E	-	13.6	1247	63:18.09S	104:26.67E	-
60 LEG7	1619	15-FEB-96	63:00.02S	104:25.99E	3901	166	1628	63:00.07S	104:26.01E	-	-	1643	63:00.13S	104:26.20E	3891
61 LEG7	1720	15-FEB-96	63:00.11S	104:26.67E	3901	3924	1846	63:00.29S	104:26.70E	-	14.6	2028	63:00.52S	104:25.64E	3901
62 LEG7	0155	16-FEB-96	63:06.60S	106:11.15E	3727	3728	0318	63:06.58S	106:11.68E	-	13.9	0503	63:06.78S	106:12.15E	3645
63 LEG7	0907	16-FEB-96	63:13.60S	107:56.52E	3327	3360	1031	63:13.90S	107:56.38E	-	14.6	1208	63:14.19S	107:56.61E	3358
64 LEG7	1655	16-FEB-96	63:20.44S	109:41.33E	3716	3726	1822	63:20.52S	109:40.91E	-	14.9	2004	63:20.45S	109:39.90E	3716
65 CAL	1604	19-FEB-96	66:15.92S	110:31.36E	56	46	1610	66:15.88S	110:31.40E	59	22.5	1616	66:15.85S	110:31.43E	59
66 LEG9	1211	23-FEB-96	65:45.43S	112:15.04E	438	420	1228	65:45.42S	112:15.13E	-	14.6	1300	65:45.47S	112:15.06E	438
67 LEG9	1643	23-FEB-96	65:25.11S	112:15.84E	322	312	1659	65:25.03S	112:15.82E	328	11.0	1731	65:24.80S	112:15.32E	348
68 LEG9	1915	23-FEB-96	65:23.87S	112:12.45E	563	578	1940	65:23.74S	112:12.27E	584	33.8	2007	65:23.56S	112:11.93E	676
69 LEG9	2222	23-FEB-96	65:19.65S	112:13.81E	1014	1088	2301	65:19.52S	112:12.66E	1106	14.8	2347	65:19.24S	112:11.48E	1124
70 LEG9	0053	24-FEB-96	65:19.09S	112:14.88E	1222	1182	0144	65:18.94S	112:13.81E	-	14.3	0234	65:18.85S	112:12.42E	1142
71 LEG9	0412	24-FEB-96	65:14.00S	112:15.24E	1587	1526	0501	65:14.20S	112:15.04E	-	13.4	0607	65:14.51S	112:14.86E	-
72 LEG9	0732	24-FEB-96	65:09.30S	112:15.00E	1843	1832	0830	65:09.45S	112:15.92E	-	13.0	0942	65:10.55S	112:16.26E	-

station number	START time	START date	START latitude	START longitude	START depth(m)	maxP (dbar)	BOTTOM time	BOTTOM latitude	BOTTOM longitude	BOTTOM depth(m)	BOTTOM altimeter	END time	END latitude	END longitude	END depth(m)
73 LEG9	1136	24-FEB-96	65:01.63S	112:14.83E	2211	2152	1237	65:01.42S	112:15.91E	-	18.0	1351	65:01.66S	112:16.17E	-
74 LEG9	1806	24-FEB-96	64:35.07S	112:14.99E	1873	1864	1903	64:35.07S	112:15.45E	1893	16.0	2017	64:35.08S	112:15.76E	1873
75 LEG9	0217	25-FEB-96	64:04.98S	112:15.05E	2518	2542	0315	64:05.02S	112:15.63E	-	16.1	0428	64:05.05S	112:15.74E	2560
76 LEG9	1017	25-FEB-96	63:34.98S	112:14.92E	3276	3260	1149	63:35.38S	112:15.51E	-	13.0	1313	63:35.33S	112:15.87E	-
77 LEG9	1944	25-FEB-96	62:59.97S	112:14.89E	3768	168	1953	62:59.97S	112:15.04E	-	-	2006	62:59.98S	112:15.28E	3788
78 LEG9	2034	25-FEB-96	62:59.97S	112:16.01E	3768	3810	2206	63:00.05S	112:17.94E	-	13.1	2350	63:00.36S	112:19.50E	-
79 LEG9	0548	26-FEB-96	63:04.54S	114:05.08E	3604	3618	0719	63:04.81S	114:05.57E	-	17.0	0857	63:04.94S	114:04.63E	-
80 LEG9	1314	26-FEB-96	63:09.20S	115:55.07E	3512	3494	1443	63:09.55S	115:56.54E	-	14.7	1614	63:09.99S	115:57.56E	-
81 LEG9	2113	26-FEB-96	63:13.79S	117:45.24E	3512	3526	2243	63:13.80S	117:47.05E	-	13.2	0017	63:13.42S	117:48.53E	-
82 LEG11	0532	28-FEB-96	65:46.56S	119:07.77E	614	598	0557	65:46.44S	119:08.35E	-	13.8	0642	65:46.53S	119:08.00E	614
83 LEG11	1304	28-FEB-96	65:42.55S	120:18.84E	450	438	1331	65:42.75S	120:18.64E	450	15.0	1406	65:43.00S	120:18.12E	450
84 LEG11	1647	28-FEB-96	65:32.50S	120:18.37E	614	574	1713	65:32.56S	120:18.59E	584	19.6	1745	65:32.80S	120:18.41E	522
85 LEG11	1851	28-FEB-96	65:31.39S	120:18.81E	948	948	1934	65:31.53S	120:19.17E	953	13.2	2013	65:31.78S	120:19.08E	829
86 LEG11	2108	28-FEB-96	65:30.72S	120:18.75E	1237	1180	2149	65:30.76S	120:18.87E	1198	15.7	2237	65:30.80S	120:19.02E	1208
87 LEG11	2341	28-FEB-96	65:29.44S	120:19.74E	1848	1824	0030	65:29.55S	120:20.16E	1838	15.4	0122	65:29.74S	120:20.41E	1833
88 LEG11	0232	29-FEB-96	65:28.34S	120:18.70E	2132	2210	0337	65:28.19S	120:18.90E	2212	15.7	0454	65:28.00S	120:19.54E	-
89 LEG11	0705	29-FEB-96	65:23.01S	120:18.95E	2764	2762	0816	65:22.89S	120:20.01E	-	14.9	0936	65:22.91S	120:21.09E	-
90 LEG11	1103	29-FEB-96	65:14.99S	120:18.87E	3071	3066	1225	65:15.00S	120:20.04E	-	18.9	1349	65:15.12S	120:21.14E	-
91 LEG11	1751	29-FEB-96	64:50.88S	120:18.87E	3061	3064	1913	64:51.31S	120:18.51E	3061	13.8	2034	64:51.91S	120:17.49E	3031
92 LEG11	0027	1-MAR-96	64:26.97S	120:18.62E	3502	3518	0154	64:27.34S	120:17.56E	3497	14.8	0545	64:28.02S	120:16.20E	-
93 LEG11	1003	1-MAR-96	64:03.13S	120:18.62E	3430	3414	1135	64:03.67S	120:17.90E	3410	17.1	1303	64:04.15S	120:17.92E	3400
94 LEG11	1637	1-MAR-96	63:38.91S	120:18.84E	3655	3652	1818	63:39.70S	120:19.57E	3635	14.3	1947	63:39.81S	120:19.09E	3620
95 LEG11	2326	1-MAR-96	63:14.78S	120:18.81E	3727	166	2336	63:14.68S	120:18.70E	-	-	2348	63:14.56S	120:18.59E	-
96 LEG11	0023	2-MAR-96	63:14.95S	120:18.93E	3737	3748	0147	63:14.38S	120:19.15E	-	12.2	0312	63:14.16S	120:18.67E	-
97 LEG11	0830	2-MAR-96	63:15.03S	122:08.91E	3839	3888	0955	63:14.71S	122:10.09E	-	14.4	1131	63:14.16S	122:09.54E	-
98 LEG11	1646	2-MAR-96	63:14.95S	123:58.77E	3983	4012	1825	63:14.70S	123:59.51E	-	14.2	2004	63:14.80S	123:59.78E	-
99 LEG11	0009	3-MAR-96	63:15.12S	125:48.76E	4116	4146	0144	63:15.51S	125:50.90E	4111	15.6	0316	63:15.62S	125:52.38E	-
100 LEG13	0739	4-MAR-96	65:35.88S	128:22.35E	378	372	0757	65:35.91S	128:21.93E	-	14.1	0830	65:36.12S	128:21.49E	-
101 LEG13	1216	4-MAR-96	65:15.98S	128:28.28E	358	352	1235	65:16.20S	128:28.26E	358	14.9	1305	65:16.54S	128:28.51E	374
102 LEG13	1605	4-MAR-96	65:11.61S	128:22.11E	614	590	1632	65:11.75S	128:21.45E	-	17.4	1709	65:11.69S	128:20.49E	563
103 LEG13	1845	4-MAR-96	65:10.70S	128:22.30E	921	952	1923	65:10.69S	128:22.00E	921	16.9	2006	65:10.78S	128:21.38E	911
104 LEG13	2132	4-MAR-96	65:09.93S	128:22.20E	1249	1272	2217	65:09.97S	128:21.61E	1269	16.0	2259	65:10.09S	128:21.07E	1229
105 LEG13	2346	4-MAR-96	65:08.88S	128:22.51E	1551	1484	0039	65:09.33S	128:22.12E	1474	12.1	0133	65:09.57S	128:21.57E	1423
106 LEG13	0241	5-MAR-96	65:05.07S	128:22.56E	1843	1804	0327	65:05.18S	128:22.40E	1843	13.7	0430	65:05.37S	128:22.56E	1823
107 LEG13	0729	5-MAR-96	64:50.01S	128:22.64E	1924	1884	0827	64:50.10S	128:23.69E	1894	15.2	0929	64:50.10S	128:24.03E	1894
108 LEG13	1221	5-MAR-96	64:40.00S	128:22.53E	2539	2522	1322	64:40.12S	128:22.27E	-	15.2	1448	64:40.80S	128:22.15E	-

station	START					maxP	BOTTOM					END			
number	time	date	latitude	longitude	depth(m)	(dbar)	time	latitude	longitude	depth(m)	altimeter	time	latitude	longitude	depth(m)
109 LEG13	1725	5-MAR-96	64:27.24S	128:22.50E	2682	2678	1824	64:27.55S	128:22.62E	2672	16.9	1930	64:28.06S	128:23.32E	2662
110 LEG13	2352	5-MAR-96	64:03.07S	128:22.59E	3583	3606	0112	64:02.98S	128:23.05E	-	12.8	0244	64:02.65S	128:23.14E	3583
111 LEG13	0714	6-MAR-96	63:39.07S	128:22.46E	3993	4010	0847	63:39.34S	128:24.88E	-	15.4	1040	63:40.08S	128:27.63E	-
112 LEG13	1452	6-MAR-96	63:15.09S	128:22.44E	4218	164	1459	63:15.18S	128:22.35E	4218	-	1512	63:15.21S	128:22.47E	4218
113 LEG13	1605	6-MAR-96	63:15.04S	128:22.42E	4218	4266	1740	63:15.57S	128:22.62E	-	13.7	1907	63:16.00S	128:23.23E	4218
114 LEG13	0034	7-MAR-96	63:15.10S	130:12.78E	4249	4302	0214	63:14.72S	130:15.07E	-	16.5	0402	63:14.46S	130:17.37E	-
115 LEG13	0855	7-MAR-96	63:15.09S	132:02.61E	4198	4250	1026	63:15.60S	132:04.60E	-	13.1	1203	63:16.42S	132:05.41E	-
116 LEG13	1804	7-MAR-96	63:15.20S	133:53.40E	4208	4260	1937	63:15.61S	133:53.63E	4208	9.6	2107	63:15.63S	133:53.38E	4208
117 LEG16	2231	11-MAR-96	63:14.91S	136:26.24E	3993	4036	0010	63:15.17S	136:27.64E	-	15.4	0147	63:15.31S	136:29.35E	-
118 LEG16	0739	12-MAR-96	63:22.42S	138:08.53E	3880	3912	0909	63:22.33S	138:08.43E	-	14.7	1043	63:22.48S	138:07.48E	-
119 LEG16	1733	12-MAR-96	63:29.97S	139:50.98E	3788	164	1745	63:29.96S	139:50.82E	-	-	1800	63:29.91S	139:50.83E	-
120 LEG16	1831	12-MAR-96	63:29.86S	139:50.64E	3788	3824	1952	63:29.55S	139:50.58E	-	15.1	2115	63:29.22S	139:50.53E	3798
121 LEG16	0358	13-MAR-96	63:54.00S	139:51.13E	3727	3750	0516	63:53.62S	139:52.57E	-	11.1	0656	63:52.78S	139:54.50E	-
122 LEG16	1139	13-MAR-96	64:17.95S	139:51.12E	3460	3456	1258	64:17.83S	139:50.59E	-	13.1	1430	64:17.40S	139:50.14E	-
123 LEG16	1911	13-MAR-96	64:41.94S	139:50.91E	2918	2910	2026	64:42.20S	139:52.00E	-	15.2	2142	64:42.10S	139:52.41E	2908
124 LEG16	0334	14-MAR-96	65:05.08S	139:50.92E	2764	2768	0451	65:05.13S	139:51.87E	-	14.4	0624	65:05.23S	139:52.94E	-
125 LEG16	1015	14-MAR-96	65:22.10S	139:50.89E	2518	2486	1113	65:22.24S	139:49.80E	-	14.1	1229	65:22.23S	139:48.88E	-
126 LEG16	1513	15-MAR-96	65:25.15S	139:50.95E	2150	2292	1612	65:25.09S	139:50.36E	-	23.7	1721	65:25.12S	139:49.78E	2294
127 LEG16	1824	15-MAR-96	65:25.65S	139:50.79E	1843	2136	1918	65:25.87S	139:50.17E	-	22.4	2025	65:26.20S	139:49.24E	-
128 LEG16	0052	16-MAR-96	65:29.85S	139:50.95E	1535	1480	0139	65:30.15S	139:51.13E	-	17.4	0237	65:30.18S	139:51.85E	-
129 LEG16	0345	16-MAR-96	65:32.74S	139:51.57E	1177	1130	0426	65:32.86S	139:51.97E	-	15.2	0515	65:32.91S	139:52.12E	-
130 LEG16	0800	16-MAR-96	65:33.93S	139:50.84E	942	910	0829	65:33.87S	139:50.25E	932	15.1	0913	65:33.68S	139:49.14E	952
131 LEG16	1126	16-MAR-96	65:34.95S	139:50.86E	614	548	1151	65:35.11S	139:50.72E	543	8.8	1230	65:35.49S	139:50.34E	451
132 LEG16	1349	16-MAR-96	65:43.03S	139:50.72E	296	288	1407	65:43.12S	139:50.34E	307	16.0	1434	65:43.45S	139:50.10E	307
133 LEG18	0511	19-MAR-96	63:29.98S	144:29.99E	3906	3952	0642	63:30.17S	144:29.07E	-	13.6	0825	63:30.88S	144:28.15E	-
134 LEG18	1444	19-MAR-96	63:30.01S	146:20.03E	3890	3926	1627	63:30.70S	146:20.84E	-	15.2	1754	63:30.94S	146:20.58E	-
135 LEG18	2254	19-MAR-96	63:29.95S	148:09.97E	3839	3868	0015	63:29.88S	148:09.85E	-	12.9	0144	63:29.90S	148:09.88E	-
136 LEG18	0627	20-MAR-96	63:30.09S	150:00.10E	3737	166	0645	63:30.13S	150:00.14E	-	-	0705	63:30.20S	149:59.98E	-
137 LEG18	0742	20-MAR-96	63:29.95S	149:59.78E	3737	3762	0902	63:30.45S	149:59.91E	-	15.9	1039	63:30.94S	150:00.16E	-
138 LEG18	1503	20-MAR-96	63:54.08S	149:59.98E	3675	3698	1634	63:53.76S	150:00.04E	-	12.2	1802	63:53.32S	150:00.05E	3675
139 LEG18	2147	20-MAR-96	64:18.04S	149:59.58E	3573	3600	2301	64:18.07S	150:00.37E	-	14.9	0024	64:18.20S	150:01.03E	3573
140 LEG18	0315	21-MAR-96	64:36.09S	149:59.77E	3481	3490	0440	64:36.66S	150:00.41E	-	15.4	0600	64:36.90S	150:00.80E	-
141 LEG18	1228	21-MAR-96	65:00.13S	149:59.86E	3317	3308	1345	65:00.25S	149:58.12E	-	12.6	1516	65:00.49S	149:56.39E	-
142 LEG18	1910	21-MAR-96	65:23.97S	150:00.19E	2923	2916	2018	65:23.73S	149:59.87E	2918	13.8	2139	65:23.65S	150:00.21E	2918
143 LEG18	0000	22-MAR-96	65:36.89S	149:59.88E	2462	2448	0054	65:36.84S	150:00.42E	2462	12.4	0201	65:36.78S	149:59.89E	2467
144 LEG18	0854	22-MAR-96	65:43.41S	149:54.54E	2099	2096	0954	65:43.29S	149:54.22E	2099	10.3	1105	65:43.18S	149:54.04E	-

station	START					maxP	BOTTOM					END			
number	time	date	latitude	longitude	depth(m)	(dbar)	time	latitude	longitude	depth(m)	altimeter	time	latitude	longitude	depth(m)
145 CM	0856	23-MAR-96	65:55.74S	145:23.86E	796	688	0938	65:56.01S	145:23.92E	676	13.1	1017	65:56.22S	145:23.51E	625
146 BIO	1140	23-MAR-96	65:56.28S	145:41.21E	573	154	1157	65:56.28S	145:41.38E	563	-	1220	65:56.19S	145:41.12E	573
147 BIO	0732	25-MAR-96	65:54.39S	146:56.74E	576	150	0748	65:54.45S	146:56.62E	-	-	0808	65:54.48S	146:56.63E	545

<u>Table 2.3:</u> Summary of samples drawn from Niskin bottles at each station, including salinity (sal), dissolved oxygen (do), nutrients (nut), chlorofluorocarbons (CFC), ^{18}O, primary productivity (pp), fast repitition rate fluorometry (frrf), and pigments (pig); Seacat cast information was not available. Note that 1=samples taken, 0=no samples taken, 2=surface sample only (i.e. from shallowest Niskin bottle).

station	sal	do	nut	CFC	^{18}O	pp	frrf	pig
1	1	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	1	1	1	1	1	0	0	0
4	1	0	0	0	0	0	0	0
5	1	0	0	0	0	0	0	0
6	1	1	1	1	1	0	1	1
7	1	1	1	1	1	0	1	1
8	1	1	1	0	1	1	1	1
9	1	1	1	1	1	0	1	1
10	1	1	1	1	1	0	1	1
11	1	1	1	1	1	0	1	1
12	1	1	1	1	1	1	1	1
13	1	1	1	1	1	0	1	1
14	1	1	1	1	1	0	1	1
15	1	1	1	1	1	0	1	1
16	0	0	0	0	0	1	1	1
17	1	1	1	1	1	0	0	0
18	1	1	1	1	1	0	1	1
19	1	1	1	1	1	0	1	1
20	1	1	1	1	1	0	1	1
21	0	0	0	0	0	1	1	1
22	1	1	1	1	1	0	0	0
23	1	1	1	1	1	0	0	0
24	1	1	1	1	1	0	0	0
25	1	1	1	1	1	0	0	0
26	1	1	1	1	1	0	0	0
27	1	1	1	1	1	0	0	0
28	1	1	1	1	1	0	0	0
29	0	0	0	0	0	1	1	1
30	1	1	1	1	1	0	0	0
31	1	1	1	1	1	0	1	1
32	1	1	1	1	1	0	1	1
33	1	1	1	1	1	0	1	1
34	1	1	1	1	1	0	1	1
35	1	1	1	1	1	1	1	1
36	1	1	1	1	1	0	1	1
37	1	1	1	1	1	0	1	1
38	1	1	1	1	1	0	1	1
39	1	1	1	1	1	0	1	1
40	1	1	1	1	1	0	1	1
41	1	1	1	1	1	0	1	1
42	1	1	1	1	1	1	1	1
43	1	0	0	0	0	0	0	0
44	1	1	1	1	1	0	0	0
45	1	1	1	1	1	0	0	0
46	1	1	1	1	1	0	0	0
47	1	1	1	1	1	0	0	0
48	1	1	1	1	1	1	1	1
49	1	1	1	1	1	0	1	1
50	1	1	1	1	1	0	1	1

Table 2.3: **(continued)**

station	sal	do	nut	CFC	^{18}O	pp	frrf	pig
51	1	1	1	1	1	0	1	1
52	1	1	1	1	1	0	1	1
53	1	1	1	1	1	0	1	1
54	1	1	1	1	1	1	1	1
55	1	1	1	1	1	0	1	1
56	1	1	1	1	1	0	1	1
57	1	1	1	1	1	0	1	1
58	1	1	1	1	1	0	1	1
59	1	1	1	1	1	0	1	1
60	0	0	0	0	0	1	1	1
61	1	1	1	1	1	0	0	0
62	1	1	1	1	1	0	0	0
63	1	1	1	1	1	0	0	0
64	1	1	1	1	1	0	0	0
65	1	0	0	0	0	0	0	0
66	1	1	1	1	1	1	1	1
67	1	1	1	1	1	0	1	1
68	1	1	1	1	1	0	1	1
69	1	1	1	1	1	0	1	1
70	1	1	1	1	1	0	1	1
71	1	1	1	1	1	1	1	1
72	1	1	1	1	1	1	1	1
73	1	1	1	1	1	0	1	1
74	1	1	1	1	1	0	1	1
75	1	1	1	1	1	0	1	1
76	1	1	1	1	1	0	1	1
77	0	0	0	0	0	1	1	1
78	1	1	1	1	1	0	0	0
79	1	1	1	1	1	0	0	0
80	1	1	1	1	1	0	0	0
81	1	1	1	1	1	0	0	0
82	1	1	1	1	1	1	1	1
83	1	1	1	1	1	0	1	1
84	1	1	1	1	1	0	1	1
85	1	1	1	1	1	0	1	1
86	1	1	1	1	1	0	1	1
87	1	1	1	1	1	0	1	1
88	1	1	1	1	1	1	1	1
89	1	1	1	1	1	1	1	1
90	1	1	1	1	1	0	1	1
91	1	1	1	1	1	0	1	1
92	1	1	1	1	1	0	1	1
93	1	1	1	1	1	0	1	1
94	1	1	1	1	1	0	1	1
95	0	0	0	0	0	1	1	1
96	1	1	1	1	1	0	0	0
97	1	1	1	1	1	0	0	0
98	1	1	1	1	1	0	0	0
99	1	1	1	1	1	0	0	0
100	1	1	1	1	1	1	1	1
101	1	1	1	1	1	0	1	1
102	1	1	1	1	1	0	1	1
103	1	1	1	1	1	0	1	1
104	1	1	1	1	1	0	1	1

Table 2.3: (continued)

station	sal	do	nut	CFC	^{18}O	pp	frrf	pig
105	1	1	1	1	1	1	1	1
106	1	1	1	1	1	0	1	1
107	1	1	1	1	1	1	1	1
108	1	1	1	1	1	0	1	1
109	1	1	1	1	1	0	1	1
110	1	1	1	1	1	0	1	1
111	1	1	1	1	1	0	1	1
112	0	0	0	0	0	1	1	1
113	1	1	1	1	1	0	0	0
114	1	1	1	1	1	0	0	0
115	1	1	1	1	1	0	0	0
116	1	1	1	1	1	0	0	0
117	1	1	1	1	1	0	0	0
118	1	1	1	1	1	0	0	0
119	0	0	0	0	0	0	1	1
120	1	1	1	1	1	0	0	0
121	1	1	1	1	1	1	1	1
122	1	1	1	1	1	0	1	1
123	1	1	1	1	1	0	1	1
124	1	1	1	1	1	1	1	1
125	1	1	1	1	1	0	1	1
126	1	1	1	1	1	0	1	1
127	1	1	1	1	1	0	1	1
128	1	1	1	1	1	1	1	1
129	1	1	1	1	1	0	1	1
130	1	1	1	1	1	0	1	1
131	1	1	1	1	1	0	1	1
132	1	1	1	1	1	0	1	1
133	1	1	1	1	1	0	0	0
134	1	1	1	1	1	0	0	0
135	1	1	1	1	1	0	0	0
136	0	0	0	0	0	1	1	1
137	1	1	1	1	1	0	0	0
138	1	1	1	1	1	0	1	1
139	1	1	1	1	1	0	1	1
140	1	1	1	1	1	1	1	1
141	1	1	1	1	1	0	1	1
142	1	1	1	1	1	0	1	1
143	1	1	1	1	1	0	1	1
144	1	1	1	1	1	1	1	1
145	1	1	1	1	1	0	0	0
146	0	0	0	0	0	0	1	1
147	0	0	0	0	0	0	1	1

Table 2.4: Bottom pressure recorder, upward looking sonar, and current meter moorings deployed/recovered during cruise AU9604. Note that for current meter moorings, mooring locations and water depths are estimates only, and instrument elevations are elevations above the bottom.

BOTTOM PRESSURE RECORDERS

deployment number	deployment/recovery time (UTC)	latitude	longitude	CTD station no.	bottom depth(m)
instruments deployed					
Hobart96	06:24, 06/01/96	44° 07.019'S	146° 12.744'E	-	998
Dumont96	00:05, 16/03/96	65° 33.71'S	139° 51.26'E	-	1024
instruments recovered					
Hobart94	06:11, 06/01/96	44° 07.18'S	146° 13.134'E	-	1028
Dumont94	23:30, 15/03/96	65° 33.67'S	139° 51.147'E	-	1024
unsuccessful recovery attempts					
Hobart91b	03:13, 06/01/96	44° 06.83'S	146° 14.03'E	-	1024

UPWARD LOOKING SONARS

site name	deployment time (UTC)	latitude	longitude	instrument depths (m)	CTD station no.	bottom depth(m)
instruments deployed						
SO-ON	21:56, 28/01/96	68° 08.30'S	76° 02.37'E	150 (ULS)	4	478
SOFORTH	13:15, 29/01/96	66° 15.28'S	77° 02.74'E	160 (ULS) 210 (CM)	5	2866

CURRENT METER MOORINGS

site name	recovery time (UTC)	latitude	longitude	current meter elevations (m)	CTD station no.	bottom depth(m)
instruments recovered						
CM2	08:02, 23/03/96	65° 55.72'S	145° 24.69'E	100 65 25 (not recovered) 15 2 - water level recorder (not recovered)	145	~740
unsuccessful recovery attempts						
CM1	24-25/03/96	65° 54.11'S	146° 55.79'E	-	-	~600
CM3	24/03/96	66° 03.13'S	148° 57.93'E	-	-	~515

2.3.2 Moorings deployed/recovered

Two bottom pressure recorders were recovered near the north and south ends of the WOCE SR3 section, and two pressure recorders were deployed as replacements. A further pressure recorder at the north end of SR3 could not be recovered. Two upward looking sonar moorings were deployed in the vicinity of Davis. One current meter mooring was recovered from the eastern end of the MARGINEX study region; two further current meter moorings in the vicinity could not be recovered. Table 2.4 summarizes all mooring locations and deployment/recovery times.

2.3.3 Drifters deployed

8 drifting Argos buoys, manufactured by Turo Technology, were deployed throughout the cruise in the MARGINEX study region (Table 2.5).

2.3.4 Principal investigators

The principal investigators for the CTD and water sample measurements are listed in Table 2.6a. Cruise participants are listed in Table 2.6b.

Table 2.5: Argos buoys deployed on cruise au9604.

Buoy id no.	deployment time (UTC)	latitude	longitude	bottom depth (m)	sea surf. temp. (^oC)	air temp. (^oC)	air pressure (hPa)
27237	12:25,12/02/96	63^o 38.78'S	101^o 37.35'E	1325	-0.51	-1.0	985.4
27239	18:48,27/02/96	65^o 09.18'S	117^o 44.95'E	1211	-0.51	-5.8	992.4
27236	20:53,03/03/96	65^o 10.34'S	125^o 48.44'E	1415	-0.49	-2.1	984.8
27235	14:41,08/03/96	64^o 38.55'S	135^o 52.52'E	1214	-0.32	-2.0	989.7
27240	05:03,11/03/96	64^o 59.87'S	136^o 26.32'E	1218	-0.13	-2.7	975.0
27238	09:15,18/03/96	65^o 54.01'S	144^o 29.60'E	1165	-1.62	-1.3	997.2
24669	10:34,24/03/96	66^o 02.50'S	148^o 59.31'E	645	-1.80	-3.2	980.6
24673	08:43,25/03/96	65^o 53.98'S	147^o 00.59'E	718	-1.76	-3.4	985.1

Table 2.6a: Principal investigators (*=cruise participant) for rosette water sampling programmes.

measurement	name	affiliation
CTD, salinity, O_2, nutrients	*Nathan Bindoff/Steve Rintoul	Antarctic CRC/CSIRO
chlorofluorocarbons	*Mark Warner	University of Washington
^{18}O	Russell Frew	Otago University
primary productivity	John Parslow	CSIRO
fast repitition rate fluorometry	*Peter Strutton(PhD student)	Flinders University
biological sampling	Harvey Marchant/*Simon Wright	Antarctic Division

Table 2.6b: **Scientific personnel (cruise participants).**

name	measurement	affiliation
Nathan Bindoff	CTD	Antarctic CRC
Tim Gibson	CTD, weather balloons	Antarctic CRC
Doug Gillespie	whale hydroacoustics, CTD	Oxford University
John Hunter	CTD	CSIRO
Ian Knott	CTD, electronics	Antarctic CRC
Mark Rosenberg	CTD, moorings	Antarctic CRC
Mike Williams	CTD	Antarctic CRC
Stephen Bray	salinity, oxygen, nutrients	Antarctic CRC
Mark Rayner	salinity, nutrients	CSIRO
Phillip Towler	oxygen	University of Melbourne
Steve Covey	CFC	University of Washington
Mark Warner	CFC	University of Washington
Clive Crossley	biological sampling	Antarctic CRC
Rick van den Enden	biological sampling	Antarctic Division
Paul Scott	biological sampling	Antarctic Division
Peter Strutton	biological sampling	Flinders University
Raechel Waters	biological sampling	Antarctic Division
Simon Wright	biological sampling, deputy voyage leader	Antarctic Division
Toby Bolton	krill	Flinders University
Jon Havenhand	krill	Flinders University
Rob King	krill	Antarctic Division
John Kitchener	krill	Antarctic Division
Steve Nicol	krill, voyage leader	Antarctic Division
Robin Thompson	krill	Antarctic Division
Patti Virtue	krill	Antarctic Division
Ian Higginbottom	hydroacoustics	Antarctic Division
Tim Pauly	hydroacoustics	Antarctic Division
Karen Evans	whale observations	Antarctic Division
Peter Gill	whale observations	Antarctic Division
Jennifer Gillot	whale observations	Antarctic Division
Deb Glasgow	whale observations	Antarctic Division
Claire Green	whale observations	Antarctic Division
Paul Hodda	whale observations	Antarctic Division
Mick Mackey	whale observations	Antarctic Division
Debbie Thiele	whale observations	Antarctic Division
Eric Woehler	ornithology	Antarctic Division
Stephanie Zador	ornithology	Antarctic Division
Pamela Brodie	programmer	Antarctic Division
Chris Boucher	electronics	Antarctic Division
Roy Francis	doctor	Antarctic Division
Gordon Keith	programmer	Antarctic Division
Steve Oakley	returnee	Antarctic Division
Tim Ryan	underway measurements	Antarctic Division
Rob Walker	gear officer	Antarctic Division

2.4 FIELD DATA COLLECTION METHODS

2.4.1 CTD and hydrology measurements

In this section, CTD and hydrology data collection and processing methods are discussed. Preliminary results of the CTD data calibration, along with data quality information, are presented in Section 2.6. CTD instrumentation, CTD and hydrology data collection techniques and water sampling methods are described in detail in previous data reports (Rosenberg et al. 1995a, 1995b, 1996).

Briefly, General Oceanics Mark IIIC (i.e. WOCE upgraded) CTD units were used, with a General Oceanics model 1015 pylon, and 10 litre General Oceanics Niskin bottles. A 24 bottle rosette package was used, with deep sea reversing thermometers (Gohla-Precision) mounted at rosette positions 2, 12 and 24. A Li-Cor photosynthetically active radiation (p.a.r.) sensor and Sea-Tech fluorometer were also attached to the package for some casts. Complete calibration information for the CTD pressure, platinum temperature and pressure temperature sensors are presented in Table 2.23, along with fluorometer and p.a.r. calibrations. Note that correct scaling of fluorescence data requires linkage with primary productivity data, while p.a.r. data requires recalculation using extinction coefficients for the signal strength (B. Griffiths, pers. comm.). The complete CTD conductivity and CTD dissolved oxygen calibrations, derived respectively from the in situ Niskin bottle salinity and dissolved oxygen samples, are presented in a later section.

The CTD and hydrology data processing and calibration techniques are described in detail in Appendix 2 of Rosenberg et al. (1995b) (referred to as “CTD methodology” for the remainder of the report), with the following updates to the methodology:

(i) the 10 seconds of CTD data prior to each bottle firing are averaged to form the CTD upcast for use in calibration (5 seconds was used previously);

(ii) in the conductivity calibration for stations 11 to 61 and stations 71 to 144, an additional term was applied to remove the pressure dependent conductivity residual.

The analytical techniques and data processing routines employed in the Hydrographic Laboratory onboard the ship are discussed in Appendix 2.1 of this report, and in Appendix 3 of Rosenberg et al. (1995b). Note the following changes to the methodology:

(i) 150 ml sample bottles were used, and 1.0 ml of reagents 1, 2 and 3 were used; the corresponding calculated value for the total amount of oxygen added with the reagents = 0.017 ml;

(ii) a mean volume of 147.00 ml for oxygen sample bottles was applied in the calculation of dissolved oxygen concentration;

(iii) nutrient autoanalyser results were processed by the software package “FASPac” (Astoria-Pacific International);

(iv) salinity substandards were measured every 12 samples typically.

2.4.2 Underway measurements

Underway data collection is as described in previous data reports; data files are described in Part 5. Note that a sound speed of 1498 ms^{-1} is used for all depth calculations, and the ship's draught of 7.3 m has been accounted for in final depth values (i.e. depths are values from the surface).

2.4.3 ADCP

The acoustic Doppler current profiler (ADCP) instrumentation is described in previous data reports. GPS data were collected by a Koden receiver for the entire cruise, receiving both GPS positions and velocities every 1 second. ADCP data processing is discussed in more detail in Dunn (a and b, unpublished reports). Logging parameters are summarised in Table 2.7, while data results for this cruise will be discussed in a future report.

Table 2.7: ADCP logging parameters.

ping parameters		*bottom track ping parameters*	
no. of bins:	60	no. of bins:	128
bin length:	8 m	bin length:	4 m
pulse length:	8 m	pulse length:	32 m
delay:	4 m		
ping interval:	minimum	ping interval:	same as profiling pings

reference layer averaging:	bins 8 to 20
ensemble averaging duration:	3 min.

2.5 MAJOR PROBLEMS ENCOUNTERED

2.5.1 Logistics

On the final CTD leg 18 (Figure 2.1b), traversed north to south, the section was prematurely terminated in a depth of ~2100 m, well short of the shelf break. Heavy ice together with time and fuel limitations did not allow further ice-breaking which would have been necessary to reach the shelf break.

2.5.2 CTD sensors

Following station 81, the CTD dissolved oxygen sensor was replaced. After the cruise, analysis of data collected with the replacement sensor indicated that the oxygen current response of the sensor was poor. Thus CTD dissolved oxygen data for the second half of the cruise was of low quality, and these data were not processed further.

For most of the cruise, conductivity calibrations were of a lower quality than for previous cruises. This was due to a combination of unstable salinometer performance and a significant pressure dependent response of both conductivity cells used on CTD 1103 (see section 6 for more details).

The fluorometer on the rosette package flooded during station 35, and was unusable for the remainder of the cruise.

2.5.3 Moorings

Of the three current meter moorings at the eastern end of the MARGINEX study region, only one was recovered, and only partially so - a current meter and a water level recorder were lost while dragging for the recovered mooring. No precise positions or water depths were available for the moorings, and no ranging equipment was included in the moorings, making the recovery operation a difficult one.

The four year pressure recorder mooring Hobart91b (Table 2.4) failed to release from the bottom mooring weight, despite flawless communication with the acoustic release. This failure was identical with that for the two moorings Dumont92a and b, described in Rosenberg et al. 1995b.

2.5.4 Other equipment

The ship's gyrocompass malfunctioned on several occasions throughout the cruise, at one stage leaving the ship with no gyro for several days. ADCP data from these times will be poor.

2.6 CTD RESULTS

This section details information relevant to the creation and quality of the final CTD and hydrology data set. For actual use of the data, the following is important:

CTD data - Tables 2.15 and 2.16, and Table 2.8;
hydrology data - Tables 2.20 and 2.21.

Historical data comparisons are made in Part 4 of this report. Data file formats are described in Part 5.

2.6.1 CTD measurements - data creation and quality

CTD data calibration and processing methods are described in detail in the CTD methodology (i.e. Appendix 2 of Rosenberg et al., 1995b, with the additions listed in section 2.4.1 of this report). Cases for cruise au9604 which vary from this methodology are detailed in this section. CTD data quality is also discussed. For conversion to WOCE data file formats, see Part 5 of this report.

The final calibration results for conductivity/salinity and dissolved oxygen, along with the performance check for temperature, are plotted in Figures 2.2 to 2.5. For temperature, salinity and dissolved oxygen, the respective residuals (T_{therm} - T_{cal}), (s_{btl} - s_{cal}) and (o_{btl} - o_{cal}) are plotted. For conductivity, the ratio c_{btl}/c_{cal} is plotted. T_{therm} and T_{cal} are respectively the protected thermometer and calibrated upcast CTD burst temperature values; s_{btl}, s_{cal}, o_{btl}, o_{cal}, c_{btl} and c_{cal} , and the mean and standard deviation values in Figures 2.2 to 2.5, are as defined in the CTD methodology (with additional definitions described below for cases where a pressure dependent residual is removed from conductivity data).

2.6.1.1 Conductivity/salinity

The conductivity calibration for CTD 1103 (stations 3 to 144) revealed problems with the salinity measurements for both the CTD and salinometers. A larger than usual conductivity calibration scatter (Figures 2.3 and 2.4) resulting from poor salinometer performance was superimposed on a pressure dependent conductivity residual resulting from CTD conductivity cell contamination. The pressure dependent conductivity residual was found for both conductivity cells used with CTD 1103, and is assumed to result from a light fouling or contamination of both cells. An extra fit was applied to remove this residual, following the same method as described in Part 1 (section 1.6.1.1) of this report. Note that station grouping for the extra fit parameter α (defined in eqn 1.1 in Part 1 of this report) was separate from and different to the initial conductivity calibration station grouping (Table 2.10). After application of the pressure dependent conductivity correction, the standard deviation of the salinity calibration scatter decreased from 0.0027 to 0.0024 (PSS78) (Figure 2.4). This standard deviation value remained high due to unstable performance of all 4 YeoKal salinometers used for salinity sample analysis on the cruise.

For the remaining stations using CTD 1193, CTD conductivity cell performance was good.

2.6.1.2 Temperature

Platinum temperature sensor performance of the CTD's was stable throughout the entire cruise, with a small offset between thermometer and CTD temperature values (Figure 2.2). Note that a post cruise temperature calibration was required for CTD 1193, as the pre cruise calibration for this instrument did not appear to be applicable.

2.6.1.3 Pressure

For stations 8, 89 and 116, data logging commenced when the CTD was already in the water, so surface pressure offset values were estimated from surrounding stations. For station 68, conductivity cell freezing interfered with the automatic estimation of surface pressure offsets (see CTD methodology), while pressure spiking interfered with pressure offset values for stations 29 and 48; for these stations, surface pressure offset values were estimated from a manual inspection of the pressure data. Note that for all these stations, any resulting additional error in the CTD pressure data is judged to be small (no more than 0.2 dbar).

2.6.1.4 Dissolved oxygen

Usable CTD dissolved oxygen data were only obtained for half of the cruise (stations 6 to 80 and station 145). For these stations, the final standard deviation value of the dissolved oxygen residuals (Figure 2.5) are less than 1% of full scale values (where full scale is approximately equal to 250 μmol/l for pressure > 750 dbar, and 350 μmol/l for pressure < 750 dbar). In most cases, the best calibration was achieved using large values of the order 12.0 for the coefficient K_1 (i.e. oxygen current slope), and large negative values of the order -2.0 for the coefficient K_3 (i.e. oxygen current bias) (Table 2.17).

2.6.1.5 Fluorescence and P.A.R. Data

Fluorescence and p.a.r. are effectively uncalibrated. These data should not be used quantitatively other than for linkage with primary productivity data.

<u>Table 2.8:</u> Summary of cautions to CTD data quality.

station no.	CTD parameter	caution
2,3	salinity	test cast - all bottles fired at same depth; salinity accuracy reduced
8	salinity	CTD conductivity cell behaviour for this station different to surrounding stations - stn 8 calibrated on its own (i.e. not grouped)
8,89,116	pressure	surface pressure offset estimated from surrounding stations
29,48,68	pressure	surface pressure offset estimated from manual inspection of data
19,24,26	oxygen	oxygen calibration fit fairly poor
146,147	salinity	conductivity calibration for stn 145 applied to these stations
11-61,71-144	salinity	additional correction applied for pressure dependent conductivity residual
81-144	oxygen	no CTD dissolved oxygen data due to faulty oxygen sensor
all stns	fluorescence/p.a.r.	fluorescence and p.a.r. sensors (where active) are uncalibrated

2.6.1.6 Summary of CTD data creation

Information relevant to the creation of the calibrated CTD data is tabulated, as follows:

* Surface pressure offsets calculated for each station are listed in Table 2.9.

* CTD conductivity calibration coefficients, including the station groupings used for the conductivity calibration, are listed in Tables 2.10 and 2.11.

* CTD raw data scans flagged for special treatment are listed in Table 2.12.

* Missing 2 dbar data averages are listed in Table 2.13.

* 2 dbar bins which are linearly interpolated from surrounding bins are listed in Table 2.14.

* Suspect 2 dbar averages are listed in Tables 2.15 and 2.16.

* CTD dissolved oxygen calibration coefficients are listed in Table 2.17. The starting values used for the coefficients prior to iteration, and the coefficients varied during the iteration, are listed in Table 2.18.

* The different protected and unprotected thermometers used for the stations are listed in Table 2.22.

* Laboratory calibration coefficients for the CTD's are listed in Table 2.23.

2.6.1.7 Summary of CTD data quality

CTD data quality cautions for the various parameters are summarised in Table 2.8.

2.6.2 Hydrology data

Quality control information relevant to the hydrology data is tabulated, as follows:

* Dissolved oxygen Niskin bottle samples flagged with the code -9 (rejected for CTD dissolved oxygen calibration) are listed in Table 2.19.

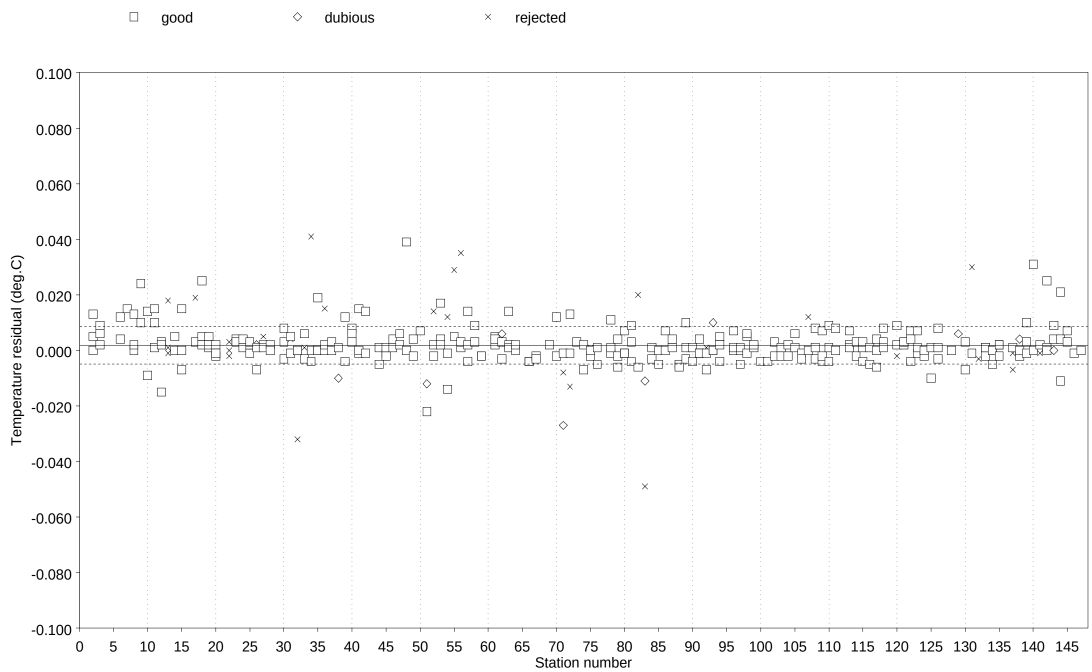
* Questionable dissolved oxygen and nutrient Niskin bottle sample values are listed in Tables 2.20 and 2.21 respectively. Note that questionable values are included in the hydrology data file, whereas bad values have been removed.

Laboratory temperature on the ship was stable, with lab temperatures at the times of nutrient analyses having a most common value of 19.6^{o}C.

For stations 23 to 26, autoanalyser peak heights for silicate were measured manually, and a linear fit was applied to the calibration standards.

For station 22, bottle salinity values were bad, and were not used in the calibration procedure.

For stations 28 and 42, phosphate data were bad.



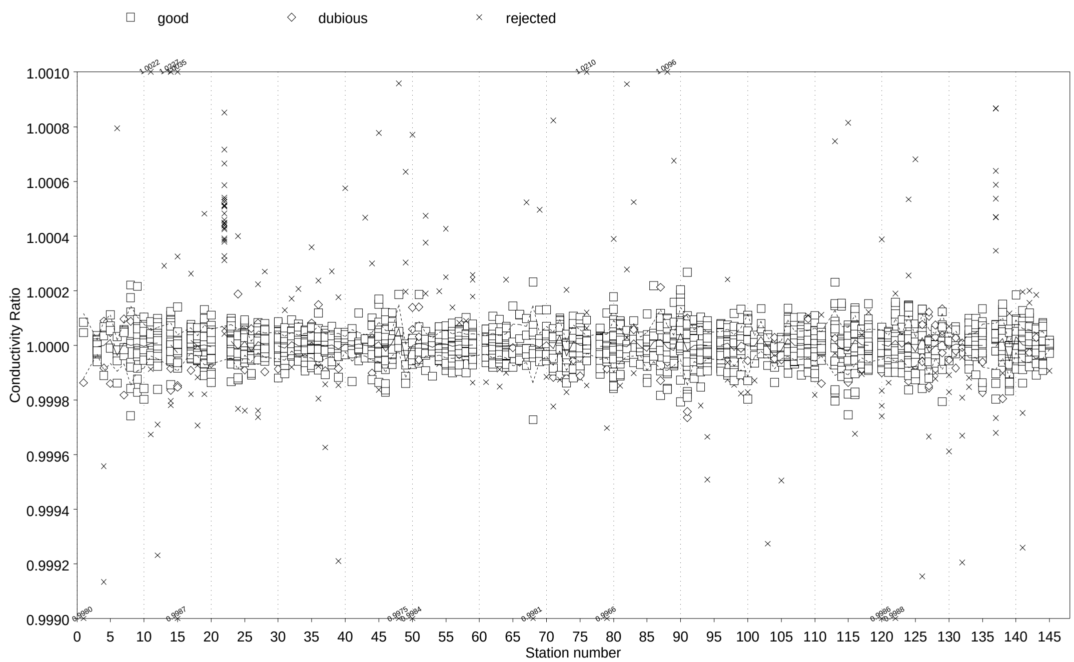
Calibration data for cruise : Au9604

Calibration file : histcal.lis

Mean offset Temperature = 0.00190312c (s.d. = 0.0068 ˚c)

Number of samples used =   289 out of   326

Figure 2.2: **Temperature residual (T_{therm} - T_{cal}) versus station number for cruise au9604. The solid line is the mean of all the residuals; the broken lines are ± the standard deviation of all the residuals (see CTD methodology). Note that the "dubious" and "rejected" categories refer to the conductivity calibration.**



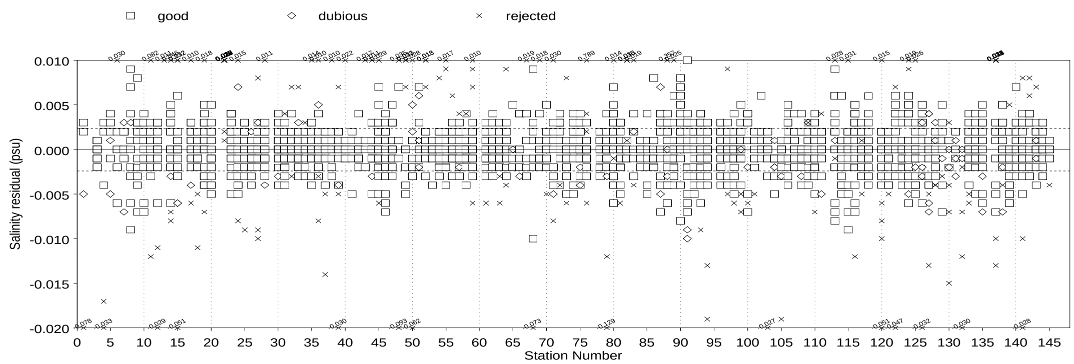
Calibration data for cruise : Au9604

Calibration file : histcal.lis

Conductivity s.d. = 0.00006

Number of bottles used = 2208 out of 2450 Mean ratio for all bottles = 1.00000

<u>Figure 2.3:</u> Conductivity ratio c_{btl}/c_{cal} versus station number for cruise au9604. The solid line follows the mean of the residuals for each station; the broken lines are ± the standard deviation of the residuals for each station (see CTD methodology).



Calibration data for cruise : Au9604

Calibration file : histcal.lis

Mean offset salinity = 0.0000psu (s.d. = 0.0024 psu)

Number of bottles used = 2208 out of 2450

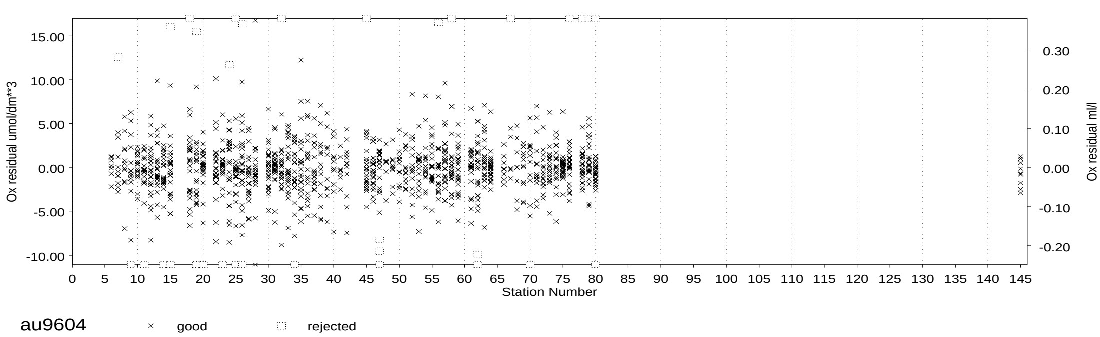
<u>Figure 2.4:</u> Salinity residual (s_{btl} - s_{cal}) versus station number for cruise au9604. The solid line is the mean of all the residuals; the broken lines are ± the standard deviation of all the residuals (see CTD methodology).

Mean of Residual = -0.031umol/dm**3

S.D. of residual = 2.744umol/dm**3 (Equiv to 0.061ml/l)

Used 1204 bottles out of total 2432

S.D. deep (>750m) 1.738umol/dm**3 (equiv to 0.039ml/l)



<u>Figure 2.5:</u> Dissolved oxygen residual (o_{btl} - o_{cal}) versus station number for cruise au9604.

<u>Table 2.9:</u> Surface pressure offsets (as defined in the CTD methodology). ** indicates that value is estimated from surrounding stations, or else determined from manual inspection of pressure data.

stn no.	surface p offset (dbar)	stn no.	surface p offset (dbar)	stn no.	surface p offset (dbar)	stn no.	surface p offset (dbar)
1	-0.25	41	-0.37	81	-0.33	121	-0.84
2	-0.61	42	-0.49	82	-0.89	122	-1.42
3	0.37	43	-0.48	83	-0.92	123	-1.01
4	0.11	44	-0.39	84	-0.56	124	-1.06
5	0.95	45	0.05	85	-0.51	125	-0.86
6	1.16	46	-0.65	86	-0.47	126	-0.84
7	1.33	47	-0.19	87	-0.35	127	-0.75
8	1.36**	48	0.00**	88	-0.75	128	-1.26
9	1.40	49	-0.40	89	-0.77**	129	-0.76
10	0.41	50	-0.15	90	-0.80	130	-0.17
11	1.61	51	-0.54	91	-0.74	131	-1.06
12	0.09	52	-0.32	92	-0.81	132	-0.27
13	0.28	53	-0.25	93	-0.88	133	-0.61
14	0.16	54	-0.99	94	-0.64	134	-0.84
15	0.04	55	-0.46	95	-0.75	135	-0.94
16	-0.06	56	-0.69	96	-0.92	136	-0.94
17	-0.03	57	-1.01	97	-0.75	137	-1.22
18	-0.24	58	-0.70	98	-0.39	138	-0.97
19	-0.22	59	-0.51	99	-0.45	139	-0.80
20	-0.36	60	-0.20	100	-0.59	140	-0.87
21	0.07	61	-1.02	101	-0.88	141	-0.93
22	-0.33	62	0.94	102	-0.65	142	-0.70
23	-0.34	63	-0.45	103	-0.35	143	-0.74
24	-0.59	64	-0.80	104	-0.40	144	-0.81
25	-0.38	65	-0.26	105	-0.56	145	0.09
26	-0.36	66	-0.45	106	-1.07	146	0.13
27	-0.26	67	-0.35	107	-0.63	147	-0.45
28	-0.46	68	-0.50**	108	-1.02		
29	-0.20**	69	-0.42	109	-0.56		
30	-1.05	70	-0.16	110	-1.03		
31	-0.33	71	-0.27	111	-1.14		
32	-0.40	72	-0.20	112	-0.49		
33	-0.53	73	-0.14	113	-1.02		
34	-0.30	74	-0.63	114	-0.76		
35	-0.53	75	-0.69	115	-0.96		
36	-0.41	76	-0.84	116	-0.90**		
37	-0.68	77	-0.49	117	-0.69		
38	-0.09	78	-0.64	118	-0.84		
39	-0.08	79	-0.47	119	-1.13		
40	-0.37	80	-0.18	120	-1.32		

Table 2.10: **CTD conductivity calibration coefficients. F_1, F_2 and F_3 are respectively conductivity bias, slope and station-dependent correction calibration terms. n is the number of samples retained for calibration in each station grouping; σ is the standard deviation of the conductivity residual for the n samples in the station grouping (see CTD methodology); α is the correction applied to CTD conductivities due to pressure dependence of the conductivity residuals (see eqn 1.1 in Part 1 of this report).**

stn grouping	F_1	F_2	F_3	n	σ	α
001 to 001	-3.4008230	0.10266676E-02	0	3	0.004993	-
002 to 002	-3.4008230	0.10266676E-02	0	3	0.004993	-
003 to 004	0.55764682	0.99645743E-03	-.28960267E-05	24	0.001263	-
005 to 007	-.52606214E-02	0.10046804E-02	0.95765457E-07	23	0.002064	-
008 to 008	0.44036103E-01	0.10031503E-02	0	11	0.004031	-
009 to 010	-.79348989E-01	0.10082906E-02	-.41941891E-07	31	0.002407	-
011 to 017	-.63365640E-01	0.10072857E-02	0.92934405E-08	98	0.001785	6.30E-07
018 to 019	-.16941205E-01	0.10029438E-02	0.16218103E-06	41	0.001701	6.30E-07
020 to 024	-.34773276E-01	0.10062501E-02	0.27600438E-07	67	0.002006	6.30E-07(stn20) 6.99E-07(stn21-24)
025 to 027	-.42861170E-01	0.10088248E-02	-.72135270E-07	65	0.001325	6.99E-07
028 to 030	-.38426094E-01	0.10043136E-02	0.84881449E-07	45	0.001317	6.99E-07
031 to 033	-.45089981E-01	0.10086500E-02	-.50005682E-07	67	0.001169	8.14E-07
034 to 035	-.16210020E-01	0.10136385E-02	-.22598949E-06	41	0.001225	8.14E-07
036 to 037	-.21369310E-01	0.10091878E-02	-.82466648E-07	31	0.001514	8.14E-07
038 to 040	-.50591527E-02	0.10050644E-02	0.20181984E-07	32	0.001201	8.14E-07
041 to 042	-.45224069E-01	0.10118294E-02	-.10457316E-06	20	0.001213	7.36E-07
043 to 044	-.89106026E-01	0.10309086E-02	-.50554005E-06	26	0.001366	7.36E-07
045 to 047	-.17972448E-02	0.10058200E-02	-.25894965E-08	69	0.001945	7.36E-07
048 to 051	-.11278398E-02	0.10018826E-02	0.75038871E-07	32	0.002178	7.36E-07(stn48-50) 6.06E-07(stn51)
052 to 054	-.22038176E-01	0.10077813E-02	-.29925844E-07	41	0.001056	6.06E-07
055 to 057	-.25708043E-01	0.10036519E-02	0.51001329E-07	63	0.001257	6.06E-07
058 to 060	-.16543813E-01	0.10067962E-02	-.11086368E-07	39	0.001133	6.06E-07
061 to 062	-.47632077E-01	0.10066633E-02	0.10413888E-07	45	0.001201	6.06E-07(stn61) - (stn62)
063 to 064	-.60785919E-02	0.10155002E-02	-.15326305E-06	40	0.001144	-
065 to 066	-.16546893E-01	0.10296772E-02	-.35846498E-06	14	0.001768	-
067 to 068	0.55308088E-02	0.10128742E-02	-.10922184E-06	13	0.003147	-
069 to 074	-.22735305E-01	0.10084174E-02	-.30649004E-07	82	0.001731	- (stn69-70) 10.16E-07(stn71-74)
075 to 076	-.86408281E-01	0.10071895E-02	0.16918503E-07	41	0.001395	10.16E-07
077 to 079	-.19036812E-01	0.10126020E-02	-.82942800E-07	44	0.001222	10.16E-07
080 to 081	-.24748542E-01	0.10069379E-02	-.84236957E-08	43	0.002302	10.16E-07(stn80) 4.09E-07(stn81)
082 to 084	-.35271471E-01	0.10118694E-02	-.62164157E-07	20	0.001201	4.09E-07
085 to 088	-.43779395E-01	0.10081677E-02	-.15567609E-07	56	0.002321	4.09E-07
089 to 091	-.26888057E-01	0.10126024E-02	-.70609756E-07	67	0.002901	4.09E-07(stn89-90) 7.45E-07(stn91)
092 to 093	-.25957370E-01	0.10035524E-02	0.29544867E-07	43	0.001936	7.45E-07
094 to 096	-.18031989E-01	0.10067845E-02	-.75915753E-08	46	0.001427	7.45E-07
097 to 099	0.72025201E-02	0.10024057E-02	0.27868859E-07	65	0.001602	7.45E-07
100 to 101	-.53994702E-01	0.10336150E-02	-.26094479E-06	15	0.002287	7.45E-07(stn100) 9.30E-07(stn101)
102 to 106	-.32221287E-01	0.10092370E-02	-.25813131E-07	54	0.001596	9.30E-07
107 to 108	-.27064708E-01	0.10121597E-02	-.55131810E-07	35	0.001449	9.30E-07
109 to 110	-.41781867E-01	0.10204373E-02	-.12507360E-06	44	0.001598	9.30E-07
111 to 116	-.51999880E-01	0.10066765E-02	0.40501302E-08	96	0.002602	10.39E-07
117 to 120	-.78123279E-01	0.10079076E-02	0.14758557E-08	62	0.001573	10.39E-07
121 to 123	-.30409364E-01	0.10153867E-02	-.74014007E-07	65	0.001666	10.33E-07
124 to 129	-.26783184E-01	0.10070376E-02	-.63658094E-08	97	0.002300	10.33E-07
130 to 132	-.99892436E-01	0.99483839E-03	0.10644714E-06	18	0.001000	10.33E-07(stn130) 6.37E-07(stn131-132)

Table 2.10: (continued)

stn grouping	F_1	F_2	F_3	n	σ	α
133 to 134	-.45705617E-01	0.10181827E-02	-.85306942E-07	44	0.001385	6.37E-07
135 to 137	-.56982632E-01	0.99366156E-03	0.10145251E-06	36	0.002465	6.37E-07
138 to 140	-.35961294E-01	0.10126337E-02	-.42141044E-07	67	0.002214	6.37E-07
141 to 142	-.18766667E-01	0.10120811E-02	-.42780742E-07	41	0.001695	6.37E-07
143 to 144	-.40630706E-01	0.98885825E-03	0.12512651E-06	40	0.001301	6.37E-07
145 to 145	0.90433855E-01	0.95596375E-03	0	6	0.000397	-
146 to 146	0.90433855E-01	0.95596375E-03	0	6	0.000397	-
147 to 147	0.90433855E-01	0.95596375E-03	0	6	0.000397	-

Table 2.11: Station-dependent-corrected conductivity slope term (F_2 + F_3 . N), for station number N, and F_2 and F_3 the conductivity slope and station-dependent correction calibration terms respectively.

stn no.	(F_2 + F_3 . N)	stn no.	(F_2 + F_3 . N)	stn no.	(F_2 + F_3 . N)	stn no.	(F_2 + F_3 . N)
1	0.10266676E-02	41	0.10075419E-02	81	0.10062556E-02	121	0.10064310E-02
2	0.10266676E-02	42	0.10074373E-02	82	0.10067720E-02	122	0.10063570E-02
3	0.98776935E-03	43	0.10091704E-02	83	0.10067098E-02	123	0.10062829E-02
4	0.98487332E-03	44	0.10086648E-02	84	0.10066477E-02	124	0.10062482E-02
5	0.10051592E-02	45	0.10057035E-02	85	0.10068445E-02	125	0.10062418E-02
6	0.10052550E-02	46	0.10057009E-02	86	0.10068289E-02	126	0.10062355E-02
7	0.10053508E-02	47	0.10056983E-02	87	0.10068134E-02	127	0.10062291E-02
8	0.10031503E-02	48	0.10054845E-02	88	0.10067978E-02	128	0.10062227E-02
9	0.10079131E-02	49	0.10055595E-02	89	0.10063182E-02	129	0.10062164E-02
10	0.10078712E-02	50	0.10056346E-02	90	0.10062476E-02	130	0.10086765E-02
11	0.10073879E-02	51	0.10057096E-02	91	0.10061770E-02	131	0.10087830E-02
12	0.10073972E-02	52	0.10062251E-02	92	0.10062705E-02	132	0.10088894E-02
13	0.10074065E-02	53	0.10061952E-02	93	0.10063001E-02	133	0.10068369E-02
14	0.10074158E-02	54	0.10061653E-02	94	0.10060709E-02	134	0.10067516E-02
15	0.10074251E-02	55	0.10064570E-02	95	0.10060633E-02	135	0.10073576E-02
16	0.10074344E-02	56	0.10065080E-02	96	0.10060557E-02	136	0.10074591E-02
17	0.10074437E-02	57	0.10065590E-02	97	0.10051090E-02	137	0.10075606E-02
18	0.10058631E-02	58	0.10061532E-02	98	0.10051368E-02	138	0.10068183E-02
19	0.10060253E-02	59	0.10061421E-02	99	0.10051647E-02	139	0.10067761E-02
20	0.10068021E-02	60	0.10061310E-02	100	0.10075206E-02	140	0.10067340E-02
21	0.10068297E-02	61	0.10072986E-02	101	0.10072596E-02	141	0.10060490E-02
22	0.10068573E-02	62	0.10073090E-02	102	0.10066040E-02	142	0.10060063E-02
23	0.10068849E-02	63	0.10058447E-02	103	0.10065782E-02	143	0.10067513E-02
24	0.10069125E-02	64	0.10056914E-02	104	0.10065524E-02	144	0.10068765E-02
25	0.10070214E-02	65	0.10063770E-02	105	0.10065266E-02	145	0.95596375E-03
26	0.10069493E-02	66	0.10060185E-02	106	0.10065008E-02	146	0.95596375E-03
27	0.10068771E-02	67	0.10055564E-02	107	0.10062606E-02	147	0.95596375E-03
28	0.10066903E-02	68	0.10054471E-02	108	0.10062055E-02		
29	0.10067751E-02	69	0.10063026E-02	109	0.10068043E-02		
30	0.10068600E-02	70	0.10062720E-02	110	0.10066792E-02		
31	0.10070999E-02	71	0.10062413E-02	111	0.10071260E-02		
32	0.10070499E-02	72	0.10062107E-02	112	0.10071301E-02		
33	0.10069999E-02	73	0.10061800E-02	113	0.10071341E-02		
34	0.10059549E-02	74	0.10061494E-02	114	0.10071382E-02		
35	0.10057289E-02	75	0.10084584E-02	115	0.10071422E-02		
36	0.10062190E-02	76	0.10084753E-02	116	0.10071463E-02		
37	0.10061365E-02	77	0.10062154E-02	117	0.10080803E-02		
38	0.10058313E-02	78	0.10061325E-02	118	0.10080818E-02		
39	0.10058515E-02	79	0.10060495E-02	119	0.10080833E-02		
40	0.10058717E-02	80	0.10062640E-02	120	0.10080847E-02		

Table 2.12: **CTD raw data scans flagged for special treatment (see previous data reports for explanation).**

station number	approximate pressure (dbar)	raw scan numbers	action taken	reason
4(downcast)	286	22602-22953	ignore	fouling of cond. cell
7(downcast)	146	10608-10626	ignore	bad data scans
145(upcast)		571-579,730-741,799-802	ignore	bad pressure data
145(upcast)		855-858,1137-1140,1404-1408	ignore	bad pressure data
145(upcast)		2218-2236,2872-2879	ignore	bad pressure data
145(upcast)		5607-5612,5703-5711	ignore	bad pressure data
146(upcast)		3097-3100,3151-3155,3260-3263	ignore	bad pressure data
146(upcast)		3286-3298,3334-3337,3388-3390	ignore	bad pressure data
146(upcast)		3421-3425,3442-3445,3477-3480	ignore	bad pressure data
147(upcast)		3036-3039,3142-3146,3158-3163	ignore	bad pressure data
147(upcast)		3210-3213	ignore	bad pressure data

Table 2.13: **Missing data points in 2 dbar-averaged files. "1" indicates missing data for the indicated parameters: T=temperature; S=salinity, σ_T, specific volume anomaly and geopotential anomaly; O=dissolved oxygen; PAR=photosynthetically active radiation; F=fluorescence. Note that jmin is the minimum number of data points required in a 2 dbar bin to form the 2 dbar average (see CTD methodology).**

station number	pressures (dbar) where data missing	T	S	O	PAR	F	reason
1	entire profile			1			no bottles for oxygen calibration
2	entire profile		1	1			no bottles for calibration
3	entire profile			1			bad oxygen data
3	3924	1	1	1	1		no. of data pts in 2 dbar bin < jmin
4,5	entire profile			1			no bottles for oxygen calibration
8	2	1	1	1	1		CTD not logging
13	618	1	1	1	1		no. of data pts in 2 dbar bin < jmin
16,21,29	entire profile			1			no bottles for oxygen calibration
17	entire profile			1			bad oxygen data
20	2852-2864			1			bad oxygen data
26	2-58			1			bad oxygen data
35	448	1	1	1	1		no. of data pts in 2 dbar bin < jmin
38	1210	1	1	1	1		no. of data pts in 2 dbar bin < jmin
40	522	1	1	1	1		no. of data pts in 2 dbar bin < jmin
41	2-16			1			bad oxygen data
43	entire profile			1			no bottles for oxygen calibration
43	100	1	1	1	1		no. of data pts in 2 dbar bin < jmin
44	2032-2104		1				fouling of cond. cell
44	entire profile			1			bad oxygen data
60	entire profile			1			no bottles for oxygen calibration
62	2	1	1	1			bad data
62	950	1	1	1	1		no. of data pts in 2 dbar bin < jmin
62	952			1			bad oxygen data
64	932-946		1				fouling of cond. cell
65,77	entire profile			1			no bottles for oxygen calibration
72	1832	1	1	1	1		no. of data pts in 2 dbar bin < jmin
74	18-28			1			bad oxygen data
75	2542	1	1	1	1		no. of data pts in 2 dbar bin < jmin
79	2-72			1			bad oxygen data
82	2	1	1				bad data

Table 2.13: **(continued)**

station number	pressures (dbar) where data missing	T	S	O	PAR	F	reason
83	438	1	1	1	1		no. of data pts in 2 dbar bin < jmin
89	2	1	1	1	1		CTD not logging
92	3518	1	1	1	1		no. of data pts in 2 dbar bin < jmin
97	3888	1	1	1	1		no. of data pts in 2 dbar bin < jmin
98	2110-3106		1				fouling of cond. cell
123	1904-2180		1				fouling of cond. cell
133	3952	1	1	1	1		no. of data pts in 2 dbar bin < jmin
134	3926	1	1	1	1		no. of data pts in 2 dbar bin < jmin
141	1804	1	1		1		no. of data pts in 2 dbar bin < jmin
81-144	entire profile			1			bad oxygen data
145	326,374,428			1			bad oxygen data
146,147	entire profile			1			no bottles for oxygen calibration
147	2-24		1				fouling of cond. cell
1-3,14-33	entire profile					1	fluorometer not installed
35	entire profile					1	bad fluorometer data
36-147	entire profile					1	fluorometer not installed

Table 2.14: **2 dbar averages interpolated from surrounding 2 dbar values, for the indicated parameters.**

station number	interpolated 2 dbar values	parameters interpolated
2	3320	T, PAR
133	1482	T, S, PAR
135	1986	T, S, PAR

Table 2.15a: **Suspect 2 dbar salinity averages (+ temperature where indicated). Note: for suspect salinity values, the following are also suspect: σ_T, specific volume anomaly, and geopotential anomaly.**

station number	suspect 2 dbar values (dbar) bad	questionable	reason
3	-	66	salinity spike in steep local gradient
4	-	64,66	salinity spike in steep local gradient
9	-	138	bad data scans
11	-	36,38	salinity spike in steep local gradient
13	-	52,54	salinity spike in steep local gradient
15	-	600	salinity spike in steep local gradient
17	-	198,200	salinity spike in steep local gradient
18	-	150,152	salinity spike in steep local gradient
20	-	2856-2870	possible fouling of conductivity cell
21	-	48	salinity spike in steep local gradient
22	-	52,54	salinity spike in steep local gradient
30	-	8,10	salinity spike in steep local gradient
32	-	170	salinity spike in steep local gradient
36	-	46	salinity spike in steep local gradient
39	-	12,14	salinity spike in steep local gradient
46	-	44,46	salinity spike in steep local gradient
59	-	42,44	salinity spike in steep local gradient
61	-	40,42	salinity spike in steep local gradient
62	-	952	possible fouling of conductivity cell
63	-	108,110	salinity spike in steep local gradient
70	-	14-20	salinity spike in steep local gradient
80	-	32,34	salinity spike in steep local gradient
85	-	36	salinity spike in steep local gradient
93	-	34,64,66	salinity spike in steep local gradient
94	-	34,42-52	salinity spike in steep local gradient
97	-	38,56	salinity spike in steep local gradient
98	-	34,36	salinity spike in steep local gradient
99	-	44,46	salinity spike in steep local gradient
104	-	36,38	salinity spike in steep local gradient
107	-	38	salinity spike in steep local gradient
109	-	32,34,138,168	salinity spike in steep local gradient
110	-	32	salinity spike in steep local gradient
111	-	40-44	salinity spike in steep local gradient
112	-	52-56	salinity spike in steep local gradient
113	-	42	salinity spike in steep local gradient
114	-	50-54	salinity spike in steep local gradient
117	-	54-58	salinity spike in steep local gradient
118	-	64	salinity spike in steep local gradient
119	-	56	salinity spike in steep local gradient (T also)
120	-	48-52	salinity spike in steep local gradient
129	-	696	salinity spike in steep local gradient
133	-	64,66	salinity spike in steep local gradient
137	-	62,64	salinity spike in steep local gradient
140	-	56,58,126	salinity spike in steep local gradient
142	-	34,36	salinity spike in steep local gradient

<u>Table 2.15b:</u> Suspect 2 dbar-averaged data from near the surface (applies to all parameters other than dissolved oxygen, except where noted).

stn	suspect 2dbar values	
no.	bad	questionable
3,4	2	4
5	2,4	-
6,7	-	2
8	-	4
10	-	2 (T okay)
11,12	-	2
13	2	4
14	2,4	6
15	-	2
16	2	4,6
17	-	2,4
18,19	-	2
20	-	2-6
21	-	2,4
22	-	2
22	-	4 (T okay)
23	-	2
24	2	-
26	2	4-8
27	2	4
29	-	2
31	2	4
32,33	-	2
34	-	2,4
34	-	6 (T okay)
35	-	2,4
35	-	6 (T okay)
36,37	-	2
39	-	2
40	-	2,4 (T okay)
41,42	-	2,4
43	2	4
44,45	-	2,4
46-48	-	2
49	-	2,4
50	-	2
51	-	2,4
52	2	-
52	-	4-14 (T okay)
53	2	-
53	-	4-14 (T okay)
54	2	4
55	2	-
56	2	4
57	-	2,4
58,59	-	2
60	-	2 (T okay)
62	4	6
63	2	4
64	-	2
65	2	4
66	-	2
66	-	4-18 (T okay)
67	2	-
68	2-60	- (T okay)
69	2,4	6
70,71	-	2
74,75	2	4
76	-	2-6
79	-	2
80	2	4
82	-	4
83	-	2
84,85	2	4
86	-	2
87	-	2,4
90	-	2
91	2	4
92	-	2,4
94	-	2
96,97	-	2
98,99	2	4
100,101	-	2
102	2	4,6
103	-	2
104	-	2,4
105	-	2
106,107	-	2,4
108	2	4
109	2	4
110,111	-	2,4
112	2	4
113	-	2
114,115	-	2,4
116-118	-	2
119	-	2,4
120	-	2
121	2	4
123	-	2,4
124	-	2
125	-	2,4
126	2	4
127	2	-
128	2	4
129	-	2,4
130	2	4,6
131	-	2
132	-	2,4
133	2	4,6
134	-	2,4
135	-	2-6
136,137	-	2
138	-	2,4
139	-	2
140	-	2,4
141,142	-	2
143,144	2	4

Table 2.16: Suspect 2 dbar-averaged dissolved oxygen data.

stn no.	suspect 2dbar values(dbar) bad	questionable	stn no.	suspect 2dbar values(dbar) bad	questionable
6	-	16-28	42	-	2-12
9	-	2-12,138,228	45	-	2
9	-	230,262,264	47	-	2,4
11	-	2	48	-	14-56
13	-	2-6	49	-	2-12
14	-	2,4	51	-	2-10
23	-	2-42	54	-	6-10
27	-	2-16	55	-	2-14
28	-	2-6,48-56	56	-	2
30	-	2-6	57	-	2,4
31	-	2-26,54-58	58	-	2-8
32	-	2	62	-	4-8,954-960
33	-	2-8	63	-	2-28
34	-	4-30	64	-	932-946
35	-	2-10	67	-	2,10-58
38	-	2-8,54-60	68	-	2-12
41	-	54-60	75	-	2

Table 2.17: CTD dissolved oxygen calibration coefficients. K_1, K_2, K_3, K_4, K_5 and K_6 are respectively oxygen current slope, oxygen sensor time constant, oxygen current bias, temperature correction term, weighting factor, and pressure correction term. dox is equal to 2.8σ (for σ as defined by eqn A2.24 in the CTD methodology); n is the number of samples retained for calibration in each station or station grouping.

station number	K_1	K_2	K_3	K_4	K_5	K_6	dox	n
1-5	-	-	-	-	-	-	-	-
6	7.418	5.00	-0.565	-0.06023	1.6962	-0.20179E-04	0.07725	7
7	6.872	5.00	-0.708	-0.13410	0.7181	0.24655E-03	0.14338	10
8	3.642	5.00	0.096	-0.12494	0.5941	-0.10229E-03	0.21158	11
9	7.093	5.00	-0.748	-0.11343	0.6713	0.89483E-04	0.23546	13
10	11.981	5.00	-1.621	-0.17472	0.9308	0.12612E-03	0.10240	17
11	6.451	5.00	-0.560	-0.14690	0.6141	0.67143E-04	0.10334	17
12	17.160	5.00	-2.450	-0.25734	1.0491	0.14873E-03	0.19673	24
13	20.289	5.00	-3.071	-0.25086	1.0967	0.17067E-03	0.19821	23
14	6.458	5.00	-0.699	-0.05269	0.2338	0.98041E-04	0.13005	23
15	14.242	5.00	-2.061	-0.16623	0.9724	0.14757E-03	0.20143	22
16-17	-	-	-	-	-	-	-	-
18	14.222	5.00	-2.049	-0.14751	1.0652	0.14078E-03	0.22139	22
19	8.206	5.00	-0.813	-0.17663	0.7010	0.61268E-04	0.21079	19
20	9.633	5.00	-1.285	-0.08468	0.7706	0.13244E-03	0.14319	20
21	-	-	-	-	-	-	-	-
22	14.502	5.00	-2.099	-0.16000	0.8689	0.14116E-03	0.22888	23
23	12.887	6.00	-1.907	-0.10053	0.8371	0.16632E-03	0.11743	22
24	13.362	5.00	-1.989	-0.11649	0.9941	0.20188E-03	0.24027	23
25	12.223	5.00	-1.746	-0.09636	0.8988	0.15115E-03	0.15767	21
26	9.611	5.00	-1.041	-0.25649	0.7004	0.80656E-04	0.25574	22
27	7.947	5.00	-0.957	-0.09613	0.6344	0.11430E-03	0.17697	24
28	12.035	5.00	-1.684	-0.15714	0.6915	0.13169E-03	0.29089	24
29	-	-	-	-	-	-	-	-

Table 2.17: (continued)

station number	K_1	K_2	K_3	K_4	K_5	K_6	dox	n
30	11.283	5.00	-1.590	-0.11215	0.5598	0.12912E-03	0.15112	24
31	10.148	5.00	-1.384	-0.08487	0.7658	0.13585E-03	0.14159	24
32	7.618	5.00	-0.916	-0.04725	0.5352	0.11641E-03	0.16382	23
33	35.331	6.00	-5.598	-0.38808	1.0868	0.20304E-03	0.18587	24
34	16.145	5.00	-2.448	-0.16724	0.9970	0.18210E-03	0.18263	23
35	13.675	5.00	-1.902	-0.17720	0.9764	0.12958E-03	0.27098	21
36	14.710	5.00	-2.116	-0.19929	0.9144	0.14117E-03	0.23900	18
37	18.358	5.00	-2.776	-0.21192	0.9571	0.15181E-03	0.17370	17
38	21.256	5.00	-3.387	-0.25768	0.8768	0.25256E-03	0.24543	14
39	10.125	5.00	-1.226	-0.12277	0.7522	-0.16664E-04	0.24269	10
40	8.252	6.00	-1.028	-0.08883	0.2829	0.22137E-03	0.20618	10
41	13.477	5.00	-1.923	-0.14286	0.8308	0.18302E-03	0.09454	8
42	13.110	5.00	-1.792	-0.11370	0.9803	0.15074E-03	0.20964	12
43-44	-	-	-	-	-	-	-	-
45	8.231	5.00	-1.044	-0.09496	0.5569	0.12043E-03	0.14826	23
46	9.107	5.00	-1.227	-0.05124	0.3477	0.12590E-03	0.11759	24
47	14.485	5.00	-2.190	-0.12723	1.2218	0.18700E-03	0.12920	21
48	2.745	8.00	1.062	0.37630	0.0352	-0.12314E-03	0.13448	6
49	17.719	8.00	-2.755	-0.19351	1.0108	0.22516E-03	0.11148	9
50	14.718	6.00	-2.083	-0.21094	0.8862	0.15609E-03	0.14124	11
51	12.666	8.00	-1.640	-0.18490	0.8430	0.73093E-04	0.13368	13
52	15.079	5.00	-2.041	-0.23234	0.8909	0.10585E-03	0.22428	14
53	16.435	5.00	-2.359	-0.21402	0.9059	0.12835E-03	0.17349	15
54	8.565	8.00	-1.023	-0.09570	0.5068	0.87403E-04	0.18297	18
55	17.456	5.00	-2.586	-0.18771	0.9519	0.14376E-03	0.14614	19
56	13.541	6.00	-1.848	-0.17231	0.8238	0.11222E-03	0.18034	22
57	17.585	5.00	-2.693	-0.18359	0.9900	0.16884E-03	0.19072	24
58	8.252	5.00	-1.050	-0.04507	0.2405	0.11100E-03	0.17519	23
59	12.812	5.00	-1.830	-0.11619	0.8256	0.13463E-03	0.15943	24
60	-	-	-	-	-	-	-	-
61	15.443	8.00	-2.249	-0.15869	0.7950	0.12621E-03	0.16280	24
62	7.552	5.00	-0.872	-0.08247	0.3376	0.89890E-04	0.18896	21
63	7.801	5.00	-0.920	-0.07044	0.3663	0.96123E-04	0.17730	24
64	10.588	8.00	-1.423	-0.09551	0.4398	0.10736E-03	0.10591	24
65	-	-	-	-	-	-	-	-
66	15.627	5.00	-2.396	-0.23340	0.7954	0.21008E-03	0.09261	8
67	10.786	5.00	-1.332	-0.12683	0.9951	0.14226E-03	0.17909	5
68	13.291	6.00	-1.900	-0.14946	0.8944	0.24323E-03	0.20779	8
69	25.046	5.00	-4.052	-0.26061	1.0344	0.20912E-03	0.14930	12
70	15.205	5.00	-2.163	-0.21336	0.8850	0.12566E-03	0.20667	11
71	7.230	5.00	-0.591	-0.22886	0.5820	0.37917E-04	0.21003	14
72	11.370	5.00	-1.454	-0.18495	0.7181	0.94158E-04	0.13537	15
73	6.947	8.00	-0.755	-0.08066	0.2406	0.86378E-04	0.14414	18
74	15.394	8.00	-2.287	-0.20745	0.9438	0.18530E-03	0.15400	18
75	7.348	5.00	-0.888	-0.04344	0.3395	0.11707E-03	0.10340	23
76	13.500	10.0	-2.049	-0.06560	1.2992	0.19319E-03	0.11749	23
77	-	-	-	-	-	-	-	-
78	10.578	5.00	-1.514	-0.04315	0.8707	0.14700E-03	0.10303	23
79	5.153	5.00	-0.414	-0.08473	0.6596	0.98564E-04	0.16396	21
80	11.496	10.0	-1.606	-0.08090	0.9995	0.14893E-03	0.07288	22
81-144	-	-	-	-	-	-	-	-
145	6.980	7.00	-0.716	-0.11934	0.5563	0.12412E-03	0.10894	9
146-147	-	-	-	-	-	-	-	-

Table 2.18: **Starting values for CTD dissolved oxygen calibration coefficients prior to iteration, and coefficients varied during iteration (see CTD methodology). Note that coefficients not varied during iteration are held constant at the starting value.**

station number	K_1	K_2	K_3	K_4	K_5	K_6	coefficients varied
1-5	-	-	-	-	-	-	-
6	9.100	5.0000	-0.200	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
7	6.600	5.0000	-0.800	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
8	6.600	5.0000	-1.100	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
9	12.400	5.0000	-1.700	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
10	11.700	5.0000	-1.400	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
11	6.700	5.0000	-0.600	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
12	9.300	5.0000	1.600	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
13	8.400	5.0000	0.400	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
14	8.300	5.0000	-0.100	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
15	11.300	5.0000	-2.400	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
16-17	-	-	-	-	-	-	-
18	10.500	5.0000	-2.500	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
19	8.200	5.0000	-0.700	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
20	9.550	5.0000	-1.300	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
21	-	-	-	-	-	-	-
22	12.600	5.0000	-2.100	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
23	9.410	6.0000	-2.100	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
24	11.170	5.0000	-2.300	-0.300E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
25	11.200	5.0000	-2.000	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
26	9.900	5.0000	-1.100	-0.450E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
27	9.300	5.0000	-0.700	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
28	12.600	5.0000	-1.400	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
29	-	-	-	-	-	-	-
30	13.600	5.0000	-0.800	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
31	10.100	5.0000	-1.400	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
32	12.000	5.0000	0.000	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
33	9.100	5.0000	-2.300	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
34	13.330	5.0000	-2.300	-0.340E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
35	12.000	5.0000	-2.000	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
36	14.400	5.0000	-1.900	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
37	7.500	5.0000	1.000	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
38	3.900	5.0000	0.500	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
39	7.900	5.0000	-1.300	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
40	8.900	6.0000	-1.000	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
41	12.400	5.0000	-2.100	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
42	12.700	5.0000	-1.900	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
43-44	-	-	-	-	-	-	-
45	9.500	5.0000	-0.800	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
46	12.700	5.0000	-0.300	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
47	13.000	5.0000	-2.100	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
48	14.610	8.0000	-0.700	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
49	14.800	8.0000	-2.200	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
50	14.900	6.0000	-2.100	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
51	14.700	8.0000	-1.000	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
52	14.200	5.0000	-2.100	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
53	15.400	5.0000	-2.300	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
54	8.700	8.0000	-1.000	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
55	15.000	5.0000	-2.200	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
56	12.100	6.0000	-1.900	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
57	14.200	5.0000	-2.400	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6

Table 2.18: **(continued)**

station number	K_1	K_2	K_3	K_4	K_5	K_6	coefficients varied
58	11.900	5.0000	0.100	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
59	11.300	5.0000	-2.100	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
60	-	-	-	-	-	-	-
61	13.750	8.0000	-2.500	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
62	8.400	5.0000	-0.700	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
63	11.000	5.0000	-2.300	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
64	11.200	8.0000	-1.300	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
65	-	-	-	-	-	-	-
66	10.800	5.0000	-1.700	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
67	10.300	5.0000	-1.500	-0.470E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
68	10.900	6.0000	-2.300	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
69	11.720	5.0000	-2.200	-0.360E-01	0.740	0.15000E-03	K_1 K_3 K_4 K_5 K_6
70	13.600	5.0000	-2.300	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
71	15.000	5.0000	-1.200	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
72	11.700	5.0000	-1.300	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
73	7.300	8.0000	-0.700	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
74	12.800	8.0000	-1.800	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
75	9.900	5.0000	-0.200	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
76	12.820	10.0000	-2.300	-0.400E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
77	-	-	-	-	-	-	-
78	10.600	5.0000	-1.500	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
79	6.500	5.0000	-0.300	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
80	14.500	10.0000	-0.900	-0.600E-01	0.700	0.15000E-03	K_1 K_3 K_4 K_5 K_6
81-144	-	-	-	-	-	-	-
145	11.400	7.0000	0.000	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
146-147	-	-	-	-	-	-	-

Table 2.19: **Dissolved oxygen Niskin bottle samples flagged as -9 for dissolved oxygen calibration. Note that this does not necessarily indicate a bad bottle sample - in many cases, flagging is due to bad CTD dissolved oxygen data.**

station number	rosette position	station number	rosette position
7	4	47	21,20,19
9	5	56	17
11	11	58	20
14	22	62	21,20
15	22,21	67	17
18	21,19	70	8
19	21,20,19,1	76	23
20	22,21,20	78	22
23	24	79	24,23,22
24	22	80	23,21
25	23,21,19		
26	22,20		
32	23		
34	24		
45	21		

Table 2.20: **Questionable dissolved oxygen Niskin bottle sample values (not deleted from hydrology data file).**

stn no.	rosette position
17	14
101	5,3

Table 2.21: **Questionable nutrient sample values (not deleted from hydrology data file).**

PHOSPHATE		NITRATE		SILICATE	
station number	rosette position	station number	rosette position	station number	rosette position
		12	9,8		
				24	7-17
26	6	26	6	26	6
34	22,11,7				
40	5				
				47	6,3
53	20				
				57	whole stn
58	12				
62	7				
74	whole stn				
		79	9-12		
				96	whole stn
		101	12		
118	5	118	5	118	5
		126	7		
		133	12		
		135	21		
144	3	144	10		

Table 2.22: **Protected and unprotected reversing thermometers used (serial numbers are listed).**

protected thermometers

station numbers	rosette position 24 thermometers	rosette position 12 thermometers	rosette position 2 thermometers
1 to 144	12095,12096	12094	12119,12120
145 to 147	12095	12094,12096	12119,12120

unprotected thermometers

station numbers	rosette position 12 thermometers	rosette position 2 thermometers
1 to 92	11992	11993
93 to 147	11993	11992

Table 2.23: Calibration coefficients and calibration dates for CTD serial numbers 1103 and 1193 (unit nos 7 and 5 respectively) used during RSV Aurora Australis cruise AU9604. Note that an additional pressure bias term due to the station dependent surface pressure offset exists for each station (eqn A2.1 in the CTD methodology). Also note that platinum temperature calibrations are for the ITS-90 scale.

	CTD serial 1103 (unit no. 7)		**CTD serial 1193 (unit no. 5)**	
	coefficient	value of coefficient	coefficient	value of coefficient
pressure calibration coefficients CSIRO Calibration Facility - 08/11/1995 / pressure calibration coefficients CSIRO Calibration Facility - 19/12/1995				
	pcal0	-2.065725e+01	pcal0	-9.105560
	pcal1	1.002878e-01	pcal1	1.008189e-01
	pcal2	4.951104e-09	pcal2	2.773686e-10
	pcal3	4.500981e-14	pcal3	0.0
	pcal4	-4.514384e-19	pcal4	0.0
platinum temperature calibration coefficients CSIRO Calibration Facility - 26/09/1995 / platinum temperature calibration coefficients CSIRO Calibration Facility - 26/06/1996				
	Tcal0	0.23396e-01	Tcal0	-0.46860e-01
	Tcal1	0.49983e-03	Tcal1	0.49879e-03
	Tcal2	0.35049e-11	Tcal2	0.27541e-11
pressure temperature calibration coefficients CSIRO Calibration Facility - 10/07/1996 / pressure temperature calibration coefficients CSIRO Calibration Facility - 09/11/1995				
	Tpcal0	1.713678e+02	Tpcal0	1.167581e+02
	Tpcal1	-4.239208e-03	Tpcal1	-2.450758e-03
	Tpcal2	1.481513e-08	Tpcal2	0.0
	Tpcal3	0.0	Tpcal3	0.0
coefficients for temperature correction to pressure CSIRO Calibration Facility - 10/07/1996 / coefficients for temperature correction to pressure CSIRO Calibration Facility - 09/11/1995				
	T_0	20.00	T_0	20.00
	S_1	-9.196843e-06	S_1	-1.474830e-05
	S_2	-7.818015e-02	S_2	-7.847037e-02

preliminary polynomial coefficients applied to fluorescence (fl) (Antarctic Division, January 1996) and photosynthetically active radiation (par) (supplied by manufacturer) raw digitiser counts

for fluorometer set to 0-30 mg/m3 range (i.e. prior to 02/02/96):

f0	-3.345252e+01
f1	1.020700e-03
f2	0.0

for fluorometer set to 0-10 mg/m3 range (i.e. from 02/02/96 onwards):

f0	-1.115084e+01
f1	3.402400e-04
f2	0.0
par0	-4.499860
par1	1.373290e-04
par2	-3.452156e-23

APPENDIX 2.1 Hydrochemistry Laboratory Report

Seawater samples were analysed for nutrient concentrations (nitrate plus nitrite, silicate, and phosphate), salinities, and dissolved oxygen concentrations. The methods used are described in Eriksen (1997). A new nutrient autoanalyser data logging system, methods of examining intra-run quality checks (tops), basic inter-run quality checks, and improved temperature control and monitoring were implemented on this cruise.

Number of samples analysed:

Nutrients (nitrate plus nitrite, silicate, phosphate) : 2470
Salinities : 2500
Dissolved oxygens : 2450

A2.1.1 NUTRIENTS

General

The same TACS cadmium reduction coil was used for all but the first run.

Nitrate + nitrite and phosphate were calibrated with first order curves, and silicate with second order.

At the end of the cruise samples were run as part of the National Low Level Nutrient Collaborative Trials (NLLNCT).

Standards were made fresh every day. They were stored at around 4_C between runs. Tops and nitrites were made fresh every couple of days, and were also stored at around 4_C.

New datalogging system

A new datalogging system was used for the first time, to replace the old DOS based 'DAPA' program. The system consisted of a Labtronics (Canada) 103 analogue to digital (A/D) board, and a Windows software package by Astoria-Pacific (USA), Faspac 1.2. Data was logged using both the Labtronics/Faspac system, and DAPA. The new program, while having some good points, was far from perfect, as summarised below. Many of the problems were to be fixed in later versions (1.30, 1.31).

Some comments on Faspac

- Good Points

* Generally, easy and quick to get to different parts of the program, and to use; especially when compared to the awkwardness of DAPA.

* Real time display of the trace is good. It is easy to look at earlier parts of a run while the run is still in progress.

* The display and calculation of calibration standards is excellent. It is real time so this aspect of machine performance can be observed before samples are opened. It is easy to delete outliers, and to see how that affects the correlation of the fitted curve, and the standard deviation of the residual between calculated and observed points.

* Real time calculation of concentrations is good, so it’s possible to see if sample concentrations look reasonable.

* Keeps track of the baseline reasonably well.

* Correcting the peak height position for spikes is easy (in contrast to DAPA).

- Fatal Points

* Crashes, from a number of different areas in different circumstances. A warning box stating that Windows has become unstable generally appears. Mostly time is lost, as data processing needs to be repeated.

* Crashes during a run with large sample numbers. Get a 'Peak Num = 6553' error message. Have lost data this way.

* Does not handle interpolation of multiple standards correctly.

- Bad Points

* Problems in 'peak search':
-peak smoothing does not function.
-does not always find top of peaks.
These work in peak search window, but do not work on real data. This is both during a run, or doing a 'rerun' of data.

* Starting Faspac causes an oscillating voltage, which is seen on the chart recorder. To reduce the problem, the following steps are performed :
Stop run, save run, exit Faspac, close 'Data logger' program, restart data logger and Faspac, 'Resume' run.

* Doesn't write Excel files properly. On reading, Excel crashes ('General protection error'). Excel also had difficulty reading text files. Excel 4 was used.

* Doesn't have a mouse driven 'Zoom' function. It is possible to zoom in on peaks, but only by inefficiently varying the horizontal and vertical scales.

* It is not exactly clear how the special symbol 'W' is used to define the baseline. It depends on the context of other W's nearby.

Problems

There was a problem with the A/D board (SN 35/91, 'original') at the mid-point voltage, where a 'glitch' was observed. It can be observed by looking at a ramped voltage input from a signal generator (see Figure A2.1.1). This affected a number of nitrate + nitrite values. The gain of the nitrate detector was reduced so that the maximum signal did not reach the voltage of the ‘glitch’.

There was a problem with the phosphate channel. On a number of runs, high phosphate values were seen for seawater samples, but not for standards prepared in saline solution. The raw output for standards was the same for different runs, indicating that the seawater samples were being read as high. On the nitrate vs phosphate plot the phosphates were seen to be high, while the nitrates were about normal. The problem seemed to be correlated with ageing of ammonium molybdate stock solution. If fresh ammonium molybdate was used the problem seemed to be reduced. At the end of the cruise some nutrient trial samples were run. The results from these indicated that the phosphate channel was running reasonably well. Affected samples were rerun.

On the silicate channel, a precipitate in the ammonium molybdate reagent was observed a few days after preparation of fresh reagent. Generally the solution was replaced to reduce the risk of particles travelling through the system.

After a pump tube change there was no response from the nitrate channel. This was traced to a faulty blocked Bran and Luebe tube.

On run 7 Faspac crashed. No reliable results were produced for silicates, and only some results from the early part of the run for nitrates and phosphates. The nitrate and phosphate samples were rerun. Silicate, which does not store well, was calculated by hand from the chart. To verify that the hand and Faspac methods of calculation produced similar results, some of the usable nitrate results from Faspac were compared to hand calculated ones, with an average difference of around 0.6% (hand calculations larger).

Tops

'Tops' are used as a check of changes in instrument responsiveness during a run. They are the same concentration as the top standard, but are made separately. They are placed at the start of a run and after every block of 12 samples.

The tops macro within A9604.XLM was used to extract tops from each *.XLS run file, calculate statistics, and collate these statistics. The rsd % and range % for the nitrate + nitrite, silicate, and phosphate channels are shown in Figure A2.1.3.

The nitrate and phosphate channels had average ranges of 2.7% and 1.8% respectively. Variations in silicate were greater, with an average range of 4.2%. The silicates had about 20 runs with tops ranges greater than 5%. These 20 were examined, and some had obvious outliers, some appeared random, and about 7 had a time dependent drift. Examples of the worst cases of tops variations for the three channels are shown in Figure A2.1.4.

In general, correcting for tops variations could affect results by up to 1 - 4%. Corrections were not applied though, as the current method of placing tops does not allow for rigorous corrections to be made. The method of correcting for tops variation would have been to assume the first set of tops gives the correct value, and variation later in the run can be referenced to these. However, the first set of tops may not be correct, and false corrections could be made.

A better method would be to use the same solution for the top standard and for tops, and to run reference tops soon after the calibration curve. Thus an absolute concentration could reliably be placed on the tops, and corrections made by comparing tops to the nominal top value. Corrections would only be made once the error in the tops exceeded some set amount. This is because applying a correction between two points is likely to introduce a new source of error.

To get an idea of the sources of error, the error in the calibration curve was looked at for two randomly selected runs, 4 and 60. A total of four calibrations were looked at for nitrate + nitrite and phosphate. Second order calculations for silicate were not looked at. Of these four curves, for nitrate and phosphate, the maximum standard error of the slope was 0.6%, and the maximum standard error of the intercept was 1.9%. It was decided not to calculate the calibration errors for every run, thus they are not included in the total error of the samples for this cruise.

Quality checks

Batches of 30-40 deep seawater samples were taken to be used as quality checks to give an indication of instrument responsiveness between runs (Figure A2.1.5). Some were run fresh and the others stored frozen (Table A2.1.2). Once the value of a batch was established it could be used to see if a run and its calibration appeared normal. The QC macro in A9604.XLM was used to sort through the run *.XLS files and extract the QC's. The QC names were prefixed by an 's'. As different batches were used this method could not effectively be used to compare runs throughout the cruise. Values could be normalised to the batch averages, but this is not likely to be reliable. Later cruises have used larger batches (~500 10ml tubes) of surface seawater.

Nutrient data handling

The files produced by Faspac are *.ACF. These contain the traces for all channels, settings information, calibration curves, and calculated concentrations. The original Faspac files were backed up as *.NEW. This was important, as occasionally when Faspac crashed the previously saved copy of the file could not be worked on as it would soon crash, so it was necessary to start from original data.

Faspac produced a 'report', a spreadsheet format of nutrient concentrations. It is supposed to produce a format that can be read directly by Excel, however this format caused Excel to crash. The text format could not easily be parsed by Excel. Eventually, data was output as Lotus *.WKS format, imported by Excel, and a macro used to convert the Lotus format to Excel format. Thus for every run there is an *.ACF file, and a corresponding *.XLS file containing the run sequence with concentrations calculated by Faspac.

The “Hydro” program was changed to process Faspac runs by reading *.FAS files, extracting the sample number and concentration information, and calling the processed file *.ACM. The information is stored in *.DAT files, along with other data. Thus any *.XLS files to be processed need to be copied as *.FAS files. If only one station in a run is required for processing, then the data needs to be cut and pasted from the *.XLS file into the *.ACM file.

Which runs a particular station was run on is shown in Table A2.1.3. This also summarises the reason a station was repeated, and if the original or repeat run was used in the final data.

An attempt was made to observe the nutrient content of the saline solution in which standards were made up in. This was done only for the phosphate channel as it has the highest gain. A rise in the baseline was observed when switching from phosphate ‘background’ solution to phosphate ‘colour’ solution. This was attributed to phosphate in the saline solution from impurities in the original solid salt, although more work is needed to confirm it is due only to this, and not due to other contributions such as refractive index change. The value was around 0.006 µM. This value was assigned to the ‘blank’ in the calibration curve. It made very little impact on the final concentrations.

A2.1.2 DISSOLVED OXYGEN

The dissolved oxygen (D.O.) titration instrument was fairly reliable and determinations were generally within World Ocean Circulation Experiment (WOCE) guidelines. Exceptions are given below. Standardisations of sodium thiosulfate solution were within WOCE guidelines but improvements could be made by the addition of a second Dosimat unit. Blanks were not measured within WOCE guidelines.

Standardisations

The object of the standardisation procedure is to obtain "4 successive titres concordant to within 0.003 mL (of thiosulfate)." This was always achieved but was hampered by continual changing of the Dosimat exchange units. Often 7 or 8 titrations were required. This was time consuming and frustrating. Variations in the sodium thiosulphate titre were often due to bubble formation in the tubing of the exchange units. These are formed by the movement of the burette syringe on removal and replacement of the unit. A second Dosimat would make the standardisation simpler and faster. One unit would be used for the preparation of the standard solution while a titration was carried out on the second unit. Other advantages include:

* elimination of the need to continually exchange units reducing wear on the units, reducing the chance of dropping the unit in rough seas and preventing the formation of bubbles in the tubing;
* method may still be used on the cruise if one unit breaks down;
* stirring rate would remain the same for each titration (currently, the rate must be changed between preparation of the standard solution and the titration).

Potassium biiodate was added to the standard solution with the dV/dt knob set to 7.5. The rate is not specified in the current instruction manual. The rate could be set in the "DODO" software.

Blank Determinations

After concordant standardisation titres were obtained 5 blank determinations were made. These were not within WOCE guidelines. The blanks varied by 0.007 mL (of thiosulfate) for any set of 5 titrations. If 50 mL of water was used for the blank determination the titration did not work. This was increased to 60 mL and the titrations were successful. The measured variation in the blanks leads to an approximate error of 0.1% in the final results.

Samples

D.O. measurements in the samples were straightforward. Two or three repeats were measured for each crate of D.O. samples. The titre of the second determination was generally 0.003 - 0.006 mL (of thiosulfate) lower than the first. The greater the titre the greater the loss of volatile iodine.

After the addition of 1 mL of sulfuric acid to the sample the bottle required about 1 minute of shaking.

Instrumentation

The Dosimat seized up on two occasions. The first happened during the addition of 15 ml of potassium biiodate to the standard solution. This was a "time-out" error as the Dosimat was delivering the solution while the computer was trying to communicate with it. This was fixed by increasing the time the computer allowed for the addition from 20 to 40 seconds and by setting dV/Dt to 7.5. The second time the Dosimat seized up was when it was switched on when the computer was switched on. If the Dosimat was switched on after the "DODO" program was started this was not a problem.

The hydraulic ram was not used. It was more convenient to hold the sample bottles so the pipette tip was just off the bottom.

Standardisations are shown in Figure A2.1.6.

A2.1.3 LABORATORIES

A number of work spaces were used. Nutrient and salinity analyses were performed in lab 3. The autoanalyser was set up on the forward bench, while the salinometer was set up on the outboard bench near the fume cupboard. Dissolved oxygen analysis and water purification took place in the photolab.

A2.1.4 TEMPERATURE MONITORING AND CONTROL

Laboratory temperature was recorded by two Tinytalk units, and measured by two mercury thermometers, an electronic thermometer, and the temperature monitor of the PID controller. An 'indoor/outdoor' electronic thermometer was used to measure fridge and freezer temperatures. One Tinytalk was positioned above the salinity crates for the duration of analysis, the other was moved around for shorter checks. One mercury thermometer was positioned above the salinity crates, the other with the DO instrumentation. An electronic thermometer was also used for spot checks. All the temperature measuring devices were placed together at the start of the cruise. The PID temperature was calibrated, and the devices agreed to within 0.5_C.

The long term Tinytalk recorded 1800 temperature points at 48 minute intervals. The file is A9604L.DTF, and the numbers have been exported to A9604L.XLS. The average temperature was 19.6 +/- 0.4 _C. See Figure A2.1.2 and Table A2.1.1. Spatial variations in laboratory temperatures were observed. Among the instrument locations in the nutrient/salinity lab, from bench top to about one metre above the bench, the temperature had a range of 3-4_C.

Table A2.1.1: Laboratory temperature recorder statistics.

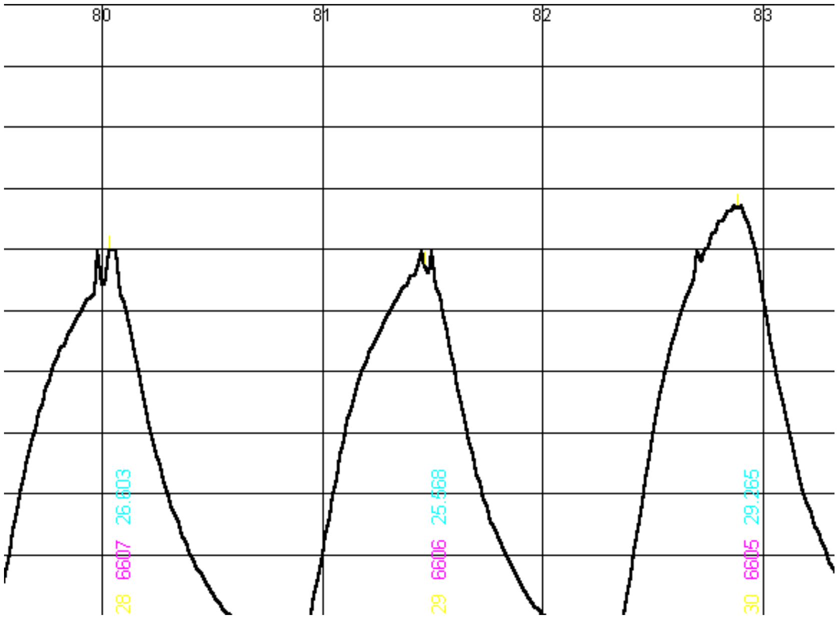
Temperature statistics from Tinytalk	
average	19.6 _C
stdev	0.4 _C
%rsd	1.9
min	18.5 _C
max	20.7 _C
range	2.2 _C
% range	11.3

Temperature control

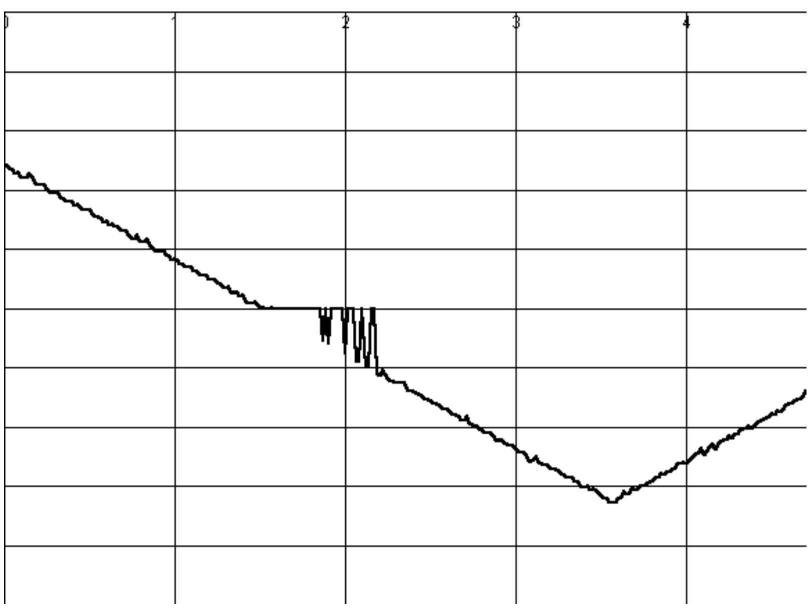
Temperature in the nutrient/salinity laboratory was controlled with the ship's air conditioning and with a heating device. The lab was cooled with 16_C air from the ships air conditioning, with the lab reheaters turned off. Heating was provided by a 'Cal control 9900' proportional, integral, and derivative (PID) controller/sensor controlling two simple fan heaters. The sensor was placed near the salinometer, at the height of the top of the salinometer. The setpoint was 19.6_C.

There was no temperature control in the dissolved oxygen lab besides the ship's air conditioning.

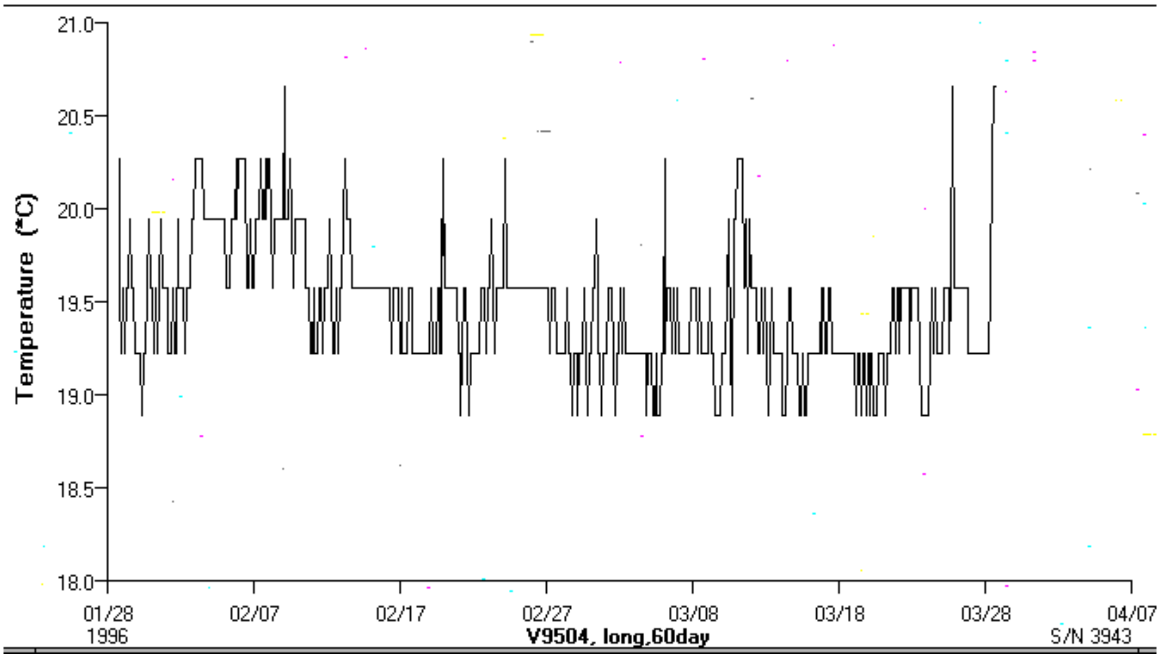
(a)



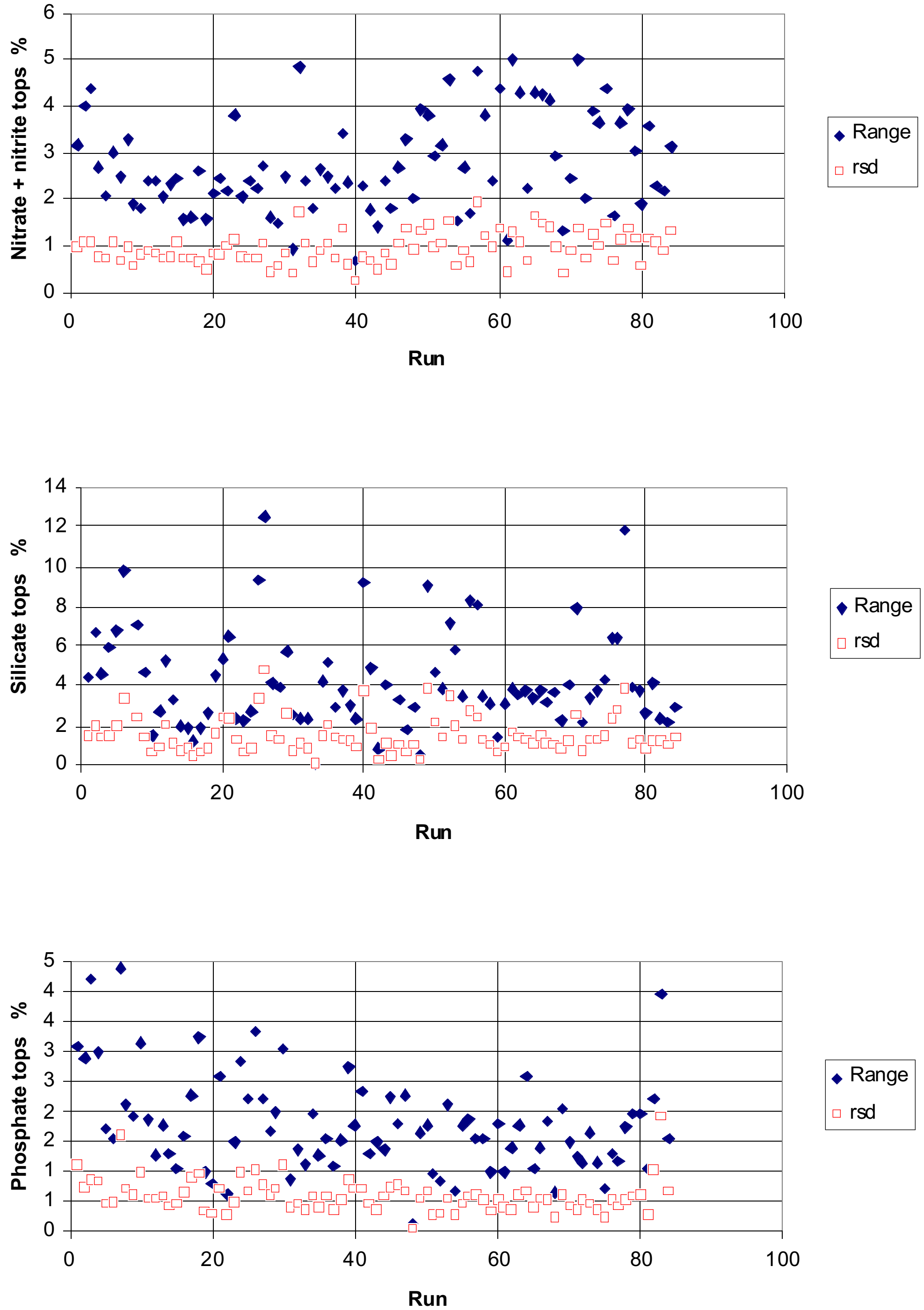
(b)



<u>Figure A2.1.1a and b:</u> 'Glitch' in nutrient A/D board: (a) real data, and (b) ramped voltage.

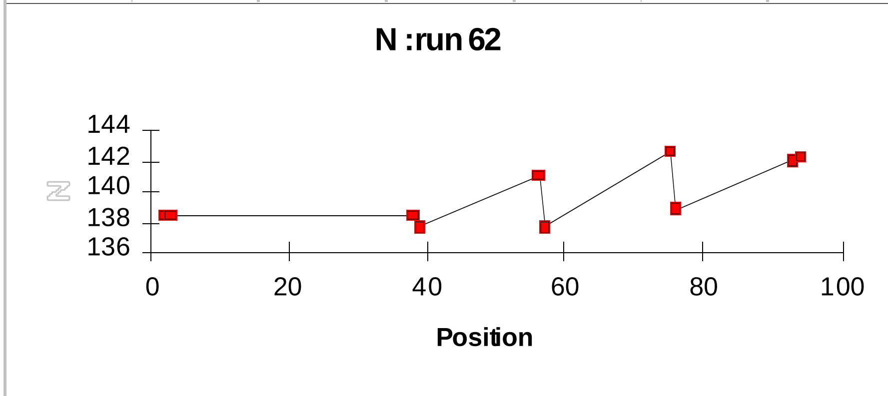


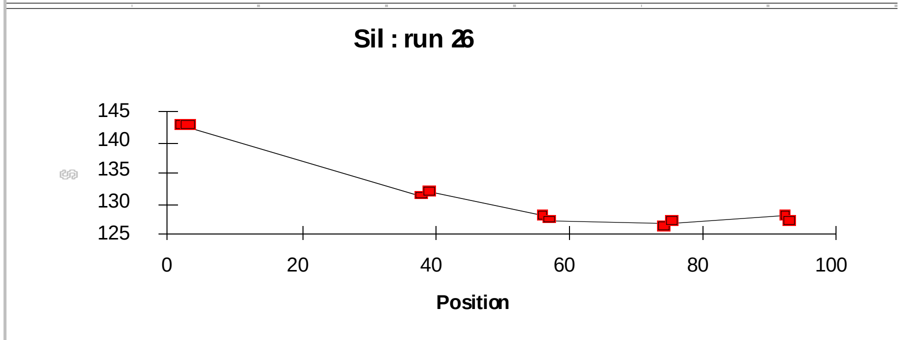
<u>Figure A2.1.2:</u> 'Tinytalk' temperature plot, 28/01/96 to 28/03/96, 48 minute time resolution; logger in film canister punctured to allow air flow, and positioned on middle of bottom shelf opposite fume cupboard in nutrient/salinity lab (lab 3).

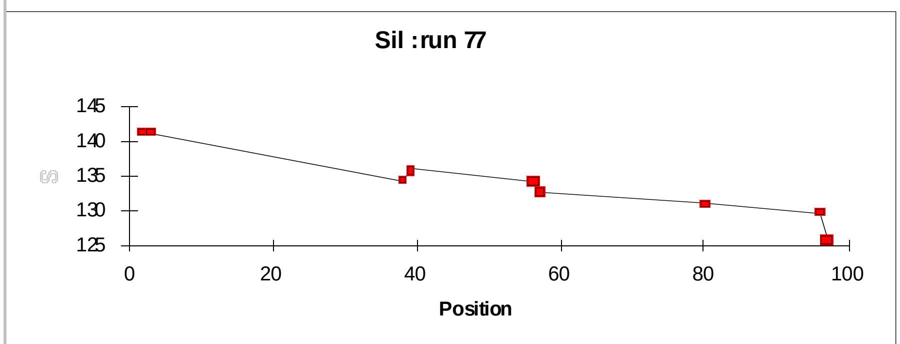


<u>Figure A2.1.3:</u> Statistics for tops used in nutrient analyses.

A9604	
4 worst sets of tops from A9604 plotted out.	







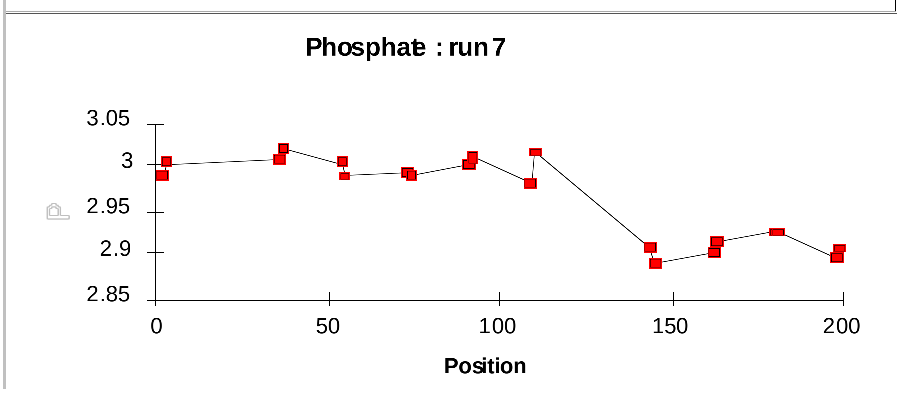


Figure A2.1.4: **Worst cases of tops variations for the 3 nutrient channels.**

Table A2.1.2: Nutrient samples run as quality checks.

A9604 nuts							
Output from QC.XLS, with labels							
Uses QC macro in A9604.XLM to extract QC's (with s prefix in name)							
File	Run	Cup	QC name	QC batch	N	S	P
					uM	uM	uM
A9604017.XLS	17	5	s6101	61	32.3	118.1	2.24
A9604018.XLS	18	5	S6101	61	32.1	121.1	2.28
A9604019.XLS	19	5	s6101	61	32.3	118.8	2.26
A9604020.XLS	20	5	S6101	61	32.7	118.5	2.23
A9604021.XLS	21	5	s6101	61	32.2	99.3	2.29
A9604022.XLS	22	5	s6101	61	32.7	117.3	2.27
A9604022.XLS	22	47	S6101	61	32.8	115.8	2.26
A9604022.XLS	22	48	S6101new	61	32.8	50.6	2.24
A9604023.XLS	23	5	s6101	61	32.6	119.7	2.25
A9604024.XLS	24	5	s6101fridge	61	32.8	120.1	2.27
A9604024.XLS	24	6	s6101freezer	61	32.7	96.6	2.25
A9604025.XLS	25	5	S6101	61	32.8	79.1	2.28
A9604026.XLS	26	5	S6101	61	33.3	113.4	2.30
A9604027.XLS	27	5	s6101	61	32.5	108.2	2.25
A9604027.XLS	34	6	s6101	61	32.5	114.0	2.33
A9604028.XLS	27	6	s7102fresh	71	32.8	117.5	2.27
A9604029.XLS	28	5	s7102	71	33.0	115.8	2.40
A9604030.XLS	29	5	s7102	71	32.7	121.5	2.55
A9604030.XLS	30	5	s7102	71	32.9	116.4	2.36
A9604030.XLS	30	96	s7102	71	33.1	112.6	2.41
A9604030.XLS	30	97	s7102	71	33.1	118.4	2.36
A9604030.XLS	30	98	s7102	71	33.2	118.2	2.38
A9604031.XLS	30	99	s7102	71	33.3	119.4	2.43
A9604032.XLS	31	5	s7102	71	32.4	117.6	2.38
A9604033.XLS	32	5	s7102	71	32.7	117.8	2.56
A9604034.XLS	33	5	s7102	71	33.3	117.3	2.59
A9604034.XLS	34	5	s7102	71	32.7	110.5	2.32
A9604035.XLS	35	5	s7102_fg thaw	71	32.1	87.3	2.19
A9604036.XLS	36	5	s7102 fridge thaw	71	32.9	109.5	2.34
A9604037.XLS	37	5	s7102 frdg thaw	71	32.6	115.3	2.35
A9604038.XLS	38	5	s7102	71	33.1	115.0	2.31
A9604039.XLS	39	5	s7102	71	33.0	106.5	2.28
A9604040.XLS	40	5	s7102	71	32.7	113.7	2.27
A9604041.XLS	41	5	s7102	71	32.0	116.2	2.27
A9604042.XLS	42	5	s7102	71	33.0	116.8	2.30
A9604043.XLS	43	5	s7102	71	32.8	116.6	2.30
A9604044.XLS	44	5	s7102 air24h	71	32.4	119.2	2.29
A9604044.XLS	44	6	s7102 frid	71	32.7	116.9	2.29
A9604045.XLS	45	5	s7102	71	32.4	115.7	2.26
A9604046.XLS	46	5	s7102	71	32.2	116.0	2.24
A9604047.XLS	47	5	s7102	71	32.8	118.5	2.28
A9604048.XLS	48	5	s7102 fdg,days	71	32.2	114.4	2.24
A9604048.XLS	49	86	s7102 air	71	33.4	127.5	2.25
A9604049.XLS	50	6	s7102,frd	71	32.6	100.5	2.26
A9604049.XLS	51	5	s7102	71	32.8	106.8	2.18
A9604049.XLS	48	6	s11603 fresh,fdg	116	32.7	126.2	2.26
A9604050.XLS	49	5	s11603	116	32.5	125.2	2.23
A9604050.XLS	49	87	s11603 frsh, fdg	116	32.9	136.7	2.26
A9604051.XLS	50	5	s11603,air	116	32.2	121.6	2.31
A9604051.XLS	51	6	s11603	116	33.2	119.3	2.24
A9604051.XLS	51	60	s11603	116	33.3	125.0	2.19
A9604052.XLS	52	5	s11603	116	32.8	128.5	2.34
A9604052.XLS	52	58	s11603	116	32.7	122.7	2.37
A9604053.XLS	53	5	s11603	116	32.4	96.6	2.32
A9604053.XLS	53	59	s11603	116	33.0	115.5	2.35
A9604053.XLS	53	96	s11603	116	32.3	113.2	2.35
A9604054.XLS	54	5	s11603	116	33.2	113.9	2.33
A9604054.XLS	54	59	s11603	116	33.1	122.2	2.32
A9604055.XLS	55	5	s11603	116	32.3	124.0	2.31
A9604055.XLS	55	59	s11603	116	32.2	118.3	2.30
A9604055.XLS	55	95	s11603	116	32.6	122.3	2.30
A9604056.XLS	56	5	s11603	116	32.8	110.0	2.29
A9604056.XLS	56	59	s11603	116	32.0	122.6	2.30
A9604057.XLS	57	5	s11603	116	33.0	87.1	2.31
A9604058.XLS	58	5	s11603	116	32.6	129.2	2.34
A9604058.XLS	58	95	s11603	116	33.7	124.4	2.30
A9604059.XLS	59	60	s11603	116	32.0	125.2	2.27
A9604059.XLS	60	5	s11603	116	32.0	124.5	2.29
A9604059.XLS	60	121	s11603	116	32.5	125.1	2.23
A9604059.XLS	62	5	s11603	116	31.5	89.2	2.24
A9604060.XLS	62	59	s11603	116	32.6	86.3	2.24
A9604060.XLS	59	5	s13002 fresh	130	31.4	90.7	2.22
A9604060.XLS	59	62	s13002 fsh	130	31.2	92.7	2.20
A9604060.XLS	59	63	s13002 fsh	130	31.5	92.6	2.20
A9604060.XLS	60	122	s13002	130	31.4	90.8	2.22
A9604061.XLS	60	123	s13002	130	31.9	90.8	2.23
A9604061.XLS	60	124	s13002	130	32.0	90.8	2.20
A9604062.XLS	61	5	s13002	130	32.8	88.4	2.20
A9604062.XLS	61	60	s13002	130	32.5	89.9	2.21
A9604062.XLS	62	96	s13002	130	32.1	90.5	2.25
A9604063.XLS	63	5	s13002	130	31.8	89.3	2.24
A9604063.XLS	63	95	s13002	130	32.1	86.4	2.23
A9604064.XLS	64	5	s13002	130	32.3	85.4	2.24
A9604064.XLS	64	94	s13002	130	31.7	89.0	2.21
A9604065.XLS	65	58	s13002	130	33.5	72.5	2.24
A9604066.XLS	66	5	s13002 4h	130	32.2	85.4	2.24
A9604066.XLS	66	59	s13002 5h	130	31.1	89.4	2.24
A9604067.XLS	67	5	s13002 4h	130	32.6	83.8	2.26
A9604067.XLS	67	58	s13002	130	32.1	87.7	2.21
A9604067.XLS	67	95	s13002	130	31.8	88.2	2.22

A9604068.XLS	68	5	s13002	130	32.3	86.8	2.24
A9604068.XLS	68	59	s13002	130	32.0	91.3	2.23
A9604069.XLS	69	5	s13002 R	130	32.2	90.5	2.24
A9604069.XLS	69	59	s13002 '139'	130	31.8	86.6	2.23
A9604069.XLS	69	96	s13002 '139'	130	32.1	87.5	2.17
A9604070.XLS	70	5	s13002	130	31.4	81.8	2.24
A9604070.XLS	70	95	s13002 4h	130	31.5	85.1	2.22
A9604071.XLS	71	5	s13002	130	31.2	64.2	2.22
A9604071.XLS	71	96	s13002	130	32.0	90.4	2.20
A9604071.XLS	73	5	s13002	130	31.7	86.8	2.28
A9604071.XLS	73	59	s13002	130	31.4	88.4	2.27
A9604071.XLS	71	6	s14102	141	31.7	101.3	2.21
A9604071.XLS	71	97	s14102	141	32.1	101.6	2.22
A9604071.XLS	71	98	s14102	141	32.1	101.1	2.25
A9604073.XLS	71	100	s14102	141	32.6	101.4	2.18
A9604073.XLS	71	101	s14102	141	31.9	100.7	2.21
A9604073.XLS	73	6	s14102	141	32.3	96.2	2.33
A9604073.XLS	73	60	s14102	141	31.7	100.0	2.32
A9604073.XLS	73	97	s14102	141	31.9	101.0	2.28
A9604074.XLS	74	5	s14102	141	32.4	89.8	2.30
A9604074.XLS	74	91	s14102	141	32.3	97.3	2.25
A9604075.XLS	75	5	s14102 2h	141	32.0	84.8	2.45
A9604075.XLS	75	74	s14102	141	32.8	101.5	2.47
A9604076.XLS	76	5	s14102 1h	141	32.1	61.5	2.26
A9604076.XLS	76	59	s14102 2h	141	32.2	100.9	2.28
A9604077.XLS	77	5	s14102	141	33.0	76.3	2.28
A9604077.XLS	77	99	s14102	141	31.7	87.4	2.31
A9604078.XLS	78	5	s14102	141	31.9	99.4	2.28
A9604078.XLS	78	67	s14102	141	32.6	96.9	2.30
A9604078.XLS	78	104	s14102	141	32.1	98.2	2.30
A9604079.XLS	79	5	s14102	141	31.7	88.4	2.23
A9604079.XLS	79	113	s14102	141	32.6	101.6	2.23
A9604080.XLS	80	5	s14102	141	32.4	63.5	2.24
A9604080.XLS	80	92	s14102	141	32.7	91.6	2.17
A9604081.XLS	81	5	s14102	141	32.3	93.9	2.24
A9604081.XLS	81	111	s14102	141	32.5	97.4	2.21
A9604082.XLS	82	5	s14102	141	30.1	96.7	2.26

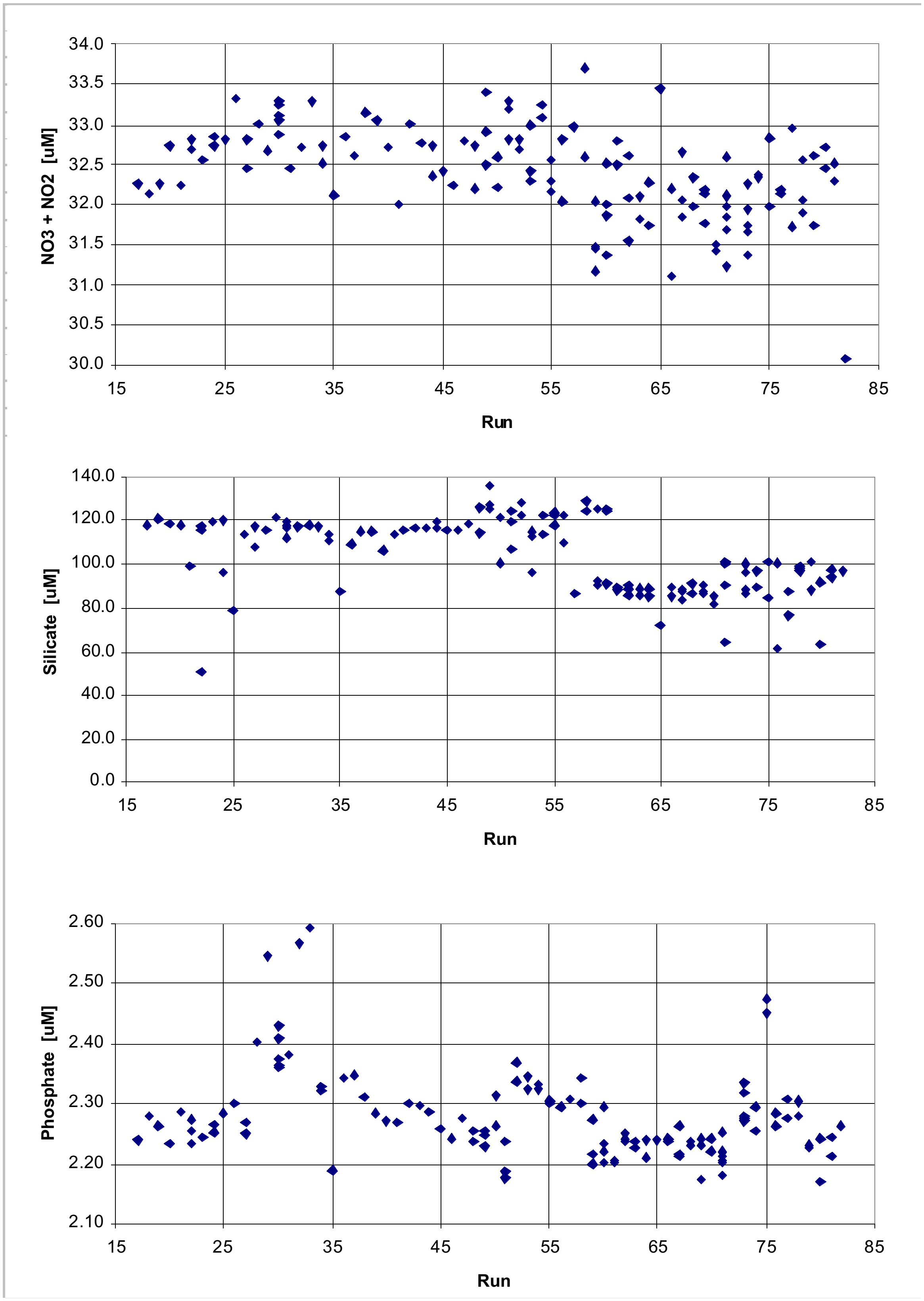


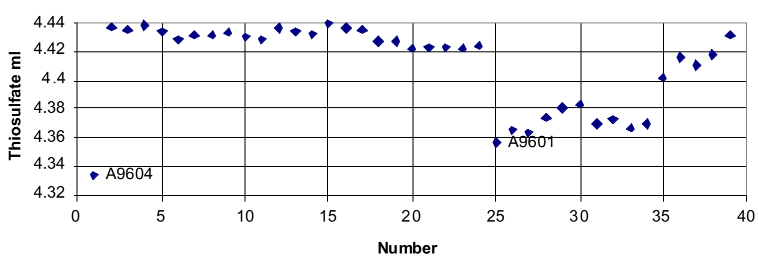
Figure A2.1.5: Nutrient samples run as quality checks.

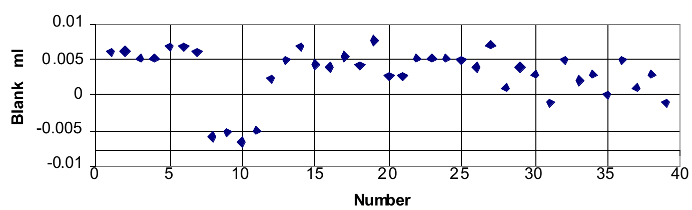
Table A2.1.3: Nutrient analysis run numbers on which stations were run.

A9604 nuts											
run vs stn											
Shows problems											
Stn	**Run first**	**Run repeat**	**Probs**	**Stn**	**Run first**	**Run repeat**	**Probs**	**Stn**	**Run first**	**Run repeat**	**Probs**
1	ns			61	23			120	55		
2	ns			62	17			121	52		
3	1		Ph	63	18			122	56		
4	ns			64	24			123	57		
5	ns			65	ns			124	54		
6	2			66	24			125	56		
7	2			67	28	82	**Ph**	126	60		
8	2			68	28	79	**Ph**	127	60		
9	2			69	28	77	**Ph**	128	59		
10	2			70	28	77	**Ph**	129	60		
11	2			71	27			130	59		
12	3	61	**Ph**	72	27			131	60		
13	3	62	**Ph**	73	29	79	**Ph**	132	60		
14	3	62	**Ph**	74	31	78	**Ph**	133	63		
15	3	63	**Ph**	75	30	80	**Ph**	134	64		
16	ns			76	30	80	**Ph**	135	65		
17	4	64	**Ph**	77	ns			136	ns		
18	4	66	**Ph**	78	34	81	**Ph**	137	67		
19	4	67	**Ph**	79	32	76	**Ph**	138	68		
20	4	70	**Ph**	80	33	58	**S Ph**	139	69		
21	ns			81	35			140	69		
22	5	70	P?	82	34			141	71		
23	7	25	**Sx Ph**	83	35			142	73		
24	7	25	**Sx Ph**	84	37			143	72		
25	7	26	**Sx Ph**	85	37			144	74		
26	7	26	**Sx Ph**	86	39			145	75	81	Ph
27	8	71	**Ph N**	87	39			146	ns		
28	8	75	**Ph**	88	36			147	ns		
29	ns			89	37						
30	9	73	**Ph N**	90	41			N	Nitrate + nitrite		
31	9	74	**Ph N**	91	43	58	**S**	S	Silicate		
32	5			92	38			P	Phosphate		
33	11	81	**Ph N**	93	39			h	high		
34	12	78	**Ph**	94	43			x	Lost data		
35	6			95	ns			ns	No sample		
36	14			96	40			**Bold**	indicates channel/s		
37	6			97	41				of repeated		
38	6			98	43				station used in final data.		
39	18			99	42						
40	18			100	45						
41	19			101	47						
42	7	29	**Sx Ph**	102	47						
43	ns			103	48						
44	19			104	48						
45	20			105	49						
46	21			106	49						
47	21			107	49						
48	10	77	**Ph**	108	50						
49	11	77	**Ph**	109	51						
50	11	77	**Ph**	110	44						
51	11	78	**Ph N**	111	45						
52	12	79	**Ph**	112	ns						
53	22			113	51						
54	13			114	46						
55	13			115	47						
56	14			116	53						
57	23			117	53						
58	15			118	55						
59	16			119	ns						
60	ns										

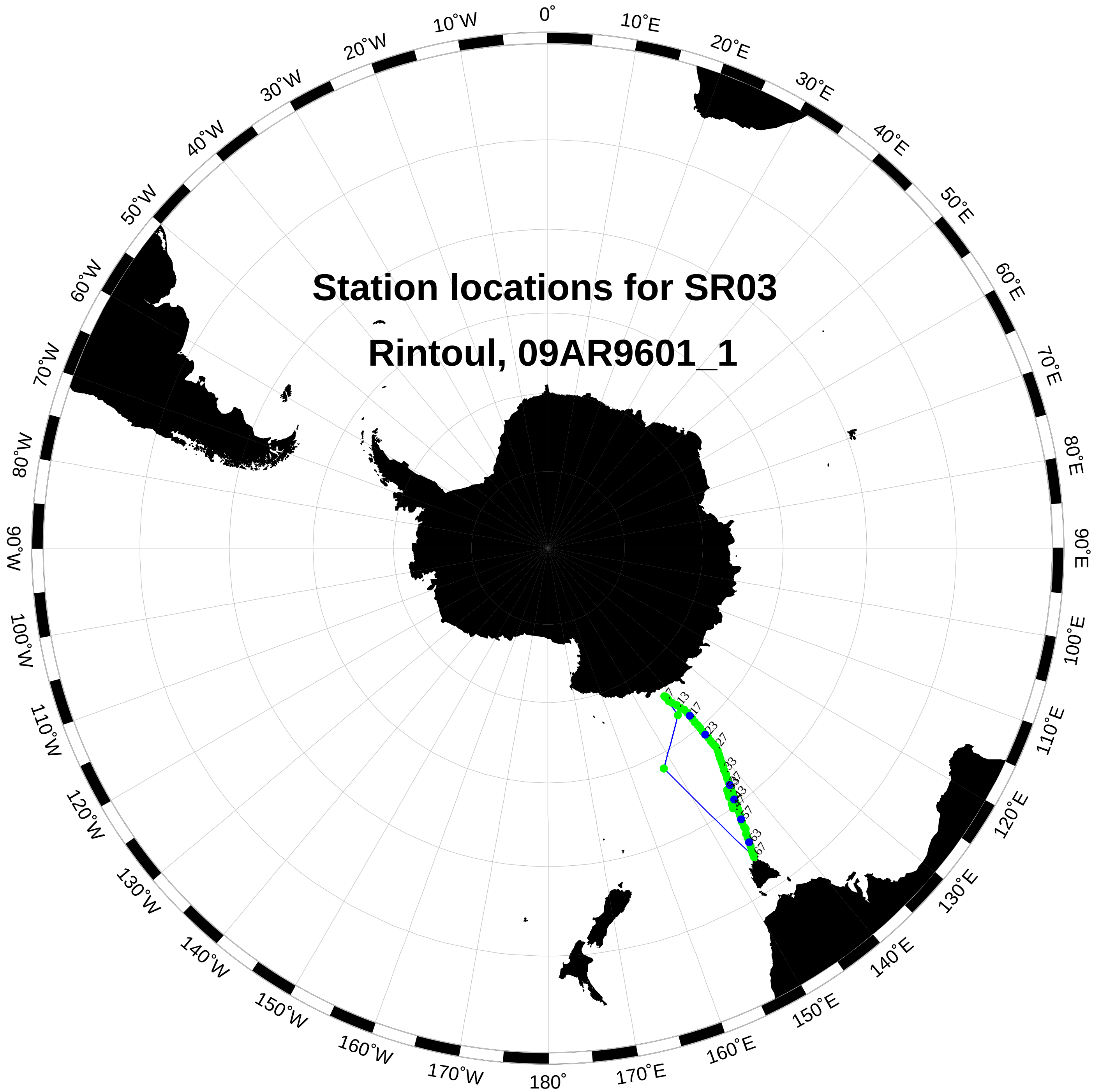
Standardisions of DO. ml of thiosulfate titrated against biiodate.
Values copied from log sheets.

Cruise	Number	Sheet	Stn 1st stn applied to	Std	Blank	Date	Biiodate batch
A9604	1	1	3	4.334	0.0060	22-Jan-96	
A9604	2	2	6	4.438	0.0063	30-Jan-96	
A9604	3	9	13	4.436	0.0053	1-Feb-96	
A9604	4	14	19	4.439	0.0053	3-Feb-96	
A9604	5	20	26	4.435	0.0068	7-Feb-96	
A9604	6	27	34	4.429	0.0068	9-Feb-96	
A9604	7	33	40	4.431	0.0060	10-Feb-96	
A9604	8	36	44	4.432	-0.0058	12-Feb-96	
A9604	9	39	47	4.434	-0.0052	13-Feb-96	
A9604	10	46	54	4.431	-0.0067	15-Feb-96	
A9604	11	53	62	4.428	-0.0050	17-Feb-96	
A9604	12	56	66	4.437	0.0022	24-Feb-96	
A9604	13	65	75	4.435	0.0050	26-Feb-96	
A9604	14	71	82	4.433	0.0068	29-Feb-96	
A9604	15	80	93	4.440	0.0044	2-Mar-96	
A9604	16	86	98	4.437	0.0040	4-Mar-96	
A9604	17	92	104	4.436	0.0054	6-Mar-96	
A9604	18	99	111	4.428	0.0042	7-Mar-96	
A9604	19	104	117	4.427	0.0078	13-Mar-96	
A9604	20	110	124	4.423	0.0028	15-Mar-96	
A9604	21	114	128	4.424	0.0028	17-Mar-96	bnk from sht 110
A9604	22	119	133	4.424	0.0053	20-Mar-96	
A9604	23	124	139	4.423	0.0053	22-Mar-96	bnk from sht 119
A9604	24	130	145	4.424	0.0053	24-Mar-96	
A9601	25	3	1	4.357	0.0050	25-Aug-96	sgb 18-8-96 no1
A9601	26	5	4	4.366	0.0040	28-Aug-96	
A9601	27	6	5	4.364	0.0070	31-Aug-96	
A9601	28	9	7	4.374	0.0010	1-Sep-96	
A9601	29	16	13	4.382	0.0040	3-Sep-96	top up sgb 18-8-96 no1
A9601	30	23	18	4.384	0.0030	6-Sep-96	top up sgb 18-8-96 no2
A9601	31	26	20	4.370	-0.0010	7-Sep-96	top up sgb 18-8-96 no2
A9601	32	32	25	4.373	0.0050	8-Sep-96	new NaI/NaOH dispensor
A9601	33	38	31	4.367	0.0020	10-Sep-96	
A9601	34	44	36	4.370	0.0030	11-Sep-96	
A9601	35	50	41	4.402	0.0000	13-Sep-96	top up sgb no 3
A9601	36	57	47	4.416	0.0050	15-Sep-96	
A9601	37	63	53	4.411	0.0010	17-Sep-96	
A9601	38	69	59	4.418	0.0030	20-Sep-96	
A9601	39	76	66	4.432	-0.0010	22-Sep-96	





<u>Figure A2.1.6:</u> Dissolved oxygen standardisations.


Station locations for SR03
Rintoul, 09AR9601_1
0°
10°E
20°E
30°E
40°E
50°E
60°E
70°E
80°E
90°E
100°E
110°E
120°E
130°E
140°E
150°E
160°E
170°E
180°
170°W
160°W
150°W
140°W
130°W
120°W
110°W
100°W
90°W
80°W
70°W
60°W
50°W
40°W
30°W
20°W
10°W

Part 3
Aurora Australis Marine Science Cruise AU9601 - Oceanographic Field Measurements and Analysis

ABSTRACT

Oceanographic measurements were conducted along WOCE Southern Ocean meridional section SR3 between Tasmania and Antarctica from August to September 1996. A total of 71 CTD vertical profile stations were taken, most to near bottom. Over 1500 Niskin bottle water samples were collected for the measurement of salinity, dissolved oxygen, nutrients, dissolved inorganic carbon, alkalinity, carbon isotopes, primary productivity, and biological parameters, using a 24 bottle rosette sampler. Near surface current data were collected using a ship mounted ADCP. Measurement and data processing techniques are summarised, and a summary of the data is presented in graphical and tabular form.

3.1 INTRODUCTION

Marine science cruise AU9601, the sixth oceanographic cruise of the Cooperative Research Centre for the Antarctic and Southern Ocean Environment (Antarctic CRC), was conducted aboard the RSV Aurora Australis from August to September 1996. The major constituent of the cruise was the collection of oceanographic data relevant to the Australian Southern Ocean WOCE Hydrographic Program, along WOCE section SR3 (Figure 3.1). This was the seventh occupation of section SR3 (and the last by the Aurora Australis under the WOCE program), and the second during a southern winter. Previous occupations of SR3 are summarised in Part 1 of this report. A further occupation of the northern half of SR3 took place in March to April of 1997 by the SCRIPPS ship R.V. Melville (principal investigators R.Watts, S. Rintoul, J. Richman, B. Petit, D. Luther, J. Filloux, J. Church, A. Chave).

This report describes the collection of oceanographic data from the SR3 section, and summarises the chemical analysis and data processing methods employed. All information required for use of the data set is presented in tabular and graphical form.

3.2 CRUISE ITINERARY

En route to Macquarie Island at the start of the cruise, the ship steamed in a straight line over the Tasmanian continental shelf for calibration tests of the ADCP. Three test CTD casts were also taken en route. Following cargo operations at Macquarie Island, the ship steamed southwest towards the southern end of the SR3 transect, taking a deep and a shallow test CTD cast on the way. A full day was spent penetrating southward into the ice before commencing the SR3 transect at the Antarctic shelf break east of Dumont D'Urville (Figure 3.1). The transect was then completed on the northward journey back to Hobart. Station spacing was decreased in the region of the Subantarctic Front, with casts taken over a series of inverted echo sounder and current meter moorings. The transect proper was interrupted briefly here for completion of several CTD casts over the eastern group of moorings in the larger mooring array (Figure 3.1) (Table 3.4). Further north, the SR3 station at latitude ~47.15^{o}S was shifted ~5 nautical miles west of the transect line to avoid the pronounced steep bathymetry encountered at this latitude on previous cruises. Following completion of the SR3 transect, two further casts were taken to test another CTD before returning to Hobart.

3.3 CRUISE SUMMARY

In the course of the cruise, 71 CTD casts were completed along the SR3 section (Figure 3.1) (Table 3.2), plus additional test locations, with most casts reaching to within 20 m of the sea floor (Table 3.2). Over 1500 Niskin bottle water samples were collected for the measurement of salinity, dissolved oxygen, nutrients (orthophosphate, nitrate plus nitrite, and reactive silicate), dissolved inorganic carbon, alkalinity, carbon isotopes (^{14}C and ^{13}C), primary productivity, and biological parameters, using a 24 bottle rosette sampler. Table 3.3 summarises samples drawn at each station. For all stations, the different samples were drawn in a fixed sequence (see previous data reports). Casts taken over mooring locations are summarised in Table 3.4. Principal investigators for the various water sampling programmes and cruise participants are listed in Tables 3.5a and b.

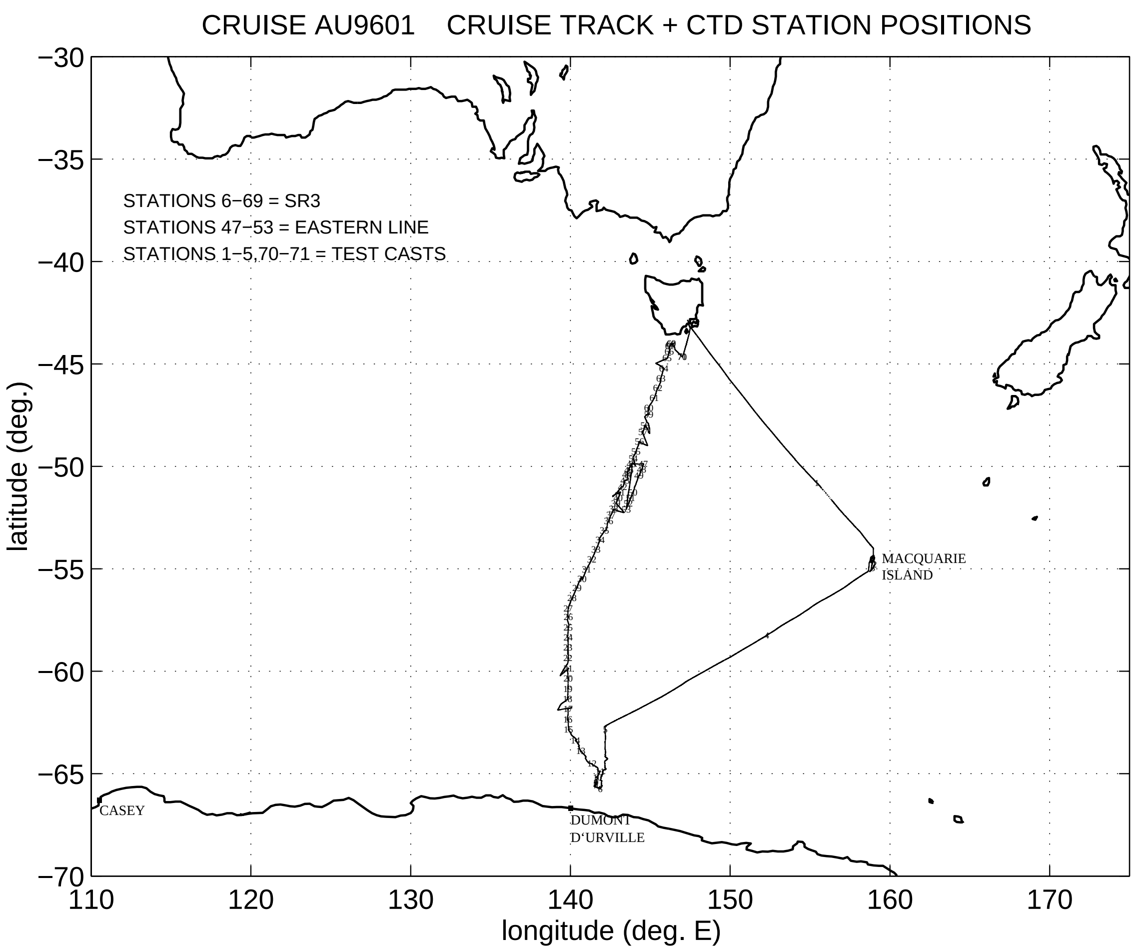


Figure 3.1: Cruise track and CTD station positions for RSV Aurora Australis cruise AU9601.

<u>Table 3.1:</u> Summary of cruise itinerary.

Expedition Designation
Cruise AU9601 (cruise acronym WASTE), encompassing WOCE section SR3

Chief Scientist
Steve Rintoul, CSIRO

Ship
RSV Aurora Australis

Ports of Call
Macquarie Island

Cruise Dates
August 22 to September 22 1996

<u>Table 3.2 (following 2 pages):</u> Summary of station information for RSV Aurora Australis cruise AU9601. The information shown includes time, date, position and ocean depth for the start of the cast, at the bottom of the cast, and for the end of the cast. The maximum pressure reached for each cast, and the altimeter reading at the bottom of each cast (i.e. elevation above the sea bed) are also included. Missing ocean depth values are due to noise from the ship's bow thrusters interfering with the echo sounder. For casts which do not reach to within 100 m of the bed (i.e. the altimeter range), or for which the altimeter was not functioning, there is no altimeter value. For station names, TEST is a test cast and EL is the eastern line (the meridional section over the eastern part of the mooring array). Note that all times are UTC (i.e. GMT). CTD unit 7 (serial no. 1103) was used for stations 4 to 69; CTD unit 5 (serial no. 1193) was used for stations 1 to 2 and 70 to 71; CTD unit 6 (serial no. 2568) was used for station 3.

station	START					maxP	BOTTOM					END			
number	time	date	latitude	longitude	depth(m)	(dbar)	time	latitude	longitude	depth(m)	altimeter	time	latitude	longitude	depth(m)
1 TEST	0715	24-AUG-96	50:48.64S	155:26.04E	4597	1026	0757	50:49.31S	155:27.15E	4604	-	0829	50:49.72S	155:27.89E	4589
2 TEST	0903	25-AUG-96	54:47.52S	159:02.91E	4607	154	0912	54:47.62S	159:03.13E	-	-	0917	54:47.67S	159:03.19E	4607
3 TEST	1048	25-AUG-96	54:56.43S	158:56.37E	3071	840	1137	54:56.48S	158:57.54E	-	-	1156	54:56.43S	158:57.67E	-
4 TEST	0536	27-AUG-96	58:14.95S	152:18.29E	2355	2564	0702	58:15.12S	152:17.62E	-	30.1	0814	58:15.03S	152:17.35E	-
5 TEST	0230	29-AUG-96	62:50.62S	142:10.90E	3993	344	0252	62:50.62S	142:11.17E	-	-	0304	62:50.67S	142:11.37E	-
6 SR3	0726	30-AUG-96	65:44.59S	141:51.94E	761	764	0812	65:44.37S	141:51.07E	773	8.7	0904	65:44.04S	141:50.28E	768
7 SR3	0554	31-AUG-96	65:34.50S	141:34.66E	1019	970	0636	65:34.30S	141:34.24E	973	7.5	0727	65:34.09S	141:33.73E	951
8 SR3	0922	31-AUG-96	65:30.25S	141:35.62E	1491	1486	1017	65:30.10S	141:35.08E	1505	9.4	1114	65:29.89S	141:34.48E	1494
9 SR3	1252	31-AUG-96	65:25.68S	141:37.33E	2125	2100	1402	65:25.45S	141:36.58E	2099	8.8	1521	65:25.15S	141:35.43E	2077
10 SR3	1844	31-AUG-96	65:10.53S	141:41.76E	2594	2544	2001	65:10.37S	141:40.14E	2529	10.3	2115	65:10.20S	141:38.34E	2551
11 SR3	0106	1-SEP-96	64:52.96S	141:51.58E	2965	2950	0241	64:52.77S	141:48.58E	-	10.0	0414	64:52.54S	141:45.55E	2920
12 SR3	0949	1-SEP-96	64:30.67S	141:20.56E	3506	3518	1136	64:30.10S	141:16.15E	3481	4.6	1329	64:29.44S	141:11.59E	3462
13 SR3	2219	1-SEP-96	63:53.74S	140:39.16E	3716	3746	2356	63:52.72S	140:38.22E	3732	11.6	0127	63:51.87S	140:38.40E	3726
14 SR3	0622	2-SEP-96	63:22.44S	140:18.76E	3801	3836	0757	63:21.22S	140:21.04E	3801	13.1	0944	63:20.08S	140:22.33E	3801
15 SR3	1442	2-SEP-96	62:51.01S	139:52.91E	3225	3262	1613	62:50.88S	139:53.65E	3246	11.7	1729	62:50.76S	139:54.28E	3251
16 SR3	2115	2-SEP-96	62:21.73S	139:50.56E	3952	3988	2254	62:21.45S	139:49.95E	-	9.9	0032	62:21.81S	139:49.38E	3963
17 SR3	0403	3-SEP-96	61:50.89S	139:51.19E	4300	4344	0543	61:51.33S	139:50.61E	-	11.0	0731	61:52.07S	139:50.25E	-
18 SR3	2101	3-SEP-96	61:21.18S	139:50.16E	4336	4392	2253	61:21.76S	139:49.39E	-	15.5	0031	61:22.25S	139:49.42E	-
19 SR3	0348	4-SEP-96	60:50.89S	139:50.83E	4392	4460	0527	60:51.16S	139:49.81E	-	3.6	0657	60:51.19S	139:49.78E	-
20 SR3	0956	4-SEP-96	60:20.95S	139:51.04E	4443	4488	1134	60:21.13S	139:51.04E	-	18.0	1312	60:21.36S	139:51.30E	-
21 SR3	1847	4-SEP-96	59:51.21S	139:51.34E	4474	4534	2038	59:51.85S	139:51.84E	-	15.3	2233	59:52.24S	139:52.74E	-
22 SR3	1547	5-SEP-96	59:21.15S	139:50.92E	4146	4174	1730	59:21.99S	139:51.21E	-	15.3	1902	59:22.30S	139:51.51E	-
23 SR3	2254	5-SEP-96	58:50.88S	139:50.56E	3911	3962	0026	58:51.22S	139:50.50E	-	15.4	0146	58:51.42S	139:51.24E	-
24 SR3	1247	6-SEP-96	58:21.01S	139:51.16E	3942	4084	1422	58:22.00S	139:51.25E	-	18.8	1554	58:22.23S	139:50.38E	-
25 SR3	1901	6-SEP-96	57:50.97S	139:51.00E	4090	4168	2052	57:51.67S	139:51.69E	-	15.3	2227	57:52.14S	139:52.12E	-
26 SR3	0714	7-SEP-96	57:20.92S	139:52.03E	4100	4212	0859	57:21.07S	139:52.35E	-	16.9	1047	57:21.00S	139:51.26E	-
27 SR3	1328	7-SEP-96	56:55.95S	139:51.10E	4100	4272	1514	56:55.93S	139:52.32E	-	19.5	1641	56:55.89S	139:52.98E	-
28 SR3	2324	7-SEP-96	56:25.80S	140:05.89E	3910	3950	0105	56:25.45S	140:07.06E	-	15.3	0228	56:25.06S	140:07.39E	-
29 SR3	0602	8-SEP-96	55:55.80S	140:24.49E	3730	3640	0751	55:55.11S	140:25.27E	-	16.5	0930	55:54.72S	140:25.78E	-
30 SR3	1738	8-SEP-96	55:29.97S	140:44.03E	3890	3900	1919	55:29.57S	140:44.95E	-	16.1	2054	55:29.13S	140:45.64E	-
31 SR3	0004	9-SEP-96	55:00.93S	141:01.35E	3225	3238	0131	55:00.55S	141:01.78E	-	12.4	0250	55:00.33S	141:01.88E	-
32 SR3	0603	9-SEP-96	54:31.92S	141:19.86E	2815	2896	0734	54:32.61S	141:19.04E	-	14.5	0857	54:32.91S	141:19.33E	-
33 SR3	1207	9-SEP-96	54:03.91S	141:36.09E	2559	2666	1205	54:03.92S	141:36.06E	-	16.9	1429	54:04.21S	141:36.90E	-
34 SR3	1736	9-SEP-96	53:34.68S	141:51.63E	2503	2672	1901	53:34.20S	141:49.77E	-	18.3	2025	53:33.50S	141:48.66E	-
35 SR3	2308	9-SEP-96	53:07.98S	142:08.17E	3122	3244	0039	53:08.43S	142:10.83E	-	23.5	0155	53:08.45S	142:12.03E	-
36 SR3	0510	10-SEP-96	52:40.03S	142:23.22E	3378	3396	0641	52:40.15S	142:24.16E	-	16.8	0807	52:40.16S	142:24.31E	-

station	START					maxP	BOTTOM					END			
number	time	date	latitude	longitude	depth(m)	(dbar)	time	latitude	longitude	depth(m)	altimeter	time	latitude	longitude	depth(m)
37 SR3	1010	10-SEP-96	52:21.93S	142:31.92E	3481	3608	1146	52:21.93S	142:32.61E	-	20.4	1308	52:22.36S	142:33.11E	-
38 SR3	1521	10-SEP-96	52:04.98S	142:42.34E	3481	3544	1652	52:05.62S	142:42.69E	-	15.2	1814	52:05.89S	142:43.00E	-
39 SR3	0344	11-SEP-96	51:48.52S	142:50.68E	3686	3782	0530	51:48.49S	142:50.71E	-	16.0	0655	51:48.60S	142:51.04E	-
40 SR3	0843	11-SEP-96	51:32.14S	142:59.19E	3686	3834	1035	51:32.07S	142:59.26E	-	18.8	1214	51:32.16S	142:59.35E	-
41 SR3	1422	11-SEP-96	51:15.70S	143:07.74E	3737	3832	1548	51:15.76S	143:07.71E	-	16.2	1713	51:15.76S	143:07.93E	-
42 SR3	0348	12-SEP-96	51:00.49S	143:16.03E	3870	3884	0517	50:59.68S	143:16.84E	-	18.1	0643	50:58.99S	143:17.54E	-
43 SR3	0904	12-SEP-96	50:40.89S	143:25.14E	3583	3556	1048	50:40.16S	143:29.77E	-	16.7	1219	50:39.58S	143:32.34E	-
44 SR3	2111	12-SEP-96	50:23.87S	143:32.09E	3580	3580	2258	50:23.71S	143:33.09E	-	16.5	0022	50:23.82S	143:33.30E	-
45 SR3	0253	13-SEP-96	50:09.63S	143:40.07E	3563	3740	0436	50:09.18S	143:40.57E	-	17.9	0602	50:08.77S	143:40.54E	-
46 SR3	0827	13-SEP-96	49:53.17S	143:48.27E	3768	3788	1010	49:53.08S	143:48.40E	-	23.1	1130	49:52.99S	143:47.92E	-
47 EL	1443	13-SEP-96	49:53.16S	144:33.90E	3768	3888	1610	49:53.13S	144:34.54E	-	18.5	1735	49:53.32S	144:34.66E	-
48 EL	2037	13-SEP-96	50:08.79S	144:27.34E	3730	3884	2233	50:08.76S	144:27.33E	-	15.9	0002	50:08.72S	144:27.38E	-
49 EL	0344	14-SEP-96	50:26.09S	144:17.95E	3420	3198	0515	50:25.96S	144:18.28E	-	13.0	0633	50:25.56S	144:19.02E	-
50 EL	1400	14-SEP-96	51:15.87S	143:54.24E	3737	3794	1532	51:15.82S	143:54.22E	-	17.2	1654	51:15.81S	143:54.34E	-
51 EL	1855	14-SEP-96	51:32.25S	143:46.65E	3686	3780	2040	51:32.29S	143:46.60E	-	17.9	2211	51:32.25S	143:46.75E	-
52 EL	0028	15-SEP-96	51:48.85S	143:37.95E	3481	3646	0159	51:48.82S	143:37.89E	-	5.8	0319	51:48.84S	143:38.16E	-
53 EL	0552	15-SEP-96	52:05.55S	143:29.43E	3532	3564	0726	52:05.52S	143:29.52E	-	16.9	0847	52:05.38S	143:29.52E	-
54 SR3	0507	16-SEP-96	49:36.47S	143:55.95E	3665	3730	0645	49:36.56S	143:55.93E	-	18.9	0808	49:36.61S	143:56.02E	-
55 SR3	1046	16-SEP-96	49:16.03S	144:06.03E	4382	4422	1256	49:16.99S	144:05.71E	-	18.5	1430	49:17.44S	144:06.22E	-
56 SR3	1822	16-SEP-96	48:47.05S	144:18.94E	4180	4148	1959	48:48.15S	144:19.39E	-	15.0	2126	48:48.75S	144:19.74E	-
57 SR3	0829	17-SEP-96	48:19.01S	144:32.00E	4000	4126	1001	48:19.79S	144:32.23E	-	15.1	1143	48:20.58S	144:32.43E	-
58 SR3	1414	17-SEP-96	47:59.94S	144:40.33E	4116	4412	1621	47:59.79S	144:40.25E	-	17.3	1750	47:59.94S	144:40.45E	-
59 SR3	1058	18-SEP-96	47:28.12S	144:53.80E	4440	4384	1302	47:28.05S	144:52.12E	-	25.6	1438	47:28.18S	144:50.88E	-
60 SR3	1704	18-SEP-96	47:09.25S	144:54.19E	4790	4882	1904	47:09.67S	144:53.08E	-	20.8	2053	47:09.91S	144:52.51E	-
61 SR3	0034	19-SEP-96	46:39.04S	145:15.19E	3378	3434	0219	46:39.61S	145:15.01E	-	21.1	0341	46:39.75S	145:14.89E	-
62 SR3	0701	19-SEP-96	46:10.00S	145:28.15E	2723	2754	1016	46:11.83S	145:28.41E	-	14.6	1134	46:12.61S	145:28.57E	-
63 SR3	1833	19-SEP-96	45:42.01S	145:39.82E	2017	2098	1945	45:42.55S	145:39.82E	-	15.6	2045	45:42.93S	145:39.93E	-
64 SR3	2355	19-SEP-96	45:13.02S	145:50.89E	2851	2892	0120	45:12.70S	145:49.78E	2887	14.7	0232	45:12.76S	145:49.69E	-
65 SR3	1141	20-SEP-96	44:42.99S	146:03.04E	3195	3222	1323	44:42.73S	146:03.82E	3195	17.0	1441	44:42.43S	146:04.75E	3220
66 SR3	1649	20-SEP-96	44:22.99S	146:11.37E	2333	2348	1800	44:23.05S	146:11.82E	2333	17.1	1907	44:23.13S	146:11.95E	2333
67 SR3	2106	20-SEP-96	44:07.05S	146:13.33E	1003	1000	2145	44:06.94S	146:13.29E	1003	17.5	2219	44:06.90S	146:13.39E	1003
68 SR3	2312	20-SEP-96	44:03.21S	146:17.21E	522	478	2347	44:03.24S	146:18.09E	481	17.4	0016	44:03.40S	146:18.52E	481
69 SR3	0105	21-SEP-96	44:00.04S	146:19.17E	236	190	0124	44:00.03S	146:19.48E	200	12.0	0142	44:00.01S	146:19.83E	179
70 TEST	1004	21-SEP-96	44:39.59S	147:00.22E	2457	318	1014	44:39.59S	147:00.37E	-	-	1024	44:39.57S	147:00.47E	-
71 TEST	1248	21-SEP-96	44:37.02S	147:00.21E	2559	2564	1415	44:37.13S	147:00.82E	-	28.5	1534	44:37.41S	147:00.97E	-

<u>Table 3.3:</u> Summary of samples drawn from Niskin bottles at each station, including salinity (sal), dissolved oxygen (do), nutrients (nut), dissolved inorganic carbon (dic), alkalinity (alk), carbon isotopes (Ctope), fluorometry (fl), and pigments (pig); Seacat casts are also listed. Note that 1=samples taken, 0=no samples taken, 2=surface sample only (i.e. from shallowest Niskin bottle or from seawater outlet).

station	sal	do	nut	dic	alk	Ctope	fl	pig	SEACAT
1	1	1	1	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0
4	1	1	1	0	0	0	0	0	1
5	1	1	1	0	0	0	0	0	0
6	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	2	1	1	1
8	1	1	1	1	1	2	1	1	1
9	1	1	1	1	1	2	0	0	0
10	1	1	1	2	2	2	1	1	1
11	1	1	1	1	1	1	1	1	1
12	1	1	1	1	1	2	1	1	1
13	1	1	1	1	1	2	1	1	1
14	1	1	1	1	1	2	1	1	1
15	1	1	1	1	1	1	0	1	1
16	1	1	1	1	1	2	1	1	1
17	1	1	1	1	1	2	1	1	1
18	1	1	1	1	1	1	1	1	0
19	1	1	1	1	2	2	1	1	1
20	1	1	1	1	1	0	0	1	1
21	1	1	1	1	1	1	1	1	1
22	1	1	1	1	1	2	0	1	1
23	1	1	1	1	1	2	1	1	1
24	1	1	1	1	1	1	0	1	1
25	1	1	1	2	2	2	1	1	1
26	1	1	1	1	1	2	1	1	1
27	1	1	1	1	1	2	0	1	1
28	1	1	1	1	1	2	1	1	1
29	1	1	1	1	1	2	1	1	1
30	1	1	1	1	1	1	0	1	1
31	1	1	1	2	2	2	1	1	1
32	1	1	1	1	1	2	1	1	1
33	1	1	1	2	2	2	0	1	1
34	1	1	1	1	1	1	0	1	1
35	1	1	1	2	2	2	1	1	1
36	1	1	1	1	1	2	1	1	1
37	1	1	1	1	1	2	0	1	1
38	1	1	1	2	2	2	0	1	1
39	1	1	1	1	1	1	1	1	1
40	1	1	1	1	1	2	1	1	1
41	1	1	1	1	1	2	0	1	1
42	1	1	1	1	1	2	1	1	0
43	1	1	1	1	1	0	1	1	0
44	1	1	1	1	1	0	1	1	0
45	1	1	1	1	1	2	1	1	0
46	1	1	1	1	1	0	1	0	0
47	1	1	1	2	2	0	0	0	0
48	1	1	1	2	2	0	0	0	0
49	1	1	1	2	2	0	0	0	0
50	1	1	1	2	2	0	0	0	0

Table 3.3: **(continued)**

station	sal	do	nut	dic	alk	Ctope	fl	pig	SEACAT
51	1	1	1	2	2	0	0	0	0
52	1	1	1	2	2	0	0	0	0
53	1	1	1	2	2	0	0	0	0
54	1	1	1	1	1	0	1	1	1
55	1	1	1	1	1	1	0	1	1
56	1	1	1	2	2	0	0	1	1
57	1	1	1	1	1	2	1	1	1
58	1	1	1	1	1	0	0	1	1
59	1	1	1	1	1	1	0	1	0
60	1	1	1	1	1	0	1	1	0
61	1	1	1	1	1	2	1	1	1
62	1	1	1	1	1	0	1	1	1
63	1	1	1	1	1	0	1	1	1
64	1	1	1	2	2	2	1	1	1
65	1	1	1	1	1	1	0	1	1
66	1	1	1	2	2	0	0	1	1
67	1	1	1	1	1	0	1	1	1
68	1	1	1	0	0	0	1	1	1
69	1	1	1	1	1	0	0	0	0
70	0	0	0	0	0	0	0	0	1
71	1	0	0	0	0	0	0	0	0

Table 3.4: **CTD stations over current meter (CM) and inverted echo sounder (IES) moorings along SR3 transect in the vicinity of the Subantarctic Front. Note that bottom depths (at the start of each CTD cast) are calculated using a sound speed of 1498 ms^{-1}. For CTD station positions, see Table 3.2.**

CTD station no.	start time	bottom depth (m)	mooring number
38	15:21, 10/09/96	3481	I18 (IES)
39	03:44, 11/09/96	3686	I16 (IES)
40	08:43, 11/09/96	3686	I14 (IES)
41	14:22, 11/09/96	3737	I12 (IES)
42	03:48, 12/09/96	3870	I10 (CM+IES)
43	09:04, 12/09/96	3583	I9 (CM+IES)
44	21:11, 12/09/96	3580	I8 (CM+IES)
45	02:53, 13/09/96	3563	I6 (IES)
46	08:27, 13/09/96	3768	I4 (IES)
47	14:43, 13/09/96	3768	I3 (IES)
48	20:37, 13/09/96	3730	I5 (IES)
49	03:44, 14/09/96	3420	I7 (IES)
50	14:00, 14/09/96	3737	I11 (IES)
51	18:55, 14/09/96	3686	I13 (IES)
52	00:28, 15/09/96	3481	I15 (IES)
53	05:52, 15/09/96	3532	I17 (IES)
54	05:07, 16/09/96	3665	I2 (IES)
58	14:14, 17/09/96	4116	I1 (IES)

<u>Table 3.5a:</u> Principal investigators (*=cruise participant) for rosette water sampling programmes.

measurement	name	affiliation
CTD, salinity, O_2, nutrients	*Steve Rintoul/Nathan Bindoff	CSIRO/Antarctic CRC
D.I.C., alkalinity, carbon isotopes	*Bronte Tilbrook	CSIRO
fluorometry	*Peter Strutton(PhD student)	Flinders University
biological sampling	Harvey Marchant/*Simon Wright	Antarctic Division

<u>Table 3.5b:</u> Scientific personnel (cruise participants).

name	measurement	affiliation
Muhammad Evri	CTD	BPPT (Indonesia)
Helen Phillips	CTD	Antarctic CRC
Steve Rintoul	CTD	CSIRO
Marie Robert	CTD	Antarctic CRC
Mark Rosenberg	CTD	Antarctic CRC
Serguei Sokolov	CTD	CSIRO
Annie Wong	CTD	Antarctic CRC
Fadli Syamsudin	CTD	BPPT (Indonesia)
Stephen Bray	salinity, oxygen, nutrients	Antarctic CRC
Ana Costalunga	oxygen	Antarctic CRC
Neale Johnston	salinity, oxygen, nutrients	Antarctic CRC
Rebecca Esmay	D.I.C., alkalinity, C isotopes	CSIRO
Mark Pretty	D.I.C., alkalinity, C isotopes	CSIRO
Bronte Tilbrook	D.I.C., alkalinity, C isotopes	CSIRO
Alison Walker	D.I.C., alkalinity, C isotopes	CSIRO
Raechel Waters	biological sampling	Antarctic Division
Simon Wright	biological sampling, voyage leader	Antarctic Division
Simon Evans	programmer	Antarctic Division
Robert Geier	programmer	Antarctic Division
Stewart Graham	doctor	Antarctic Division
Alan Poole	electronics	CSIRO
Sandra Potter	deputy voyage leader, fishing	Antarctic Division
Peter Strutton	underway data, fluorometry	Antarctic Division/Flinders University
Andrew Tabor	gear officer, fishing	Antarctic Division
Wojciech Wierzbicki	electronics	Antarctic Division
Karen Wilson	fishing	Marine Studies Centre (Tasmania)
Steve Oakley	returnee	Antarctic Division

3.4 FIELD DATA COLLECTION METHODS

3.4.1 CTD and hydrology measurements

CTD and hydrology instrumentation, data collection and processing methods are as described in Part 2 of this report. The hydrology laboratory report for this cruise can be found in Appendix 3.1. Preliminary results of the CTD data calibration, along with data quality information, are presented in Section 3.6. Calibration information for CTD sensors are presented in Table 3.22. Note that no photosynthetically active radiation (p.a.r.) sensor or fluorometer were attached to the rosette package for this cruise. P.a.r. and fluorescence data were collected by a Seabird "Seacat" CTD, which was deployed separately (Table 3.3) (these data are not discussed further in this report).

The following updates apply to the CTD data processing and hydrology analytical techniques:

(i) in the conductivity calibration for stations 10 to 21, an additional term was applied to remove the pressure dependent conductivity residual;

(ii) salinity bottle samples were analysed using a Guildline Autosal model 8400B (YeoKal salinometers had been used on all previous cruises); substandard measurements were not required, owing to the stability of the Autosal; international seawater standards were measured at the start and end of each day's analysis.

3.4.2 Underway measurements

Underway data collection is as described in previous data reports; data files are described in Part 5. Note that a sound speed of 1498 ms^{-1} is used for all depth calculations.

3.4.3 ADCP

The acoustic Doppler current profiler (ADCP) instrumentation is described in previous data reports. Logging parameters are summarised in Table 3.6, while data results for this cruise will be discussed in a future report.

Table 3.6: ADCP logging parameters.

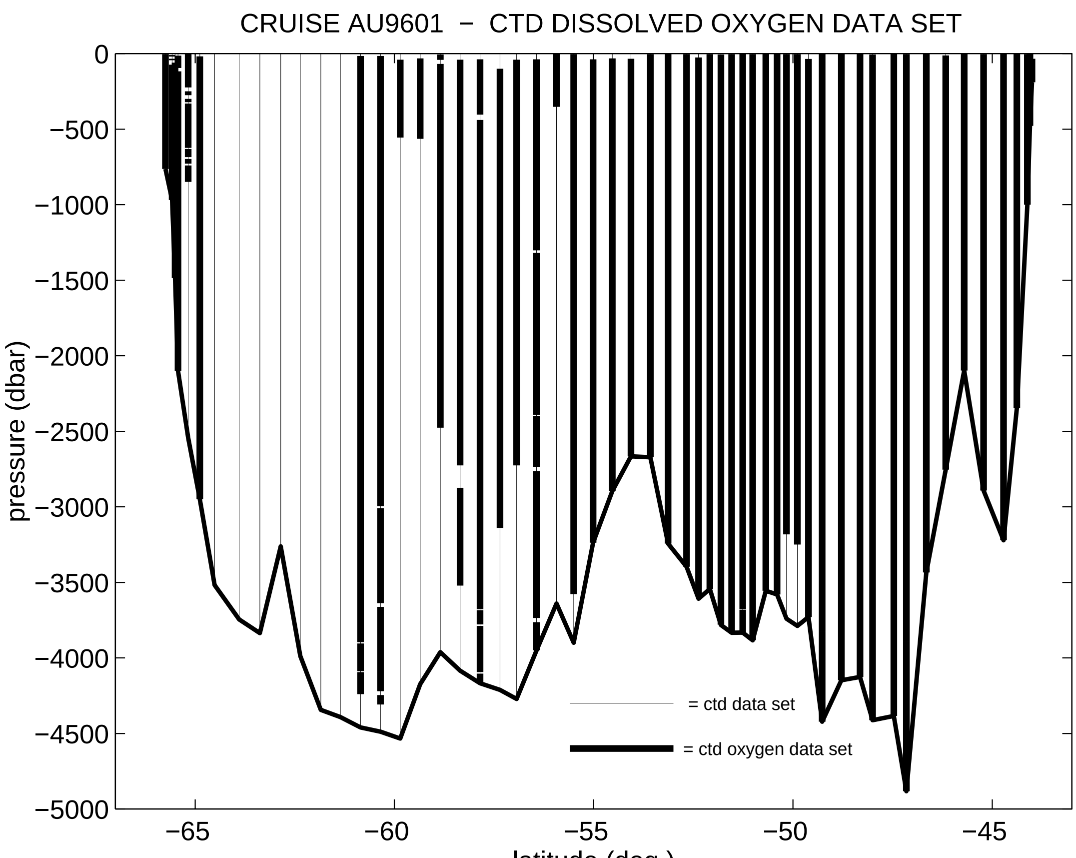
ping parameters		*bottom track ping parameters*	
no. of bins:	60	no. of bins:	128
bin length:	8 m	bin length:	4 m
pulse length:	8 m	pulse length:	32 m
delay:	4 m		
ping interval:	minimum	ping interval:	same as profiling pings

reference layer averaging:	bins 8 to 13
ensemble averaging duration:	3 min.

3.5 MAJOR PROBLEMS ENCOUNTERED

After completion of station 6 at the southernmost end of the SR3 transect, the ship encountered thick pack ice while attempting to head northward. At one point the ship became stuck on top of an ice pressure ridge. Ballast waters were shifted and the vessel was freed after a total delay of 15 hours. No major logistical problems were encountered for the remainder of the voyage, with all scheduled work being completed.

The only significant problem with the instrumentation was the large amount of unusable CTD dissolved oxygen data. These bad data often occurred near the bottom of casts. Figure 3.2 summarises the spatial coverage of good CTD dissolved oxygen data (note that bottle dissolved oxygen data is good for the entire transect).



<u>Figure 3.2:</u> CTD dissolved oxygen data coverage along SR3 transect for cruise AU9601.

3.6 CTD RESULTS

This section details information relevant to the creation and quality of the final CTD and hydrology data set. For actual use of the data, the following is important:

CTD data - Tables 3.14 and 3.15, and Table 3.7;
hydrology data - Tables 3.19 and 3.20.

Historical data comparisons are made in Part 4 of this report. Data file formats are described in Part 5.

3.6.1 CTD measurements - data creation and quality

The final calibration results for conductivity/salinity and dissolved oxygen, along with the performance check for temperature, are plotted in Figures 3.3 to 3.6 (see Part 1 of this report for further details of the parameters plotted). For conversion to WOCE data file formats, see Part 5 of this report.

3.6.1.1 Conductivity/salinity

The conductivity calibration for CTD 1103 (stations 4 to 69) was of high quality (Figures 3.4 and 3.5), due in part to stable performance of the new Guildline salinometer. Note that for stations 10 to 21, the CTD conductivity cell was slightly fouled (the fouling was not discovered until after completion of station 21). This fouling resulted in a pressure dependent conductivity residual after initial calibration. An extra fit (Table 3.9) was applied to remove this residual, following the same method as described in Part 1 (section 1.6.1.1) of this report.

A small discontinuity of the order 0.0018 (PSS78) may exist in the CTD salinity data between stations 1-23 and stations 24-69 due to differences in International Standard Seawater batches, as described in section 3.6.2 below.

For test stations 1 and 2 using CTD 1193, CTD salinity accuracy is diminished (accurate to ~0.01 (PSS78)) as the only salinity samples available for calibration were collected from a single depth at station 1. For the test stations 3, 70 and 71, no bottle data are available for calibration of the CTD.

At ~580 dbar on the downcast of station 62, the ship's engine shutdown and all power was lost, leaving the ship adrift. The downcast was resumed approximately 2 hours later without retrieving the CTD. A small discontinuity at ~580 dbar may therefore be present in all parameters due to any local horizontal gradients.

3.6.1.2 Temperature

Platinum temperature sensor performance of the CTD's was stable throughout the cruise, with a moderate mean offset between thermometer and CTD temperature values (Figure 3.3).

3.6.1.3 Dissolved oxygen

The final standard deviation value of the dissolved oxygen residuals (Figure 3.6) is less than 1% of full scale values (where full scale is approximately equal to 250 μmol/l for pressure > 750 dbar, and 350 μmol/l for pressure < 750 dbar). Unusual calibration coefficient values were found for some stations (Table 3.17), in particular for station 30 where the coefficient $K_5 >> 1$. CTD dissolved oxygen calibration for this station was of a lower quality than for other stations.

3.6.1.4 Summary of CTD data creation

Information relevant to the creation of the calibrated CTD data is tabulated, as follows:

* Surface pressure offsets calculated for each station are listed in Table 3.8.

* CTD conductivity calibration coefficients, including the station groupings used for the conductivity calibration, are listed in Tables 3.9 and 3.10.

* CTD raw data scans flagged for special treatment are listed in Table 3.11.

* Missing 2 dbar data averages are listed in Table 3.12.

* 2 dbar bins which are linearly interpolated from surrounding bins are listed in Table 3.13.

* Suspect 2 dbar averages are listed in Tables 3.14 and 3.15.

* CTD dissolved oxygen calibration coefficients are listed in Table 3.16. The starting values used for the coefficients prior to iteration, and the coefficients varied during the iteration, are listed in Table 3.17.

* The different protected and unprotected thermometers used for the stations are listed in Table 3.21.

* The pressure and temperature laboratory calibration coefficients for the CTD's used are listed in Table 3.22.

3.6.1.5 Summary of CTD data quality

CTD data quality cautions for the various parameters are summarised in Table 3.7.

<u>Table 3.7:</u> Summary of cautions to CTD data quality.

station no.	CTD parameter	caution
1,2	salinity	test cast - all bottles fired at same depth; salinity accuracy reduced
10-21	salinity	additional correction applied for pressure dependent conductivity residual
30	oxygen	oxygen calibration fit fairly poor
62	all	ship broke down - will be a discontinuity in downcast due to horizontal drift
1-23/24-69	salinity	discontinuity in salinity data of 0.0018 (PSS78) between the 2 station groups due to ISS batch difference
1-40	oxygen	values larger than for remaining stations by ~4µmol/l

3.6.2 Hydrology data

Quality control information relevant to the hydrology data is tabulated, as follows:

* Dissolved oxygen Niskin bottle samples flagged with the code -9 (rejected for CTD dissolved oxygen calibration) are listed in Table 3.18.

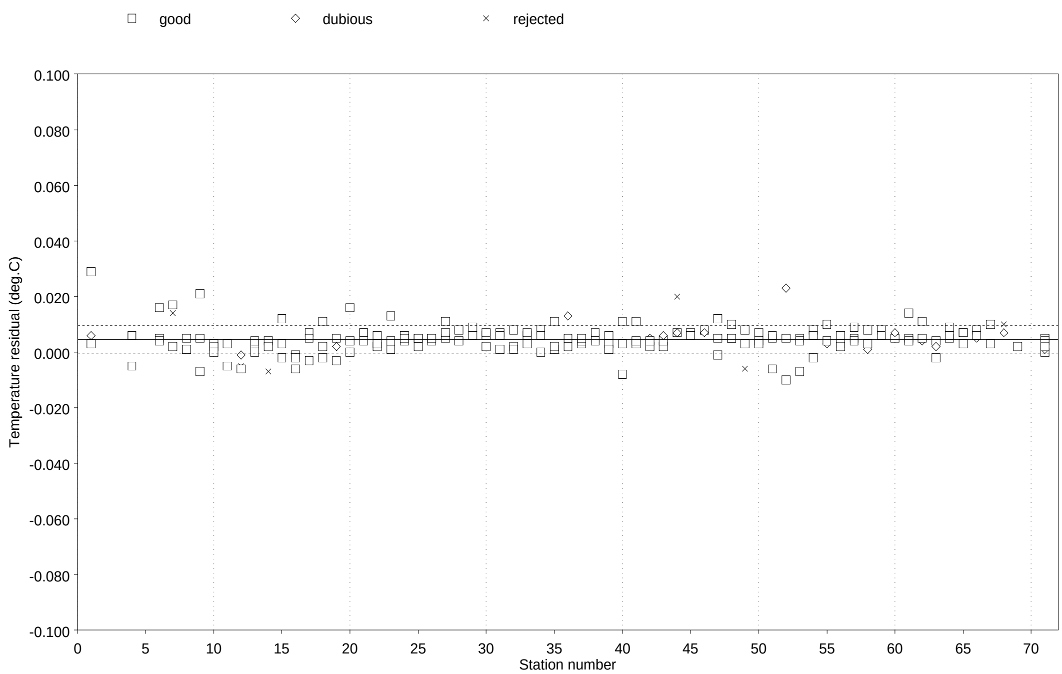
* Questionable dissolved oxygen and nutrient Niskin bottle sample values are listed in Tables 3.19 and 3.20 respectively. Note that questionable values are included in the hydrology data file, whereas bad values have been removed.

Laboratory temperature on the ship was stable, with lab temperatures at the times of nutrient analyses having a most common value of 20^{o}C.

International Standard Seawater (ISS) batch P128 (18th July 1995)) was used for salinity sample anaylses of stations 1-23, while batch P130 (21st March 1996) was used for stations 24-69. Standardisation values on the salinometer were consistently different for these two ISS batches, indicating a problem with one of the batches. A discontinuity is therefore present in salinity bottle values, with station 24-69 values higher than station 1-23 values by 0.0018 ±0.0003 (PSS78). It is not known which ISS batch is at fault.

For dissoved oxygen data, stations 1 to 40 bottle values (and therefore CTD values also) are ~4µmol/l larger than for the remaining stations 41 to 69. Note that a jump in standardisation values for the laboratory analyses occurred between stations 40 and 41, accounting for the two groups of dissolved oxygen data. See Part 4 of this report for a more detailed discussion.

For stations 16 and 17 nutrient data, autoanalyser peak heights were measured manually.



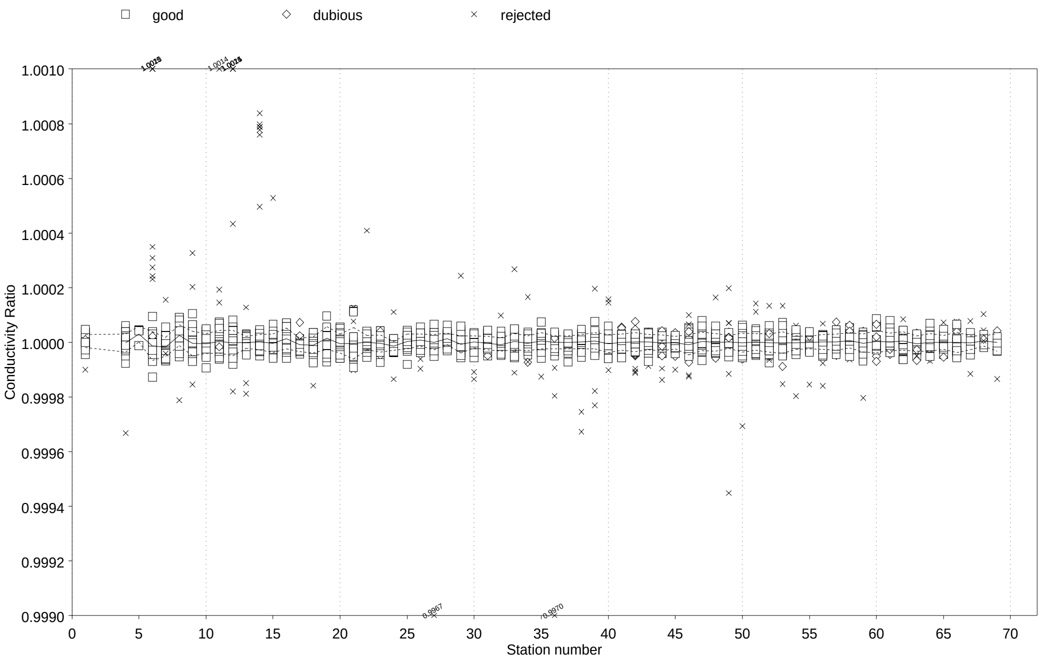
Calibration data for cruise : Au9601

Calibration file : histcal.lis

Mean offset Temperature = 0.00463312c (s.d. = 0.0050 ˚c)

Number of samples used = 187 out of 193

Figure 3.3: **Temperature residual (T_{therm} - T_{cal}) versus station number for cruise au9601. The solid line is the mean of all the residuals; the broken lines are ± the standard deviation of all the residuals (see CTD methodology). Note that the "dubious" and "rejected" categories refer to the conductivity calibration.**



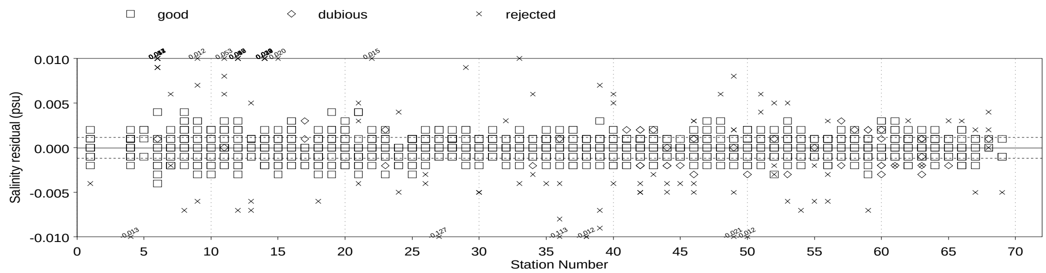
Calibration data for cruise : Au9601

Calibration file : histcal.lis

Conductivity s.d. = 0.00003

Number of bottles used = 1382 out of 1534 Mean ratio for all bottles = 1.00000

Figure 3.4: **Conductivity ratio c_{btl}/c_{cal} versus station number for cruise au9601. The solid line follows the mean of the residuals for each station; the broken lines are ± the standard deviation of the residuals for each station (see CTD methodology).**



Calibration data for cruise : Au9601

Calibration file : histcal.lis

Mean offset salinity = 0.0000psu (s.d. = 0.0012 psu)

Number of bottles used = 1382 out of 1534

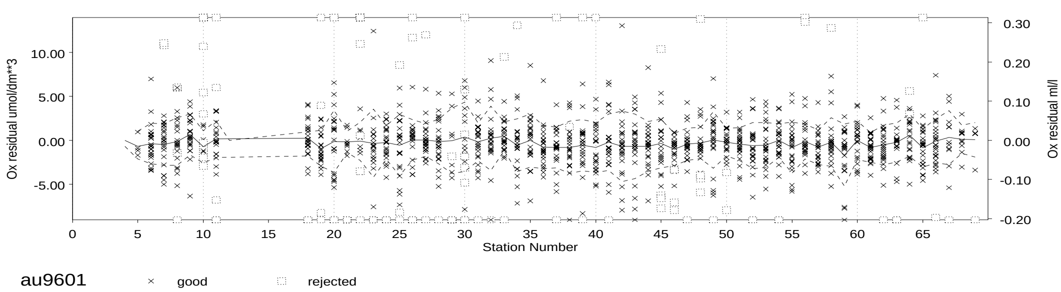
<u>Figure 3.5:</u> Salinity residual (s_{btl} - s_{cal}) versus station number for cruise au9601. The solid line is the mean of all the residuals; the broken lines are ± the standard deviation of all the residuals (see CTD methodology).

Mean of Residual = -0.353umol/dm**3

S.D. of residual = 2.557umol/dm**3 (Equiv to 0.057ml/l)

Used 1177 bottles out of total 1504

S.D. deep (>750m) 1.839umol/dm**3 (equiv to 0.041ml/l)



<u>Figure 3.6:</u> Dissolved oxygen residual (o_{btl} - o_{cal}) versus station number for cruise au9601. The solid line follows the mean residual for each station; the broken lines are ± the standard deviation of the residuals for each station (see CTD methodology).

Table 3.8: **Surface pressure offsets (as defined in the CTD methodology).**

stn no.	surface p offset (dbar)	stn no.	surface p offset (dbar)	stn no.	surface p offset (dbar)	stn no.	surface p offset (dbar)
1	0.78	19	-2.68	37	-2.92	55	-2.66
2	0.61	20	-3.07	38	-2.84	56	-2.70
3	0.77	21	-2.73	39	-2.42	57	-3.18
4	-2.55	22	-2.20	40	-2.50	58	-3.08
5	-2.06	23	-2.71	41	-3.00	59	-2.69
6	-2.41	24	-2.60	42	-2.03	60	-2.77
7	-2.31	25	-2.65	43	-2.61	61	-3.19
8	-2.16	26	-2.85	44	-2.95	62	-2.81
9	-2.27	27	-2.69	45	-2.78	63	-3.15
10	-2.67	28	-2.52	46	-2.64	64	-3.01
11	-2.57	29	-2.99	47	-2.96	65	-3.02
12	-2.83	30	-2.89	48	-2.68	66	-3.13
13	-2.71	31	-3.25	49	-3.11	67	-3.13
14	-2.68	32	-2.88	50	-2.59	68	-3.35
15	-2.80	33	-3.28	51	-2.74	69	-3.15
16	-2.54	34	-2.59	52	-3.07	70	0.89
17	-2.70	35	-3.05	53	-3.31	71	0.41
18	-2.67	36	-2.69	54	-2.47		

Table 3.9: **CTD conductivity calibration coefficients. F_1, F_2 and F_3 are respectively conductivity bias, slope and station-dependent correction calibration terms. n is the number of samples retained for calibration in each station grouping; σ is the standard deviation of the conductivity residual for the n samples in the station grouping (see CTD methodology); α is the correction applied to CTD conductivities due to pressure dependence of the conductivity residuals (see eqn 1.1 in Part 1 of this report).**

stn grouping	F_1	F_2	F_3	n	σ	α
001 to 001	-.74396631	0.98848575E-03	0	19	0.000758	-
002 to 002	-.74396631	0.98848575E-03	0	19	0.000758	-
003 to 003	-	-	-	-	-	-
004 to 009	0.38105131E-01	0.10026968E-02	-.17129059E-07	109	0.001151	-
010 to 012	0.29464364E-01	0.10029643E-02	-.42023366E-07	63	0.001082	-1.72220E-06
013 to 014	0.22334088E-01	0.10031561E-02	-.28439980E-07	38	0.000808	-2.89414E-06
015 to 017	0.25912709E-01	0.10022619E-02	0.54122684E-07	71	0.000975	-3.23843E-06
018 to 021	0.17743922E-01	0.10042234E-02	-.38849067E-07	89	0.001224	-1.25810E-06
022 to 023	0.10979836E-02	0.10062176E-02	-.14796191E-07	45	0.000810	-
024 to 033	-.12532344E-01	0.10063905E-02	-.61267260E-10	224	0.000741	-
034 to 037	0.20512016E-02	0.10060457E-02	-.32684513E-08	83	0.000750	-
038 to 040	-.27578964E-01	0.10069364E-02	-.12822740E-08	60	0.000879	-
041 to 042	-.24668828E-01	0.10063144E-02	0.13021786E-07	41	0.000940	-
043 to 047	-.19096958E-01	0.10068804E-02	-.42245725E-08	106	0.000944	-
048 to 049	-.20424480E-01	0.10065386E-02	0.38684723E-08	40	0.000814	-
050 to 053	-.34297624E-01	0.10072630E-02	-.15337700E-08	86	0.001002	-
054 to 056	-.18440140E-01	0.10073180E-02	-.11331976E-07	61	0.000756	-
057 to 059	-.19465081E-01	0.10061536E-02	0.94647529E-08	68	0.000993	-
060 to 061	-.17832191E-01	0.10045096E-02	0.35861141E-07	45	0.001197	-
062 to 065	-.18907083E-01	0.10069848E-02	-.42532668E-08	89	0.000932	-
066 to 069	-.19880267E-01	0.10067129E-02	0.65647745E-09	45	0.001026	-
070 to 070	-.74396631	0.98848575E-03	0	19	0.000758	-
071 to 071	-.74396631	0.98848575E-03	0	19	0.000758	-

Table 3.10: **Station-dependent-corrected conductivity slope term ($F_2 + F_3 . N$), for station number N, and F_2 and F_3 the conductivity slope and station-dependent correction calibration terms respectively.**

stn no.	($F_2 + F_3 . N$)	stn no.	($F_2 + F_3 . N$)	stn no.	($F_2 + F_3 . N$)	stn no.	($F_2 + F_3 . N$)
1	0.98848575E-03	19	0.10034853E-02	37	0.10059247E-02	55	0.10066947E-02
2	0.98848575E-03	20	0.10034465E-02	38	0.10068877E-02	56	0.10066834E-02
3	-	21	0.10034076E-02	39	0.10068864E-02	57	0.10066931E-02
4	0.10026283E-02	22	0.10058920E-02	40	0.10068851E-02	58	0.10067025E-02
5	0.10026112E-02	23	0.10058772E-02	41	0.10068483E-02	59	0.10067120E-02
6	0.10025940E-02	24	0.10063891E-02	42	0.10068613E-02	60	0.10066612E-02
7	0.10025769E-02	25	0.10063890E-02	43	0.10066988E-02	61	0.10066971E-02
8	0.10025598E-02	26	0.10063890E-02	44	0.10066946E-02	62	0.10067211E-02
9	0.10025426E-02	27	0.10063889E-02	45	0.10066903E-02	63	0.10067169E-02
10	0.10025441E-02	28	0.10063888E-02	46	0.10066861E-02	64	0.10067126E-02
11	0.10025021E-02	29	0.10063888E-02	47	0.10066819E-02	65	0.10067084E-02
12	0.10024601E-02	30	0.10063887E-02	48	0.10067243E-02	66	0.10067563E-02
13	0.10027864E-02	31	0.10063886E-02	49	0.10067281E-02	67	0.10067569E-02
14	0.10027579E-02	32	0.10063886E-02	50	0.10071863E-02	68	0.10067576E-02
15	0.10030737E-02	33	0.10063885E-02	51	0.10071848E-02	69	0.10067582E-02
16	0.10031278E-02	34	0.10059345E-02	52	0.10071833E-02	70	0.98848575E-03
17	0.10031819E-02	35	0.10059313E-02	53	0.10071817E-02	71	0.98848575E-03
18	0.10035242E-02	36	0.10059280E-02	54	0.10067060E-02		

Table 3.11: **CTD raw data scans flagged for special treatment (see previous data reports for explanation).**

station number	approximate pressure (dbar)	raw scan numbers	action taken	reason
4	98	14011-14220,14392-14422	ignore	wake effect in steep gradient
4	106	15123-15275	ignore	wake effect in steep gradient
5	6-41	8352-13559	ignore	preliminary dip to 41 dbar
5	110	17848-18017	ignore	wake effect in steep gradient
6	3-30	2605-8552	ignore	preliminary dip to 30 dbar
6	11-16	2633-9148	ignore	fouling of cond. cell
7	8-22	2313-6115	ignore	preliminary dip to 22 dbar
8	9-28	1534-5118	ignore	preliminary dip to 28 dbar
9	9-40	6951-13639	ignore	preliminary dip to 40 dbar
11	10-158	11617-31172	ignore	preliminary dip to 158 dbar
12	9-31	3185-8956	ignore	preliminary dip to 31 dbar
14	9-25	1987-6352	ignore	preliminary dip to 25 dbar
17	9-33	3939-9105	ignore	preliminary dip to 33 dbar
19	7-39	4544-9809	ignore	preliminary dip to 39 dbar
20	8-35	3049-7411	ignore	preliminary dip to 35 dbar
28	1302-1354	74227-76421	ignore	fouling of cond. cell
29	8-30	5451-9404	ignore	preliminary dip to 30 dbar
34	576	57543-57686	ignore	fouling of cond. cell
58	329	30437-30772	ignore	fouling of cond. cell
62	199	19731-19995	ignore	fouling of cond. cell
66	226	22795-22871	ignore	fouling of cond. cell
71		81471-7,81548-81620,81683-5	ignore	bad data
71		81780-2,81753-81768	ignore	bad data
71		125721-3,126067-126114	ignore	bad data

Table 3.12: **Missing data points in 2 dbar-averaged files. "1" indicates missing data for the indicated parameters: T=temperature; S=salinity, σ_T, specific volume anomaly and geopotential anomaly; O=dissolved oxygen. Note that jmin is the minimum number of data points required in a 2 dbar bin to form the 2 dbar average (see CTD methodology).**

station number	pressures (dbar) where data missing	T	S	O	reason
1,2	entire profile			1	no bottles for oxygen calibration
3	entire profile	1	1	1	no calibration data
4	2	1	1		bad data
4	entire profile			1	CTD oxygen hardware fault
5	2,4	1	1		bad data
5	2-14			1	bad data
6	2	1	1		bad data
7	2-8	1	1		bad data
7	2,22-32,46-72			1	bad data
8	2-58			1	bad data
9	2-8	1	1		bad data
9	2-12,98-116			1	bad data
10	226-248,278-298,324-328			1	bad data
10	626-630,688-696,730-738			1	bad data
10	852-bottom			1	bad data
11	2	1	1		bad data
11	2-16			1	bad data
12	2,4	1	1		bad data
14	2,4	1	1		bad data
15-18	2	1	1		bad data
12-18	entire profile			1	bad data
19	2-14,3898-3902,4090-4092			1	bad data
19	4242-bottom			1	bad data
20	2	1	1		bad data
20	2-14,2998-3008,3640-3660			1	bad data
20	4222-4244,4310-bottom			1	bad data
21	2	1	1		bad data
21	2-38,558-bottom			1	bad data
22	2	1	1		bad data
22	2-30,566-bottom			1	bad data
23	2,4	1	1		bad data
23	2,44-66,2478-bottom			1	bad data
24	2,4	1	1		bad data
24	2-38,2728-2872,3524-bottom			1	bad data
25	2-36,406-438,3680-3682			1	bad data
25	3780-3786,4096-4102,4162-4168			1	bad data
26	2-98,3142-bottom			1	bad data
27	2-38,2728-bottom			1	bad data
28	2	1	1		bad data
28	1304-1318	1	1		fouling of conductivity cell
28	2-36,1304-1318,3738-3762			1	bad data
28	2392-2398,2738-2762			1	bad data
29	354-bottom			1	bad data
30	2	1	1		bad data
30	2,3580-bottom			1	bad data
31	2,4	1	1		bad data
31	2-36			1	bad data
32	2	1	1		bad data
32	2-30			1	bad data
33	2-32			1	bad data

Table 3.12: (continued)

station number	pressures (dbar) where data missing	T	S	O	reason
34	2	1	1	1	bad data
36	2	1	1	1	bad data
37	4-24,3588-bottom			1	bad data
38	2	1	1	1	bad data
39	2,4			1	bad data
39	3782	1	1	1	no. of data pts in 2dbar bin < jmin
40	2	1	1	1	bad data
41	3678			1	bad data
42	2	1	1	1	bad data
45	2	1	1		bad data
45	2,3184-bottom			1	bad data
46	2,3252-bottom			1	bad data
47,48	2	1	1		bad data
48	3400-bottom			1	bad data
49	2,4	1	1		bad data
50	2	1	1		bad data
50	2,3352-bottom			1	bad data
52-54	2	1	1		bad data
52	2,4			1	bad data
53	2			1	bad data
54	2-34			1	bad data
58	2	1	1		bad data
58	2,4			1	bad data
60	2			1	bad data
62	2	1	1		bad data
62	2-10			1	bad data
64	2	1	1	1	bad data
67	2	1	1		bad data
69	2	1	1		bad data
69	2-32			1	bad data
70	entire profile	1	1	1	no calibration data
71	entire profile	1	1	1	no calibration data

Table 3.13: 2 dbar averages interpolated from surrounding 2 dbar values, for the indicated parameters.

station number	interpolated 2 dbar values	parameters interpolated
20	3692	T, S

Table 3.14a: **Suspect 2 dbar salinity averages (+ temperature where indicated). Note: for suspect salinity values, the following are also suspect: σ_T, specific volume anomaly, and geopotential anomaly.**

station number	suspect 2 dbar values (dbar) bad	questionable	reason
4	-	90,92	salinity spike in steep local gradient
5	-	98,100,106	salinity spike in steep local gradient
5	-	114,116,120	salinity spike in steep local gradient
6	-	6-10	possible fouling of conductivity cell
7	-	800-804,820,828	salinity spike in steep local gradient
7	826	-	salinity spike in steep local gradient
14	70	-	salinity spike in steep local gradient
15	76	-	salinity spike in steep local gradient
15	-	78,80	salinity spike in steep local gradient
17	110	-	salinity spike in steep local gradient
19	-	136-142	salinity spike in steep local gradient
20	-	100-106,114	salinity spike in steep local gradient
20	-	128,130,136	salinity spike in steep local gradient
22	-	150,152,162,164	salinity spike in steep local gradient
39	144	-	salinity spike in steep local gradient
43	656,692	-	salinity spike in steep local gradient
52	-	178,292	salinity spike in steep local gradient
60	-	1160,1276-1280	salinity spike in steep local gradient
60	-	1322-1326	salinity spike in steep local gradient
65	-	1010,1014	salinity spike in steep local gradient
65	1012	-	salinity spike in steep local gradient

Table 3.14b: **Suspect 2 dbar-averaged data from near the surface (applies to all parameters other than dissolved oxygen, except where noted).**

stn no.	suspect 2dbar values bad	questionable	stn no.	suspect 2dbar values bad	questionable
4	-	4-10	52	4	-
5	-	6	53	-	4
6	-	6-10	54	-	4
8	2	-	56	2	-
11	-	4	58	-	4
12	-	6,8	59	2	-
16	-	4 (T okay)	60	-	2 (T okay)
18	-	4,6	61	-	2
19	2-6	-	62	-	4
20	4,6	-	63	-	2
21	4-8	10-14	65	-	2
22	4	-	66	2	4
24	6	-	67	-	4
25	-	2	68	-	2,4
26	-	2,4	69	-	4
27	-	2			
29	2	-			
35	2	4,6			
37	-	2-6			
41	-	2			
42	4	6-10			
44	-	2			
46	2	-			
47	-	4			
48	4	-			
50	4	-			

Table 3.15: **Suspect 2 dbar-averaged dissolved oxygen data.**

stn no.	suspect 2dbar values(dbar) bad	questionable	stn no.	suspect 2dbar values(dbar) bad	questionable
6	-	4	41	-	2
20	-	58-62,80-82	42	-	4,6,12-34
23	6-18	-	43	-	2
29	-	2-8	44	2-10	-
30	-	4-56,2176-3578	46	-	4-10
34	-	4-8	50	-	12-32
35	-	38,40,52,54,68	51	-	2-6
36	-	4	56	-	2
37	-	34,36	57	-	2-34
38	-	14-18	60	-	4-10
39	-	12-24			
40	-	4,6			

Table 3.16: **CTD dissolved oxygen calibration coefficients. K_1, K_2, K_3, K_4, K_5 and K_6 are respectively oxygen current slope, oxygen sensor time constant, oxygen current bias, temperature correction term, weighting factor, and pressure correction term. dox is equal to 2.8σ (for σ as defined by eqn A2.24 in the CTD methodology); n is the number of samples retained for calibration in each station or station grouping.**

station number	K_1	K_2	K_3	K_4	K_5	K_6	dox	n
1-4	-	-	-	-	-	-	-	-
5	7.977	5.00	-0.903	-0.15206	0.65057	0.19386E-03	0.08607	4
6	2.216	5.00	0.250	-0.13008	0.25629	0.53099E-04	0.14567	24
7	0.922	5.00	0.502	-0.12390	0.11961	0.12705E-04	0.14944	22
8	0.942	5.00	0.632	-0.22443	0.48146	0.19279E-04	0.16980	19
9	3.650	8.00	0.315	-0.31208	0.74841	0.45625E-04	0.14580	24
10	1.181	5.00	0.484	-0.10030	0.20991	-0.46710E-04	0.11310	10
11	7.372	8.00	-0.984	-0.03645	0.12896	0.13085E-03	0.13112	18
12-18	-	-	-	-	-	-	-	-
19	9.970	5.00	-1.309	-0.13446	0.71125	0.10492E-03	0.12424	20
20	10.893	5.00	-1.574	-0.10461	0.68169	0.10988E-03	0.22049	20
21	8.782	7.00	-1.164	-0.10375	0.27859	0.23859E-03	0.07780	8
22	10.780	8.00	-1.159	-0.18501	0.74659	-0.30282E-03	0.13646	8
23	13.095	5.00	-1.881	-0.14275	0.71999	0.12092E-03	0.24383	18
24	13.788	8.00	-2.059	-0.15753	0.45006	0.11444E-03	0.12085	21
25	15.839	8.50	-2.414	-0.17273	0.61228	0.12524E-03	0.21887	21
26	10.964	6.00	-1.593	-0.08905	0.50065	0.13016E-03	0.14554	18
27	14.482	6.00	-2.076	-0.17650	0.51565	0.63161E-04	0.11809	22
28	11.079	6.00	-1.659	-0.04909	1.23120	0.15427E-03	0.15871	23
29	11.232	8.00	-1.723	-0.02111	0.71090	0.28299E-03	0.23383	7
30	12.399	5.00	-1.917	-0.04067	3.41140	0.21041E-03	0.24999	15
31	13.137	5.00	-1.984	-0.09521	0.92360	0.14840E-03	0.13421	23
32	12.151	5.00	-1.818	-0.07098	0.31861	0.12694E-03	0.22956	21
33	11.447	5.00	-1.684	-0.06222	0.20779	0.12393E-03	0.10320	22
34	14.974	7.00	-2.250	-0.14137	0.93157	0.14922E-03	0.19063	22
35	13.503	5.00	-2.034	-0.10348	1.55730	0.18499E-03	0.18944	23
36	13.167	5.00	-1.952	-0.11089	0.93079	0.14698E-03	0.15666	22
37	12.810	5.00	-1.897	-0.09934	0.92874	0.14852E-03	0.14493	22
38	13.964	5.00	-2.049	-0.14110	1.10950	0.14467E-03	0.18674	22
39	12.315	5.00	-1.779	-0.11737	1.15650	0.14835E-03	0.18201	22
40	12.799	5.00	-1.872	-0.10613	0.84008	0.12872E-03	0.17978	22
41	13.666	5.00	-2.016	-0.12765	0.92883	0.13385E-03	0.20248	23

Table 3.16: **(continued)**

station number	K_1	K_2	K_3	K_4	K_5	K_6	dox	n
42	13.239	5.00	-1.985	-0.11293	0.88499	0.15201E-03	0.25177	24
43	12.990	5.00	-1.931	-0.11076	0.91703	0.15071E-03	0.23118	24
44	12.650	8.00	-1.860	-0.10660	0.91335	0.13240E-03	0.17877	23
45	11.968	5.00	-1.835	-0.05606	0.39845	0.16464E-03	0.17434	20
46	11.624	5.00	-1.703	-0.08886	0.93062	0.15078E-03	0.11577	20
47	11.238	5.00	-1.651	-0.07039	0.76785	0.14245E-03	0.11352	23
48	10.654	5.00	-1.527	-0.07438	0.89526	0.14189E-03	0.11396	20
49	10.460	5.00	-1.513	-0.06562	1.00040	0.15150E-03	0.20295	22
50	13.487	5.00	-2.003	-0.13628	1.12640	0.16671E-03	0.09998	22
51	11.429	5.00	-1.674	-0.07639	0.87000	0.14268E-03	0.11557	24
52	13.893	5.00	-2.011	-0.16381	1.21440	0.15485E-03	0.16197	22
53	11.973	5.00	-1.723	-0.09890	0.99061	0.13249E-03	0.16167	24
54	8.123	5.00	-1.096	-0.03568	0.97237	0.12951E-03	0.12116	22
55	10.257	5.00	-1.441	-0.07503	0.92291	0.12490E-03	0.18500	24
56	13.329	5.00	-2.015	-0.10473	0.80404	0.14212E-03	0.12378	22
57	11.954	5.00	-1.764	-0.09596	0.91435	0.14067E-03	0.12476	24
58	14.906	5.00	-2.207	-0.15879	1.00730	0.13214E-03	0.17453	23
59	12.717	8.00	-1.914	-0.09111	0.77570	0.14559E-03	0.21816	24
60	14.505	5.00	-2.192	-0.13230	0.92839	0.14503E-03	0.13844	22
61	11.118	5.00	-1.613	-0.08351	0.90790	0.14216E-03	0.11000	24
62	10.148	5.00	-1.437	-0.08017	1.05690	0.15153E-03	0.14261	23
63	9.048	5.00	-1.232	-0.06994	1.18910	0.11739E-03	0.13847	19
64	11.613	8.00	-1.851	-0.05570	0.79147	0.15911E-03	0.15317	22
65	10.876	5.00	-1.562	-0.07559	0.92785	0.14065E-03	0.13997	23
66	10.325	5.00	-1.345	-0.11909	1.18150	0.10524E-03	0.15732	23
67	10.556	5.00	-1.583	-0.05825	0.93328	0.18770E-03	0.19300	11
68-69	5.606	5.00	-0.384	-0.03367	0.95645	0.57658E-04	0.11008	15

Table 3.17: **Starting values for CTD dissolved oxygen calibration coefficients prior to iteration, and coefficients varied during iteration (see CTD methodology). Note that coefficients not varied during iteration are held constant at the starting value.**

station number	K_1	K_2	K_3	K_4	K_5	K_6	coefficients varied
1-4	-	-	-	-	-	-	-
5	8.900	5.0000	-0.700	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
6	5.200	5.0000	1.000	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
7	4.000	5.0000	1.300	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
8	3.600	5.0000	1.300	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
9	3.400	8.0000	0.900	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
10	2.100	5.0000	0.700	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
11	7.420	8.0000	-0.960	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
12-18	-	-	-	-	-	-	-
19	10.240	5.0000	-1.100	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
20	12.500	5.0000	-1.300	-0.400E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
21	10.800	7.0000	-0.800	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
22	9.800	8.0000	-0.900	-0.450E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
23	12.700	5.0000	-1.500	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
24	8.300	8.0000	-0.350	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6

Table 3.17: **(continued)**

station number	K_1	K_2	K_3	K_4	K_5	K_6	coefficients varied
25	15.600	8.5000	-2.200	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
26	11.900	6.0000	-1.400	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
27	13.900	6.0000	-1.900	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
28	11.200	6.0000	-1.600	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
29	11.200	8.0000	-1.700	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
30	12.150	5.0000	-1.800	-0.370E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
31	14.100	5.0000	-1.700	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
32	13.800	5.0000	-1.400	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
33	12.900	5.0000	-1.300	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
34	14.000	7.0000	-1.700	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
35	14.900	5.0000	-1.700	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
36	13.800	5.0000	-1.700	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
37	14.100	5.0000	-1.700	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
38	14.900	5.0000	-2.100	-0.360E-01	0.900	0.15000E-03	K_1 K_3 K_4 K_5 K_6
39	13.500	5.0000	-1.900	-0.380E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
40	13.110	5.0000	-1.600	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
41	14.100	5.0000	-2.000	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
42	13.700	5.0000	-1.800	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
43	13.600	5.0000	-1.800	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
44	13.550	8.0000	-1.850	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
45	12.300	5.0000	-1.800	-0.400E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
46	12.900	5.0000	-1.450	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
47	12.500	5.0000	-1.200	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
48	12.000	5.0000	-1.050	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
49	12.600	5.0000	-1.400	-0.360E-01	0.770	0.15000E-03	K_1 K_3 K_4 K_5 K_6
50	14.400	5.0000	-2.100	-0.550E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
51	12.900	5.0000	-1.400	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
52	14.500	5.0000	-2.000	-0.700E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
53	12.800	5.0000	-1.500	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
54	8.000	5.0000	-1.100	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
55	11.700	5.0000	-1.200	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
56	13.800	5.0000	-2.000	-0.360E-01	0.550	0.15000E-03	K_1 K_3 K_4 K_5 K_6
57	13.000	5.0000	-1.700	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
58	16.200	5.0000	-2.350	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
59	14.300	8.0000	-1.800	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
60	14.500	5.0000	-2.100	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
61	12.300	5.0000	-1.300	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
62	11.600	5.0000	-1.100	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
63	10.700	5.0000	-1.100	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
64	11.400	8.0000	-1.900	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
65	12.500	5.0000	-1.200	-0.360E-01	0.740	0.15000E-03	K_1 K_3 K_4 K_5 K_6
66	11.400	5.0000	-1.200	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
67	10.000	5.0000	-1.800	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
68-69	5.600	5.0000	-0.400	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6

Table 3.18: **Dissolved oxygen Niskin bottle samples flagged as -9 for dissolved oxygen calibration. Note that this does not necessarily indicate a bad bottle sample - in many cases, flagging is due to bad CTD dissolved oxygen data.**

station number	rosette position	station number	rosette position
7	21,9	38	8
8	24,23,22,21,20	39	21,19
10	24,21,13,11-1	40	17
11	24,21,20,19,18,6	41	18
18	24,20	45	18,3,2,1
19	24,5,2,1	46	15,3,2,1
20	24,21,2,1	47	12
21	24,15-1	48	19,3,2,1
22	20,15-1	49	20
23	6,5,4,3,2,1	50	2,1
24	24,2,1	52	21,20
25	24,20,18	54	24,19
26	24,23,22,21,2,1	56	19,18
27	24,1	58	23
28	24	62	24
29	17-1	63	5,4,3,2,1
30	23,19,7,5,4,3,2,1	64	7,4
31	24	65	18
32	24	66	19
33	24,19	67	14
34	18	69	12
37	24,1		

Table 3.19: **Questionable dissolved oxygen Niskin bottle sample values (not deleted from hydrology data file).**

stn no.	rosette position
11	6
13	23
19	5
38	8
64	7,4

Table 3.20: **Questionable nutrient sample values (not deleted from hydrology data file).**

PHOSPHATE		NITRATE		SILICATE	
station number	rosette position	station number	rosette position	station number	rosette position
6	15,14,13	6	8		
		7	7,5		
				10	6
13	23	13	23	13	23
24	3	24	3		
26	2				
27	9	27	9		
29	22	29	22		
31	4	31	4		
32	4				
		35	2		
		38	9		
		60	4		

Table 3.21: Protected and unprotected reversing thermometers used (serial numbers are listed).

protected thermometers

station numbers	rosette position 24 thermometers	rosette position 12 thermometers	rosette position 2 thermometers
1 to 70	12095,12096	12094	12119,12120
71	12095 (pos. 24); 12096 (pos.17); 12094 (pos.12); 12120 (pos. 7); 12119 (pos. 2)		

unprotected thermometers

station numbers	rosette position 12 thermometers	rosette position 2 thermometers
1 to 27	11993	11992
28 to 71	11992	11993

Table 3.22: Calibration coefficients and calibration dates for CTD serial numbers 1103 and 1193 (unit nos 7 and 5 respectively) used during RSV Aurora Australis cruise AU9601. Note that an additional pressure bias term due to the station dependent surface pressure offset exists for each station (eqn A2.1 in the CTD methodology). Also note that platinum temperature calibrations are for the ITS-90 scale.

CTD serial 1103 (unit no. 7) coefficient	value of coefficient	CTD serial 1193 (unit no. 5) coefficient	value of coefficient
pressure calibration coefficients CSIRO Calibration Facility - 10/07/1996		*pressure calibration coefficients CSIRO Calibration Facility - 05/07/1996*	
pcal0	-1.851190e+01	pcal0	-1.107604e+01
pcal1	1.002735e-01	pcal1	1.008327e-01
pcal2	6.097416e-09	pcal2	0.0
pcal3	0.0	pcal3	0.0
pcal4	0.0	pcal4	0.0
platinum temperature calibration coefficients CSIRO Calibration Facility - 27/06/1996		*platinum temperature calibration coefficients CSIRO Calibration Facility - 26/06/1996*	
Tcal0	0.28797e-01	Tcal0	-0.46860e-01
Tcal1	0.49988e-03	Tcal1	0.49879e-03
Tcal2	0.35049e-11	Tcal2	0.27541e-11
pressure temperature calibration coefficients CSIRO Calibration Facility - 10/07/1996		*pressure temperature calibration coefficients CSIRO Calibration Facility - 05/07/1996*	
Tpcal0	1.713678e+02	Tpcal0	1.299013e+02
Tpcal1	-4.239208e-03	Tpcal1	-2.541029e-03
Tpcal2	1.481513e-08	Tpcal2	-7.814892e-09
Tpcal3	0.0	Tpcal3	0.0
coefficients for temperature correction to pressure CSIRO Calibration Facility - 10/07/1996		*coefficients for temperature correction to pressure CSIRO Calibration Facility - 05/07/1996*	
T_0	20.00	T_0	20.00
S_1	-9.196843e-06	S_1	-1.578863e-05
S_2	-7.818015e-02	S_2	-6.349700e-02

APPENDIX 3.1 Hydrochemistry Laboratory Report

Seawater samples were analysed for nutrient concentrations (nitrate plus nitrite, silicate, and phosphate), salinities, and dissolved oxygen concentrations. The methods used are described in Eriksen (1997). A new type of salinometer, improvements to nutrient autoanalyser chemistries, improvements to inter-run quality checks, and improvements to dissolved oxygen methods were implemented on this cruise.

Number of samples analysed:

Nutrients (nitrate plus nitrite, silicate, phosphate) : 1520
Salinities : 1560
Dissolved oxygens : 1610

A3.1.1 NUTRIENTS

The Alpkem auto-analyser performed well on this cruise as did the new version (1.31) of Faspac software. Phosphate, silicate and nitrate + nitrite were analysed for all sites. Nitrate and nitrite were not analysed separately as only three channels could be run concurrently.

A 20 L carbuoy of seawater was filtered through a GFF filter, mixed and sub sampled into 10 ml tubes, then frozen immediately. At least two of these samples were run with each run and used as an in-house quality control. It was found that this sample was stable for the duration of the trip. See Figure A3.1.2 and Table A3.1.2.

The sample racks were covered with aluminium foil when in the sampler, making sure that it was not in contact with the sample. This served to reduce splashing, sample carryover and the possibility of airborne contamination.

On a couple of occasions there was a shift in the baseline on one or more of the channels. This was generally due to either foreign matter or a bubble becoming lodged in the flow cell. For these runs the affected peaks were either measured manually from the chart or repeated.

The temperature of the laboratory near the Auto-analyser was stable, remaining in the range of 19.5_ to 20.5_ for the voyage.

All channels were run without the colour reagent for at least six sites (approximately 150 samples) to calculate an average background matrix correction. For both nitrate + nitrite and silicate channels there was no significant background matrix, but for phosphate a background matrix of 0.088 µmol/l was measured. There has been no correction applied to the phosphate results: this facilitates comparisons with previous cruise results as no corrections have been applied in the past (see Part 4 of this report).

Some modifications were made to the methodology used in previous cruises, as follows.

Nitrate + Nitrite

The nitrate + nitrite channel was unstable for the first ten runs, with the bubble pattern breaking down in the cadmium tube. This resulted in poor peak shape and inconsistent results for the QC (quality check) and duplicate samples. The cadmium tube was replaced with a new tube and the duplicate samples were run for the nitrate + nitrite results only. The new cadmium tube resulted in a much better flow pattern with no problems with either duplicate or QC samples.

Sample :- Flow rate 0.32 ml/min
Nitrogen :- Flow rate 0.23 ml/min
Reagent 1 :- Imidazole (4.25 g/L) + Hydrochloric acid (1.15 ml/L) + Brij (0.5 ml/L)
Flow rate 0.32 ml/min
Reagent 2 :- Sulphanilamide (3.12 g/L) + Hydrochloric acid (31 ml/L) + Brij (0.5 ml/L)
Flow rate 0.16 ml/min
Reagent 3 :- N-1 Naphthylethylene di-amine di-hydrochloride (0.31 g/L) + Brij (0.5 ml/L)
Flow rate 0.16 ml/min
Debubbler :- Flow rate 0.42 ml/min

Phosphate

The reagent for the phosphate was changed from a single mixed reagent to two reagents. The ammonium molybdate and sulphuric acid were in reagent one and the ascorbic acid and antimony potassium tartrate were in reagent two. This was done to prolong the working life of the reagents from about 8 hours to at least 24 hours. It also made it easier to do the background matrix correction run. The pH of the system was lowered slightly from what had been used in the past because the buffering effect of the seawater resulted in the pH of the system being raised to a level where the silicate may have interfered with the phosphate chemistry.

On the first couple of runs there was a great deal of peak diffusion, with the trace not coming back to baseline between samples. The system was rebuilt with all tubing connections being checked and redone if necessary. This did not fix the problem to any degree. It was noticed that the heating coil being used was for a silicate channel. This was changed for a phosphate module, which fixed the problem. Although it seems that the heating coils are constructed of the same type of tubing (PEEK) with the phosphate coil being of greater length (which would not account for the problem), and although the sales rep advised that there was no difference that he was aware of, it appears to be the source of the problem.

It was noticed that while there was a need for wetting agent to be used for the system to run smoothly, an excess of the wetting agent caused the baseline both to become noisy and to gradually shift. The wetting agent currently in use is dowfax, which is lauryl sulphate based. It may be worth using straight lauryl sulphate which is in use in other laboratories - it has been noted to depress the sensitivity if in excess, but not to affect the baseline.

On one occasion the Eppendorf syringe used to add the sulphuric acid appeared to have affected the baseline noise level, possibly by plasticisers or contamination being introduced to the reagent. After replacing the syringe the baseline noise returned to its previous level.

Sample :- Flow rate 0. 80 ml/min
Air :- Flow rate 0.23 ml/min
Reagent 1 :- Dowfax (2 ml/L)
Flow rate 0.80 ml/min
Reagent 2 :- Ammonium molybdate (5.04 g/L) + Sulphuric acid (56 ml/L)
Flow rate 0.23 ml/min
Reagent 3 :- Ascorbic acid (4.56 g/L) + Antimony potassium tartrate (0.1275 g/L)
Flow rate 0.23 ml/min
Debubbler :- Flow rate 0. 42 ml/min

Silicate

The silicate channel did not give any problems for the duration of the cruise, the only modification to the system being that no acetone was used in the reagent. The silicate channel is currently being heated to 37_C to stabilise the baseline and improve the duplicate and replicate results. Some more work needs to be done to rule out interferences, such as from phosphate, or other possible errors.

Sample :- Flow rate 0.23 ml/min
Air :- Flow rate 0.23 ml/min
Reagent 1 :- Ammonium molybdate (10 g/L) + Sulphuric acid (2.8 ml/L) + Dowfax (1 ml/L)
Flow rate 0.42 ml/min
Reagent 2 :- Oxalic acid (50 g/L) + Dowfax (0.5 ml/L)
Flow rate 0.32 ml/min
Reagent 3 :- Ascorbic acid (17.6 g/L)
Flow rate 0.42 ml/min
Debubbler :- Flow rate 0.60 ml/min

Sampler :- Total pumping rate of artificial seawater into the sampler = 3.39 ml/min
Total pumping rate of artificial seawater out of the sampler 5.78 ml/min

Artificial Seawater :- Sodium Chloride (39 g/L)

The oscillating baseline problem which occurs when Faspac is started is still present. Some work was done looking at grounding of detectors and computers, looking at the wiring of ground to the A/D board, and at further shielding, with no success.

The 'glitch' problem with the A/D board at the mid-point voltage was fixed by purchasing a new A/D board from Labtronics. Although the 'glitch' is still present, it is now negligible.

The version of data logging software used, Faspac 1.31, was an improvement on that used on cruise AU9604 (Faspac 1.2). It did not crash, and produced Excel files which did not cause Excel to crash. The Excel files had a text format, which the output from Faspac 1.2 did not have, so Hydro was modified to convert the cells to numbers, using the 'VALUE' command.

The method of making tops was improved. Previously, standards were made up in six 100 ml volumetric flasks, and tops were made up in a 500 ml volumetric flask. The top standard and the ‘tops’ were nominally the same concentration, but small differences were possible since they were made up separately. Now all the standards but the top standard are made up as previously. The top standard is made in a 500 ml volumetric flask, and this is also used to make the ‘tops’. Thus the ‘tops’ and top standard have the same source, and the only variation should be due to the process of pouring into 10 ml sample tubes. A comparison was made between the top standard made in a 100 ml flask and a 500 ml flask. No difference was seen. The advantage of making the top standard and ‘tops’ together is that if a run is found to be unstable, corrections can be made by equating ‘tops’ values with the top standard.

As usual ‘tops’ were used to monitor intra-run stability of the system. All the tops for all three channels were examined manually by the operator and found to be satisfactory.

A variation from normal data processing was used. As usual Faspac produced .ACF files, and exported data as .XLS files. Normally the .XLS files represent runs, and can have tops extracted to examine run stability, or have the error in the calibration curve. However on this cruise data was cut and pasted from these .XLS files, thus destroying the integrity of run information. If further examination of the data were required it would be necessary to repeat the export process from Faspac. Care would be needed to separate the new intact .XLS files from the old fragmented .XLS files.

A3.1.2 SALINITIES

A Guildline 'Autosal' salinometer, SN 62549, was used. This was the first time the CRC had used this instrument. The reliability of the instrument was excellent, in contrast to experience with Yeo-Kal salinometers. The instrument was stable enough so that a secondary 'substandard' was not necessary.

A peristaltic pump from Ocean Scientific was used to pump in samples. Pump speeds 1, 2, or 3 were used. There was no difference to the result between these pump speeds if the samples were temperature equilibrated.

The salinometer has a capability of logging data directly to a computer, but this was not used as an interface was not built in time.

The “Hydro” program was modified so that the double conductivity ratio given by the Guildline salinometer could be entered and converted to salinity.

The biggest problem was with bubbles forming on the electrodes of the conductivity cell. These collected mostly in the first and last electrodes. We had been advised by Guildline that the bubbles had no effect, and by Ocean Scientific that a few bubbles would have no effect, but that a lot of bubbles might. Causes of error would be restricting electrical current flow, and changing the volume of seawater within the cell. A quick test showed that a few bubbles made no difference, and CSIRO users have also found this. However, it is not clear to what extent bubbles may eventually affect results, and the cell was debubbled after every crate of 24 samples, and before every standardisation. The cell was debubbled by rinsing with ethanol or ethanol with Brij. Both were equally effective. The ethanol was found to corrode the inlet and outlet tubes of the peristaltic pump, so the inbuilt air pump was used for pumping ethanol. Methanol was also tried, but was not as effective as ethanol.

Two sets of standards were used, P128 and P130. The standards were compared by standardising the instrument with one standard, measuring the other standard, and comparing it with its nominal value. It was found that P128 read 0.0018 +/- 0.0003 (PSS78) higher than P130. The cause of this difference is not known. If the cause is that P128 is more concentrated than its nominal value, then any samples measured with the salinometer standardised with P128 would appear lower than they really are. It is also assumed that any errors in standardisation will result in an offset across the range of measured salinities. If this is also true, then any samples measured with the salinometer standardised with P128 would appear 0.0018 (PSS78) lower than they really are. This would mean a correction of 0.0018 (PSS78) would need to be added on (no correction was applied to the data).

The standardisation values are in Figure A3.1.3. The comparison of P128 and P130 is in Table A3.1.3.

A crate of 24 samples were analysed for calibration of the underway thermosalinograph. This was entered into Hydro as station 300.

A3.1.3 DISSOLVED OXYGEN

Dissolved oxygen analyses generally went well. Problems are described below.

By using the READVOLT.BAS program the factors which most affected the current across the electrodes could be observed. It was seen that the position of the beaker and the stirring rate had profound effects, whereas the addition of sodium thiosulfate or potassium biiodate had only moderate effects. This indicated that effort was needed to keep the stirring rate and position of electrodes in the beaker constant.

The magnetic stirrer which had previously been used for the salinity substandard was used for stirring during preparation of the biiodate standard. This meant that the stirring rate control knob on the Dosimat could be left at the same value. Previously stirring of the biiodate standard had been done with the Dosimat magnetic stirrer, so that the actual titration speed always varied slightly, as the stirring rate of standards and samples is different.

The “Newwink” program was modified so that blanks could be done entirely with the single Dosimat base unit. Previously, the 1 mL of biiodate had been added using a manual dispenser. “Hydro” was modified in the handling of sample repeats. It now has the first value as the default value.

As with other cruises there were problems with standardising to WOCE precision. One of the Optifix dispensers had had some extra tubing placed on the end of the tip. Taking this off seemed to improve precision. As has been noted previously, a second Dosimat base unit for dispensing standards would improve the procedure.

Standardisations are shown in Figure A2.1.6 of Appendix 2.1.

A3.1.4 LABORATORIES

Nutrients, salinities, and dissolved oxygens were analysed in the wet lab, with water purification in the 'photolab.' Nutrients and salinities were performed on the aft bench, on the inboard and outboard sides respectively. Dissolved oxygens were performed over the inboard sink.

A3.1.5 TEMPERATURE CONTROL AND MEASUREMENT

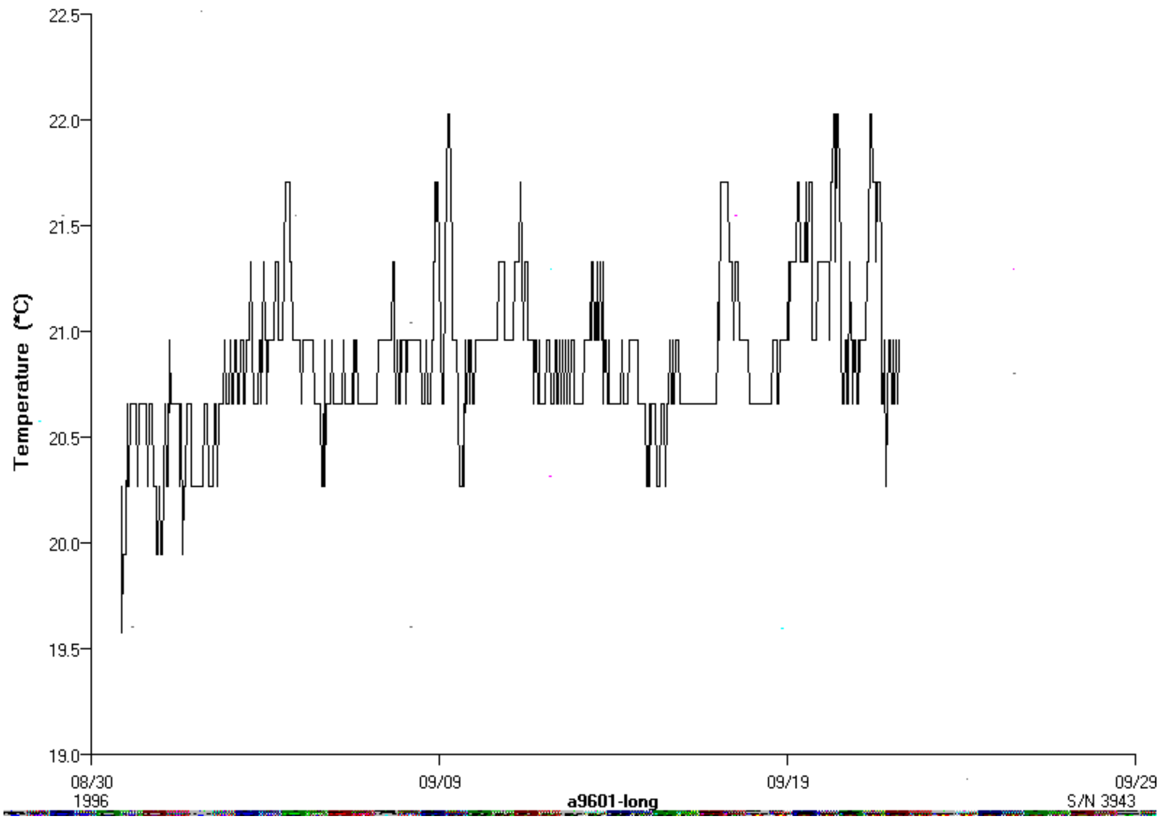
There were two temperature control units. The first was the lab air conditioner. This was set at around 19_C. The second was the PID temperature controller, which had a set point of 20.1_C. The temperature sensor was placed above the salinity crates. The ships air conditioning outlets above the instruments were taped closed. The sea door access to the trawl deck was kept shut. Laboratory temperature was recorded by two Tinytalk units, and measured by two mercury thermometers, an electronic thermometer, and the temperature monitor of the PID controller. An 'indoor/outdoor' electronic thermometer was used to measure fridge and freezer temperatures. One Tinytalk was positioned above the salinity crates for the duration of analysis, the other was moved around for shorter checks. One mercury thermometer was positioned above the salinity crates, the other with the DO instrumentation. An electronic thermometer was also used for spot checks. All the temperature measuring devices were placed together at the start of the cruise. The PID temperature was calibrated, and the devices agreed to within 0.5_C.

The mercury thermometer with the DO instrumentation was in the range of 19.5 to 20.5_C.

The long term Tinytalk recorded 1342 temperature points at 24 minute intervals. The average temperature was 20.9 +/- 0.4 _C. See Figure A3.1.1 and Table A3.1.1. There was some spatial variation, which had a range of +/- 2_C among the instrument locations. This was from the bench top to the height of the top of the salinometer.

<u>Table A3.1.1:</u> Laboratory temperature recorder statistics.

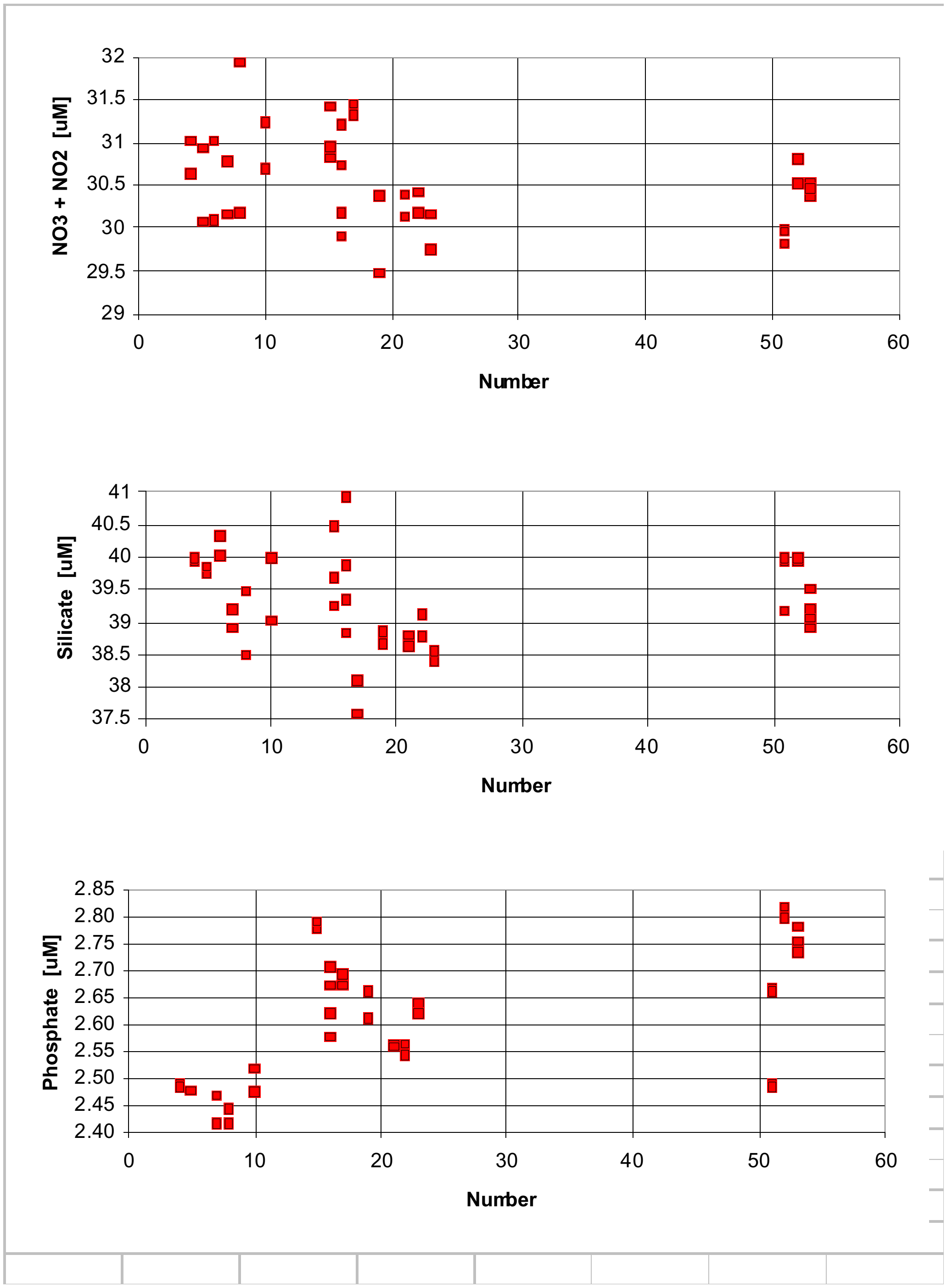
Temperature statistics from Tinytalk	
average	20.9
stdev	0.4
%rsd	1.7
min	19.6
max	22.0
range	2.4
% range	11.5



<u>Figure A3.1.1:</u> 'Tinytalk' temperature plot, 24 minute time resolution.

Table A3.1.2: Nutrient samples run as quality checks.

A9601							
QC's extracted							
	Run	NO3+NO2		Sil		Phos	
		Volts	uM	Volts	uM	Volts	uM
average			30.52		39.32		1.97
stdev			0.54		0.70		0.05
%rsd			1.8		1.8		2.7
min			29.47		37.57		1.88
max			31.94		40.91		2.11
range			2.46		3.33		0.23
range%			8.1		8.5		11.6
A9601004.ACM	4	2.62	31.0	2.66	39.9	2.49	1.98
A9601004.ACM	4	2.59	30.6	2.66	40.0	2.49	1.97
A9601005.ACM	5	2.53	30.9	2.66	39.8	2.48	1.96
A9601005.ACM	5	2.47	30.1	2.66	39.8	2.48	1.96
A9601006.ACM	6	2.55	31.0	2.59	40.3		1.93
A9601006.ACM	6	2.49	30.1	2.58	40.0		1.92
A9601007.ACM	7	5.31	30.8	2.58	38.9	2.42	1.98
A9601007.ACM	7	5.22	30.2	2.60	39.2	2.47	2.04
A9601008.ACM	8	5.21	30.2	2.58	38.5	2.42	1.97
A9601008.ACM	8	5.45	31.9	2.62	39.5	2.44	2.00
A9601010.ACM	10	5.57	30.7	2.51	39.0	2.47	2.05
A9601010.ACM	10	5.65	31.2	2.55	40.0	2.52	2.10
A9601015.ACM	15	5.84	31.4	2.67	39.3	2.78	2.11
A9601015.ACM	15	5.76	31.0	2.65	39.7	2.78	1.94
A9601015.ACM	15	5.74	30.8	2.69	40.5	2.79	1.95
A9601016.ACM	16	5.71	30.2	2.56	38.8	2.62	1.94
A9601016.ACM	16	5.87	31.2	2.60	39.9	2.71	2.03
A9601016.ACM	16	5.66	29.9	2.58	39.3	2.58	1.89
A9601016.ACM	16	5.79	30.7	2.65	40.9	2.67	2.00
A9601017.ACM	17	5.57	31.4	2.51	38.1	2.69	1.97
A9601017.ACM	17	5.55	31.3	2.49	37.6	2.67	1.95
A9601019.ACM	19	5.57	29.5	2.33	38.9	2.61	1.91
A9601019.ACM	19	5.71	30.4	2.32	38.6	2.66	1.97
A9601021.ACM	21	5.63	30.4	2.51	38.8	2.56	1.89
A9601021.ACM	21	5.59	30.1	2.50	38.6	2.56	1.89
A9601022.ACM	22	5.71	30.4	2.44	39.1	2.57	1.90
A9601022.ACM	22	5.68	30.2	2.43	38.8	2.54	1.88
A9601023.ACM	23	5.40	30.2	2.52	38.4	2.64	1.95
A9601023.ACM	23	5.34	29.8	2.53	38.6	2.62	1.93
A9601051.ACM	51	5.66	30.0	2.71	39.2	2.67	2.00
A9601051.ACM	51	5.66	30.0	2.71	39.2	2.66	1.99
A9601051.ACM	51	5.65	30.0	2.66	39.9	2.49	1.98
A9601051.ACM	51	5.62	29.8	2.66	40.0	2.49	1.97
A9601052.ACM	52	5.67	30.5	2.66	39.9	2.80	2.01
A9601052.ACM	52	5.72	30.8	2.66	40.0	2.82	2.03
A9601053.ACM	53	5.68	30.4	2.58	38.9	2.75	2.01
A9601053.ACM	53	5.68	30.4	2.60	39.2	2.74	1.99
A9601053.ACM	53	5.70	30.5	2.62	39.5	2.78	1.97
A9601053.ACM	53	5.69	30.5	2.60	39.1	2.76	1.94



<u>Figure A3.1.2:</u> Nutrient samples run as quality checks.

Calibration of Guildline salinometer							
SN 62 549							
0.01 = 1-2 counts on std dial=0.002-0.004 psu							
Date	Std	Lab temp	Sal temp	IAPSO batch	Nom Sal	Nom Sal	Location
					1R	2R	
13-Aug-96	4.49	19		P126	0.99987	1.99974	CSIRO
24-Aug-96		18		P126	0.99987	1.99974	Outlier
25-Aug-96	4.45	20.1	21	P128	0.99986	1.99972	a9601
29-Aug-96	4.52	20.1	21	P128	0.99986	1.99972	
1-Sep-96	4.58	20.1	21	P128	0.99986	1.99972	
2-Sep-96	4.58	20.1	21	P128	0.99986	1.99972	
3-Sep-96	4.57	20.1	21	P128	0.99986	1.99972	
4-Sep-96	4.49	20.1	21	P128	0.99986	1.99972	
7-Sep-96	4.44	20.1	21	P128	0.99986	1.99972	
9-Sep-96	4.52	20.1	21	P128	0.99986	1.99972	
9-Sep-96	4.61	20.1	21	P130	0.99997	1.99994	
10-Sep-96	4.61	20.1	21	P130	0.99997	1.99994	
11-Sep-96	4.603	20.1	21	P130	0.99997	1.99994	
12-Sep-96	4.55	20.1	21	P130	0.99997	1.99994	
13-Sep-96	4.55	20.1	21	P130	0.99997	1.99994	
14-Sep-96	4.57	20.1	21	P130	0.99997	1.99994	
15-Sep-96	4.59	20.1	21	P130	0.99997	1.99994	
17-Sep-96	4.49	20.1	21	P130	0.99997	1.99994	
18-Sep-96	4.525	20.1	21	P130	0.99997	1.99994	
20-Sep-96	4.525	20.1	21	P130	0.99997	1.99994	
21-Sep-96	4.525	20.1	21	P130	0.99997	1.99994	

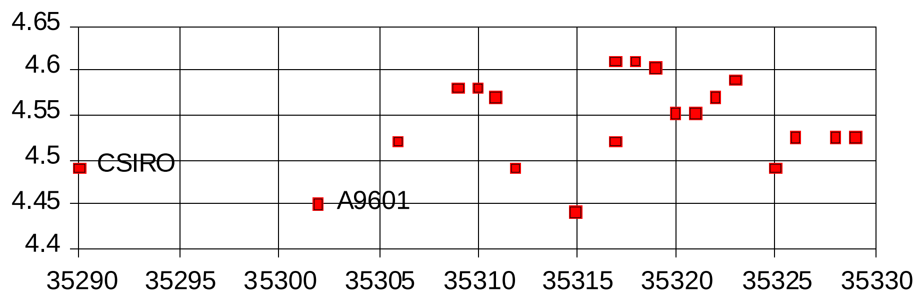


Figure A3.1.3: **Salinometer standardisation values.**

Calculates salinity (psu) from conductivity or double conductivity														
Looks at standardisations on A9601.														
Sal standardised with one std, and the other one then measured.														
Sheet	Std	Std	Measured	Stdse	Measured value			Nominal value			Diff (meas-nom)		Diff, abs	
	num.			value	R	2R	T	R	2R	psu	2R	psu	psu	
16	4	P128	P130	4.44	0.99993	1.99985	21	0.99997	1.9999	34.999	-0.00009	-34.9988	34.9988	
16	5	P128	P130	4.44	0.99993	1.99985	21	0.99997	1.9999	34.999	-0.00009	-34.9988	34.9988	
21	3	P128	p130	4.44	0.99993	1.99985	21	0.99997	1.9999	34.999	-0.00009	-34.9988	34.9988	
22	3	P128	p130	4.52	0.99993	1.99986	21	0.99997	1.9999	34.999	-0.00008	-34.9988	34.9988	
25	3	P130	p128	4.61	0.99990	1.99979	21	0.99986	1.9997	34.994	0.00007	-34.9945	34.9945	
	4	p130	p128	4.61	0.99992	1.99983	21	0.99986	1.9997	34.994	0.00011	-34.9945	34.9945	
29	3	p130	p128	4.61	0.99992	1.99983	21	0.99986	1.9997	34.994	0.00011	-34.9945	34.9945	
29	4	p130	p128	4.61	0.99991	1.99982	21	0.99986	1.9997	34.994	0.00010	-34.9945	34.9945	
												av	34.9967	psu
P128 is 0.0018 +/- 0.0003 psu higher than P130												st dev	0.0023	psu
												%rsd	0	%

<u>Table A3.1.3:</u> Comparison of ISS batches P128 and P130.

Part 4
Aurora Australis Southern Ocean Oceanographic Cruises, 1991 to 1996 - Inter-cruise Comparisons and Data Quality Notes

4.1 INTRODUCTION

Marine science cruise AU9601 aboard the RSV Aurora Australis was the seventh and last in a series of oceanographic cruises from 1991 to 1996, taking CTD measurements along Southern Ocean transects, mostly under the WOCE program (Table 4.1). In this part of the report, brief data comparisons are made between the cruises, and data quality notes relevant to the cruise set are discussed.

Table 4.1: RSV Aurora Australis Southern Ocean oceanographic cruises, 1991 to 1996. Note the following: PET=Princess Elizabeth Trough section, FORMEX=Formation Experiment, MARGINEX=Antarctic Margin Experiment; au9309 and au9391 were part of the same cruise; the southern end of SR3 was occupied as part of MARGINEX.

cruise	transect	occupation date	direction of occupation
au9101	SR3 (WOCE)	October 1991	2/3 north to south, 1/3 south to north
au9309	SR3 (WOCE)	March 1993	north to south
au9391	P11 (WOCE)	April 1993	west to east then north to south
au9407	SR3 (WOCE)	January 1994	north to south
au9407	PET	January 1994	south to north
au9404	S4 (WOCE)	Dec. 1994 - Jan. 1995	west to east
au9404	SR3 (WOCE)	January-February 1995	south to north
au9501	SR3 (WOCE)	July-August 1995	north to south
au9501	FORMEX	August 1995	-
au9604	MARGINEX	January-March 1996	-
au9601	SR3 (WOCE)	August-September 1996	south to north

4.2 INTER-CRUISE DATA COMPARISONS

In this section, a brief comparison of salinity, dissolved oxygen and nutrient data is made between the seven cruises. Most of the discussion refers to data from the SR3 section. The primary aim of the comparison is to assess the inter-cruise compatibility of measurements and data quality for the entire data set. Comparisons with earlier data sets are discussed in Rosenberg et al. (1995a).

4.2.1 Salinity

Inter-cruise comparisons

Inter-cruise salinity comparisons in earlier data reports (Rosenberg et al., 1995a, 1995b and 1996) revealed significant variation in salinity measurements for the different cruises. The YeoKal salinometers used (Table 4.2) were identified as the most likely source of error. For cruise AU9601, the last cruise in the series, a Guildline salinometer was used for the first time, with a manufacturer-quoted salinity accuracy of 0.001 (PSS78) as compared to 0.003 (PSS78) for the YeoKal instruments. As a result, high quality CTD salinity data were obtained for this cruise (see Part 3 of this report). To assess inter-cruise errors in salinity measurements, salinity data from each cruise are compared to data from AU9601. Specifically, the meridional variation of the salinity maximum (i.e. for Lower Circumpolar Deep Water as defined by Gordon, 1967) along the SR3 section for each cruise is compared to the equivalent values for AU9601 (Figures 4.1a and b). For the comparison, 2 dbar-averaged CTD data are used i.e. CTD salinity at the nearest 2 dbar bin to the salinity maximum for each station. Note that in the Figure 4.1 comparison of cruises au9601 and au9101, au9601 data are linearly interpolated to the au9101 station positions. For the other cruises in the figure, salinity differences are only formed between station pairs which are separated by less than 1.5 nautical miles of latitude.

Table 4.2: Summary of International Standard Seawater (ISS) batches and salinometers used for salinity sample analyses on cruises, including RV Melville cruise me9706.

cruise	*ISS batch number (+ date)*	*station numbers*
au9101	P115 (6th Feb. 1991)	1-35
au9309	P121 (8th Sept. 1992)	1-63
au9391	P121 (8th Sept. 1992)	1-64
au9407	P123 (10th June 1993)	1-79
au9407	P121 (8th Sept. 1992)	80-102
au9404	P123 (10th June 1993)	1-85
au9404	P121 (8th Sept. 1992)	86-107
au9501	P126 (29th Nov. 1994)	1-208
au9604	P128 (18th July 1995)	1-25, 69-74, 110-145
au9604	P126 (29th Nov. 1994)	26-68, 75-109
au9601	P128 (18th July 1995)	1-23
au9601	P130 (21st March 1996)	24-69
me9706	P130 (21st March 1996)	2-49

cruise	*salinometer serial number*	*station numbers*
au9101	601003 (YeoKal)	1-35
au9309	601003 (YeoKal)	1-63
au9391	601003 (YeoKal)	1-64
au9407	601855 (YeoKal)	1-86
au9407	601003 (YeoKal)	87-102
au9404	601855 (YeoKal)	1-107
au9501	601830 (YeoKal)	1-208
au9604	601003 (YeoKal)	1-23, 43-47, 139-141
au9604	601439 (YeoKal)	24-25
au9604	601855 (YeoKal)	26-42, 48-68, 142-145
au9604	601440 (YeoKal)	69-138
au9601	62549 (Guildline)	1-69
me9706	62549 (Guildline)	2-30
me9706	62548 (Guildline)	31-49

The following approximate mean salinity differences for data along the SR3 transect at the deep salinity maximum are evident from Figures 4.1 and 4.2:

cruise comparison	approximate mean salinity difference (PSS78)
au9601-au9101	-0.005 (south of ~49.5^{o}S)
au9601-au9309	-0.008
au9601-au9407	-0.001
au9601-au9404	-0.004
au9601-au9501	0.001
au9601-au9604	insufficient data for comparison
au9601-me9706	-0.002

These values summarise the inter-cruise compatibility of salinity data. No significant correlation is evident between ISS batch numbers used and the observed salinity differences between cruises, and the salinometers remain the most likely source of error. A further partial occupation of the SR3 transect down to 57^{o}S was made by the RV Melville in March to April 1997 (cruise me9706, principal investigators R.Watts, S. Rintoul, J. Richman, B. Petit, D. Luther, J. Filloux, J. Church, A. Chave). Guildline salinometers were used for salinity analyses (Table 4.2), with the hope of determining whether inter-cruise compatibility improves using these more stable salinometers. Comparing the meridional variation of the deep water salinity maximum for cruises au9601 and me9706 (Figure 4.2), a mean difference au9601-me9706 of ~-0.002 is clearly observed. This difference is less variable than for other cruises (Figure 4.1), due to stable performance of the Guildlines. Nevertheless this difference is clearly significant, and indicates that 0.002 (PSS78) is at the limit of achievable salinity accuracy when comparing different cruises.

Small scale variance of salinity signal

Close examination of vertical CTD profiles reveals a small scale structuring, at vertical scales of the order 2 dbar, which is not consistent between different cruises. To assess whether this variability is a real oceanic feature, salinity and temperature vertical profile data variance was investigated for all cruises, as follows. Vertical salinity and temperature 2 dbar-averaged profiles were smoothed by calculating a running mean of width 12 dbar (i.e. ±3 pressure bins), centered on each pressure bin. A mean "variance" V around the smoothed profiles was then calculated for each vertical salinity profile (and similarly for temperature):

$$V_s = \left[\sum_{i=1001}^{bottom} (|s_{smooth} - s|)_i \right] / n \qquad \text{(eqn 4.1)}$$

for s_{smooth} the smoothed salinity, the ith 2 dbar pressure bin, and n equal to the number of 2 dbar pressure bins from 2002 dbar to the bottom of the profile. Note that only data below 2000 dbar were examined, to avoid steep vertical gradients and regions of high mixing. To allow a realistic comparison between different cruises, equivalent station positions along the SR3 transect were investigated. Variances were calculated for stations lying within the two latitude ranges 45 to 50°S and 54 to 58°S - choice of these two latitude ranges excludes stations lying within the major frontal regions where greater inter-cruise variability might occur. (Note that cruise au9391 is an exception, as it lies along the P11 transect - for this cruise, significant horizontal frontal structure was observed in the 54 to 58°S latitude range, and the results are not directly comparable to SR3 data.) The results in Table 4.3 show values of V_s and V_t (for salinity and temperature respectively) averaged over the specified station groups for each cruise.

<u>Table 4.3:</u> Vertical variance of CTD salinity and temperature data below 2000 dbar, for given latitude ranges along the SR3 transect (with the exception of cruise au9391, along the P11 transect). For the CTD's, "B" and "C" indicate a MarkIIIB and MarkIIIC respectively. "c-cell" is the condition of the CTD conductivity cell.

	latitude 45°S to 50°S					latitude 54°S to 58°S				
cruise	stn nos.	CTD no.	c-cell	mean V_s (PSS78)	mean V_t (°C)	stn nos.	CTD no.	c-cell	mean V_s (PSS78)	mean V_t (°C)
au9309	6-15	1197B	used	0.00031	0.00089	25-33	1197B	used	0.00031	0.00082
au9391	*19-28*	*1073B*	*used*	*0.00022*	*0.00065*	*37-44*	*1073B*	*used*	*0.00024*	*0.00079*
au9407	7-22	2568C	used	0.00026	0.00086	34-45	2568C	used	0.00025	0.00072
au9404	92-102	1193C	suspect	0.00025	0.00087	74-80	1193C	suspect	0.00038	0.00076
au9501	6-17	1103C	new	0.00047	0.00078	30-37	1193C	suspect	0.00023	0.00070
au9601	46,54-64	1103C	new	0.00045	0.00083	25-33	1103C	new	0.00041	0.00071
me9706	3-4,6-7, 40-43	1013B	new	0.00024	0.00087	19-26	1013B	new	0.00028	0.00078

V_s values are unlikely to be affected by pressure noise. Firstly, if any noise is present in the raw pressure signal, this would be averaged out in the 2 dbar binning. Moreover for CTD 1103, where the highest V_s values occur, the pressure signal is significantly less noisy than for other instruments. Secondly, for casts taken in either calm conditions or in the ice, and where pressure reversals are therefore minimal, no drop in V_s values are evident.

V_t values within each latitude range are fairly consistent between cruises compared with V_s values, which show much more variation. In particular, V_t values are consistently lower in the 54-58°S region than in the 45-50°S region - this suggests that the fine structure is a real measurement, not an electronic artifact of the instrumentation.

The magnitude of V_s appears to be dependent on:

* the magnitude of V_t ;
* the condition of the conductivity cell;
* the particular instrument in use.

Firstly, inspection of individual stations reveals that when V_s exceeds a certain threshold level, there is a strong dependence of V_s on the magnitude of V_t (Figure 4.3). Below this value, there is no significant dependence. This however does not account for the high inter-cruise variation of V_s evident in Table 4.3. The results for cruise au9501 (Figure 4.4) demonstrate a dependence of V_s on the condition of the conductivity cell: V_s is significantly higher for the 45-50^{o}S latitude range where a new cell is in use, compared to the southern stations where a suspect cell was used. In addition, comparing the 54-58^{o}S values for cruises au9501 and au9601, V_t values are comparable, whereas V_s is much lower for the suspect conductivity cell. In fact from Figure 4.3, there is a different dependency of V_s on V_t for the suspect conductivity cell. Lastly, there also appears to be a dependence of V_s on the instrument in use. The most striking difference is between V_s values for cruises me9706 and au9601, even though new conductivity cells were used in both cases (and note that V_t values for the two cruises are comparable). Apparently some instruments are more reponsive than others - this may be related to differences between MarkIIIB and MarkIIIC CTD's, or simply differences between individual instruments.

To summarise, new conductivity cells appear to be more responsive to fine structure in the water column, however the quantitative value of small scale vertical salinity variations may also depend on the CTD in use. In more extreme cases, this fine structure includes small vertical density inversions, with typical magnitudes in the range 0.001 to 0.005 kg.m^{-3}.

4.2.2 Dissolved oxygen

Dissolved oxygen bottle data along the SR3 transect for cruises au9407 and onwards are compared in Figures 4.5a and b. For all these cruises, oxygen bottle samples were analysed using the automated titration system developed by Woods Hole Oceanographic Institution (Knapp et al., 1990). Data from the earlier cruises au9101, au9309 and au9391, where samples were analysed using a manual titration method (Eriksen and Terhell, in prep.), are discussed in previous data reports (Rosenberg et al., 1995a and b). Note that in Figure 4.5, axes limits do not include the entire data set, focussing rather on deep and intermediate water masses to allow easier visual comparison between cruises. Also note that for cruise au9604, data from the longitude range 128 to 150^{o}E are plotted to provide more points for comparison.

In summary, the following dissolved oxygen data appear to be consistent:

au9407
au9404
au9501 stations 22 and onwards
au9604
au9601 stations 41 and onwards

The following inconsistencies are apparent:

au9501 stations 1-21: values smaller by ~6μmol/l
au9601 stations 1-40: values larger by ~4μmol/l

Note that the above deviation values are approximate averages only - deviations for individual samples may vary slightly with the magnitude of dissolved oxygen concentration. Examination of standardisation values for the laboratory analyses reveals the source of error: for cruise au9501, a drift in standardisation values was noted up until station 21, however restandardisations were not carried out; for cruise au9601, a jump in standardisation values occurred after station 40 (see Appendix 3.1). Clearly, standardisation values for dissolved oxygen analyses must be examined more closely during future cruises.

4.2.3 Nutrients

Phosphate and nitrate+nitrite

Phosphate and nitrate+nitrite data for cruises au9404 and onwards are compared in Figure 4.6 while data for all cruises are summarised in Figure 4.7. Note that the inconsistent results for cruise au9101 (Figure 4.7), due to higher phosphate values, are discussed in Rosenberg et al. (1995a).

The nitrate+nitrite to phosphate ratio is mostly consistent for cruises au9309 and au9407 (Figure 4.7), and for cruises au9404, au9501 and au9604 (Figures 4.6a and b); however the ratio differs for cruise au9601 (Figure 4.6c). Comparison of vertical nutrient profiles at equivalent station positions for different cruises reveals that the difference is due to phosphate, rather than nitrate+nitrite data. Phosphate values for au9601 are lower than the values for other cruises by ~0.1µmol/l. As discussed in Appendix 3.1 of this report, the phosphate carryover effect is believed to have been minimised for cruise au9601 by alterations to the analysis techniques. For au9601, the autoanalyser peaks for phosphate analyses very nearly return to the baseline level from where peak integration occurs, minimising any carryover error. For previous cruises, autoanalyser peaks for phosphate analyses do not return all the way to the baseline level. This carryover error artificially increases peak height values, and could be a cause for slightly higher phosphates for previous cruises compared to au9601. Note that the offset is unlikely to be a constant - there may be a dependence on phosphate concentration, and on instrument settings. Phosphate measurements on future cruises using the same techniques as for cruise au9601 will confirm whether the observed difference of ~0.1µmol/l in Figure 4.6c does indeed represent an error in all the previous cruises.

Near surface phosphate and nitrate+nitrite

From Figure 4.6b, the near surface nutrient data for au9604 clearly differs from the remaining data. Moreover, the lower the near surface nutrient value, the greater the deviation from the bestfit line. From inspection of all the cruises (Figure 4.7), this feature is apparent for data collected in Antarctic waters (i.e. south of the Polar Front) during the austral summer i.e. cruises au9407, au9404 and au9604. In addition, the feature can be seen in summer data collected by the Eltanin (Gordon et al., 1982) (Figure 4.7) along a meridional transect at 132^{o}E. There are two possible explanations for the feature:

(a) the phosphate carryover error, discussed in previous data reports (see section 6.2.1 in Rosenberg et al., 1995b), results in depressed phosphate values near the surface; this error is amplified where vertical phosphate gradients are steep, as is the case for near surface Antarctic waters during an austral summer;

(b) alternatively, the feature is real, indicating a stronger depletion of phosphate relative to nitrate+nitrite by biological activity in Antarctic waters during the summer.

Note that for cruises au9407 and au9404, many surface phosphate samples were bad due to the phosphate carryover effect, and much of the relevant nitrate+nitrite to phosphate ratio data are missing for these cruises. Whether explanation a or b applies is inconclusive. As already discussed, the phosphate carryover error is believed to have been minimised for cruise au9601. Thus to confirm whether the near surface phosphate depletion is an error or a real feature, more summertime Antarctic zone nutrient data are needed using the analysis techniques of cruise au9601.

Matrix correction

For analysis of nutrients, samples are initially run against nutrient standards (see Appendix 3, Rosenberg et al., 1995b). The colour reagent is then removed, and samples are run again against the nutrient standards. The peak observed when run without the colour reagent is due mainly to a “matrix effect” (i.e. a detector response due to refractive properties of the sample water), and should be corrected for. The size of the matrix effect is dependent on chemistry and detection wavelength. Ideally, the magnitude of the effect should be checked for each nutrient sample. For cruise au9601, the effect was negligible for nitrate+nitrite and silicate analyses, however a significant effect was observed for phosphates. A mean magnitude of the matrix effect for phosphates was obtained by measuring the effect for two vertical phosphate profiles, from the north and south ends of the transect. The value, equal to 0.088 μmol/l, should be subtracted from au9601 phosphate if the matrix effect correction is desired. Note that the matrix effect was not investigated for previous cruises, so to maintain consistency of the entire data set, the correction has not been applied to cruise au9601.

Silicate

Silicate data along the SR3 transect for cruises au9309 and onwards are compared in Figure 4.8. Note that most of the comparisons are for stations outside the strong frontal regions. Most of the silicate data for the different cruises agree to within 5 μmol/l, and in general no consistent offset between cruises is evident.

4.2.4 Pressure

Small differences in the quality of CTD pressure data between different cruises occurs according to the CTD instrument in use. The two fundamental differences in instruments are as follows:

(i) MarkIIIB CTD's employ a stainless steel type strain gauge for measuring pressure; there is no pressure temperature correction, and separate downcast and upcast laboratory calibrations are used to compensate for hysteresis of the pressure response. The more accurate WOCE upgraded MarkIIIC CTD's use a titanium type strain gauge, and include a pressure temperature correction - the hysteresis of these sensors is small compared with the stainless steel type, and a downcast laboratory calibration only is applied to all pressure data. The manufacturer quoted accuracies of pressure data from the two types of pressure sensor are ±6.5 dbar for the Mark IIIB units (used for cruises au9101, au9309 and au9391), and ±1.2 dbar for the Mark IIIC's (used for all remaining cruises).

(ii) The level of noise in the raw pressure signal differs for the different instruments. In general, the titanium type sensors in the MarkIIIC's display a higher noise level than the stainless steel type in the MarkIIIB's (Millard et al., 1993), and a small error may be introduced into surface pressure offset values, as described in previous data reports. Of the MarkIIIC's used, CTD 1193 was noisiest and CTD 2568 a little less so; both however were significantly noisier than CTD 1103. This pressure signal noise, up to 1 dbar in amplitude for CTD 1193, can result on occasion in 2 dbar pressure bins (for the pressure monotonically increasing data files) with too few raw data points for the formation of a 2 dbar average (see CTD methodology in Rosenberg et al. 1995b for pressure calculations). For details on individual cruises, and information on which instruments were used, see the data reports for each cruise.

4.2.5 Temperature

Comparison of calibrated CTD platinum temperature data T_{cal} to mercury reversing thermometer measurements T_{therm} on all the cruises allows the inter-cruise compatibility of temperatures to be assessed. Note that the same laboratory calibrations were applied to the reversing thermometers for all cruises, although a different set of thermometers was used for cruises au9309/au9391. Reversing thermometer calibrations are assumed to remain stable over the entire period. Moreover, the thermometer to CTD comparison for different cruises shows the same variation for the different thermometers used, supporting the assumption of stable thermometer calibrations. Thus any temperature errors are attributed to calibration problems for the CTD platinum temperature. For cruise au9101, insufficient thermometer measurements were made for a check of CTD temperature.

Although manufacturer quoted accuracies for the reversing thermometers are only of the order 0.01°C, thermometer resolution is usually significantly better; and given the reasonably large number of data points obtained, it is estimated that CTD temperature performance can be assessed to an accuracy of ~0.003°C. Mean differences (T_{therm} - T_{cal}) are summarised in Table 4.4. The following CTD temperature calibration problems are evident:

(i) For the first half of cruise au9309, the CTD temperature is incompatible with other cruises by >0.01°C.

(ii) For cruise au9501 where CTD 1103 was used, there is a CTD temperature calibration error of ~0.007°C (the post cruise CTD temperature calibration was used). Pre and post cruise temperature calibrations were significantly different, and a temperature error occurs when either calibration is applied (see au9501 data report).

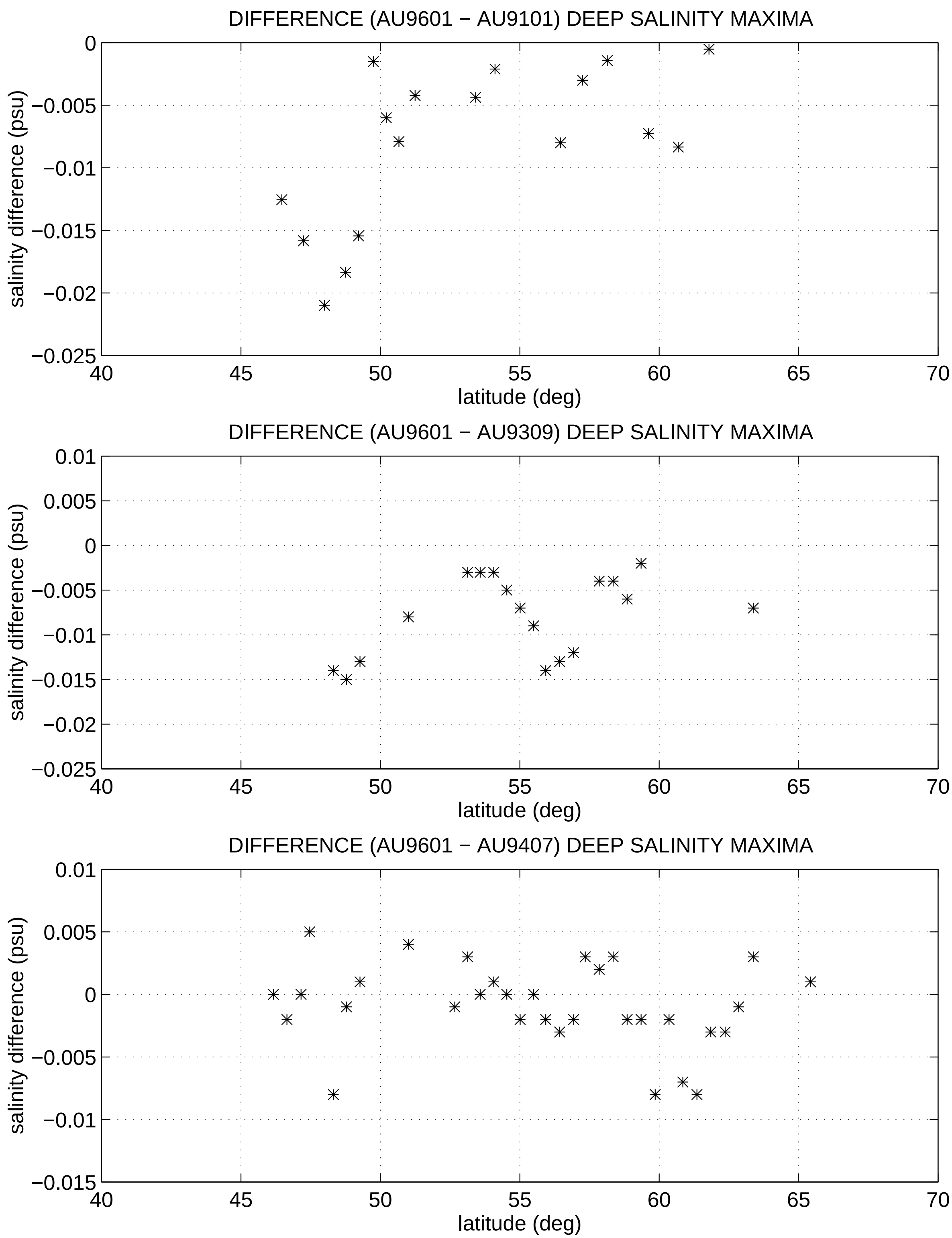
(iii) For cruise au9601, the difference value of ~0.005°C is large enough to be significant. In this case, a pre cruise calibration was used.

(iv) For cruise au9407, the temperature calibration is good, except for an apparent non-linearity at lower temperatures (stations 61-82). See Rosenberg et al. (1995b) for more details.

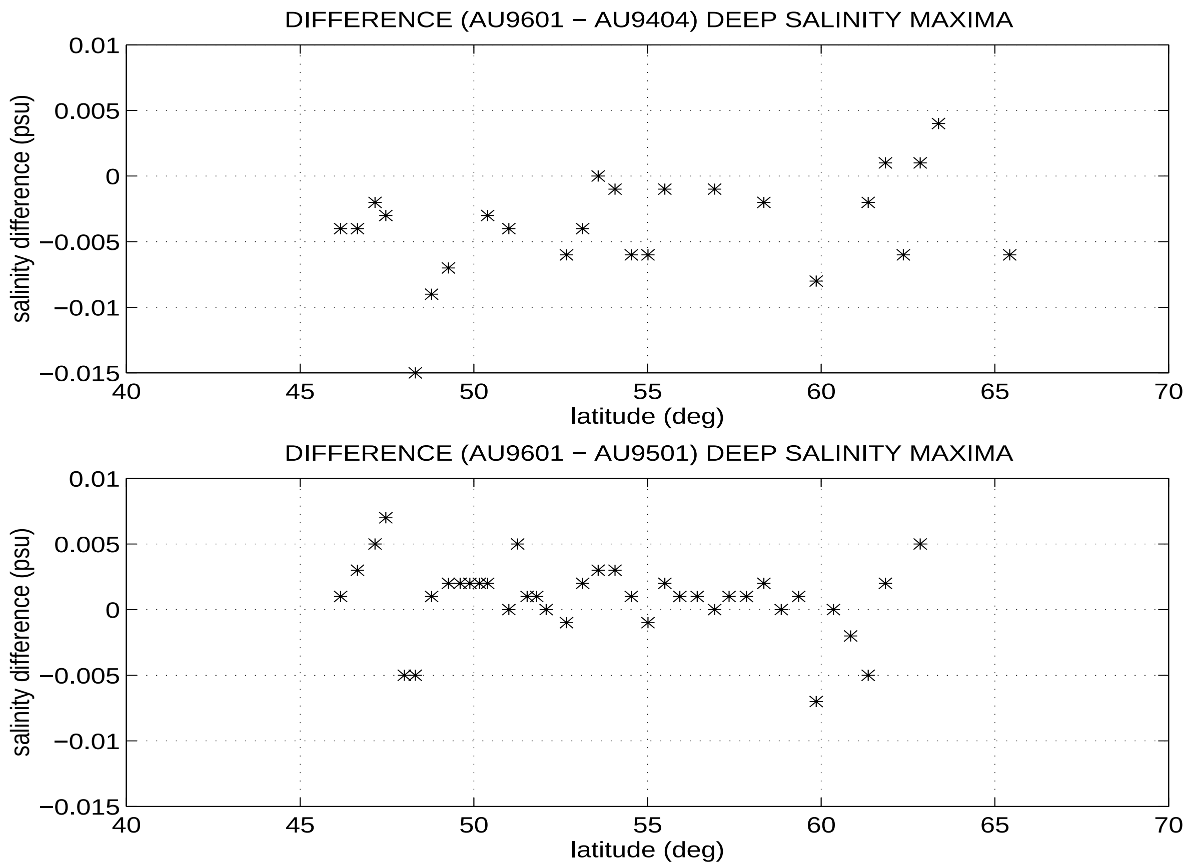
(v) For cruise au9404, a CTD temperature calibration error was apparent for CTD 1193 (stations 19-106). A constant correction of -0.007°C was applied to all CTD temperature data. Some error may however remain due to this assumption of a constant offset.

Table 4.4: Mean and standard deviation of temperature residual (T_{therm} - T_{cal}) for different cruises.

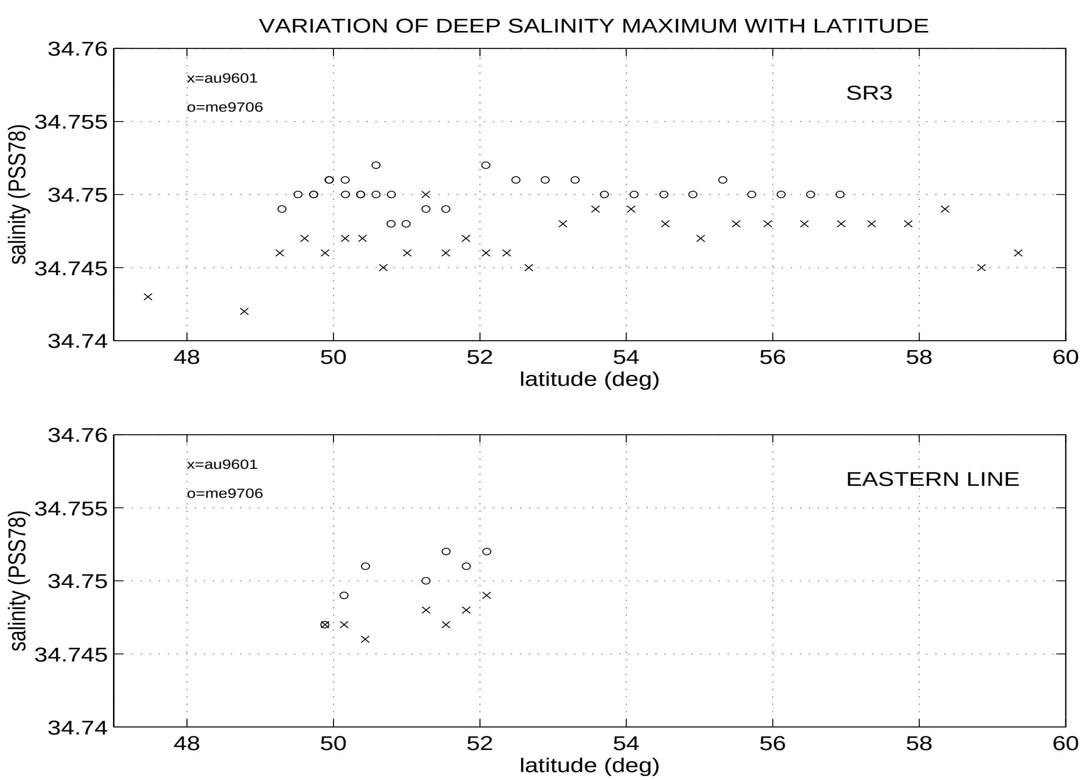
cruise (station nos.)	CTD no.	mean of (T_{therm} - T_{cal}) (deg. C)	standard dev. of (T_{therm} - T_{cal}) (deg. C)	no. of samples
au9309 (1-35)	1197	-0.0139	0.0110	51
au9309 (36-63)/au9391 (1-63)	1073	-0.0022	0.0109	121
au9407 (1-60 and 83-102 only)	2568	0.0014	0.0131	95
au9404 (1-106)	1193/1103	0.0017	0.0090	243
au9501 (1-29,46-103,106-208)	1103	-0.0071	0.0078	155
au9501 (30-45)	1193	0.0011	0.0041	33
au9604 (1-147)	1103/1193	0.0019	0.0068	289
au9601 (1-71)	1103/1193	0.0046	0.0050	187



<u>Figure 4.1a:</u> Variation south along the SR3 transect of the deep salinity maximum: salinity differences between cruise au9601 and cruises au9101, au9309 and au9407. For au9101 comparison, au9601 values are linear interpolations between station positions; for cruises au9309 and au9407 comparisons, differences are only formed between station pairs separated by no more than 1.5 nautical miles of latitude.



<u>Figure 4.1b:</u> Variation south along the SR3 transect of the deep salinity maximum: salinity differences between cruise au9601 and cruises au9404, au9501. Differences are only formed between station pairs separated by no more than 1.5 nautical miles of latitude.



<u>Figure 4.2:</u> Variation south along the SR3 transect of the deep salinity maximum for cruises au9601 (Aurora Australis) and me9706 (Melville), both using Guildline salinometers.

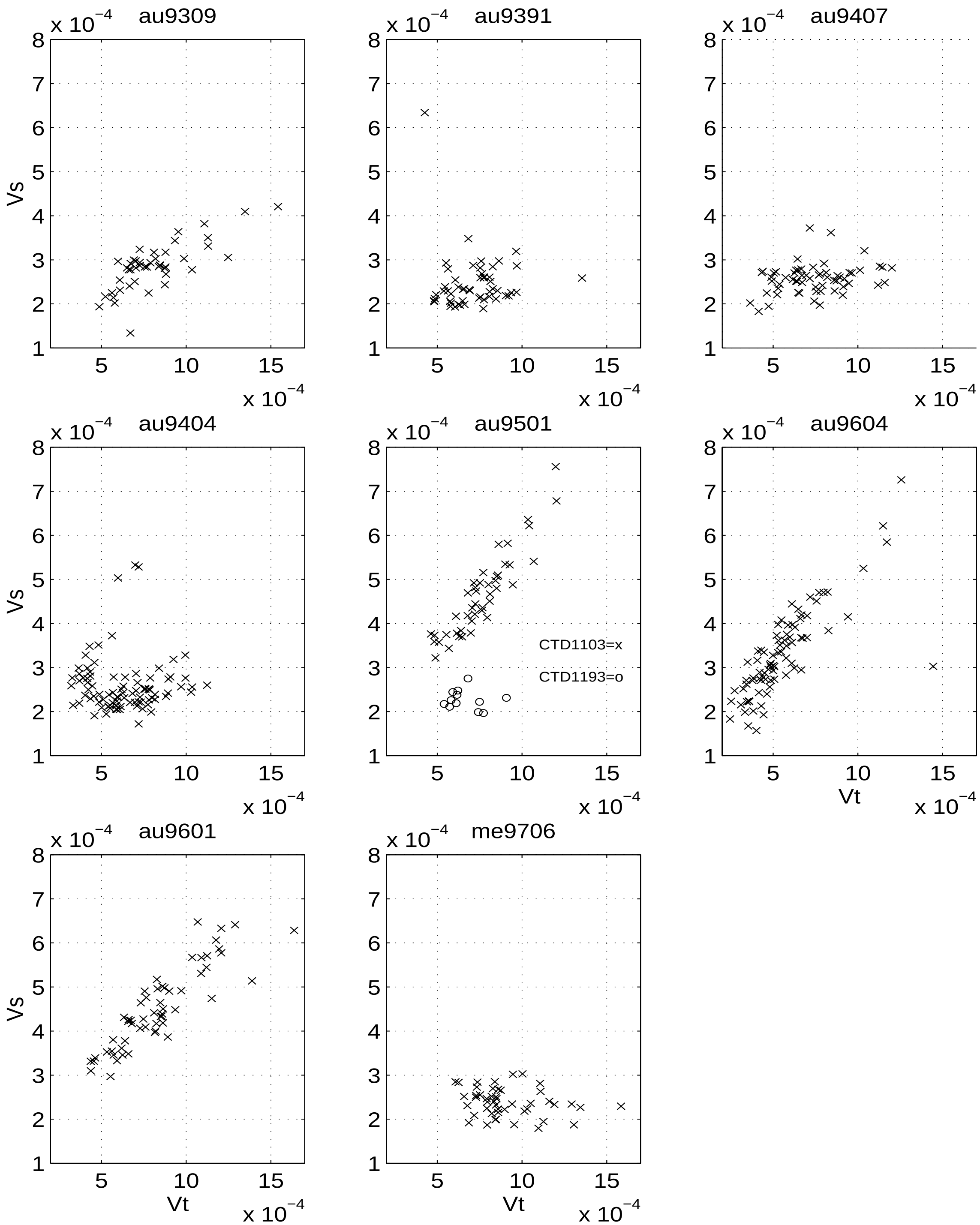


Figure 4.3: V_s versus V_t for all cruises along all transects. Note that all stations are plotted, except for a small number with large V_t values.

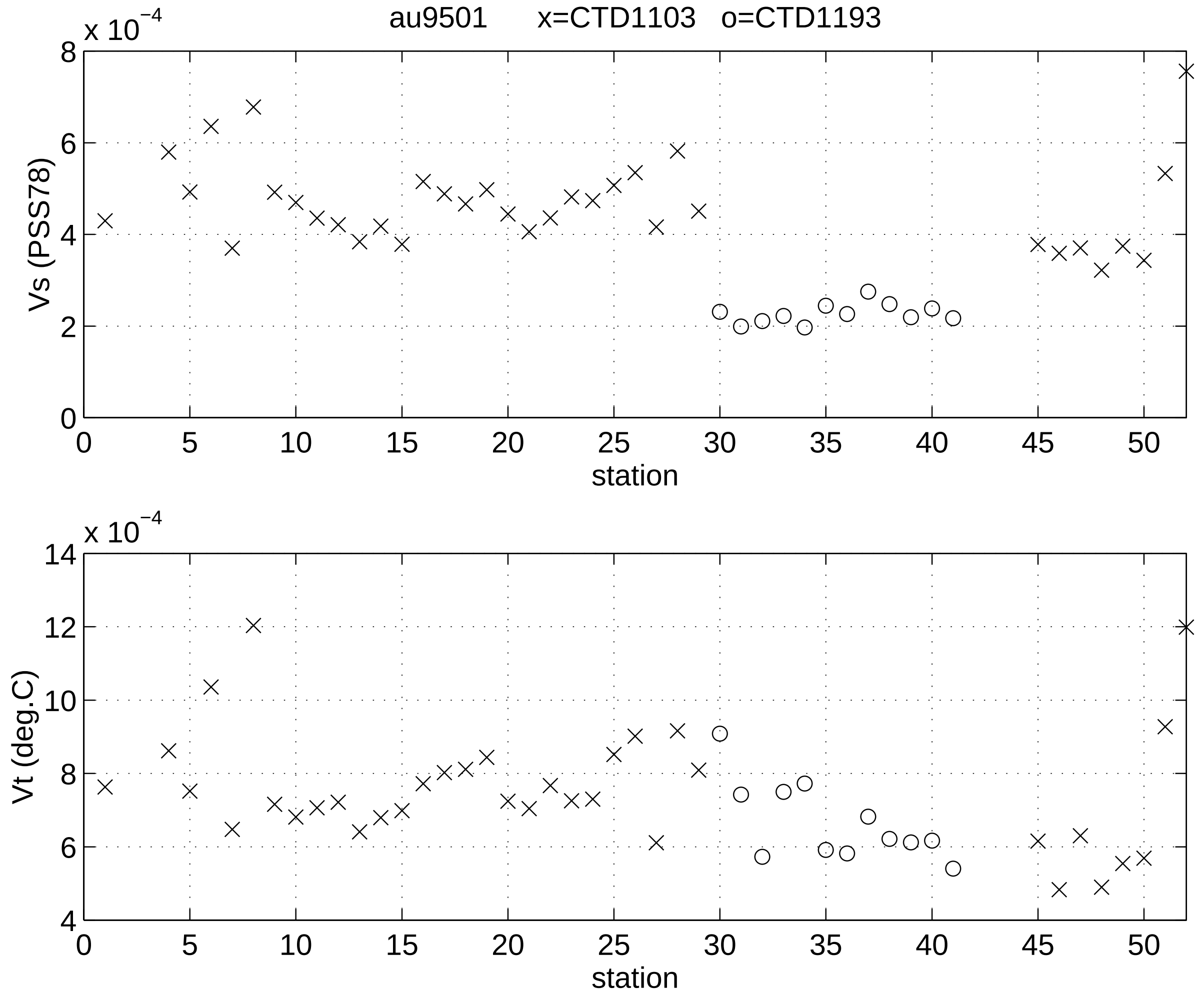
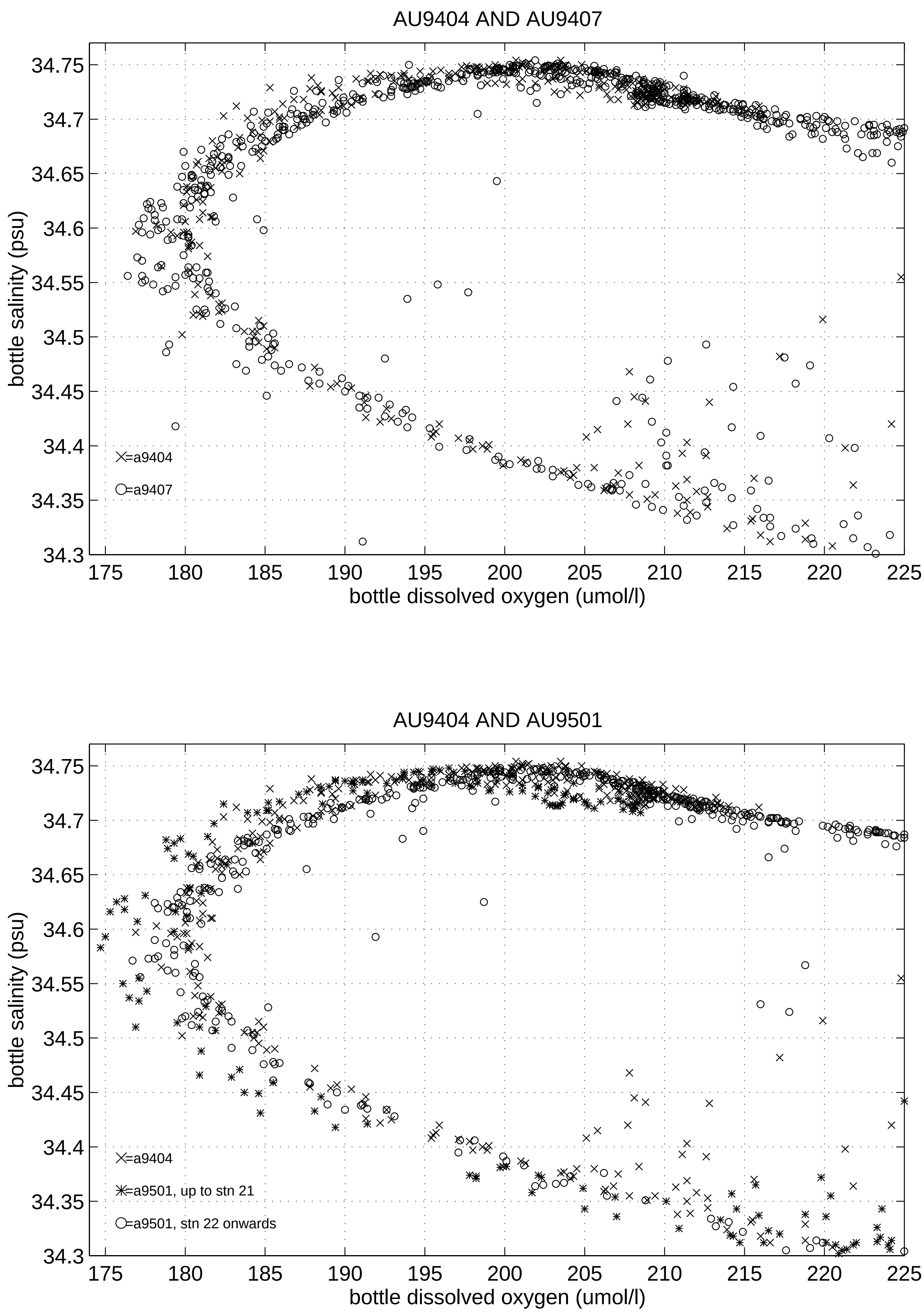
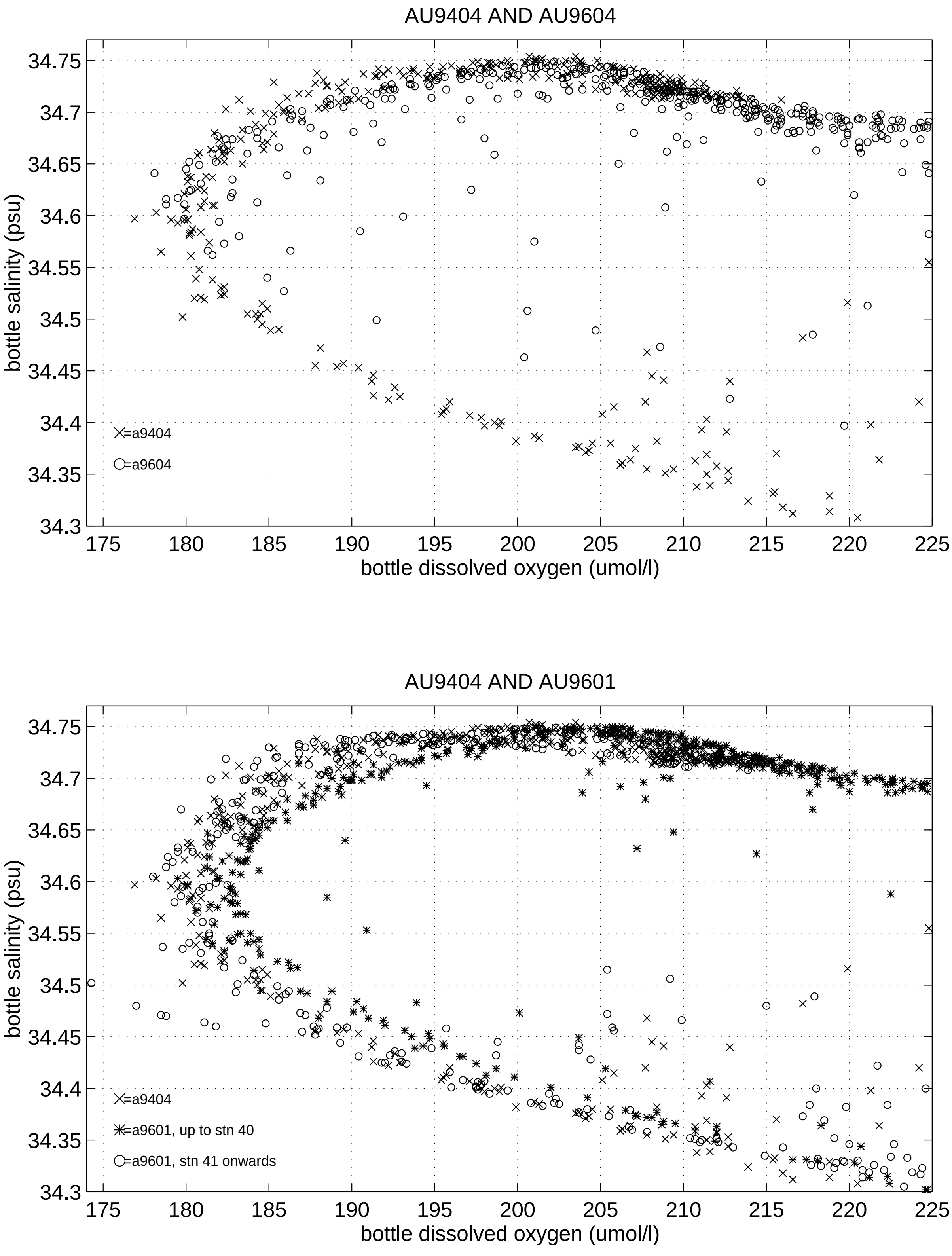


Figure 4.4: **Variation of V_s and V_t for individual stations for cruise au9501, along the SR3 transect.**

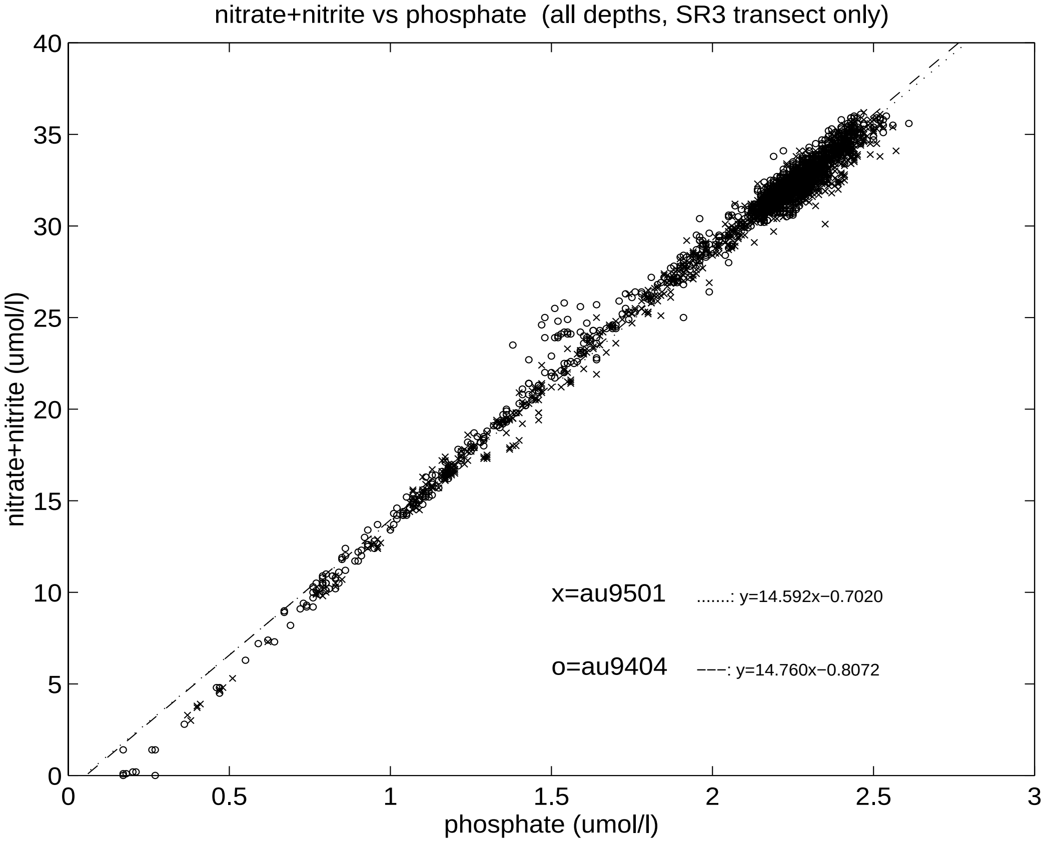


<u>Figure 4.5a:</u> Dissolved oxygen bottle data comparison for cruises au9404, au9407 and au9501, SR3 data only. Note that scale is expanded i.e. not all data are on the plot.

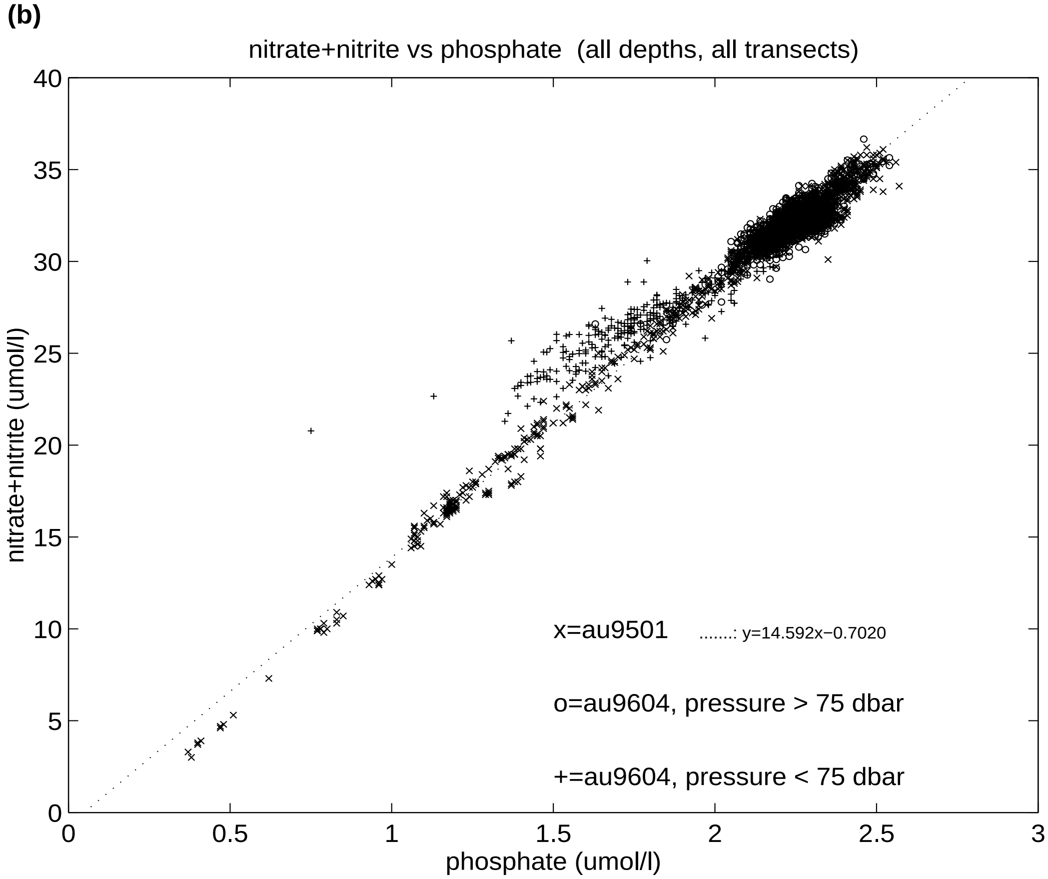


<u>Figure 4.5b:</u> Dissolved oxygen bottle data comparison for cruises au9404, au9604 and au9601, SR3 data only (except for au9604, where data from the longitude range 128 to 150 °E are plotted). Note that scale is expanded i.e. not all data are on the plot.

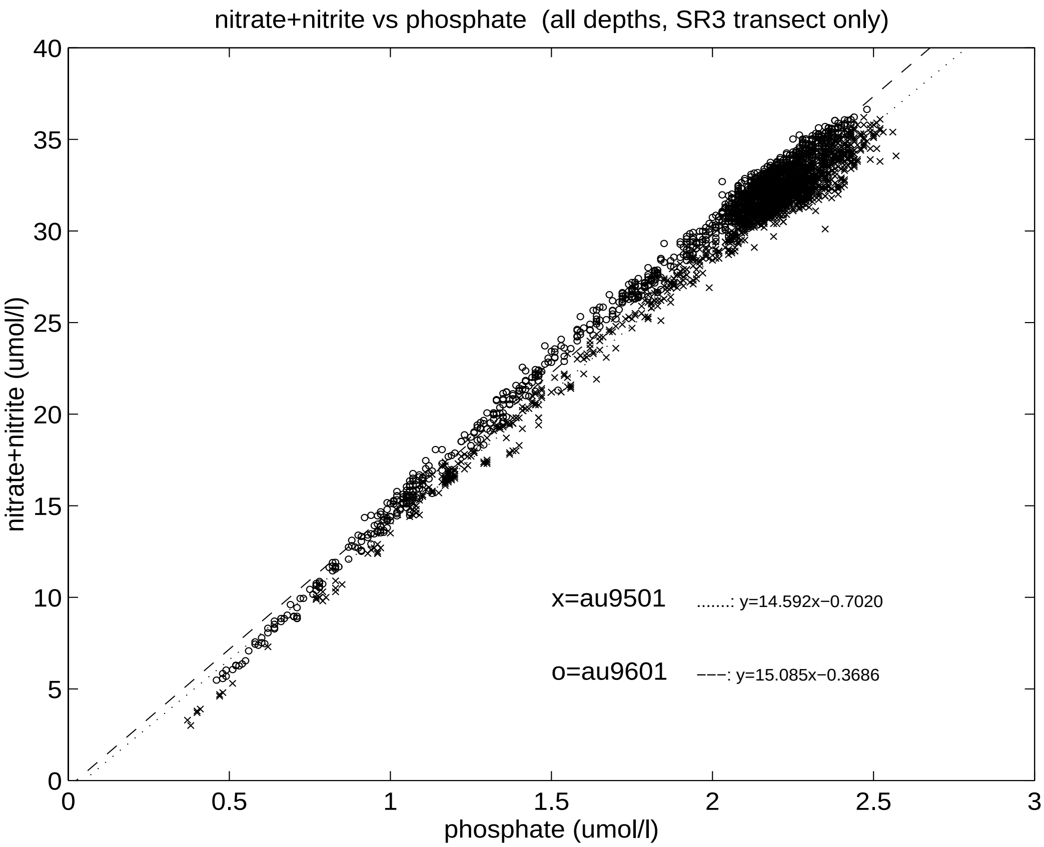
(a)


nitrate+nitrite vs phosphate (all depths, SR3 transect only)
nitrate+nitrite (umol/l)
phosphate (umol/l)
x=au9501
.......: y=14.592x−0.7020
o=au9404
−−−: y=14.760x−0.8072

(b)

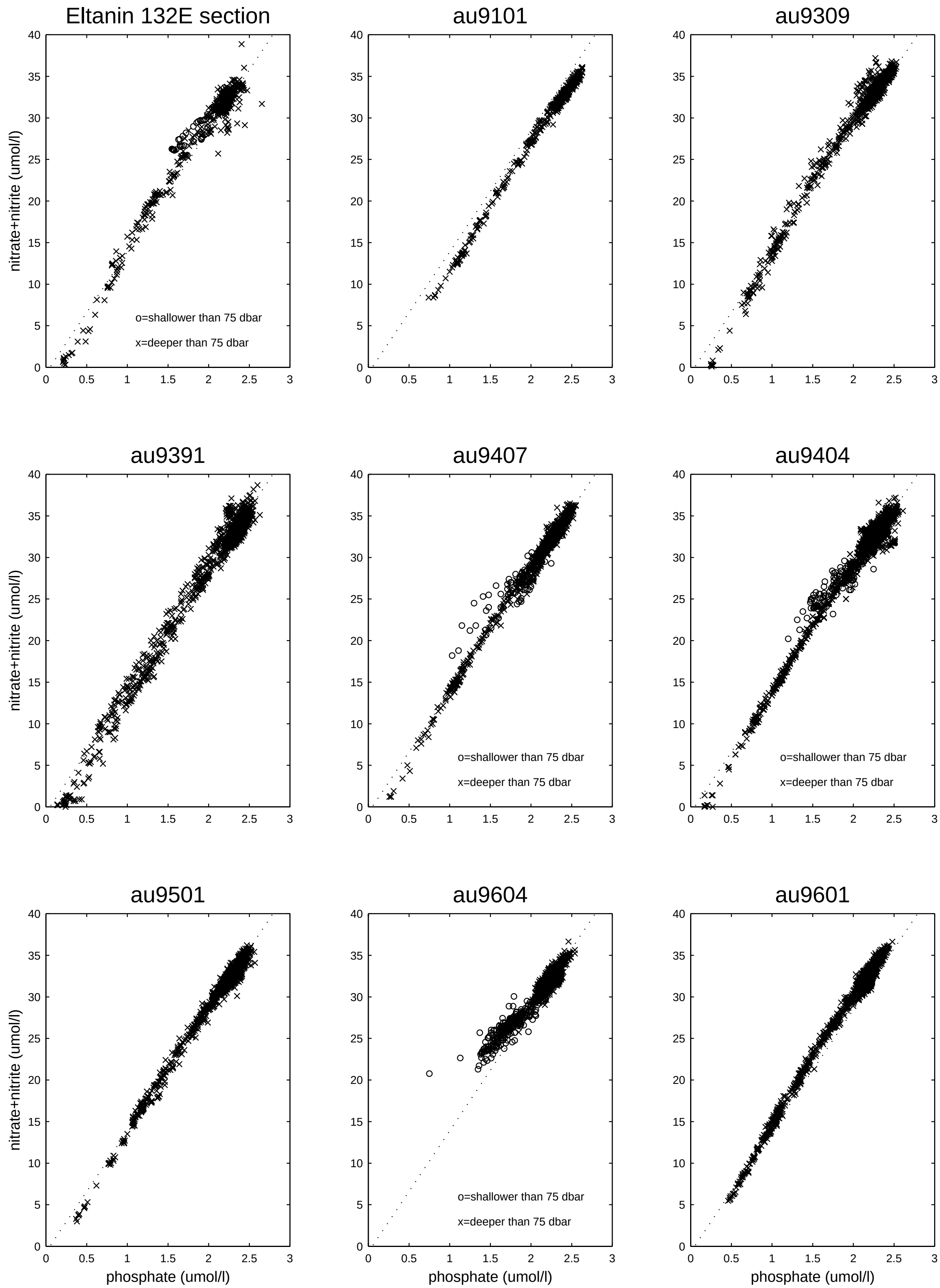

nitrate+nitrite vs phosphate (all depths, all transects)
nitrate+nitrite (umol/l)
phosphate (umol/l)
x=au9501
.......: y=14.592x−0.7020
o=au9604, pressure > 75 dbar
+=au9604, pressure < 75 dbar

(c)



<u>Figure 4.6 (previous page and this page):</u> Bulk plot of nitrate+nitrite versus phosphate for:
(a) all au9501 and au9404 data along the SR3 transect, together with linear best fit lines;
(b) all au9501 and au9604 data along all transects, with linear best fit line for au9501;
(c) all au9501 and au9601 data along the SR3 transect, together with linear best fit lines.

PHOSPHATE vs NITRATE+NITRITE RATIO, WITH AU9501 BEST FIT LINE



<u>Figure 4.7:</u> Nitrate+nitrite versus phosphate for Aurora Australis oceanographic cruises, plus Eltanin data from Gordon et al. (1982). The linear best fit line for cruise au9501 is included on each plot.

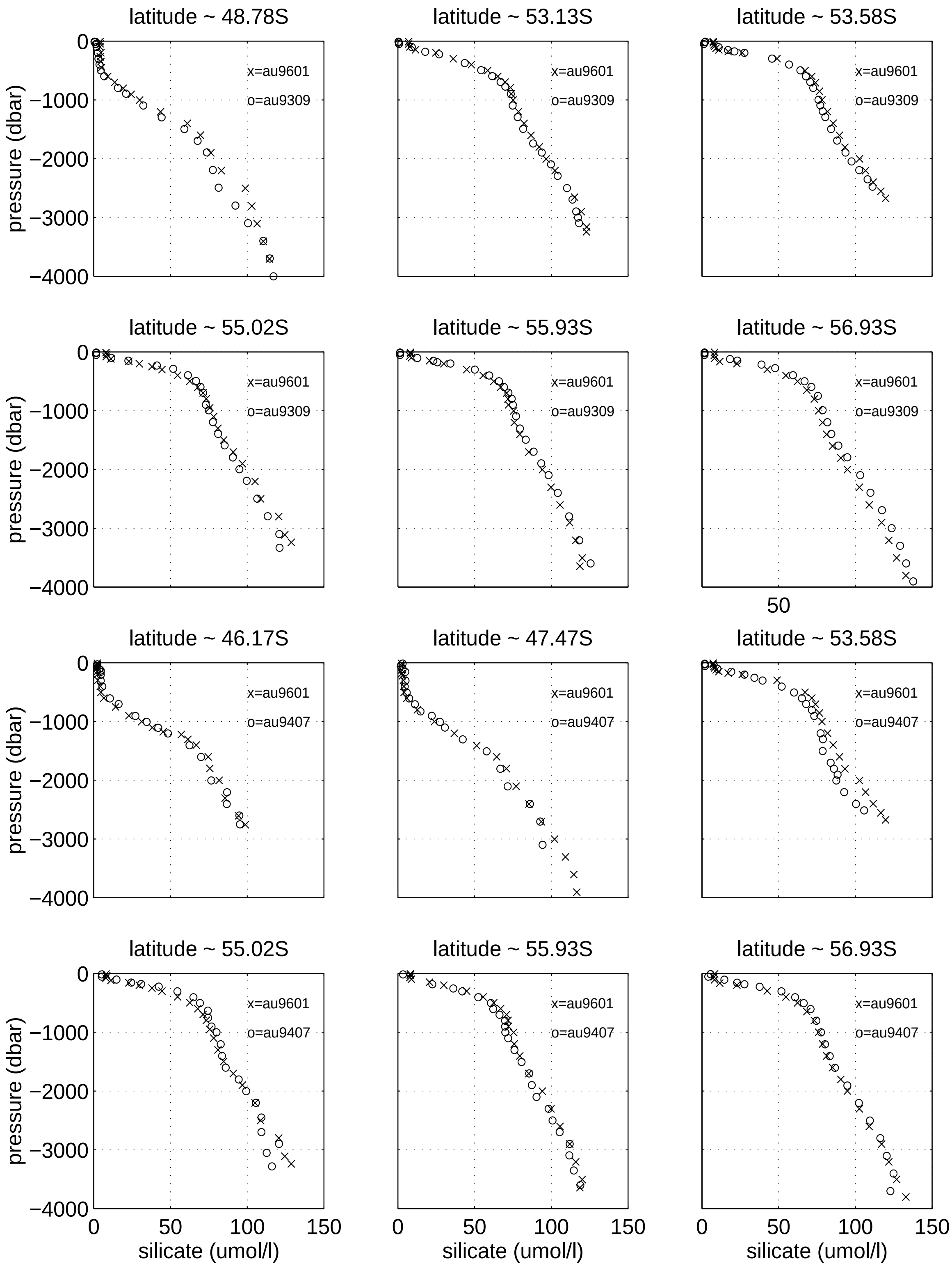
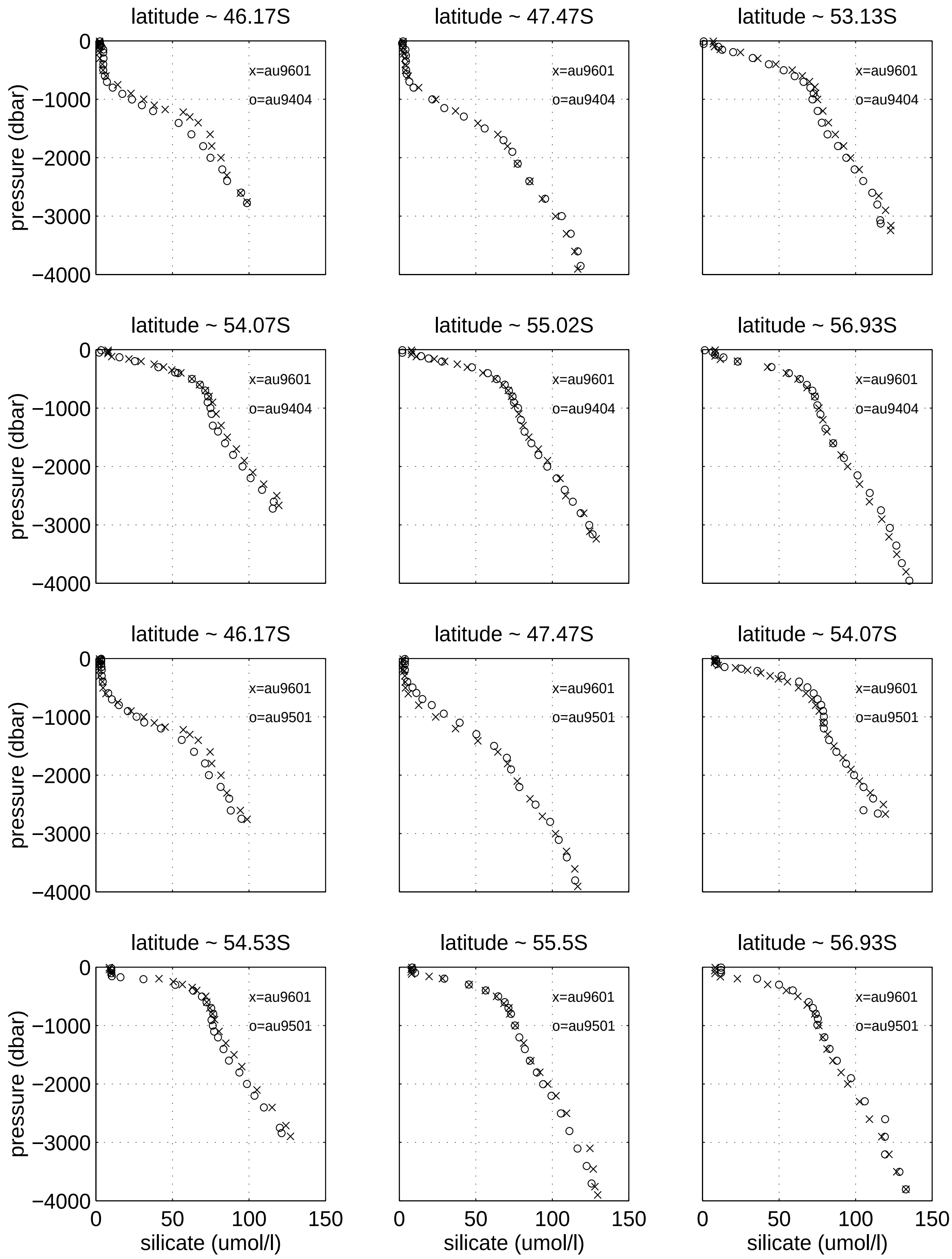


Figure 4.8a: **Comparison of vertical silicate concentration profiles between cruises au9601 and au9309, and cruises au9601 and au9407, for selected stations along the SR3 transect. Note that data below 4000 dbar are not included in the plots.**



<u>Figure 4.8b:</u> Comparison of vertical silicate concentration profiles between cruises au9601 and au9404, and cruises au9601 and au9501, for selected stations along the SR3 transect. Note that data below 4000 dbar are not included in the plots.

Part 5
Data File Types and Formats

5.1 UNDERWAY MEASUREMENTS

The underway measurements for the cruise, as logged automatically by the ship's data logging system, and quality controlled by human operator (Ryan, 1995), are contained in column formatted ascii files. The two file types contain 10 sec digitised data, and 15 min averaged data. In both cases, missing data or data flagged as bad are replaced by the null value -999. The files are padded out to commence on the first digitising interval of the first day in the file, and ending at the last digitising interval on the last day in the file.

5.1.1 10 second digitised underway measurement data

Data at the minimum digitised interval of 10 sec. are contained in files named *.alf (Table 5.1), where the data filename prefix corresponds to the cruise acronym. A two line header is followed by the data as follows:

column	parameter
1	decimal time (0.0=midnight on December 31st, therefore, for example, 1.5=midday on January 2nd)
2	day
3	month
4	year
5	hour
6	minute
7	second
8	latitude (decimal degrees, +ve=north, -ve=south)
9	longitude (decimal degrees, +ve=east, -ve=west)
10	depth (m)
11	sea surface temperature (^{o}C) (measured at the seawater inlet at 7 m depth)
12	air pressure (hPa) (included for cruises au9501, au9604 and au9601)
13	wind speed (knots) (included for cruise au9501 only)
14	wind direction (deg. true) (included for cruise au9501 only)
15	roll (included for cruise au9501 only)
16	pitch (included for cruise au9501 only)

Note that all times are UTC.

Table 5.1: Example 10 sec digitised underway measurement file (*.alf file).

```
Aurora Australis data - GPS pos. (deg), depth (m), sea surface temp (deg C)
 decimaltime  day mn  yr   hr m  s        lat        lon          depth   SST
  70.00000004  12  3 1993   0  0  0      -999.0000 -999.0000     -999.0 -999.00
  70.00011578  12  3 1993   0  0 10      -999.0000 -999.0000     -999.0 -999.00
  70.00023148  12  3 1993   0  0 20       -44.0044  146.3534      284.6   15.20
  70.00034722  12  3 1993   0  0 30       -44.0044  146.3529     -999.0   15.20
  70.00046296  12  3 1993   0  0 40       -44.0044  146.3530      283.5   15.20
  70.00057870  12  3 1993   0  0 50       -44.0044  146.3523      287.4   15.20
  70.00069444  12  3 1993   0  1  0       -44.0043  146.3519      282.2   15.20
  70.00081019  12  3 1993   0  1 10       -44.0044  146.3515      282.4   15.20
```

5.1.2 15 minute averaged underway measurement data

15 minute averaged data are contained in files named *.exp (Table 5.2), where the data filename prefix corresponds to the cruise acronym. Note that wind direction and ship's heading are instantaneous values. All times represent the *centre* of the averaging interval. A two line header is followed by the data as follows:

column	parameter
1	decimal time (as for 10 sec digitised files)
2	latitude (as for 10 sec digitised files)
3	longitude (as for 10 sec digitised files)
4	air pressure (hPa)
5	wind speed (knots)
6	wind direction (deg. true)
7	port air temperature (^{o}C)
8	starboard air temperature (^{o}C)
9	port relative humidity (%)
10	starboard relative humidity (%)
11	quantum radiation (μmol/s/m^2)
12	ship speed (knots) (speed through the water)
13	ship heading (deg. true)
14	ship roll (deg.)
15	ship pitch (deg.)
16	sea surface salinity (parts per thousand) (from seawater inlet at 7 m depth)
17	sea surface temperature (^{o}C) (at seawater inlet, 7 m depth)
18	average fluorescence (arbitrary units) (from seawater inlet at 7 m depth)
19	seawater flow (l/min) (flow rate at seawater inlet)

Note that all times are UTC.

<u>Table 5.2:</u> Example 15 min averaged underway measurement file (*.exp file).

Aurora Australis DLS data: dumped by EXPORT. Column units: days,deg,deg,hPa,knots,degTrue,degC,degC,%,%,umol/s/m2,knots,degTrue,deg,deg,ppt,degC, - ,l/min

decimaltime	lat	long	airP	windsp	windd	poairT	stairT	pohum	sthum	qrad	shipspd	shiphdg	roll	pitch	ssSAL	ssT	avfluo	seaflow
70.00520833	-44.00310	146.33583	1022.2	19.6	293	14.2	14.2	93	88	-999	6.56	235.5	1.185341	0.486591	35.175	15.20	-999.000	9.95
70.01562500	-44.00076	146.31305	1022.3	22.1	290	14.2	14.3	92	87	-999	1.15	235.5	1.295333	0.346111	35.165	15.10	-999.000	9.97
70.02604167	-44.00056	146.31239	1022.3	20.6	305	14.0	14.0	94	89	-999	0.00	235.5	2.568000	0.287667	35.159	15.10	-999.000	9.98
70.03645833	-44.00036	146.31232	1022.2	20.6	298	14.1	14.0	94	89	-999	0.00	235.5	1.303000	0.274444	35.165	15.10	-999.000	9.99
70.04687500	-44.00000	146.31136	1022.2	20.1	298	14.0	14.0	95	90	-999	0.00	234.5	1.380111	0.433667	35.166	15.10	-999.000	9.99
70.05729167	-43.99958	146.31143	1022.2	20.7	288	14.1	14.1	94	89	222	0.00	234.5	1.801667	0.464667	35.165	15.10	-999.000	9.97
70.06770833	-43.99918	146.31229	1022.3	18.5	295	13.8	14.1	96	90	170	0.00	234.5	1.619333	0.398334	35.164	15.20	-999.000	9.99

5.2 2 DBAR AVERAGED CTD DATA FILES

The final format in which CTD data is distributed is as 2 dbar averaged data, contained in column formatted ascii files, named *.all (Table 5.3) (the file name prefix is discussed in Appendix 2 of Rosenberg et al., 1995b). Averaging bins are centered on even pressure values, starting at 2 dbar. A 15 line header is followed by the data, as follows:

column	parameter
1	pressure (dbar)
2	temperature (^{o}C) (ITS-90)
3	salinity (PSS78)
4	σ_T = density-1000 (kg.m^{-3})
5	specific volume anomaly x 10^{8}(m^{3}.kg^{-1})
6	geopotential anomaly (J.kg^{-1})
7	dissolved oxygen (μmol.l^{-1})
8	number of data points used in the 2 dbar averaging bin
9	standard deviation of temperature values in the 2 dbar bin
10	standard deviation of conductivity values in the 2 dbar bin
11	fluorescence (mg.m^{-3}) (uncalibrated)
12	photosynthetically active radiation (μmol.s^{-1}.m^{2}) (uncalibrated)

All files start at the 2 dbar pressure level, incrementing by 2 dbar for each new data line. Missing data are filled by blank characters (this most often applies to dissolved oxygen data).

Table 5.3: Example 2 dbar averaged CTD data file (*.all file).

```
SHIP                 : R.V. Aurora Australis
 STATION NUMBER      :    4
 DATE                : 02-JAN-1994  (DAY NUMBER   2)
 START TIME          : 1020 UTC = Z
 BOTTOM TIME         : 1100 UTC = Z
 FINISH TIME         : 1222 UTC = Z
 CRUISE         : Au94/07
 START POSITION      : 44:07.03S 146:13.35E
 BOTTOM POSITION     : 44:07.14S 146:13.71E
 FINISH POSITION     : 44:06.61S 146:13.95E
 MAXIMUM PRESSURE: 1038 DECIBARS
 BOTTOM DEPTH        :   1015    METRES
```

PRESS	TEMP (T-90)	SAL	SIGMA-T	S.V.A.	G.A.	D.O.				fluorescence	p.a.r.
2.0	11.899	34.773	26.432	158.69	0.032	277.6	30	0.001	0.007	0.95569E+01	-0.49498E+00
4.0	11.899	34.778	26.436	158.41	0.063	280.3	30	0.001	0.001	0.10817E+02	-0.63459E+00
6.0	11.903	34.779	26.436	158.46	0.095	281.1	45	0.001	0.002	0.90911E+01	-0.60488E+00
8.0	11.903	34.778	26.435	158.55	0.127	278.0	41	0.000	0.000	0.80700E+01	-0.58265E+00
10.0	11.903	34.778	26.435	158.60	0.159	278.6	32	0.001	0.001	0.75122E+01	-0.66496E+00
12.0	11.904	34.778	26.435	158.66	0.190	280.2	32	0.001	0.001	0.72758E+01	-0.55944E+00
14.0	11.905	34.778	26.435	158.72	0.222	281.5	40	0.000	0.000	0.73697E+01	-0.62194E+00
16.0	11.907	34.779	26.435	158.76	0.254	277.5	34	0.002	0.002	0.69932E+01	-0.56719E+00
18.0	11.908	34.780	26.435	158.77	0.286	275.7	25	0.002	0.002	0.68356E+01	-0.63807E+00

5.3 HYDROLOGY DATA FILES

Files named *.bot (where the filename prefix is the the cruise code e.g. a9407) are column formatted ascii files containing the hydrology data, together with CTD upcast burst data (Table 5.4). The columns contain the following values:

column	parameter
1	station number
2	CTD pressure (dbar)
3	CTD temperature (^{o}C)
4	reversing thermometer temperature (^{o}C)
5	CTD conductivity ($mS.cm^{-1}$)
6	CTD salinity (PSS78)
7	bottle salinity (PSS78)
8	ortho phosphate concentration ($\mu mol.l^{-1}$)
9	nitrate + nitrite concentration ($\mu mol.l^{-1}$)
10	reactive silicate concentration ($\mu mol.l^{-1}$)
11	bottle dissolved oxygen concentration ($\mu mol.l^{-1}$)
12	bottle quality flag (-1=rejected, 0=suspect, 1=good)
13	niskin bottle number

Missing data values are filled by a decimal point (surrounded by blank characters). Parameters 2,3,5 and 6 are mean values from the upcast CTD burst data at the time of bottle firing, where each burst contains the data 10 sec previous to the time of bottle firing. Parameters 7 to 11 are laboratory values for the hydrology analyses. Parameter 12, the bottle quality flag, is relevant to the calibration of CTD salinities - bottles flagged 1 and 0 are used for calibration, while those flagged -1 are rejected. Criteria for flagging of the bottle data are discussed elsewhere (Appendix 2 of Rosenberg et al., 1995b). Parameter 13, the niskin bottle number, is a unique identifier for each bottle. Note that the bottle number does not always correspond with rosette position.

Table 5.4: Example hydrology data file (*.bot file).

2	8.556	15.155	15.154	43.109	35.032	35.031	0.29	8.80	7.7	247.10	1	11
2	25.593	15.111	.	43.076	35.034	35.035	0.28	0.20	3.7	248.50	1	9
2	50.992	15.105	.	43.085	35.038	35.038	0.27	0.30	2.2	249.10	1	8
2	73.718	14.188	.	42.227	35.068	35.077	0.48	4.40	2.8	228.70	-1	7
2	98.376	12.840	.	40.910	35.055	35.051	0.66	7.70	2.5	227.60	-1	6
2	123.524	12.490	.	40.618	35.089	35.081	0.76	9.60	3.0	223.10	-1	5
2	148.516	11.904	.	40.025	35.052	35.067	0.85	11.10	3.4	223.30	-1	4
2	200.278	11.085	.	39.174	34.963	34.965	0.90	13.30	4.0	226.40	-1	3
2	247.807	10.678	10.691	38.758	34.914	34.914	1.02	13.90	4.1	230.40	0	2
2	289.188	9.625	.	37.640	34.769	34.794	1.13	15.80	4.8	232.40	-1	1
3	8.609	15.984	15.958	44.199	35.274	35.275	.	0.20	1.6	270.80	1	16
3	21.504	15.975	.	44.198	35.276	35.275	0.25	0.20	1.5	266.60	1	15
3	48.210	15.935	.	44.171	35.277	35.276	0.25	0.40	0.7	264.60	1	14
3	73.795	15.897	.	44.140	35.273	35.270	0.27	0.80	1.6	238.30	-1	13
3	98.905	14.011	.	42.238	35.229	35.236	0.63	7.50	2.3	.	-1	12
3	148.674	12.557	.	40.763	35.155	35.155	0.81	10.90	4.1	216.00	0	11
3	197.813	11.432	.	39.575	35.033	35.033	0.92	12.80	3.9	227.30	1	10
3	298.658	10.110	.	38.158	34.828	34.831	1.10	15.40	4.6	230.70	1	9
3	396.295	9.214	.	37.238	34.702	34.703	1.28	18.70	6.0	226.20	-1	8
3	496.675	8.371	.	36.405	34.604	34.603	1.52	22.50	9.3	210.60	1	7
3	597.207	7.385	.	35.469	34.524	34.524	1.71	25.90	14.6	199.30	1	6
3	697.115	6.587	.	34.751	34.487	34.486	1.90	28.30	20.6	195.30	1	5
3	778.707	5.739	.	33.995	34.458	34.458	2.05	30.50	27.8	.	1	4
3	900.509	4.315	.	32.710	34.381	34.382	2.20	32.70	33.6	198.50	1	3
3	1000.091	4.027	4.029	32.574	34.471	34.471	2.34	34.30	49.6	171.00	1	302
3	1113.395	3.403	.	32.110	34.517	34.522	2.42	35.40	61.3	169.90	-1	1

4	23.926	15.341	.	43.397	35.121	35.120	0.26	0.10	0.6	230.60	1	23
4	49.736	15.198	.	43.231	35.088	35.087	0.26	0.30	0.6	229.10	1	22
4	99.651	13.388	.	41.599	35.202	35.200	0.77	9.00	2.6	200.60	1	21
4	148.952	12.164	.	40.341	35.114	35.122	0.86	12.90	3.8	221.80	-1	20
4	196.847	11.114	.	39.222	34.985	34.980	0.95	11.40	3.6	233.30	-1	119
4	298.033	9.997	.	38.028	34.804	34.803	1.02	13.80	.	254.10	-1	118
4	384.198	9.235	.	37.228	34.676	34.677	.	.	.	256.20	-1	17
4	495.853	8.452	.	36.455	34.578	34.577	1.43	20.70	8.1	232.70	-1	16

5.4 STATION INFORMATION FILES

Station information files, named *.sta (Table 5.5) (where the filename prefix is the cruise code), contain position, time, bottom depth and maximum pressure of cast for CTD stations. The CTD instrument number is specified in the file header. Position and time (UTC) are specified at the start, bottom and end of the cast, while the bottom depth is for the start of the cast. Note that small inconsistencies may exist between bottom depth and maximum pressure, due to drift of the vessel between the start and bottom of the cast. In addition, a single value is used for the sound velocity in seawater for echo sounder calculations (1498 m.s^{-1}), which may cause small errors in water depth values.

Table 5.5: Example CTD station information file (*.sta file).

RSV Aurora Australis   Cruise : Au93/09   CTD station list   (CTD unit 4)

stat no.	time	date	start latitude	start longitude	bottom depth(m)	max P (dbar)	time	bottom latitude	bottom longitude	time	end latitude	end longitude
1	2032	11-MAR-93	44:06.73S	146:14.35E	1000	956	2118	44:06.37S	146:14.35E	2154	44:06.19S	146:14.60E
2	0027	12-MAR-93	44:00.06S	146:18.61E	300	289	0042	44:00.03S	146:18.77E	0115	43:59.97S	146:18.64E
3	0513	12-MAR-93	44:07.51S	146:14.89E	1100	1115	0549	44:07.48S	146:15.06E	0632	44:07.39S	146:15.23E
4	0854	12-MAR-93	44:27.89S	146:07.94E	2340	2335	0938	44:27.52S	146:07.30E	1028	44:27.32S	146:07.51E
5	1437	12-MAR-93	44:56.71S	145:56.67E	3380	3465	1606	44:56.10S	145:56.52E	1727	44:55.56S	145:56.36E

5.5 WOCE DATA FORMAT

This section is relevant only to data submitted to the WHP Office. For WOCE format data, file format descriptions as detailed above should be ignored. Data files submitted to the WHP Office are in the standard WOCE format as specified in Joyce and Corry (1994).

5.5.1 CTD 2 dbar-averaged data files

* CTD 2 dbar-averaged file format is as per Table 4.7 of Joyce and Corry (1994), 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.
* Files are named as in the CTD methodology, except that for WOCE format data the suffix ".all" is replaced with ".ctd".
* The quality flags for CTD data are defined in Table 5.6. Data quality information is detailed in earlier sections of this report.

5.5.2 Hydrology data files

* Hydrology data file format is as per Table 4.5 of Joyce and Corry (1994), with quality flags defined in Tables 5.7 and 5.8.
* Files are named as in the CTD methodology, except that for WOCE format data the suffix ".bot" is replaced by ".sea".
* 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.
* CTD temperature (including theta), CTD pressure and CTD salinity are all derived from upcast CTD burst data; CTD dissolved oxygen is derived from downcast 2 dbar-averaged data.
* Raw CTD pressure values are not reported.
* SAMPNO is equal to the rosette position of the Niskin bottle.
* Salinity samples rejected for conductivity calibration, as per eqn A2.20 in Rosenberg et al. (1995b), are not flagged in the .sea file.
* Dissolved oxygen samples rejected for CTD dissolved oxygen calibration, as per Tables 1.18, 2.19 and 3.18 in Parts 1, 2 and 3 respectively of this report, are not flagged in the .sea file.

5.5.3 Conversion of units for dissolved oxygen and nutrients

5.5.3.1 Dissolved oxygen

Niskin bottle data

For the WOCE format files, 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

$$C_k = 1000\, C_l / \rho(\theta,s,0) \qquad \text{(eqn 5.1)}$$

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

$$\theta = \theta(T,s,p) \qquad \text{(eqn 5.2)}$$

for the *in situ* temperature T, salinity s and pressure p values at which the Niskin bottle was fired. Note that T, s and p are upcast CTD burst data averages.

CTD data

In the WOCE format files, CTD dissolved oxygen data are converted to µmol/kg by the same method as above, except that T, s and p in eqns 5.1 and 5.2 are CTD 2 dbar-averaged data.

5.5.3.2 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

$$C_k = 1000\ C_l\ /\ \rho(T_l,s,0) \qquad \text{(eqn 5.3)}$$

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. Note that the following values were used for T_l :

cruise au9501, T_l=18.0°C
cruise au9604, T_l=19.6°C
cruise au9601, T_l=20.0°C

Upcast CTD burst data averages are used for s.

<u>Table 5.6:</u> Definition of quality flags for CTD data (after Table 4.10 in Joyce and Corry, 1994). These flags apply both to CTD data in the 2 dbar-averaged *.ctd files, and to upcast CTD burst data in the *.sea files.

flag	definition
1	not calibrated with water samples
2	acceptable measurement
3	questionable measurement
4	bad measurement
5	measurement not reported
6	interpolated over >2 dbar interval
7	despiked
8	this flag not used
9	parameter not sampled

<u>Table 5.7:</u> Definition of quality flags for Niskin bottles (i.e. parameter BTLNBR in *.sea files) (after Table 4.8 in Joyce and Corry, 1994).

flag	definition
1	this flag is not used
2	no problems noted
3	bottle leaking
4	bottle did not trip correctly
5	not reported
6,7,8	these flags are not used
9	samples not drawn from this bottle

<u>Table 5.8:</u> Definition of quality flags for water samples in *.sea files (after Table 4.9 in Joyce and Corry, 1994).

flag	definition
1	this flag is not used
2	acceptable measurement
3	questionable measurement
4	bad measurement
5	measurement not reported
6	mean of replicate measurements
7	manual autoanalyser peak measurement
8	this flag not used
9	parameter not sampled

5.5.4 Station information files

* File format is as per section 3.3 of Joyce and Corry (1994), and files are named as in the CTD methodology, except that for WOCE format data the suffix ".sta" is replaced by ".sum".
* 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. Missing depths are due to interference of the ship's bow thrusters with the echo sounder signal.
* 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.

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