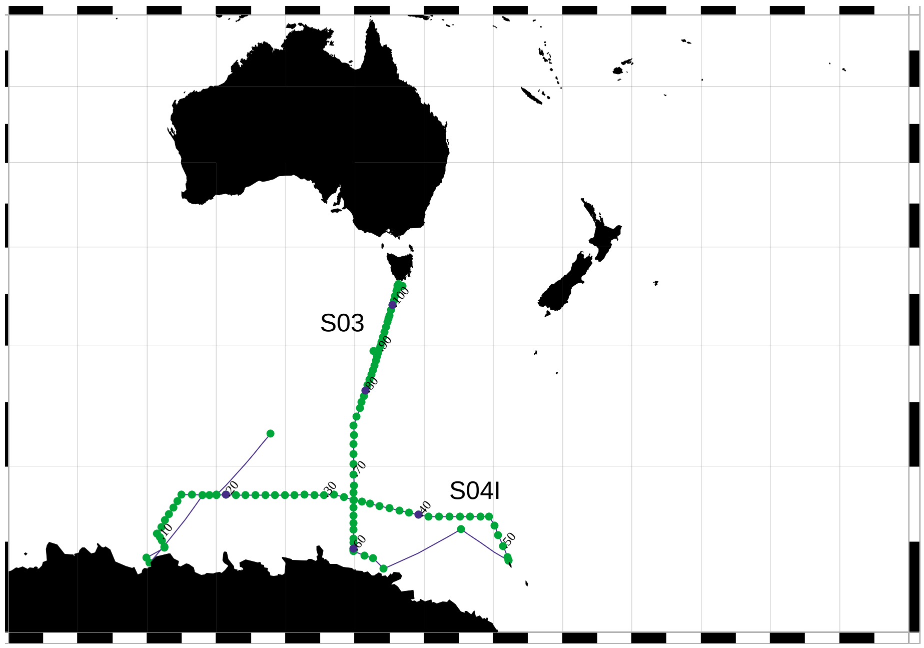
A. Cruise Narrative: S03 and S04I



A.1. Highlights

WHP Cruise Summary Information

WOCE line designation	**S03 and S04I**	
Expedition designation (ExpoCode)	**09AR9404_1**	
Chief scientist and affiliation	**Steve Rintoul/ CSIRO***	
Ship	RSV Aurora Australis	
Cruise dates	1994.DEC.13 to 1995.FEB.02	
Ports of call	Casey	
Number of stations	107	
Geographic boundaries S03	43° 59.79' S 139° 47.95' E 155° 19.95' E 66° 36.84' S	
Geographic boundaries S04I	57° 30.52' S 109° 54.21' E 162° 15.49' E 66° 15.84' S	
Floats and drifters deployed	0	
Moorings deployed or recovered	4 current meter moorings	
*CSIRO Division of Marine Research	tel:	61-3-6232-5393
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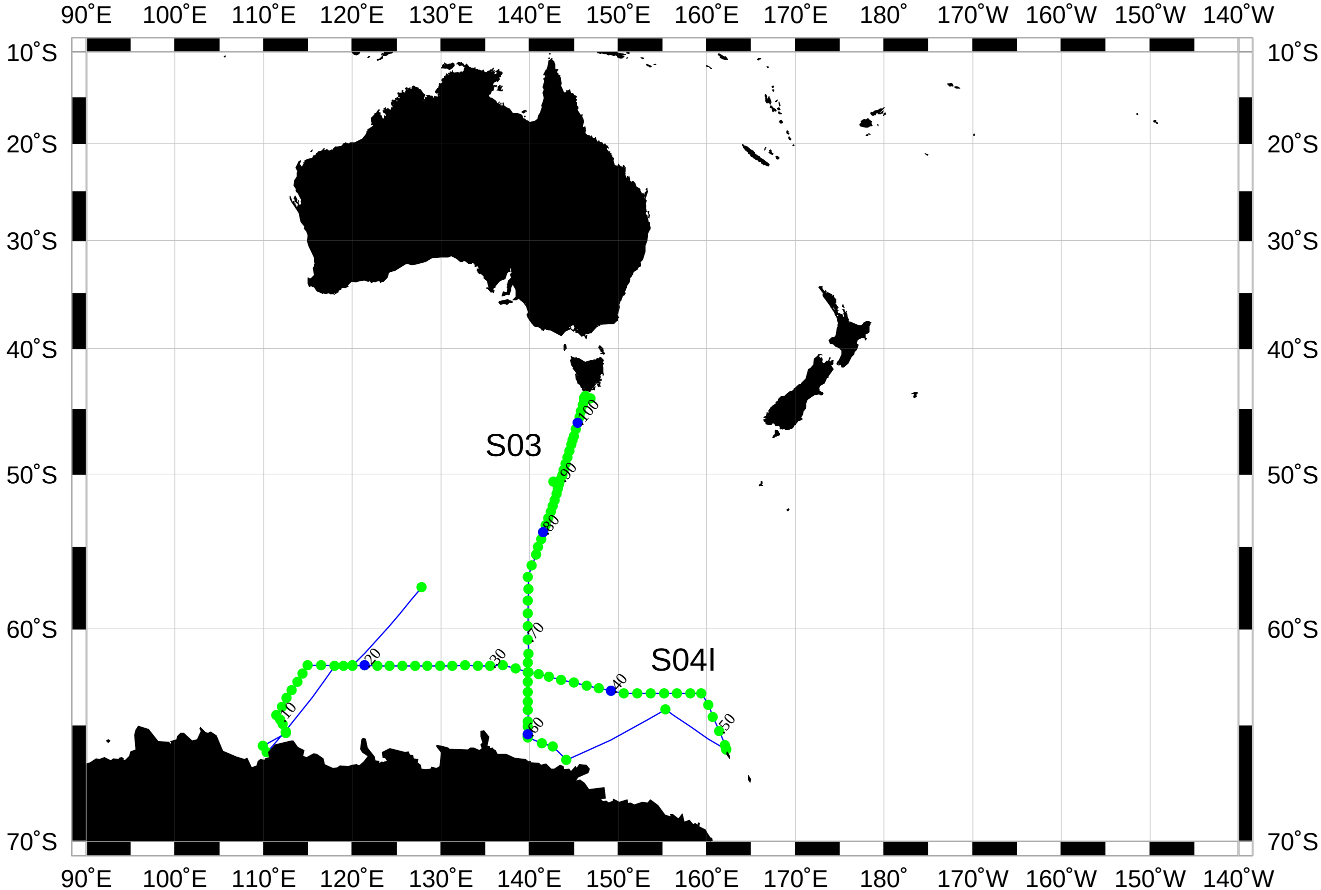
Authors	Mark Rosenberg, Steve Bell John Bullister	Ruth Eriksen, Steve Rintoul Robert Key

WHP Cruise and Data Information

Instructions: Click on any item to locate primary reference(s) or use navigation tools above.

Cruise Summary Information	Hydrographic Measurements
Description of scientific program	CTD measurements
	Conductivity
Geographic boundaries of the survey	Dissolved oxygen
Cruise track (figure)	Summary
Description of stations	CTD data quality
Description of parameters sampled	Pressure
	Salinity
	Temperature
Moorings deployed or recovered	Dissolved Oxygen
Principal Investigators for all measurements	Bottle Data
Cruise Participants	Nutrients
	CFCs
Problems and goals not achieved	
Underway Data Information	**DQE Reports**
	CTD
Bathymetry	S/O_2/nutrients
Acoustic Doppler Current Profiler (ADCP)	^{14}C
Thermosalinograph and related measurements	
XBT and/or XCTD	
Methodology and Calibrations	**References Acknowledgments**
CTD and hydrology measurements	HYD/CTD HYD/CTD
CTD Instrumentation	APNDX 2
CTD instrument calibrations	CFCs
CTD and hydrology data collection techniques	^{14}C
Water sampling methods	
Hydrology analytical methods	
	Data Processing Notes

Station locations for S03, S04I



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N.B. This Report was originally published as:

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With the exceptions of:

Arnold Mantyla's Bottle Data Quality Evaluation
John Bullister's CFC-11 and CFC-12 Report
Robert Key's AMS C14 Report
WHPO's Data Processing Notes

Author's original WOCE line numbers (S4 and SR3) were changed to S04I and S03 as established at the WOCE Data Products Committee Meeting, April 2000.

ABSTRACT

Oceanographic measurements were conducted along WOCE Southern Ocean meridional section S03 between Tasmania and Antarctica, and along the part of WOCE Southern Ocean zonal section S04I lying between approximately 110 and 162^{o}E, from December 1994 to February 1995. An array of 4 current meter moorings at approximately 51^{o}S in the vicinity of the S03 line was successfully recovered. A total of 107 CTD vertical profile stations were taken, most to near bottom. Over 2380 Niskin bottle water samples were collected for the measurement of salinity, dissolved oxygen, nutrients, chlorofluorocarbons, helium, tritium, dissolved inorganic carbon, alkalinity, carbon isotopes, dissolved organic carbon, dimethyl sulphide/dimethyl sulphoniopropionate, iodate/iodide, 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.

1 INTRODUCTION

Marine science cruise AU9404, the third 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 December 1994 to February 1995. The major constituent of the cruise was the collection of oceanographic data relevant to the Australian Southern Ocean WOCE Hydrographic Program, along WOCE sections S04I (traversed west to east) and S03 (traversed south to north) (Figure 1). The primary scientific objectives of this program are summarised in

Rosenberg et al. (1995a). Section S03 was occupied three times previously, in the spring of 1991 (Rintoul and Bullister, submitted), in the autumn of 1993 (Rosenberg et al., 1995a), and in the summer of 1993/94 (Rosenberg et al., 1995b). Zonal section S04I represents a circumnavigation of the globe in the Southern Ocean, with the various parts to be completed by different WOCE participants. The part of S04I completed on this cruise (Figure 1) was a first time occupation. At the western end of the S04I transect, seven of the stations were occupied by the Woods Hole Oceanographic Institute ship R.V. Knorr (M. McCartney, pers. comm.) several days prior to occupation by the Aurora Australis. These stations are intended to provide cross-calibrations for the tracer samples and CTD measurements collected by both vessels.

An array of four full depth current meter moorings, in the vicinity of the S03 line at the latitude of the Subantarctic Front, was successfully recovered. The moorings had been deployed in the autumn of 1993 by the Aurora Australis, and at the time of writing, have since been redeployed in the same region by the SCRIPPS ship R.V. Melville as part of a larger mooring array (principal investigators Luther, D., Chave, A., Richman, J., Filloux, J., Rintoul, S. and Church, J.). Additional CTD measurements were made at the four mooring locations.

This report describes the collection of oceanographic data from the S03 and S04I transects, and summarises the chemical analysis and data processing methods employed. Brief comparisons are also made with existing historical data. All information required for use of the data set is presented in tabular and graphical form.

2 CRUISE ITINERARY

The cruise commenced with recovery of one of the current meter moorings at ~50^o 25'S (Table 4). Increasing winds prevented further recoveries, so it was decided to continue south leaving retrieval of the remaining moorings for the return leg to Hobart. En route to the Australian Antarctic base Casey, a deep water test CTD cast was conducted, and three CTD stations were occupied along the S04I transect. An upward looking sonar mooring (Bush, 1994) (Table 5) was recovered in the vicinity of Casey; an unsuccessful attempt was made to recover an additional upward looking sonar mooring. Following approximately a week of cargo operations at Casey, the S04I transect proper commenced at ~110^{o}E. Due to time constraints, the originally planned station spacing of 30 nautical miles was increased to 45 nautical miles for most of the S04I transect. Included in the section were stations coinciding with the 7 stations occupied by the Knorr (stations 11, 12, 13, 14, 15, 16 and 17 in Table 2 correspond respectively with Knorr stations 85, 87, 88, 89, 90, 91 and 92). Also included were stations coinciding with locations sampled on the meridional sections S03 and P11 (see Rosenberg et al., 1995a, for description of the P11 transect). Favourable sea ice and weather conditions permitted conclusion of S04I in 560 m of water just off Young Island in the Balleny Island group (Figure 1).

On the return west to the start of the S03 section, a shallow test cast was conducted to test the Niskin bottles for CFC blank levels. The S03 section commenced with 4 CTD stations at various locations on the shelf in the d'Urville Sea, beginning near Commonwealth Bay. Further north, between 61.3^{o}S and 55.5^{o}S, the station spacing was again increased from 30 to 45 nautical miles, due to further time constraints. Following recovery of the remaining 3 current meter moorings (Table 4) around the Subantarctic Front and additional CTD casts at these sites, the S03 section was completed. A final CTD cast was conducted to test a suspect instrument before returning to Hobart.

3 CRUISE SUMMARY

3.1 CTD casts and water samples

In the course of the cruise, 107 CTD casts were completed along the S04I and S03 sections (Figure 1) (Table 2), plus additional locations, with most casts reaching to within 15 m of the sea floor (Table 2). Over 2380 Niskin bottle water samples were collected for the measurement of salinity, dissolved oxygen, nutrients (orthophosphate, nitrate plus nitrite, and reactive silicate), chlorofluorocarbons, helium, tritium, dissolved inorganic carbon, alkalinity, carbon isotopes (^{14}C and ^{13}C), dissolved organic carbon, dimethyl sulphide/dimethyl sulphoniopropionate, iodate/iodide, ^{18}O, primary productivity, and biological parameters, using a 24 bottle rosette sampler. Table 3 provides a summary of samples drawn at each station. Principal investigators for the various water sampling programmes are listed in Table 6a. For all stations, the different samples were drawn in a fixed sequence, as discussed in section 4.1.3. The methods for drawing samples are discussed in section 4.1.4.

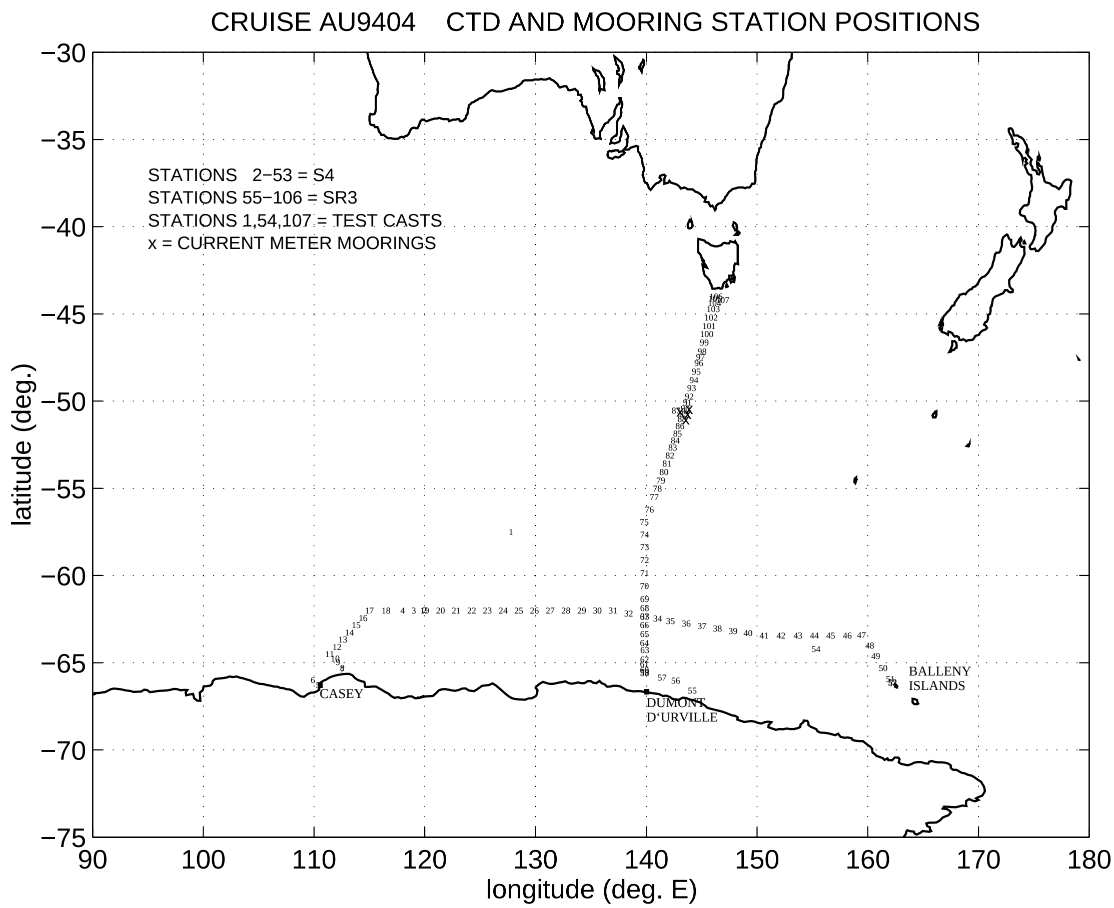


Figure 1: CTD station positions for RSV Aurora Australis cruise AU9404 along WOCE transects S04I and S03, and current meter mooring locations.

Table 2 (following 3 pages): Summary of station information for RSV Aurora Australis cruise AU9404. 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. Note that all times are UTC (i.e. GMT). CTD unit 7 (serial no. 1103) was used for stations 1 to 18; CTD unit 5 (serial no. 1193) was used for stations 19 to 106; CTD unit 6 (serial no. 2568) was used for station 107.

		START						BOTTOM						END			
Station number		time	date	latitude	longitude	depth (m)	maxP (dbar)	time	latitude	longitude	depth (m)	altimeter	time	latitude	longitude	depth (m)
1	TEST	0023	20-DEC-94	57:30.52S	127:47.81E	4690	4308	0311	57:32.11S	127:49.47E	-	-	0355	57:32.32S	127:50.31E	4700
2	S04I	1531	21-DEC-94	61:59.51S	120:00.55E	4170	4186	1700	61:59.06S	120:01.68E	4170	-	1837	61:58.78S	120:01.76E	4170
3	S04I	2147	21-DEC-94	62:00.30S	119:00.65E	4215	4266	2322	62:00.67S	119:02.14E	4215	-	0115	62:01.00S	119:04.59E	4215
4	S04I	0556	22-DEC-94	61:59.97S	118:00.14E	4260	4304	0752	62:00.30S	118:01.60E	4260	-	0949	62:00.81S	118:03.48E	4260
5	S04I	1206	2-JAN-95	66:15.84S	110:22.41E	203	182	1215	66:15.79S	110:22.35E	-	20.0	1223	66:15.73S	110:22.42E	199
6	S04I	1439	2-JAN-95	65:59.05S	109:54.21E	255	192	1516	65:59.26S	109:54.96E	183	9.7	1544	65:59.51S	109:55.07E	158
7	S04I	1412	3-JAN-95	65:23.42S	112:33.55E	482	644	1457	65:23.10S	112:33.20E	656	17.4	1548	65:22.73S	112:32.86E	737
8	S04I	1750	3-JAN-95	65:18.37S	112:32.75E	1170	1120	1835	65:18.52S	112:32.25E	1157	13.7	1939	65:17.89S	112:32.04E	1164
9	S04I	2354	3-JAN-95	64:57.93S	112:10.14E	2310	2284	0115	64:57.66S	112:09.60E	2315	13.1	0224	64:57.44S	112:09.31E	2321
10	S04I	0416	4-JAN-95	64:44.42S	111:55.21E	2250	2274	0536	64:44.88S	111:55.05E	2300	9.5	0708	64:44.82S	111:54.89E	2300
11	S04I	1002	4-JAN-95	64:30.92S	111:24.85E	2900	2866	1127	64:30.87S	111:25.77E	2860	13.5	1303	64:30.63S	111:27.38E	2860
12	S04I	1606	4-JAN-95	64:06.06S	112:05.20E	2360	2304	1704	64:06.06S	112:05.92E	2315	11.0	1829	64:06.20S	112:06.66E	2290
13	S04I	2057	4-JAN-95	63:41.02S	112:36.06E	3358	3364	2226	63:40.80S	112:36.48E	3360	12.2	0001	63:40.28S	112:35.89E	3365
14	S04I	0308	5-JAN-95	63:16.51S	113:12.28E	3590	3596	0441	63:16.50S	113:13.00E	-	13.5	0628	63:16.69S	113:13.49E	-
15	S04I	1112	5-JAN-95	62:50.95S	113:48.94E	3450	3494	1220	62:50.82S	113:49.10E	-	-	1348	62:50.58S	113:49.06E	-
16	S04I	1713	5-JAN-95	62:25.17S	114:26.07E	4080	4118	1831	62:25.33S	114:25.68E	4086	12.9	2026	62:25.95S	114:25.45E	4080
17	S04I	2304	5-JAN-95	62:00.05S	114:59.98E	4250	4286	0033	62:00.03S	115:01.00E	4255	12.6	0214	62:00.09S	115:02.40E	4245
18	S04I	0607	6-JAN-95	62:00.17S	116:29.70E	4250	4290	0744	61:59.69S	116:30.46E	4250	14.0	0936	61:59.70S	116:31.81E	4250
19	S04I	1730	6-JAN-95	61:59.98S	119:59.82E	4180	4220	1914	62:00.32S	120:01.36E	4175	12.9	2049	62:00.48S	120:02.95E	4182

START							BOTTOM						END			
Station number		time	date	latitude	longitude	depth (m)	maxP (dbar)	time	latitude	longitude	depth (m)	altimeter	time	latitude	longitude	depth (m)
20	S04I	0001	7-JAN-95	62:00.02S	121:24.93E	4153	4174	0139	61:59.80S	121:26.89E	4150	13.2	0331	61:59.70S	121:28.11E	4140
21	S04I	0711	7-JAN-95	62:00.01S	122:49.60E	4250	4290	0842	62:00.17S	122:50.44E	4250	5.5	1031	62:00.54S	122:51.60E	4250
22	S04I	1356	7-JAN-95	61:59.91S	124:14.98E	4267	4306	1520	62:00.11S	124:15.38E	4265	7.1	1704	62:00.66S	124:15.49E	4265
23	S04I	2027	7-JAN-95	61:59.92S	125:39.57E	4338	4378	2211	62:00.22S	125:39.58E	4337	18.1	2349	62:00.34S	125:39.54E	4335
24	S04I	0328	8-JAN-95	62:00.04S	127:04.94E	4360	4410	0510	62:00.44S	127:05.46E	4365	17.0	0700	62:01.13S	127:05.55E	4360
25	S04I	1033	8-JAN-95	62:00.04S	128:29.96E	4400	4448	1221	62:00.73S	128:31.57E	4400	12.3	1406	62:01.23S	128:32.95E	4400
26	S04I	1709	8-JAN-95	61:59.83S	129:54.96E	4490	4540	1903	62:00.25S	129:56.74E	4495	15.6	2041	62:00.70S	129:58.36E	4499
27	S04I	0008	9-JAN-95	62:00.07S	131:19.79E	4530	4586	0150	62:00.57S	131:20.04E	4540	15.0	0329	62:01.08S	131:20.45E	4540
28	S04I	0704	9-JAN-95	62:00.10S	132:44.80E	4460	4514	0858	61:59.92S	132:45.64E	4460	17.6	1054	62:00.09S	132:46.83E	4460
29	S04I	1454	9-JAN-95	62:01.23S	134:10.49E	4370	4414	1634	62:01.41S	134:11.11E	4370	12.4	1826	62:01.30S	134:11.22E	4370
30	S04I	2205	9-JAN-95	62:00.19S	135:35.04E	4335	4376	2359	62:00.35S	135:35.07E	4330	11.9	0151	61:59.81S	135:35.31E	-
31	S04I	0611	10-JAN-95	61:59.99S	137:00.09E	3900	3964	0800	61:59.94S	137:01.31E	3850	13.7	0949	61:59.34S	137:01.14E	3900
32	S04I	1311	10-JAN-95	62:10.08S	138:24.63E	3990	4036	1453	62:09.51S	138:27.19E	4020	14.7	1650	62:09.01S	138:29.60E	4031
33	S04I	2009	10-JAN-95	62:21.05S	139:51.96E	3950	3994	2155	62:21.54S	139:53.39E	3970	13.2	2343	62:22.09S	139:53.47E	3960
34	S04I	0357	11-JAN-95	62:28.75S	141:01.77E	4180	4230	0638	62:28.15S	141:03.29E	4205	13.4	0820	62:27.38S	141:04.32E	4210
35	S04I	1130	11-JAN-95	62:35.86S	142:11.92E	4140	4170	1335	62:35.86S	142:12.37E	4140	14.9	1515	62:35.68S	142:12.58E	4140
36	S04I	1925	11-JAN-95	62:45.08S	143:36.91E	4110	4154	2118	62:45.83S	143:36.16E	4125	14.5	2300	62:46.56S	143:36.82E	4125
37	S04I	0215	12-JAN-95	62:53.96S	145:01.65E	4030	4058	0411	62:54.22S	145:03.26E	4030	13.1	0602	62:54.13S	145:04.60E	4030
38	S04I	0910	12-JAN-95	63:03.00S	146:26.98E	3955	3982	1047	63:03.12S	146:27.96E	3955	14.6	1238	63:03.43S	146:29.37E	3955
39	S04I	1541	12-JAN-95	63:11.17S	147:50.05E	3915	3940	1728	63:10.65S	147:50.90E	3920	16.0	1858	63:10.33S	147:51.15E	3920
40	S04I	2227	12-JAN-95	63:18.27S	149:11.87E	3810	3820	0006	63:18.64S	149:12.55E	3780	12.6	0150	63:18.82S	149:12.47E	3800
41	S04I	0502	13-JAN-95	63:25.89S	150:38.93E	3765	3780	0634	63:25.89S	150:39.78E	3755	10.1	0805	63:25.59S	150:39.75E	3755
42	S04I	1116	13-JAN-95	63:26.03S	152:10.57E	3680	3694	1250	63:25.64S	152:10.83E	3680	16.5	1439	63:25.24S	152:10.98E	3680
43	S04I	1749	13-JAN-95	63:26.11S	153:41.67E	3125	3122	1902	63:26.19S	153:41.41E	3110	13.3	2019	63:26.25S	153:40.98E	3115
44	S04I	2323	13-JAN-95	63:26.10S	155:10.47E	2960	3108	0052	63:26.10S	155:10.90E	3116	13.6	0212	63:25.77S	155:11.32E	3135
45	S04I	0525	14-JAN-95	63:26.01S	156:39.18E	3230	3226	0656	63:25.85S	156:39.08E	3230	17.4	0812	63:25.75S	156:39.11E	3230
46	S04I	1147	14-JAN-95	63:26.03S	158:10.12E	2550	2638	1308	63:26.03S	158:09.91E	-	19.0	1418	63:25.62S	158:09.43E	-
47	S04I	1917	14-JAN-95	63:25.74S	159:26.55E	2710	1020	1956	63:25.64S	159:26.43E	2710	-	2010	63:25.49S	159:26.69E	2700
48	S04I	0149	15-JAN-95	64:00.62S	160:10.96E	2880	2844	0302	64:00.89S	160:10.71E	2870	20.7	0418	64:01.29S	160:11.02E	2870
49	S04I	0949	15-JAN-95	64:37.34S	160:43.55E	3050	3088	1113	64:37.32S	160:44.28E	3070	14.8	1241	64:36.91S	160:45.12E	3130
50	S04I	2005	15-JAN-95	65:17.95S	161:24.01E	3100	3096	2120	65:18.04S	161:23.80E	3100	13.8	2246	65:18.20S	161:23.80E	3100
51	S04I	0527	16-JAN-95	65:56.27S	162:03.08E	2970	2964	0648	65:56.02S	162:03.34E	2970	17.1	0803	65:55.52S	162:03.49E	2970
52	S04I	1042	16-JAN-95	66:06.84S	162:14.65E	1510	1552	1150	66:06.67S	162:14.18E	1510	14.6	1259	66:06.41S	162:13.83E	1560

START							BOTTOM						END			
Station number		time	date	latitude	longitude	depth (m)	maxP (dbar)	time	latitude	longitude	depth (m)	altimeter	time	latitude	longitude	depth (m)
53	S04I	1443	16-JAN-95	66:09.13S	162:15.49E	567	550	1505	66:09.10S	162:15.34E	568	11.0	1533	66:09.03S	162:15.18E	572
54	TEST	0301	18-JAN-95	64:13.75S	155:19.95E	3210	1038	0345	64:13.93S	155:19.70E	3210	-	0417	64:14.00S	155:19.65E	3210
55	S03	0525	19-JAN-95	66:35.97S	144:09.76E	850	812	0556	66:36.28S	144:09.63E	850	17.1	0640	66:36.84S	144:09.33E	850
56	S03	1412	19-JAN-95	66:00.55S	142:39.77E	455	436	1441	66:00.51S	142:39.20E	458	14.1	1505	66:00.64S	142:39.06E	460
57	S03	1910	19-JAN-95	65:50.53S	141:25.71E	332	308	1920	65:50.58S	141:25.58E	329	14.6	1950	65:50.44S	141:24.97E	335
58	S03	2312	19-JAN-95	65:34.98S	139:51.24E	595	526	2338	65:35.12S	139:50.37E	528	11.5	0013	65:35.43S	139:49.25E	436
59	S03	0137	20-JAN-95	65:32.24S	139:51.19E	1300	1242	0234	65:32.49S	139:51.11E	1300	17.4	0337	65:32.58S	139:50.69E	1260
60	S03	0444	20-JAN-95	65:25.93S	139:50.77E	1875	1988	0550	65:26.26S	139:50.68E	1950	19.2	0654	65:26.48S	139:51.07E	-
61	S03	0905	20-JAN-95	65:04.98S	139:50.83E	2795	2750	1020	65:04.75S	139:51.64E	2680	17.5	1131	65:04.35S	139:52.41E	2590
62	S03	1304	20-JAN-95	64:49.03S	139:50.94E	2600	2570	1417	64:49.40S	139:49.38E	2585	12.0	1538	64:50.10S	139:47.95E	2530
63	S03	1819	20-JAN-95	64:16.92S	139:52.08E	3470	3472	1930	64:17.16S	139:51.31E	3465	11.8	2047	64:17.20S	139:51.36E	3465
64	S03	2301	20-JAN-95	63:51.92S	139:50.81E	3743	3758	0042	63:51.57S	139:52.15E	3748	13.9	0242	63:51.27S	139:54.55E	3748
65	S03	0528	21-JAN-95	63:21.19S	139:50.91E	3820	3832	0653	63:21.70S	139:50.47E	3810	13.0	0828	63:22.16S	139:51.22E	3810
66	S03	1051	21-JAN-95	62:51.09S	139:50.70E	3220	3224	1216	62:50.85S	139:51.08E	3230	17.0	1348	62:50.61S	139:51.54E	3250
67	S03	1659	21-JAN-95	62:20.78S	139:50.44E	3970	3988	1821	62:20.45S	139:49.66E	3960	15.4	1946	62:20.20S	139:49.60E	3960
68	S03	2215	21-JAN-95	61:50.98S	139:51.26E	4300	4338	0001	61:51.09S	139:51.16E	4301	15.1	0145	61:51.32S	139:51.11E	4300
69	S03	0426	22-JAN-95	61:21.06S	139:51.48E	4340	4390	0608	61:21.89S	139:53.30E	4340	14.9	0744	61:22.57S	139:54.52E	4345
70	S03	1124	22-JAN-95	60:35.99S	139:50.67E	4440	4472	1258	60:36.15S	139:49.93E	4435	14.1	1449	60:35.91S	139:48.93E	4430
71	S03	1815	22-JAN-95	59:50.90S	139:50.94E	4485	4532	2006	59:50.88S	139:51.78E	4480	11.0	2139	59:51.12S	139:52.93E	4480
72	S03	0121	23-JAN-95	59:05.96S	139:51.25E	3950	3954	0308	59:05.67S	139:51.61E	3905	12.9	0440	59:05.94S	139:51.86E	3925
73	S03	0818	23-JAN-95	58:21.11S	139:51.22E	4000	4082	0944	58:21.07S	139:51.71E	4020	12.1	1103	58:20.91S	139:52.44E	4000
74	S03	1734	23-JAN-95	57:38.75S	139:51.77E	4250	4134	1921	57:38.83S	139:52.72E	-	16.4	2055	57:38.99S	139:53.62E	-
75	S03	0400	24-JAN-95	56:55.80S	139:49.74E	4100	4066	0551	56:56.10S	139:49.69E	-	-	0726	56:56.07S	139:50.39E	-
76	S03	1258	24-JAN-95	56:12.73S	140:17.60E	3620	3658	1433	56:12.03S	140:17.54E	-	15.1	1609	56:11.60S	140:17.12E	-
77	S03	1935	24-JAN-95	55:30.06S	140:44.00E	3915	4186	2116	55:30.07S	140:44.29E	-	19.9	2243	55:30.03S	140:44.65E	-
78	S03	0154	25-JAN-95	55:00.82S	141:00.81E	3300	3164	0323	55:00.48S	141:00.91E	3200	16.1	0442	55:00.58S	141:00.81E	3200
79	S03	0712	25-JAN-95	54:32.38S	141:19.09E	2850	2784	0842	54:31.26S	141:19.08E	2825	17.4	0947	54:30.95S	141:18.25E	2910
80	S03	1224	25-JAN-95	54:03.87S	141:35.86E	2600	2732	1351	54:03.33S	141:36.00E	2720	17.5	1511	54:02.98S	141:35.93E	2720
81	S03	1753	25-JAN-95	53:35.18S	141:52.10E	2590	2542	1912	53:34.95S	141:53.05E	2490	15.9	2016	53:35.00S	141:53.20E	2515
82	S03	2305	25-JAN-95	53:07.90S	142:08.18E	3125	3142	0015	53:07.52S	142:08.51E	3150	16.1	0130	53:07.48S	142:08.64E	3150
83	S03	0402	26-JAN-95	52:40.06S	142:23.46E	3400	3396	0525	52:40.31S	142:24.37E	3400	10.1	0649	52:40.48S	142:24.41E	3390
84	S03	0906	26-JAN-95	52:15.97S	142:38.13E	3500	3532	1008	52:15.82S	142:38.72E	3500	13.6	1118	52:16.00S	142:40.31E	3520
85	S03	1336	26-JAN-95	51:51.13S	142:50.05E	3620	3650	1517	51:51.45S	142:51.75E	3610	14.1	1650	51:51.78S	142:52.86E	3615

Station number		START						BOTTOM					END			
		time	date	latitude	longitude	depth (m)	maxP (dbar)	time	latitude	longitude	depth (m)	altimeter	time	latitude	longitude	depth (m)
86	S03	0950	27-JAN-95	51:26.06S	143:02.99E	3730	3782	1113	51:25.95S	143:03.69E	3750	13.0	1237	51:26.29S	143:03.88E	3710
87	S03	1752	27-JAN-95	50:33.31S	142:41.33E	3830	3844	1938	50:33.09S	142:43.09E	3800	14.8	2121	50:32.49S	142:44.91E	-
88	S03	0635	28-JAN-95	51:01.97S	143:13.93E	3800	3892	0814	51:02.60S	143:13.85E	-	11.3	0927	51:02.71S	143:13.74E	-
89	S03	1121	28-JAN-95	50:43.05S	143:24.06E	3650	3726	1250	50:43.21S	143:24.39E	3650	13.2	1424	50:43.53S	143:24.69E	3665
90	S03	1647	28-JAN-95	50:24.88S	143:32.04E	3588	3604	1822	50:25.23S	143:33.00E	3608	15.5	1938	50:25.72S	143:33.82E	-
91	S03	2151	28-JAN-95	50:05.08S	143:43.24E	4060	4038	2350	50:04.80S	143:44.91E	-	16.7	0114	50:04.65S	143:45.64E	-
92	S03	0318	29-JAN-95	49:44.03S	143:52.96E	3540	3502	0450	49:43.11S	143:54.13E	3400	19.9	0601	49:42.90S	143:54.66E	3510
93	S03	1155	29-JAN-95	49:16.03S	144:06.03E	4225	4346	1345	49:15.50S	144:07.83E	-	16.5	1532	49:15.26S	144:09.02E	-
94	S03	1818	29-JAN-95	48:47.02S	144:19.01E	4150	4218	2015	48:46.58S	144:19.20E	4160	15.8	2146	48:46.36S	144:19.40E	4140
95	S03	0153	30-JAN-95	48:18.66S	144:32.00E	4005	4070	0337	48:18.45S	144:31.86E	4000	4.4	0519	48:18.95S	144:33.03E	4095
96	S03	0745	30-JAN-95	47:48.04S	144:45.07E	3925	3932	0931	47:47.88S	144:46.14E	3850	9.9	1058	47:47.73S	144:45.82E	3850
97	S03	1238	30-JAN-95	47:27.94S	144:53.89E	4270	4354	1432	47:27.23S	144:53.70E	-	14.6	1616	47:26.69S	144:53.94E	-
98	S03	1852	30-JAN-95	47:09.06S	145:02.97E	4000	4012	2039	47:09.04S	145:03.06E	-	16.4	2210	47:08.97S	145:02.97E	-
99	S03	0041	31-JAN-95	46:38.89S	145:15.06E	3350	3374	0215	46:38.16S	145:15.37E	3350	14.7	0333	46:37.65S	145:14.88E	3350
100	S03	0545	31-JAN-95	46:09.92S	145:28.08E	2730	2778	0658	46:09.22S	145:27.90E	2770	17.3	0807	46:08.87S	145:27.54E	2770
101	S03	1019	31-JAN-95	45:41.77S	145:40.32E	2000	1962	1130	45:41.64S	145:40.36E	1875	19.5	1221	45:41.37S	145:40.21E	1820
102	S03	1438	31-JAN-95	45:13.01S	145:51.10E	2860	2892	1601	45:13.40S	145:50.37E	-	13.8	1715	45:13.78S	145:50.16E	2800
103	S03	1948	31-JAN-95	44:42.98S	146:03.06E	3200	3220	2119	44:42.58S	146:01.93E	3190	15.1	2233	44:42.36S	146:01.16E	3210
104	S03	0043	1-FEB-95	44:22.95S	146:10.85E	2345	2344	0157	44:22.98S	146:11.01E	2345	14.1	0301	44:22.98S	146:11.02E	2345
105	S03	0431	1-FEB-95	44:06.89S	146:12.99E	1000	1012	0522	44:07.16S	146:13.24E	1010	17.2	0556	44:07.50S	146:13.26E	1070
106	S03	0707	1-FEB-95	44:00.00S	146:19.01E	254	228	0723	43:59.86S	146:18.95E	255	10.1	0749	43:59.79S	146:19.06E	255
107	TEST	1047	1-FEB-95	44:11.83S	146:54.77E	1200	1142	1136	44:11.71S	146:55.01E	1180	60.0	1226	44:12.08S	146:55.15E	1233

Table 3: Summary of samples drawn from Niskin bottles at each station, including salinity (sal), dissolved oxygen (do), nutrients (nut), chlorofluorocarbons (CFC), helium/tritium (He/Tr), dissolved inorganic carbon (dic), alkalinity (alk), carbon isotopes (Ctope), dissolved organic carbon (doc), dimethyl sulphide/dimethyl sulphoniopropionate (dms), iodate/iodide (i), ^{18}O, primary productivity (pp), "Seacat" casts (cat), and the following **biological samples**: pigments (pig), lugols iodine fixed plankton counts (lug), Coulter counter for particle sizing (cc), bacteria counts (bac), samples to determine presence of viruses inside algae (vir), flow cytometry (fc), video recording (vid), samples for culturing (cul), and transmission electron microscopy (te). Note that 1=samples taken, 0=no samples taken, 2=surface sample only (i.e. from shallowest Niskin bottle); and some biology samples taken from a surface bucket only. Also note that at stations 33, 50, 58, 67, 81 and 94, primary productivity samples were additionally filtered to measure d.o.c. content.

															biology								
sta		sal	do	nut	CFC	He/Tr	dic/alk	Ctope	doc	dms	i	^{18}O	pp	cat	pig	lug	cc	bac	vir	fc	vid	cul	te
1	Test	1	1	1	1	1	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0
2	S04I	1	1	1	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
3	S04I	1	1	1	0	0	0	0	0	0	1	0	1	1	0	1	0	1	1	0	1	0	0
4	S04I	1	1	1	1	0	1	0	0	1	1	0	1	1	0	1	0	1	1	0	1	0	1
5	S04I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	S04I	1	1	1	1	1	0	0	0	0	1	1	1	1	1	1	1	1	1	0	1	0	0
7	S04I	1	1	1	1	1	0	0	0	0	1	1	1	1	1	1	0	1	1	0	1	0	0
8	S04I	1	1	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
9	S04I	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	S04I	1	1	1	1	0	0	0	0	0	1	0	1	1	1	1	0	1	1	0	1	0	0
11	S04I	1	1	1	1	1	1	1	0	0	0	1	0	0	1	1	0	1	1	0	0	0	0
12	S04I	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0
13	S04I	1	1	1	0	0	1	0	0	0	1	0	1	1	1	1	1	1	1	0	1	0	1
14	S04I	1	1	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
15	S04I	1	1	1	0	0	1	0	0	0	0	0	0	0	1	1	1	1	1	0	1	0	0
16	S04I	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	S04I	1	1	1	1	1	1	1	0	0	1	1	1	0	1	1	0	1	1	0	0	0	0

														biology								
sta		sal	do	nut	CFC	He/Tr	dic/alk	Ctope	doc	dms	i	^{18}O	pp	cat	pig	lug	cc	bac	vir	fc	vid	cul	te
18	S04I	1	1	1	1	0	0	0	0	1	0	0	1	1	1	1	0	1	1	0	1	0	0
19	S04I	1	1	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
20	S04I	1	1	1	0	0	1	0	0	0	1	0	1	1	1	1	0	1	1	0	1	0	0
21	S04I	1	1	1	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
22	S04I	1	1	1	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	1	1	0
23	S04I	1	1	1	1	1	1	1	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0
24	S04I	1	1	1	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	1	0	1
25	S04I	1	1	1	1	0	1	0	0	1	1	0	0	0	1	0	1	1	1	0	0	0	0
26	S04I	1	1	1	1	0	0	0	0	0	1	0	1	1	1	1	1	1	1	0	1	0	0
27	S04I	1	1	1	1	1	1	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
28	S04I	1	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
29	S04I	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	S04I	1	1	1	0	0	0	0	0	0	1	0	1	0	1	1	1	1	1	0	1	1	1
31	S04I	1	1	1	1	1	1	1	0	0	0	1	0	0	1	0	0	0	0	0	1	1	0
32	S04I	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33	S04I	1	1	1	1	1	1	1	0	1	1	1	1	1	1	0	1	1	1	0	1	0	0
34	S04I	1	1	1	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	1	1	0
35	S04I	1	1	1	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0
36	S04I	1	1	1	0	0	0	0	0	0	1	0	1	1	1	1	1	1	1	0	1	1	1
37	S04I	1	1	1	1	1	1	1	0	0	0	1	0	0	1	0	0	0	0	0	1	1	0
38	S04I	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
39	S04I	1	1	1	1	0	1	0	0	0	1	0	1	1	1	1	1	1	1	0	1	0	0
40	S04I	1	1	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0
41	S04I	1	1	1	1	1	1	1	0	1	0	1	1	1	1	1	1	1	1	0	0	0	0
42	S04I	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
43	S04I	1	1	1	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
44	S04I	1	1	1	0	0	0	0	0	0	0	0	1	1	1	0	1	1	1	0	1	0	1
45	S04I	1	1	1	1	1	1	1	0	0	0	1	0	0	1	0	1	1	1	0	1	0	0
46	S04I	1	1	1	1	0	0	0	0	0	0	0	0	0	1	0	1	1	1	0	1	1	0
47	S04I	1	1	1	1	0	1	0	0	0	1	0	1	0	1	0	0	0	0	0	1	0	0

															biology								
	sta	sal	do	nut	CFC	He/Tr	dic/alk	Ctope	doc	dms	i	^{18}O	pp	cat	pig	lug	cc	bac	vir	fc	vid	cul	te
48	S04I	1	1	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
49	S04I	1	1	1	1	1	1	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
50	S04I	1	1	1	1	0	2	0	0	0	1	0	1	1	1	1	1	1	1	0	0	1	0
51	S04I	1	1	1	1	1	1	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
52	S04I	1	1	1	1	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	1	1	1
53	S04I	1	1	1	0	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
54	TEST	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55	S03	1	1	1	1	1	1	1	0	1	0	1	1	0	1	0	1	1	1	0	0	0	0
56	S03	1	1	1	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	1	1	1
57	S03	1	1	1	0	0	1	0	0	0	1	1	0	0	1	0	0	0	0	0	1	1	0
58	S03	1	1	1	1	1	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0
59	S03	1	1	1	1	0	0	0	0	0	0	1	0	0	1	0	1	1	1	1	0	0	0
60	S03	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0
61	S03	1	1	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
62	S03	1	1	1	1	0	0	0	0	0	1	1	0	0	1	0	0	0	0	1	1	1	0
63	S03	1	1	1	1	1	1	1	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0
64	S03	1	1	1	0	0	2	0	1	0	0	0	1	1	1	1	1	1	1	1	1	1	0
65	S03	1	1	1	1	1	1	0	0	1	0	1	0	0	1	0	0	0	0	1	1	1	0
66	S03	1	1	1	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	1	1	1	0
67	S03	1	1	1	1	0	1	1	0	0	1	0	1	1	1	0	0	0	0	0	1	0	0
68	S03	1	1	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	1	0
69	S03	1	1	1	1	1	1	1	0	1	0	1	0	0	1	0	1	1	1	1	1	1	0
70	S03	1	1	1	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	1	1	1	0
71	S03	1	1	1	1	0	1	0	0	0	1	0	1	1	1	0	1	1	1	1	1	1	0
72	S03	1	1	1	1	0	2	0	1	0	0	0	1	1	1	1	1	1	1	1	1	0	0
73	S03	1	1	1	1	1	1	1	0	1	0	1	0	0	1	0	0	0	0	1	1	1	0
74	S03	1	1	1	1	0	2	0	0	0	1	0	1	0	1	0	1	1	1	1	1	0	1
75	S03	1	1	1	1	0	1	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1
76	S03	1	1	1	1	0	2	0	0	0	1	0	0	0	1	0	0	0	0	1	0	0	0
77	S03	1	1	1	1	1	1	1	0	1	1	1	1	1	1	0	0	0	0	1	1	0	0

sta		sal	do	nut	CFC	He/Tr	dic/alk	Ctope	doc	dms	i	^{18}O	pp	cat	pig	lug	cc	bac	vir	fc	vid	cul	te
															biology								
78	S03	1	1	1	0	0	0	0	1	0	0	0	1	1	1	1	1	1	1	1	1	0	0
79	S03	1	1	1	1	0	1	0	0	0	1	0	0	0	1	0	0	0	0	1	0	0	0
80	S03	1	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	1	0
81	S03	1	1	1	1	1	1	1	0	0	1	1	1	1	1	0	1	1	1	1	0	1	0
82	S03	1	1	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0
83	S03	1	1	1	1	0	1	0	0	0	1	0	1	1	1	1	1	1	1	1	1	1	0
84	S03	1	1	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	1	0	1
85	S03	1	1	1	1	1	1	1	0	0	1	1	0	0	1	0	0	0	0	1	1	1	1
86	S03	1	1	1	1	0	1	0	0	1	0	0	0	0	1	0	0	0	0	1	1	1	0
87	S03	1	1	1	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	1	0	0	0
88	S03	1	1	1	1	0	0	0	0	1	1	0	0	0	1	0	0	0	0	1	0	0	0
89	S03	1	1	1	1	1	1	1	0	0	0	1	0	0	1	0	0	0	0	1	0	0	0
90	S03	1	1	1	0	0	0	0	1	0	1	0	1	1	1	0	1	1	1	1	1	0	0
91	S03	1	1	1	1	0	1	0	0	1	1	0	1	1	1	0	0	0	0	0	1	0	0
92	S03	1	1	1	1	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0
93	S03	1	1	1	1	1	1	1	0	0	1	1	0	0	1	0	0	0	0	0	1	0	0
94	S03	1	1	1	1	0	0	0	0	1	1	0	1	1	1	0	0	0	0	0	0	0	0
95	S03	1	1	1	1	0	1	0	0	0	1	0	0	0	1	0	1	1	1	0	0	0	0
96	S03	1	1	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
97	S03	1	1	1	1	1	1	1	0	0	1	1	0	0	1	0	0	0	0	1	0	0	0
98	S03	1	1	1	1	0	0	0	1	0	1	0	1	1	1	0	0	0	0	1	0	0	0
99	S03	1	1	1	1	0	1	0	0	1	0	0	1	1	1	1	1	1	1	1	0	0	0
100	S03	1	1	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
101	S03	1	1	1	1	1	1	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
102	S03	1	1	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
103	S03	1	1	1	1	0	1	0	1	0	1	0	1	1	1	0	0	0	0	0	0	0	0
104	S03	1	1	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
105	S03	1	1	1	1	0	1	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
106	S03	1	1	1	0	0	2	0	0	0	1	0	1	1	1	0	0	0	0	0	0	0	0
107	Test	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 4: Current meter moorings recovered along S03 transect (positions given are at times of deployment). Recovery times are for last mooring component.

site name	Recovery time (UTC)	bottom depth (m)	latitude	longitude	current meter depths (m).	nearest CTD station no
SO2	03:52, 28/01/95	3770	50° 33.19'S	142° 42.49'E	300	87 S03
						600
						1000
						2000
						3200
SO3	00:42, 27/01/95	3800	51° 01.54'S	143° 14.35'E	300	88 S03
						600
						1000
						2000
						3200
SO4	05:57, 27/01/95	3580	50° 42.73'S	143° 24.15'E	300	89 S03
						600
						1000
						2000
						3200
SO5	~09:30, 15/12/94	3500	50° 24.95'S	143° 31.97'E	1000	90 S03
						2000
						3200

Table 5: Upward looking sonar (ULS) mooring recovered (including current meter [CM]) (positions given are at times of deployment). Recovery time is for last mooring component.

site name	recovery time (UTC)	bottom depth (m)	latitude	longitude	instrument depths (m)	CTD station no.
SOFAR	01:15, 24/12/94	3260	63° 17.746'S	107° 49.429'E	150 (ULS)	-
					200 (CM)	
SONEAR	failed to recover					-

3.2 Moorings recovered

An array of four current meter moorings was recovered (Table 4) along the S03 transect line. A single upward looking sonar mooring was recovered near Casey; an unsuccessful attempt was made to locate a second upward looking sonar mooring (Table 5).

3.3 XBT/XCTD deployments

A total of 43 XBT and 26 XCTD deployments were made along the S03 transect. The data were processed further by CSIRO Division of Oceanography (R. Bailey, pers. comm.). Results are not reported here.

3.4 Principal investigators

The principal investigators for the CTD and water sample measurements are listed in Table 6a. Cruise participants are listed in Table 6b.

Table 6a: Principal investigators (*=cruise participant) for water sampling programmes.

Measurement	name	affiliation
CTD, salinity, O_2, nutrients	*Steve Rintoul	CSIRO
chlorofluorocarbons	John Bullister	NOAA, U.S.A.
helium, tritium, ^{18}O	Peter Schlosser	LDEO, USA
D.I.C., alkalinity, carbon isotopes	*Bronte Tilbrook	CSIRO
D.O.C.	Tom Trull	Antarctic CRC
D.M.S.	Graham Jones	James Cook University
iodate/iodide	Ed Butler	CSIRO
primary productivity	John Parslow	CSIRO
biological sampling	*Simon Wright	Antarctic Division

Table 6b: Scientific personnel (cruise participants).

name	measurement	affiliation
Ian Knott	CTD, electronics	Antarctic CRC
Simon Marsland	CTD	Antarctic CRC
Phil Morgan	CTD	CSIRO
Steve Rintoul	CTD, moorings	CSIRO
Mark Rosenberg	CTD, moorings	Antarctic CRC
Tim Vizer	CTD	Antarctic CRC
Andrew Woolf	CTD	Antarctic CRC
Steve Bell	salinity, oxygen, nutrients	Antarctic CRC
Ruth Eriksen	salinity, oxygen, nutrients	Antarctic CRC
Adam Leggett	oxygen	Melbourne University
Craig Neill	CFC	NOAA
David Wisegarver	CFC	NOAA
Dee Breger	helium, tritium, ^{18}O	LDEO
Brendan Coutts	D.I.C., alkalinity, C isotopes	Antarctic CRC

name	measurement	affiliation
Roger Dargaville	D.I.C., alkalinity, C isotopes	Melbourne University
Bronte Tilbrook	D.I.C., alkalinity, C isotopes	CSIRO
Susannah Hunter	D.O.C.	Antarctic CRC
Mark Curran	D.M.S.	James Cook University
Megan McDonald	D.M.S.	James Cook University
Anna Brandao	iodate/iodide	Antarctic CRC
Pru Bonham	primary productivity	CSIRO
Fiona Scott	biological sampling	Antarctic Division
Peter Pendoley	biological sampling	Antarctic Division
Simon Wright	deputy voyage leader, biological sampling	Antarctic Division
David James	ornithology	RAOU
Tim Reid	ornithology	RAOU
Rob Easther	voyage leader	Antarctic Division
Vera Hansper	computing	Antarctic Division
David Little	doctor	Antarctic Division
Tim Osborne	computing	Antarctic Division
Andrew Tabor	gear officer, moorings	Antarctic Division
Mark Underwood	electronics	Antarctic Division
Adam Connolly	reporter	The Mercury

LDEO Lamont-Doherty Earth Observatory
RAOU Royal Australasian Ornithologists Union

4 FIELD DATA COLLECTION METHODS

4.1 CTD and hydrology measurements

In this section, CTD, hydrology, and ADCP data collection and processing methods are discussed. Preliminary results of the CTD data calibration, along with data quality information, are presented in Section 6.

4.1.1 CTD Instrumentation

The CTD instrumentation is described in Rosenberg et al. (1995b). Briefly, General Oceanics Mark IIIC (i.e. WOCE upgraded) CTD units were used. A 24 position rosette package, including a General Oceanics model 1015 pylon, and 10 litre General Oceanics Niskin bottles, was deployed for all casts. Deep sea reversing thermometers (Gohla-Precision) were mounted at rosette positions 2, 12 and 24. A Sea-Tech fluorometer and Li-Cor photosynthetically active radiation sensor were also attached to the package for some casts (Table 22).

4.1.2 CTD instrument and data calibration

Complete calibration information for the CTD pressure, platinum temperature and pressure temperature sensors are presented in Appendix 1. Pre cruise pressure and platinum temperature calibrations were available for all three CTD units, performed at the CSIRO Division of Oceanography Calibration Facility, with the exception of CTD unit 6, where manufacturer supplied platinum temperature calibration coefficients were used for the single test cast where this instrument was used. Pre cruise manufacturer supplied calibrations of the pressure temperature sensors were used for the cruise data. Note that readings from this sensor are applied in a correction formula for pressure data. The complete CTD conductivity and 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 fluorescence and p.a.r. data (Appendix 1). These calibrations are not expected to be correct - correct scaling of fluorescence and p.a.r. data awaits linkage with primary productivity and Seacat (section 3.2) data.

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). Note however 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) 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 previous cruises, jmin=10);

(iii) in the conductivity calibration for some stations, 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.

4.1.3 CTD and hydrology data collection techniques

Data collection techniques are described in Rosenberg et al. (1995b). A fixed sequence was followed for the drawing of water samples on deck, as follows:

first sample: CFC
D.O.C
dissolved oxygen
DMS/DMSP
helium
D.I.C.
alkalinity
carbon isotopes
primary productivity
salinity
nutrients
iodate/iodide
^{18}O
tritium
last sample: biology

(see Table 3 for a summary of which samples were drawn at each station).

4.1.4 Water sampling methods

The methods used for drawing the various water samples from the Niskin bottles are described here.

Chlorofluorocarbons:

100 ml samples are taken using precision ground glass syringes, following a series of rinses; care is taken to ensure bubble free samples.

Dissolved organic carbon:

Sample jar volume = 250 ml (jars baked for 12 hours at 550^{o}C)
During d.o.c. sampling, polyethylene gloves were worn by the sampler. The gloves were changed every second sample.

* rinse spiggot copiously with sample water
* rinse sample jar twice
* fill jar with ~200 ml and screw cap on tightly

After sampling, the jars are stored in the dark in a freezer at -18^{o}C.

***Dissolved oxygen**:*

sample bottle volume = 150 ml

Bottles are washed and left partially filled with fresh water before use. Tight fitting silicon tubing is attached to the Niskin spiggot for sample drawing. Pickling reagent 1 is 3 M $MnCl_2$ (1.0 ml used); reagent 2 is 8 N NaOH/4 M NaI (1.0 ml used); reagent 3 is 10 N H_2SO_4 (1.0 ml used).

* start water flow through tube for several seconds, making sure no bubbles remain in tube
* pinch off flow in tube, and insert into bottom of sample bottle
* let flow commence slowly into bottle, gradually increasing by releasing tubing, at all times ensuring no bubbles enter the sample and that turbulence is kept to a minimum
* fill bottle, overflow by at least one full volume
* pinch off tube and slowly remove so that bottle remains full to the brim, then rinse glass stopper
* immediately pickle with reagents 1 then 2, inserting reagent dispenser at least 1 cm below water surface
* insert glass stopper, ensuring no bubbles are trapped in sample
* thoroughly shake sample (at least 30 vigorous inversions)
* store samples in the dark until analysis
* acidify samples with reagent 3 immediately prior to analysis

***DMS and DMSP**:*

Sample containers are quickly rinsed, then filled. For shallow samples only, a 750 ml amber glass bottle is used. For full profile sampling, samples for filtering are collected in 250 ml polyethylene screwcap jars; unfiltered samples are collected in 140 ml amber glass bottles.

***Helium**:*

Plastic tubing is attached to both ends of a 2 foot length of copper tubing, with one of the plastic tubes attached to the Niskin spiggot. The copper tube is self flushed as air bubbles work out of the intake tube; the copper and plastic tube are struck to ensure no bubbles are trapped during filling. The plastic hoses are clamped, and the assembly removed to a hydraulic press where the copper tube is cut and crimped at either end, and in the middle.

***Dissolved inorganic carbon**:*

sample bottle volume = 250 ml

Tight fitting silicon tubing is attached to the Niskin spiggot for sample drawing. Samples are poisoned with 100 ml of a saturated solution of $HgCl_2$.

* drain remaining old sample from the bottle
* start water flow through tube for several seconds, making sure no bubbles remain in tube

* insert tube into bottom of inverted sample bottle, allowing water to flush bottle for several seconds
* pinch off flow in tube, and invert sample bottle to upright position, keeping tube in bottom of bottle
* let flow commence slowly into bottle, gradually increasing, at all times ensuring no bubbles enter the sample
* fill bottle, overflow by one full volume, and rinse cap
* shake a small amount of water from top, so that water level is between threads and bottle shoulder
* insert tip of poison dispenser just into sample, and poison
* screw on cap, and invert bottle several times to allow poison to disperse through sample

***Alkalinity**:*

These are sampled and poisoned in the same fashion as dissolved inorganic carbon, except that 500 ml bottles are used.

***Carbon Isotopes**:*

These are sampled and poisoned in the same fashion as dissolved inorganic carbon, except that 500 ml glass stoppered vacuum flasks are used, and vacuum grease is placed around the stopper before inserting.

***Primary productivity**:*

Sampled from casts taken during daylight hours; samples were drawn for analysis of primary productivity and suspended particle size (taken from the shallowest four Niskin bottles). At most primary productivity sites, a Seabird "Seacat" CTD was deployed to obtain vertical profiles of photosynthetically active radiation (p.a.r.) and fluorescence from the top part of the water column. For primary productivity samples, 500 ml blacked out plastic jars are quickly rinsed then gently filled with ~400 ml of water through a length of tubing attached to the Niskin spiggot. Samples for particle size analysis are collected in 250 ml plastic bottles (with a single quick rinse prior to filling).

***Salinity**:*

sample bottle volume = 300 ml

* drain remaining old sample from the bottle (bottles are always stored approximately 1/3 full with water between stations)
* rinse bottle and cap 3 times with 100 ml of sample (shaking thoroughly each time); on each rinse, contents of sample bottle are poured over the Niskin bottle spiggot
* fill bottle with sample, to bottle shoulder, and screw cap on firmly

At all filling stages, care is taken not to let the Niskin bottle spiggot touch the sample bottle.

***Nutrients**:*

sample tube volume = 12 ml

Two nutrient sample tubes are filled simultaneously at each Niskin bottle.
* rinse tubes and caps 3 times
* fill tubes
* shake out water from tubes so that water level is at or below marking line 2 cm below top of tubes (10 ml mark), and screw on caps firmly

After sampling, one set of tubes are refrigerated for analysis within 12 hours; the duplicate set of tubes are placed in a freezer until required.

***Iodate**:*
same as for nutrients

***Iodide**:*
same as for nutrients, except 100 ml plastic bottle used.

***^{18}O**:*

Sample bottle volume = 20 ml

Sample bottles given 3 quick rinses, then filled.

***Tritium**:*

1 litre argon-filled bottles are filled to the top, minus headspace.

***Biological sampling**:*

Several different analyses were performed on the biological water samples, as listed in Table 3. Biological samples were usually drawn from the shallowest four or five Niskin bottles, with additional samples collected from a surface bucket.

4.1.5 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 (300 ml bottles had been used previously), and 1.0 ml of reagents 1, 2 and 3 were used (2.0 ml used previously); the corresponding calculation value for the total amount of oxygen added with the reagents = 0.017 ml (0.034 ml previously);

(ii) exact oxygen sample bottle volumes were individually measured, and applied for each individual bottle in the calculation of dissolved oxygen concentration.

4.2 Underway measurements

Throughout the cruise, the ship's data logging system continuously recorded bottom depth, ship's position and motion, surface water properties and meteorological information. All measurements were quality controlled during the cruise, to remove bad data (Ryan, 1995).

After quality controlling of the automatically logged GPS data set, gaps (due to missing data and data flagged as bad) are automatically filled by dead-reckoned positions (using the ship's speed and heading). Positions used for CTD stations are derived from this final GPS data set. Bottom depth is measured by a Simrad EA200 12 kHz echo sounder. 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).

Seawater is pumped on board via an inlet at 7 m below the surface. A portion of this water is diverted to the thermosalinograph (Aplied Microsystems Ltd, model STD-12), and to the fluorometer (Turner Design, peak sensitivity for chlorophyll-a). Sea surface temperatures are measured by a sensor next to the seawater inlet at 7 m depth.

The underway measurements for the cruise are contained in column formatted ascii files. The two file types are as follows (see Appendix 4 in Rosenberg et al., 1995b, for a complete description):

(i) 10 second digitised underway measurement data, including time, latitude, longitude, depth and sea surface temperature;

(ii) 15 minute averaged data, including time, latitude and longitude, air pressure, wind speed and direction, air temperature, humidity, quantum radiation, ship speed and heading, roll and pitch, sea surface salinity and temperature, average fluorescence, and seawater flow.

4.3 ADCP

A vessel mounted acoustic Doppler current profiler (ADCP) was installed in the hull during dry-docking of the ship in mid 1994. The unit is a high power 150 kHz narrow band ADCP produced by RD Instruments. The four transducer heads are mounted in a concave Janus configuration, with the beams 30 degrees off vertical, and with the transducers aligned at 45^o to fore and aft. The transducers are mounted in a seachest ~7 m below the water surface, behind a 81 mm thick low density polyethylene window, with the window flush to the ship’s hull. The inside of the seachest is lined with acoustic tiles (polyurethane with barytes and air microsphere fillers), and filled with hypersaline water.

ADCP data were logged on a Sparc 5 Sun workstation. Logging parameters are listed in Table 7. An array of sounders is mounted on the ship for use in hydroacoustic biology surveys (T. Pauly, pers. comm.). When these sounders are in operation, firing of the

ADCP is synchronised with the sounder trigger pulses, to avoid interference between the two systems. When this synchronisation is active, the ADCP ping rate is lowered by ~35%. When the ADCP system bottom tracking is active, the ping rate is decreased by ~50 %. Gyrocompass heading data were logged on the Sun through a synchro to digital converter, at a one second sampling frequency. GPS data collected by a Lowrance receiver were also logged by the Sun; the Lowrance unit received GPS positions every 2 seconds, and GPS velocities every 2 seconds, with positions and velocities received on alternate seconds. ADCP data processing is discussed in more detail in Dunn (a and b, unpublished reports).

Table 7: ADCP logging parameters.

ping parameters		***bottom track ping parameters***	
no. of bins:	50	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 averageing:		bins 3 to 6 (13/12/94-13/01/95 i.e. files 1-86)	
		bins 3 to 10 (13/01/95-21/01/95 i.e. files 87-107)	
		bins 3 to 13 (21/01/95-01/02/95 i.e. files 108-136)	
ensemble averageing duration:		3 min.	

5 MAJOR PROBLEMS ENCOUNTERED

5.1 Logistics

The only significant logistic problem was shortage of time, due in part to delayed cargo operations at Casey. For part of the transects, as mentioned above, station spacing was increased to 45 nautical miles, to ensure completion of the oceanographic work in the available time.

5.2 CTD sensors

Various problems occurred with the CTD sensors over the course of the cruise. For CTD 1103 (used for the first 18 stations), the conductivity output became increasingly noisy after station 10, resulting in random salinity noise with an amplitude up to ~0.01 psu. The CTD was finally changed to CTD 1193 following station 18. After the cruise, the noise problem in CTD 1103 was traced to loosely mounted cards inside the housing.

Conductivity noise was minimal for CTD 1193, however the conductivity cell response showed a strong pressure dependence. In addition, the same conductivity cell displayed significant hysteresis between the down and upcasts. These problems are discussed in more detail in section 6. Following station 56, the conductivity cell on CTD 1193 was changed for a spare. The spare cell functioned well, except for a transient error when first entering the water - the cell appeared to need soaking near the surface for up to 2 minutes, before a stable conductivity reading was reached.

Prior to station 95, moisture was discovered entering the CTD 1193 housing, causing corrosion of the fast temperature sensor connector. The fault was traced to pits in the o-ring seats of the metal mounting plate on which the conductivity and fast temperature sensors are mounted. As a temporary fix, the connectors were sprayed with a water displacing agent, and the space behind the sensors in the housing was filled with grease. No leakage occurred for the remaining stations, however one or more of these substances caused slight contamination of the conductivity cell, resulting in a small amount of signal noise over the next few stations.

For both CTD 1103 and 1193, the oxygen sensor oil reservoir housing could not be screwed tightly onto the mounting connector threads. As a result, any impact, such as caused by the instrument breaking through the water surface on deployment, caused the housing to move sufficiently for the silicon oil to drain past the o-ring, and resulting in loss of data (see section 6). This occurred several times early in the cruise. Following station 28, 2 adjacent o-rings (instead of the usual 1) were installed in the oxygen oil reservoir housing, solving the oil drainage problem.

Following station 76, 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.

The altimeter did not function for the first 4 stations, thus these CTD casts were only taken to within ~100 to 200 m of the bottom. Following station 4, the problem was traced to a burnt out chip in CTD 1103. The altimeter performed well for the remainder of the cruise, allowing close CTD approaches to the bottom (Table 2).

5.3 Other equipment

The first few days of bathymetry data were lost due to problems with the 12 kHz echo sounder transducer. Good bathymetry data was obtained starting from 19/12/94 UTC.

Routing of the aft CTD winch wire resulted in serious kinking of the wire on several occasions - the wire required retermination each time. Following station 33, operations were changed to the forward CTD winch wire, and no more serious problems occurred for the remainder of the cruise.

One of the upward looking sonar moorings (Table 5) could not be located with the acoustic release surface transducer. No attempt was made to send the release command, owing to the significant sea ice coverage. At the time of writing, further recovery attempts indicated the mooring was no longer present at the deployment site.

6 RESULTS

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

CTD data: Tables 14 and 15, and section 6.1.2;
hydrology data: Tables 18 and 19.
Historical data comparisons are made in section 7.
Data file formats are described in Appendix 4 of Rosenberg et al. (1995b).

6.1 CTD measurements

6.1.1 Creation of CTD 2 dbar-averaged and upcast burst data

Conductivity

Four different conductivity cells were used during the cruise, as follows:

conductivity cell 1, stations 1-18 (using CTD 1103);
conductivity cell 2, stations 19-56 (using CTD 1193);
conductivity cell 3, stations 57-106 (using CTD 1193);
conductivity cell 4, station 107 (using CTD 2568).

With the exception of cell 4, all the conductivity cells displayed large transient errors when entering the water. In addition, cell 3 displayed significant hysteresis between downcast and upcast conductivity data. As a result, for stations 1 to 106, upcast CTD data was used for all the 2 dbar-averaged pressure, temperature and conductivity data. Note that station 107 data were not used.

The response of conductivity cells 1 and 2 showed a pressure dependence, much stronger in the case of cell 2. For both these cells (i.e. stations 1 to 56), the pressure dependent conductivity residual was removed by the following steps:

- 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.

- Next, for each station grouping (Table 11), a linear pressure dependent fit was found for the conductivity residuals i.e. for station grouping i, fit parameters α_i (Table 11) and β_i were found from

    - $(c_{btl} - c_{cal})_n = \alpha_i p_n + \beta_i$ (eqn 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.

- 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).

Dissolved oxygen

For stations 19 to 106, 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. No CTD oxygen data was obtained for stations 1 to 18, due to a hardware fault in CTD 1103.

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%.

Summary

stations 1-18: all CTD data from upcast; weak pressure dependent conductivity residual removed; no CTD dissolved oxygen data;

stations 19-56: CTD data from upcast, except for dissolved oxygen data (downcast); strong pressure dependent conductivity residual removed.

stations 57-106: CTD data from upcast, except for dissolved oxygen data (downcast).

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 10.

- Missing 2 dbar data averages are listed in the files avmiss.out and avoxmiss.out (the latter for CTD dissolved oxygen).

- CTD conductivity calibration coefficients, including the station groupings used for the conductivity calibration, are listed in Tables 11 and 12.

- CTD raw data scans flagged for special treatment are listed in Table 13.

- Suspect 2 dbar averages are listed in Tables 14 and 15. The file avinterp.out lists 2 dbar averages which are linear interpolations of the surrounding 2 dbar averages.

- CTD dissolved oxygen calibration coefficients are listed in Table 16. The starting values used for the coefficients prior to iteration, and the coefficients varied during the iteration, are listed in Table 17.

- Stations containing fluorescence and photosynthetically active radiation data are listed in Table 22.

- The different protected and unprotected thermometers used for the stations are listed in Table 23.

6.1.2 CTD data quality

The final calibration results for conductivity/salinity and dissolved oxygen, along with the performance check for temperature, are plotted in Figures 2 to 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. Note that for stations where a correction was made for the pressure dependent conductivity error, c_{cal} here refers to the final calibrated value after the correction. 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 to 5, are as defined in the CTD methodology.

CTD data quality cautions for the various parameters are discussed below. Table 8 contains a summary of these cautions.

Pressure

The titanium strain gauge pressure sensors used in the Mark IIIC CTD's display a higher noise level than the older stainless steel strain gauge models, with a typical rms of ~±0.2 dbar (Millard et al., 1993). Noise in the pressure signal for CTD 1193 (used for stations 19 to 106) was found to be higher than this, with spikes of up to 1 dbar amplitude occurring. In the creation of CTD raw data files monotonically increasing with pressure (see CTD methodology), pressure spikes with a width exceeding 3 data points are retained as real values. Thus as a result of the high noise levels for CTD 1193, a large number of 2 dbar bins were missing, as not enough data points were present in these bins to form a bin average. 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 previous cruises, jmin=10). Note that jmin=6 was used for the entire cruise. For remaining missing bins, values were linearly interpolated between surrounding bins, except where the local temperature gradient exceeded 0.005°C between the surrounding bins i.e. temperature gradient > 0.00125 degrees/dbar.

For stations 48, 54 and 72, surface pressure offset values fell on small pressure spikes, thus the final surface pressure offsets were estimated from a manual inspection of the pressure data. A manual estimate was also required for station 55. The surface pressure offset values for stations 66 and 76 were estimated from the surrounding stations (Table 10). Any resulting additional error in the CTD pressure data is judged to be small (no more than 0.2 dbar).

For stations 7, 11, 16, 28, 65 and 66, flooding of the dissolved oxygen sensor with seawater resulted in bad pressure temperature data (as discussed in Rosenberg et al., 1995b). To allow accurate calculation of pressure in dbar, the following pressure temperature data were used in pressure calculations for these stations:

station with bad pressure temperature	used pressure temperature data from this station for upcast
7	8
11	10
16	17
28	27
65	64
66	67 for p≥2000 dbar
66	66 for p<2000 dbar

Note that the pressure temperature profiles chosen above provide the closest match to the assumed pressure temperature profiles for stations 7, 11, 16, 28, 65 and 66, and any errors are judged to be small (<0.3 dbar).

Salinity

The conductivity ratios for all bottle samples are plotted in Figure 3, while the salinity residuals are plotted in Figure 4. The final standard deviation values for the salinity residuals (Figure 4) indicate the CTD salinity data over the whole cruise is accurate to within ±0.002 psu.

No conductivity residual correction was made for stations 1 and 54: all bottles were fired at the same depth for these stations (test casts), so that any pressure dependent conductivity residual (section 6.1.1) could not be quantified. Note that as a result, the salinities for these stations can only be considered as accurate to ~0.01 psu.

Bottle salinity data was lost for station 24, due to malfunction of the salinometer. The station was grouped with surrounding stations for conductivity calibration (Table 11).

No conductivity residual correction (section 6.1.1) was made for stations 3 to 10 and 52 to 53, as no pressure dependent conductivity residual was found for these stations.

Temperature

The temperature residuals are shown in Figure 2, along with the mean offset and standard deviation of the residuals. The thermometer value used in each case is the mean of the two protected thermometer readings (protected thermometers used are listed in Table 23). 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.

For CTD 1193 (stations 19 to 106), there was a problem with the laboratory calibration of the platinum temperature sensor. With the original pre-cruise calibration coefficients, an offset of 0.007^{o}C was found between CTD and reversing thermometer temperature values. As a consequence, an additional offset value of -0.007^{o}C (Appendix 1) was applied to all CTD temperature values for stations 19 to 106.

<u>Table 8:</u> 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
5	all parameters	data for this station bad, due to CTD power supply problem
7	pressure	station 8 pressure temperature profile used for pressure calculation
11	pressure	station 10 pressure temperature profile used for pressure calculation
16	pressure	station 17 pressure temperature profile used for pressure calculation
24	salinity	CTD conductivity calibrated with bottles from surrounding stations
28	pressure	station 27 pressure temperature profile used for pressure calculation
47	salinity, oxygen	most bottles tripped on the fly - may introduce small inaccuracy into
54	salinity	test cast - all bottles fired at same depth; salinity accuracy reduced
65	pressure	station 64 pressure temperature profile used for pressure calculation
66	pressure	surface pressure offset estimated from surrounding stations
66	pressure	station 67 pressure temperature profile used for pressure calculation for $p \geq 2000$ dbar
76	pressure	surface pressure offset estimated from surrounding stations
107	all parameters	data not used for this station (test cast only)

station no.	CTD parameter	caution
2-4,11-51,55-56	salinity	additional correction applied for pressure dependent conductivity
19 to 106	temperature	additional calibration offset value based on comparison with reversing thermometer data
1 to 107	fluorescence/p.a.r.	fluorescence and p.a.r. sensors (where active) are uncalibrated
1 to 18	oxygen	no CTD dissolved oxygen data due to faulty hardware
28,65,66	oxygen	no CTD dissolved oxygen data due to oil drainage from sensor housing

Dissolved Oxygen

After the cruise, the CTD dissolved oxygen data for CTD 1103 (stations 1 to 18) was found to be unusable. The fault was traced to incorrect wiring in the factory-provided oxygen sensor mounting.

The dissolved oxygen residuals are plotted in Figure 5. The final standard deviation values are within 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 general, good calibrations of the CTD dissolved oxygen data were obtained using the in situ bottle data, however some atypical values were found for the calibration coefficients (Tables 16 and 17) (see the CTD methodology for full details of calibration formulae). For most stations, the best calibration was achieved using large values of the order 10.0 for the coefficient K_1 (i.e. oxygen current slope), and large negative values of the order -1.5

for the coefficient K_3 (i.e. oxygen current bias). This, however, is not considered relevant to actual data quality.

In addition, the following unusual coefficient values were found (for typical values, see Millard and Yang, 1993, and Millard, 1991):

stations 56 and 58: $K_5 > 1$ (usually expect $0<K_5<1$);
stations 58 and 105: $K_6 < 0$ (usually expect a positive value);

Despite some atypical calibration coefficient values, all dissolved oxygen calibrations are considered valid.

Oil drainage from the oxygen sensor mounting resulted in unusable dissolved oxygen data for stations 28, 65 and 66.

No oxygen bottle samples were collected for station 54. No attempt was made to calibrate the dissolved oxygen data for this station.

Dissolved oxygen data were not processed for station 107 (a working sensor was not fitted).

Fluorescence and P.A.R. Data

As discussed in section 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.

6.2 Hydrology data

6.2.1 Hydrology data quality

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

- Questionable dissolved oxygen and nutrient Niskin bottle sample values are listed in Tables 18 and 19 respectively. Note that questionable values are included in the hydrology data file, whereas bad values have been removed.
- Laboratory temperatures at the times of nutrient analyses are listed in Table 20.
- Dissolved oxygen Niskin bottle samples flagged with the code -9 (rejected for CTD dissolved oxygen calibration) are listed in Table 21.

For station 47, the cast was abandoned at ~1000 on the downcast, due to ice floes around the CTD wire. During retrieval, bottles at rosette positions 1 to 18 were tripped on the fly. For station 48, 8 bottles did not trip, due to malfunction of the rosette pylon.

Nutrients

For the phosphate analyses, it was found that the autoanalyser peak height of a sample which was run immediately after a series of wash solution vials (low nutrient sea water) was suppressed by, on average, 2%, as discussed in section 6.2.1 of Rosenberg et al. (1995b). For stations 1 to 34, samples thus affected (typically from rosette positions 12 and 24) were treated as bad data. Following station 34, 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 samples.

Surface phosphate values for many of the remaining stations still remain artificially suppressed - in Figure 9 the low phosphate values, in the vicinity of the nitrate+nitrite concentration of ~25 umol/l, are all near surface samples. Moreover, these samples all occur in regions where the steepest vertical gradients in nutrient concentrations are found. As a result of the steep vertical gradients, near surface phosphate concentrations are much lower than for the remainder of the water column, and any suppression of the phosphate autoanalyser peaks for the near surface samples will become amplified when data are viewed as ratios (Figure 9). These questionable near surface phosphate samples are listed in Table 19.

For surface silicate samples at stations 71 to 104, the autoanalyser silicate peaks were spiked, causing problems in the automatic peak integration performed by the software DAPA (see Appendix 3 in Rosenberg et al., 1995b). The replicate surface sample (one of the dummy samples for the phosphate analysis) did not show the same response, so the replicate was used for measuring the peak height.

The following notes also apply to the nutrient data:

- For station 107, no nutrient samples were collected.
- For the station 62, all nutrient concentrations were derived from manual measurements of autoanalyser peak heights, using the strip chart recordings.

6.2.2 Hydrology sample replicates

The accuracy and precision of bottle data are considered relative to the full scale deflection of measurement for nutrients

phosphate:	3.0 μmol/l
nitrate+nitrite:	35.0 μmol/l
silicate:	140 μmol/l

and relative to the maximum data value for dissolved oxygen

dissolved oxygen: ~350 μmol/l for pressure < 750 dbar
~250 μmol/l for pressure > 750 dbar.

In general, no organised sample replication was carried out, thus the replicate data set discussed here is small. Most replicate data were obtained opportunistically, from multiple fired Niskin bottles taken during bottle test casts, or from depths sampled in both casts of shallow/deep cast pairs. Two types of replicate data were obtained from the hydrology data set, as follows.

Replicate samples drawn from the same Niskin bottle

A series of repeat nutrient samples were drawn from 2 different Niskin bottles at station 32. At each of the Niskins, the absolute value of the differences about the mean value were formed (Figure 6a). Precision values for phosphate, nitrate+nitrite and silicate are respectively 0.16%, 0.22% and 0.35% of the full scale deflection (Table 9a).

Table 9a: Precision data for replicates drawn from same Niskin bottle.

parameter	standard deviation of differences	% of full scale deflection	number of samples	number of sample groups
phosphate	0.0047 μmol/l	0.16	22	2
nitrate+nitrite	0.0765 μmol/l	0.22	24	2
silicate	0.4906 μmol/l	0.35	24	2

Replicate samples drawn from different Niskin bottles tripped at same depth

At several stations, multiple Niskin bottles were fired at a single depth. For each set of Niskin bottles tripped at a single depth, a mean value m_x was calculated for the sample set and the differences $x-m_x$ formed, where x is the phosphate, nitrate+nitrite, silicate, salinity or dissolved oxygen bottle value; the standard deviation of all $x-m_x$ values for the replicate data was calculated. Absolute values of the differences $x-m_x$ are shown in Figure 6b, and the results are summarised in Table 9b. It is assumed that these precision values would be further reduced if sample groups were drawn from the same Niskin bottle.

Table 9b: Precision data for replicates drawn from Niskin bottles tripped at the same depth.

parameter	standard deviation of $x-m_x$	% of full scale or max. value	number of samples	number of sample groups
phosphate	0.0061 µmol/l	0.20	59	24
nitrate+nitrite	0.1473 µmol/l	0.42	66	27
silicate	0.6266 µmol/l	0.45	67	27
salinity	0.0007 psu	-	67	27
dissolved oxygen	0.1446 µmol/l	0.06	66	27

7 HISTORICAL DATA COMPARISONS

In this section, a brief comparison is made between the au9404 cruise data, and data from the previous cruise au9407 (Rosenberg et al., 1995b).

7.1 Dissolved oxygen

Vertical profiles of CTD dissolved oxygen concentrations for cruises au9404 and au9407 are compared in Figure 7. Note that dissolved oxygen concentrations of bottle samples for both cruises were measured using the WHOI automated method (see Appendix 3, Rosenberg et al., 1995b). Concentration values for the two cruises are in general consistent.

7.2 Salinity

The meridional variation of the salinity maximum for the two cruises i.e. for Lower Circumpolar Deep Water (as defined by Gordon, 1967) is compared in Figure 8. For the comparison, CTD 2 dbar data were used i.e. CTD salinity, temperature and pressure values at the nearest 2 dbar bin to the salinity maximum for each station. Note that in the figure, property differences are only formed between station pairs (i.e. corresponding au9404 and au9407 stations) which are separated by less than 1.5 nautical miles of latitude.

There appears to be a mean offset of ~0.003 psu between the two cruises (Figure 8), smaller than the large salinity offset of ~0.007 psu found between cruises au9309 and au9407 (Appendix 6 in Rosenberg et al., 1995b). Note that there is no consistent biasing of the temperature or pressure data (Figure 8), suggesting that the difference is due to salinity alone, the same result as found for the comparison between earlier cruises. In summary, the following approximate mean salinity differences are evident for the successive occupations of the S03 transect:

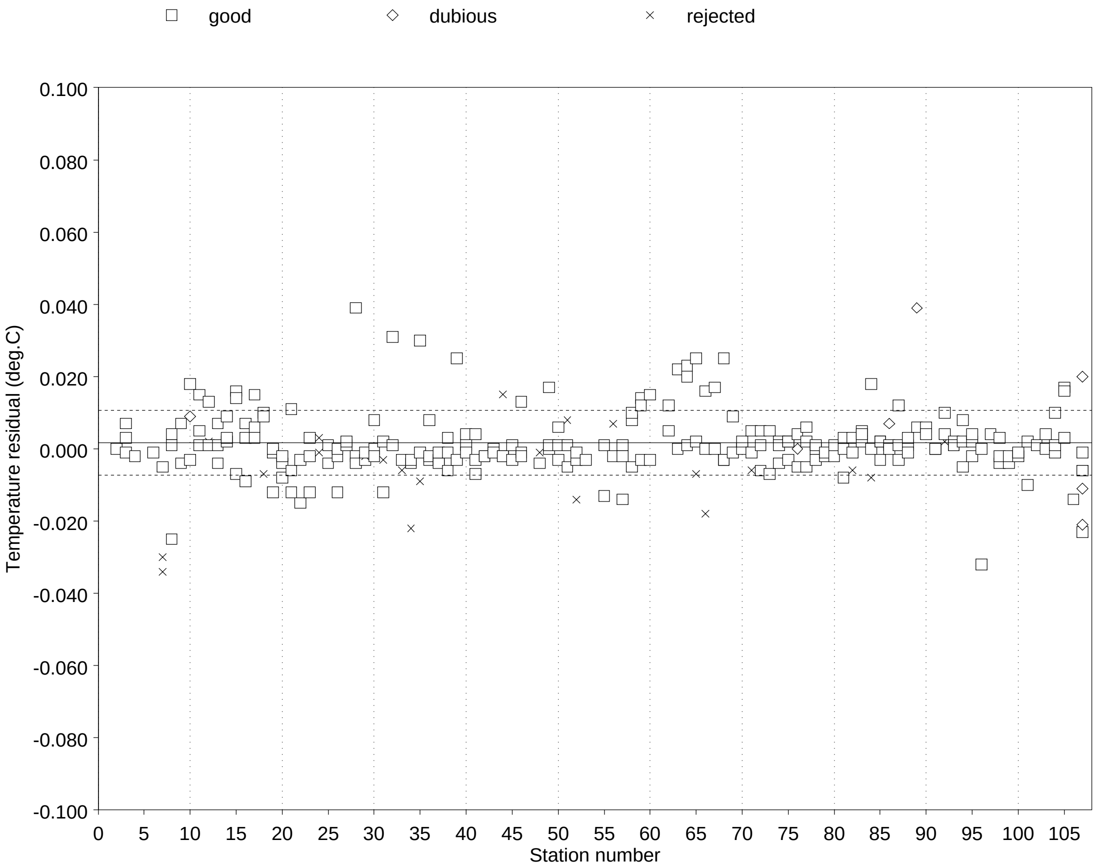
cruise comparison	mean salinity difference
au9309-au9101	< 0.002 psu
au9309-au9407	0.007 psu
au9404-au9407	0.003 psu

As discussed in Rosenberg et al. 1995b, the most likely source of any systematic salinity error is the salinometers (YeoKal Mk IV) used for the analysis of salinity samples from the Niskin bottles. However, the exact cause of the error remains inconclusive. At the time of writing, two more recent occupations of S03 stations await processing, while a further transect of S03 is planned using more accurate salinometers (Guildline Autosals). These later data sets may clarify any instrument errors.

7.3 Nutrients

Phosphate and nitrate+nitrite concentrations are in general consistent for the au9404 and au9407 data, revealed by comparison of the nitrate+nitrite to phosphate ratio (Figure 9). Note that for au9404, the depressed phosphate values at the approximate nitrate+nitrite level of 25 µmol/l are all near surface values, and are to be regarded as questionable data (see section 6.2.1 for more details).

There is a small non-linearity in the nitrate+nitrite to phosphate ratio for both cruises, with low nutrient values lying below the best fit linear relationship (Figure 9). A similar trend is evident in data from cruise au9309 (Figure A6.4 in Rosenberg et al., 1995b), and data along the P11 transect from cruise au9391 (Figure A6.10 in Rosenberg et al., 1995a) (although there is more scatter in the au9391 data). For cruise au9404, these low values correspond with near surface samples north of the Subantarctic Front (Figure 10) i.e. north of ~50^{o}S. Note that at both the Subantarctic and Subtropical Fronts (at ~50^{o}S and ~45.5^{o}S respectively from inspection of surface temperatures in Figure 10), there is a sharp horizontal gradient in surface nutrient values, with concentrations decreasing to the north across the fronts. A corresponding northward decrease in the nitrate+nitrite to phosphate ratio is also evident (Figure 10), accounting for the non-linearity in the ratio at low nutrient concentrations (Figure 9). This effect, also observed in the earlier cruises, appears to be a real feature.



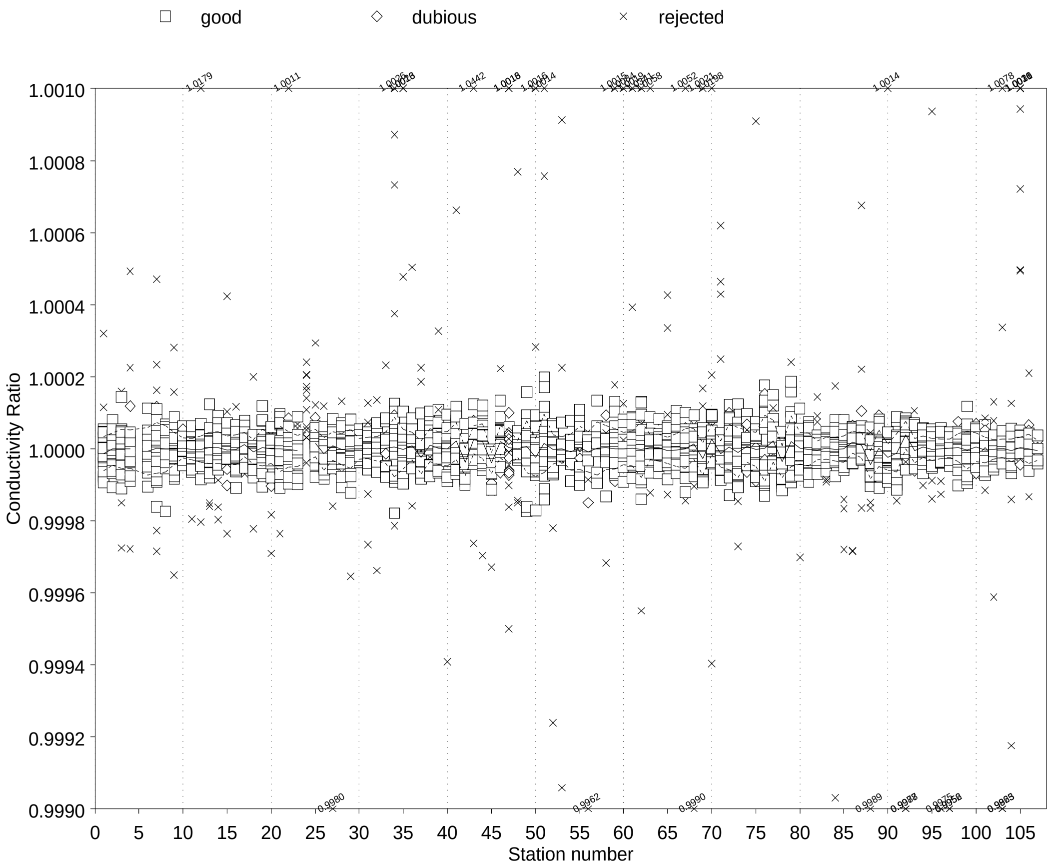
Calibration data for cruise : Au9404

Calibration file : histcal.lis

Mean offset Temperature = 0.00166312c (s.d. = 0.0090 ˚c)

Number of samples used = 243 out of 265

Figure 2: Temperature residual (T_{therm} - T_{cal}) versus station number for cruise au9404. The solid line is the mean of all the residuals; the broken lines are ± the standard deviation of all the residuals (as defined in the CTD methodology). Note that the "dubious" and "rejected" categories refer to the conductivity calibration.



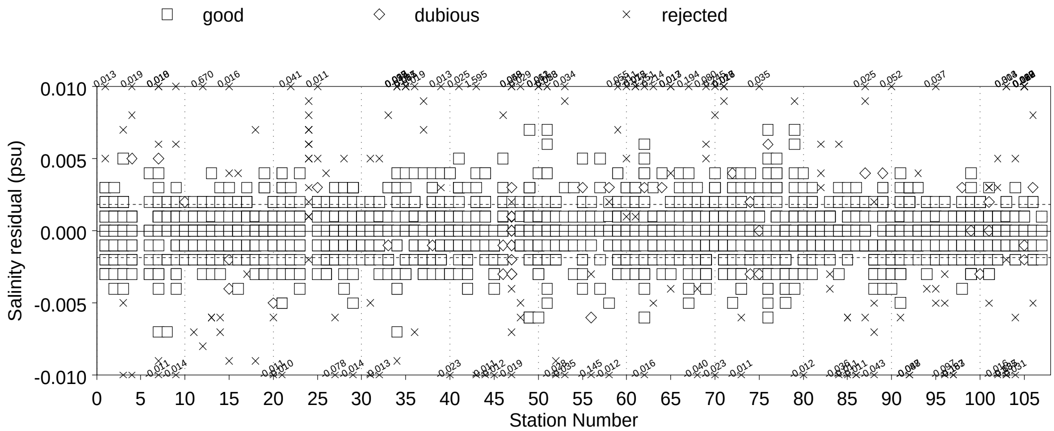
Calibration data for cruise : Au9404

Calibration file : histcal.lis

Conductivity s.d. = 0.00005

Number of bottles used = 2129 out of 2379 Mean ratio for all bottles = 1.00000

Figure 3: Conductivity ratio c_{btl}/c_{cal} versus station number for cruise au9404. 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 (as defined in the CTD methodology).



Calibration data for cruise : Au9404

Calibration file : histcal.lis

Mean offset salinity = 0.0000psu (s.d. = 0.0018 psu)

Number of bottles used = 2129 out of 2379

Figure 4: Salinity residual (s_{btl} - s_{cal}) versus station number for cruise au9404. The solid line is the mean of all the residuals; the broken lines are ± the standard deviation of all the residuals (as defined in the CTD methodology).

Mean of Residual = -0.257umol/dm**3

S.D. of residual = 2.881umol/dm**3 (Equiv to 0.065ml/l)

Used 1849 bottles out of total 1947

S.D. deep (>750m) 2.107umol/dm**3 (equiv to 0.047ml/l)

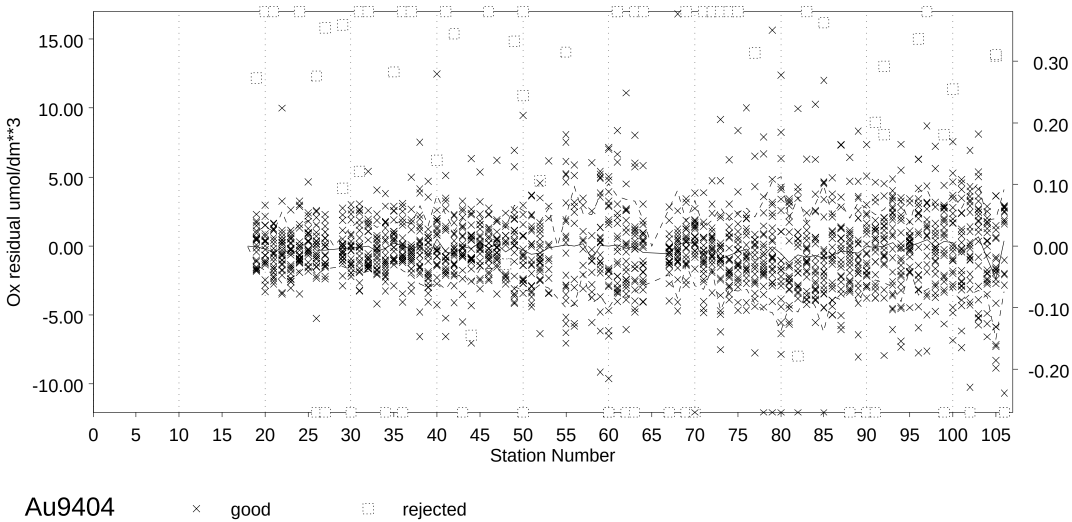


Figure 5: Dissolved oxygen residual (o_{btl} - o_{cal}) versus station number for cruise au9404. The solid line follows the mean residual for each station; the broken lines are ± the standard deviation of the residuals for each station (as defined in the CTD methodology).

(a)

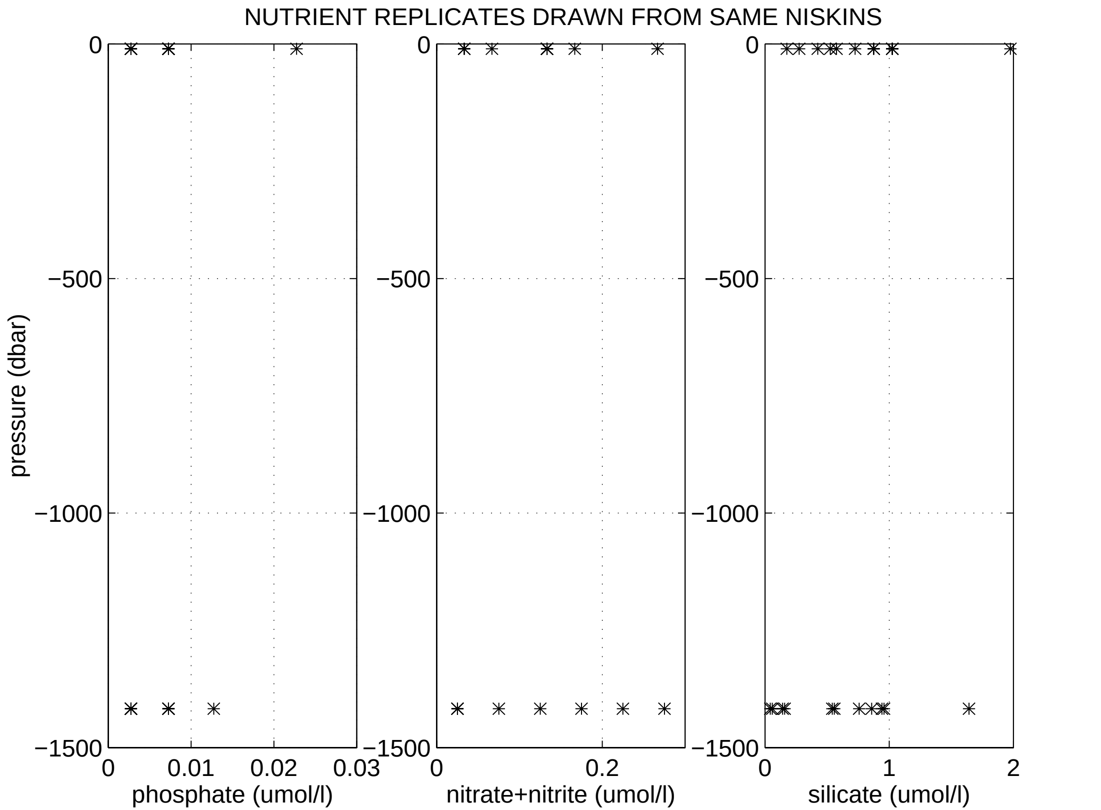


Figure 6: Absolute value of parameter differences for replicate samples, for replicates drawn from (a) the same Niskin bottle, and (b) different Niskins tripped at the same depth. Note that differences are between parameter values and depth mean.

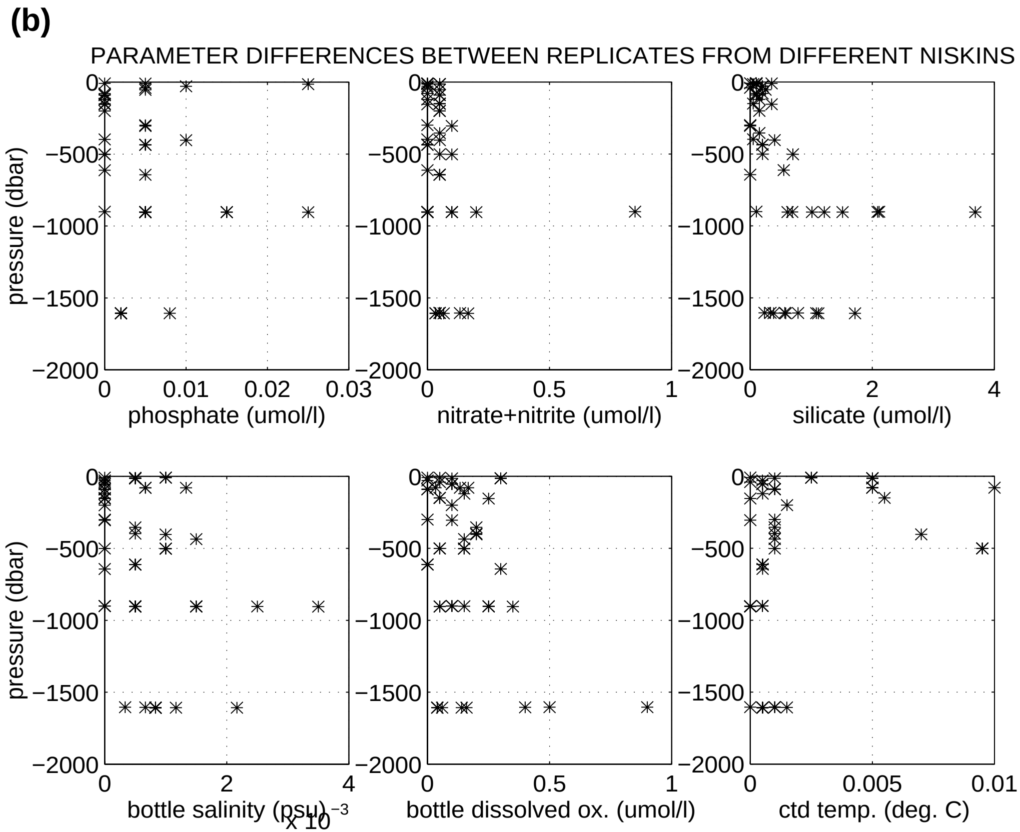


Figure 6: Absolute value of parameter differences for replicate samples, for replicates drawn from (a) the same Niskin bottle, and (b) different Niskins tripped at the same depth. Note that differences are between parameter values and depth mean.

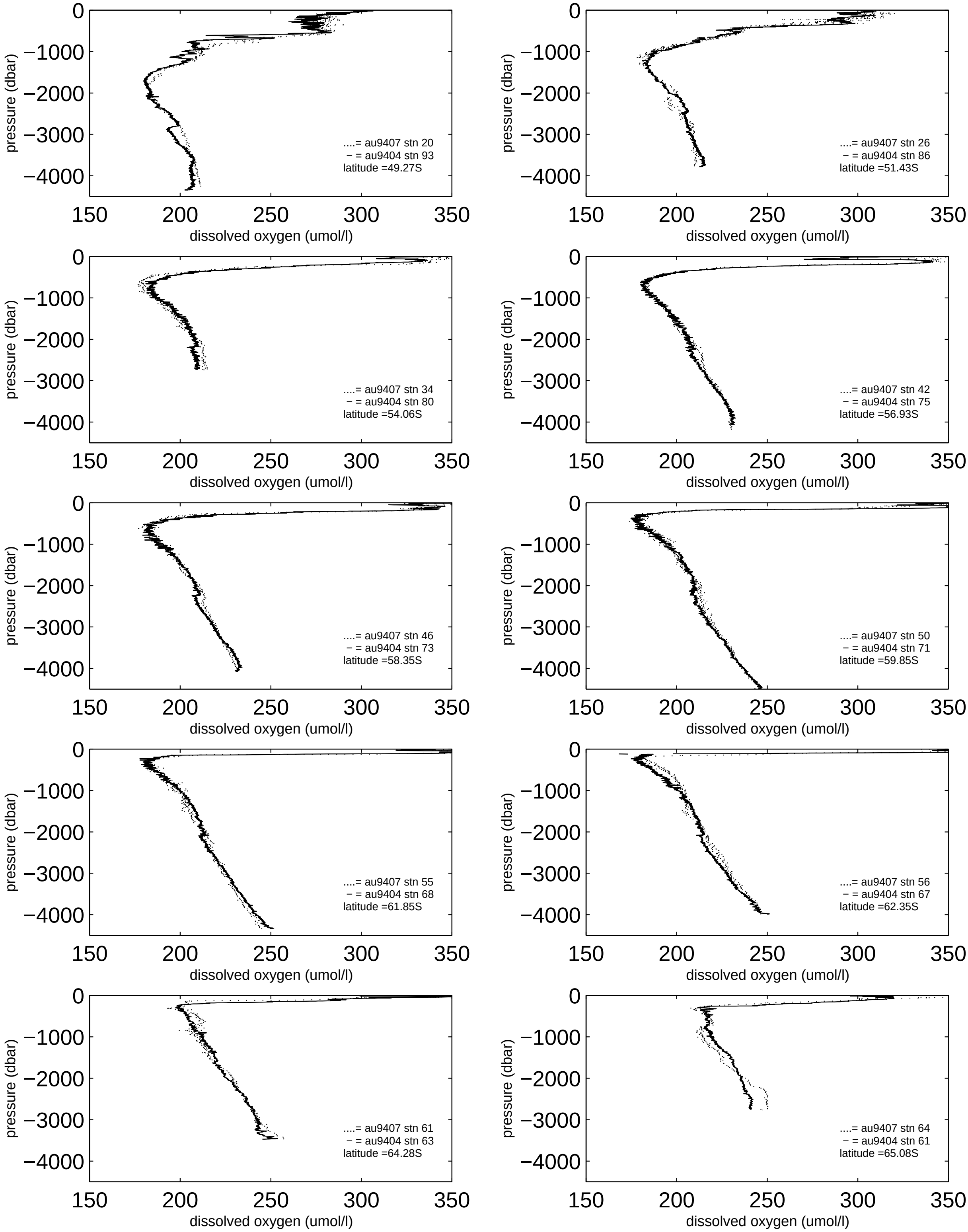


Figure 7: CTD dissolved oxygen vertical profile data for comparison of au9404 and au9407 data.

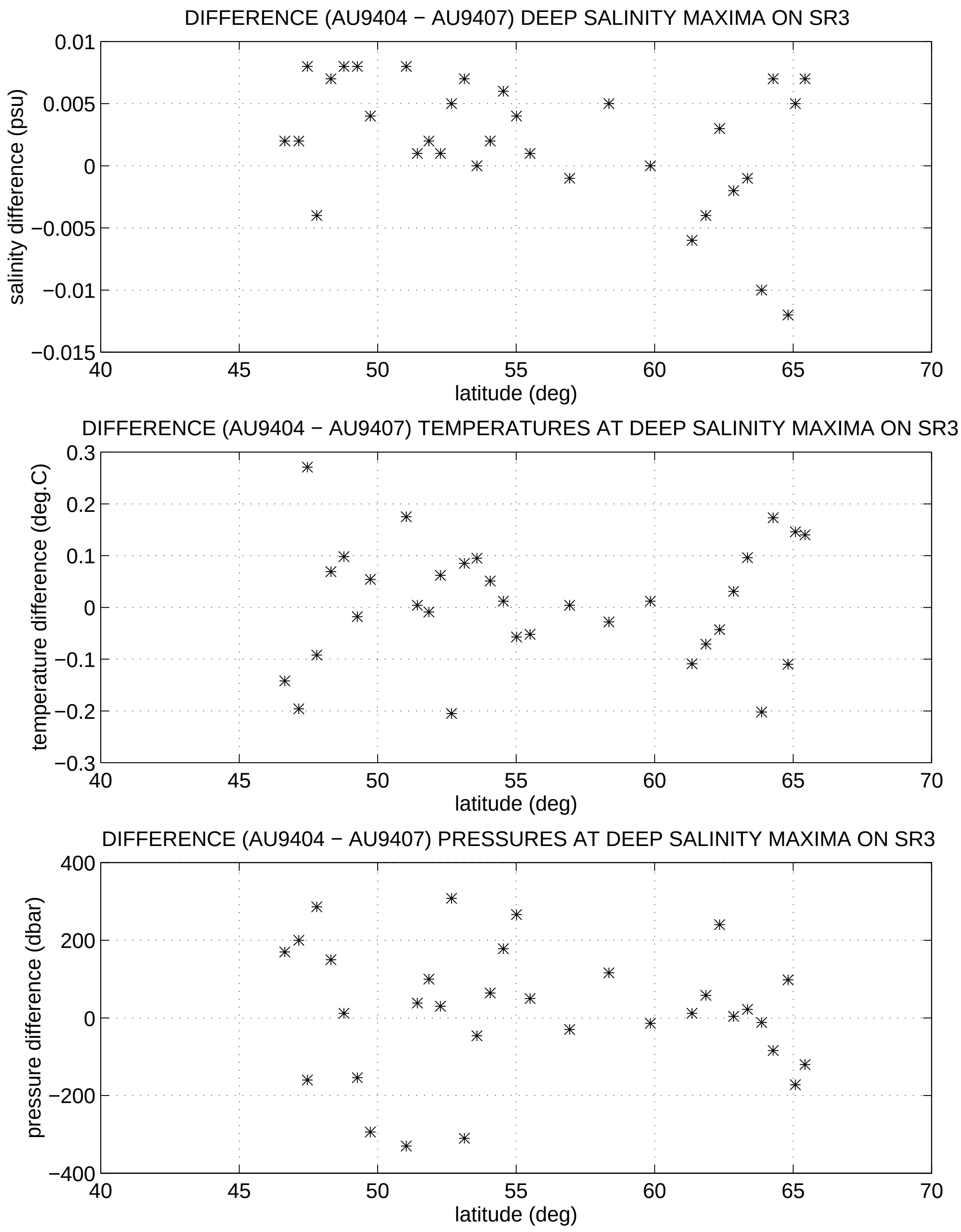


Figure 8: Variation with latitude south along the S03 transect of properties at the deep salinity maximum (marking the Lower Circumpolar Deep Water): property differences are between cruise au9404 and cruise au9407 i.e. au9404 value minus au9407 value. Note that differences are formed only between stations from the two cruises which are separated by no more than 1.5 nautical miles of latitude.

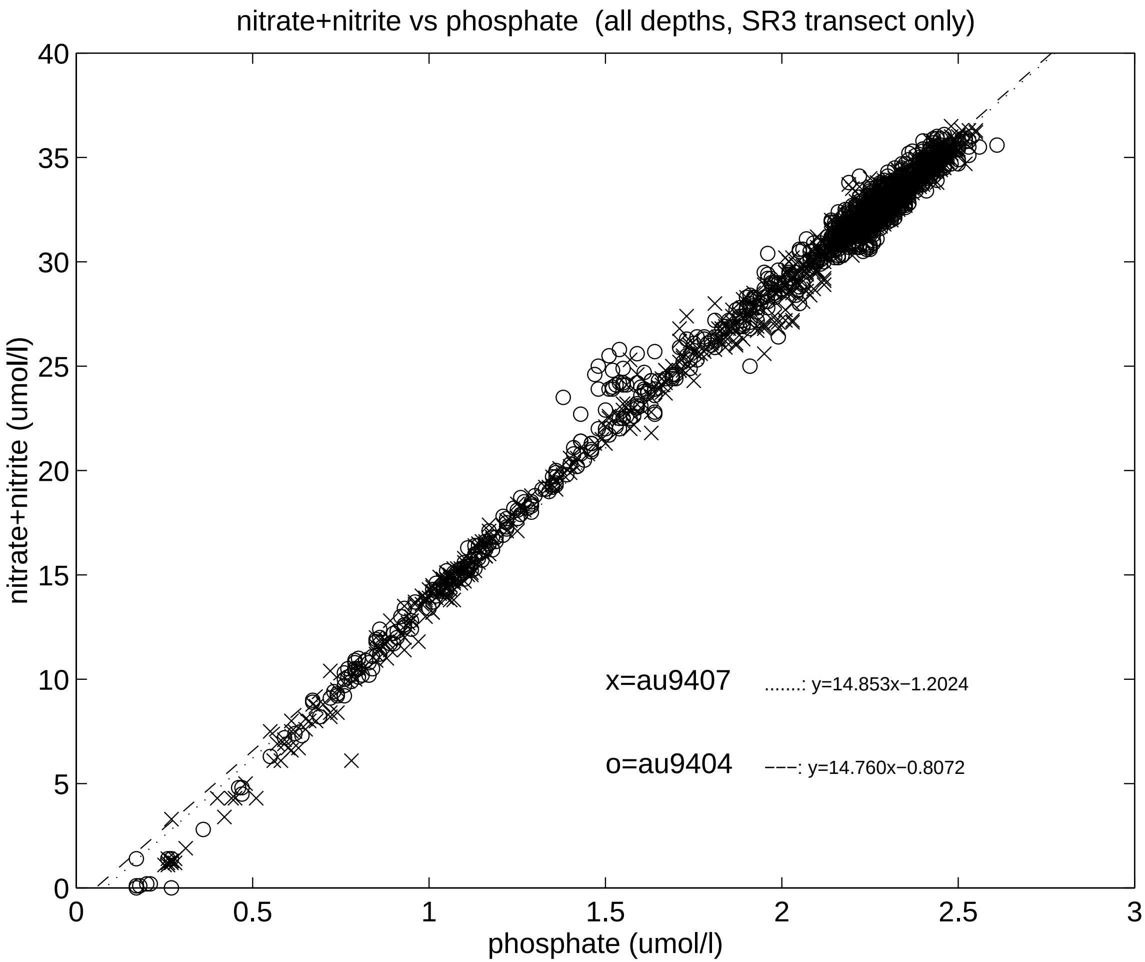


Figure 9: Bulk plot of nitrate+nitrite versus phosphate for all au9404 and au9407 data along the S03 transect, together with linear best fit lines.

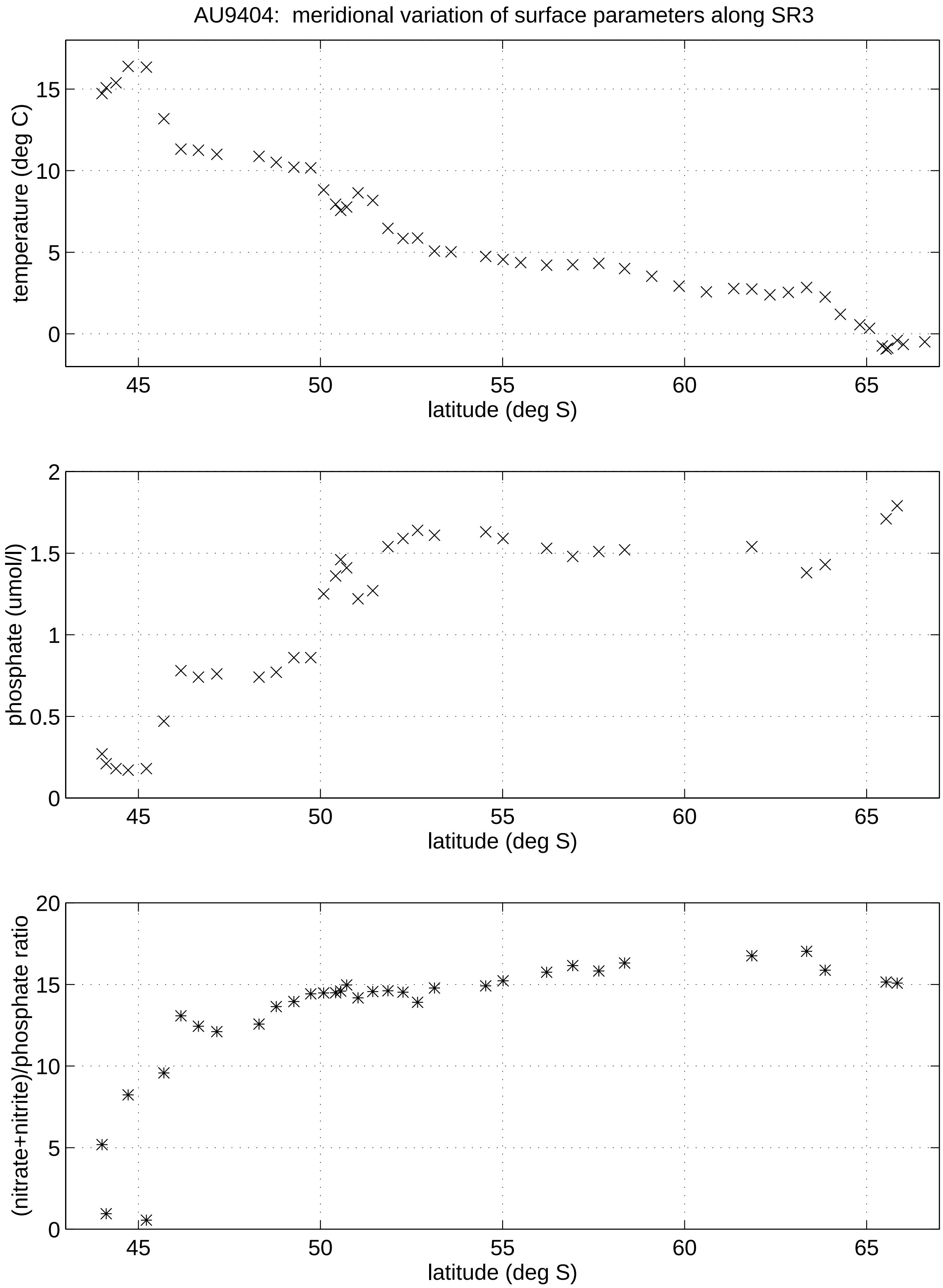


Figure 10: Meridional variation along the S03 transect of CTD temperature, phosphate concentration, and nitrate+nitrite to phosphate ratio, all at the near surface Niskin bottle.

Table 10: 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	Test	-1.15	28	S04I	-1.19	55	S03	-1.40**	82	S03	-1.86
2	S04I	-2.87	29	S04I	-1.04	56	S03	-1.25	83	S03	-1.57
3	S04I	-2.42	30	S04I	-0.71	57	S03	-1.51	84	S03	-1.47
4	S04I	-3.36	31	S04I	-1.47	58	S03	-1.57	85	S03	-1.84
5	S04I	-3.17	32	S04I	-1.40	59	S03	-1.49	86	S03	-1.47
6	S04I	-3.63	33	S04I	-0.93	60	S03	-1.41	87	S03	-1.25
7	S04I	-2.16	34	S04I	-0.84	61	S03	-0.87	88	S03	-1.42
8	S04I	-3.46	35	S04I	-0.87	62	S03	-1.50	89	S03	-1.47
9	S04I	-2.24	36	S04I	-0.57	63	S03	-1.48	90	S03	-1.59
10	S04I	-3.31	37	S04I	-1.98	64	S03	-1.28	91	S03	-1.77
11	S04I	-3.45	38	S04I	-1.54	65	S03	-1.83	92	S03	-2.02
12	S04I	-3.24	39	S04I	-1.14	66	S03	-1.32**	93	S03	-1.77
13	S04I	-3.55	40	S04I	-0.94	67	S03	-1.32	94	S03	-1.29
14	S04I	-3.75	41	S04I	-1.06	68	S03	-1.17	95	S03	-1.28
15	S04I	-3.24	42	S04I	-0.84	69	S03	-1.28	96	S03	-1.74
16	S04I	-3.86	43	S04I	-1.13	70	S03	-1.36	97	S03	-1.86
17	S04I	-3.73	44	S04I	-1.03	71	S03	-1.04	98	S03	-1.94
18	S04I	-2.96	45	S04I	-1.61	72	S03	-0.90**	99	S03	-1.46
19	S04I	-0.40	46	S04I	-0.60	73	S03	-0.87	100	S03	-2.24
20	S04I	-0.29	47	S04I	-0.59	74	S03	-1.07	101	S03	-1.49
21	S04I	-1.08	48	S04I	-1.00**	75	S03	-1.09	102	S03	-1.77
22	S04I	-0.63	49	S04I	-1.08	76	S03	-1.66**	103	S03	-1.55
23	S04I	-0.82	50	S04I	-0.92	77	S03	-1.66	104	S03	-1.34
24	S04I	-0.32	51	S04I	-0.66	78	S03	-1.32	105	S03	-1.52
25	S04I	-0.42	52	S04I	-1.22	79	S03	-1.67	106	S03	-1.73
26	S04I	-0.72	53	S04I	-1.58	80	S03	-2.37			
27	S04I	-0.93	54	Test	-1.10**	81	S03	-1.94			

Table 11: 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 (eqn A2.19 in the CTD methodology); α is the correction applied to CTD conductivities due to pressure dependence of the conductivity residuals (eqn 1).

Station grouping	F_1	F_2	F_3	n	σ	α
001 to 002 S04I	-0.55151931E-01	0.98768159E-03	-0.25816422E-06	43	0.001388	0 (stn 1)
						0.7039725E-06 (stn 2)
003 to 004 S04I	-0.55896676E-01	0.98729002E-03	-0.10392899E-07	35	0.001552	0.7039725E-06
005 to 006 S04I	-1.3093410	0.10322266E-02	0	9	0.001772	0
007 to 008 S04I	-0.54926719E-01	0.98668229E-03	0.31628388E-07	33	0.001976	0
009 to 010 S04I	-0.84408096E-01	0.98892340E-03	-0.11378698E-06	43	0.001072	0
011 to 012 S04I	-0.79525457E-01	0.98788105E-03	-0.17868175E-07	45	0.000863	1.4608959E-06
013 to 014 S04I	-0.47581367E-01	0.98643852E-03	0.20690218E-07	43	0.001268	0.8503317E-06
015 to 018 S04I	-0.90261955E-01	0.98726571E-03	0.52286883E-07	87	0.001082	1.1245280E-06
019 to 020 S04I	0.35624898E-01	0.95488768E-03	0.12901507E-06	44	0.001376	-3.9074269E-06
021 to 022 S04I	0.35077650E-01	0.95983939E-03	-0.11562160E-06	46	0.001699	-3.1360125E-06
023 to 027 S04I	0.21164570E-02	0.95849180E-03	-0.70763325E-08	85	0.001277	-3.8628606E-06
028 to 029 S04I	0.10941363E-01	0.95544232E-03	0.89732482E-07	46	0.001467	-4.1948918E-06
030 to 031 S04I	0.88594631E-02	0.95649136E-03	0.50457051E-07	43	0.000846	-4.2553530E-06
032 to 033 S04I	0.19440563E-01	0.96028342E-03	-0.84564608E-07	43	0.001096	-3.7799151E-06
034 to 035 S04I	-0.60553073	0.98311882E-03	-0.18690584E-06	40	0.002047	-0.5076831E-06
036 to 038 S04I	0.36708276E-01	0.95577090E-03	0.21875702E-07	66	0.001375	-3.1761190E-06
039 to 040 S04I	0.82647512E-01	0.95203109E-03	0.77198775E-07	45	0.001361	-2.9058778E-06
041 to 043 S04I	0.19447580E-01	0.95736474E-03	-0.79680507E-08	68	0.001541	-2.3631424E-06
044 to 046 S04I	0.30237096E-01	0.95680538E-03	-0.27308193E-08	66	0.001468	-1.8128443E-06
047 to 048 S04I	0.59998387E-01	0.96962316E-03	-0.28862853E-06	31	0.001060	-0.9916311E-06

Station grouping	F_1	F_2	F_3	n	σ	α
049 to 051 S04I	0.40529276E-01	0.95536507E-03	0.20374809E-07	67	0.001983	-1.0150511E-06
052 to 053 S04I	0.72904220E-01	0.94224468E-03	0.25347666E-06	30	0.001039	0
054 to 056 S03	-0.16437023E-01	0.94840277E-03	0.18430266E-06	40	0.001547	0 (stn 54)
						1.1052417E-05(stn55)
						2.9457907E-05(stn56)
057 to 058 S03	0.83091393E-01	0.97579514E-03	-0.36657863E-06	19	0.001715	
059 to 060 S03	0.38970365E-01	0.95136388E-03	0.77236642E-07	41	0.001387	
061 to 062 S03	0.10962147E-01	0.96004529E-03	-0.52779303E-07	43	0.001912	
063 to 065 S03	0.53262814E-02	0.96057593E-03	-0.57406289E-07	62	0.001059	
066 to 067 S03	-0.67340513E-02	0.95711703E-03	0.32602246E-08	43	0.001515	
068 to 071 S03	0.26176288E-01	0.95501467E-03	0.16981713E-07	81	0.001365	
072 to 074 S03	-0.33286342E-01	0.96114393E-03	-0.39304776E-07	65	0.001755	
075 to 076 S03	-0.24514632E-01	0.95585560E-03	0.26753495E-07	45	0.002289	
077 to 079 S03	-0.38553928E-01	0.95780877E-03	0.79812009E-08	64	0.001975	
080 to 081 S03	-0.64523829E-02	0.95852101E-03	-0.14973816E-07	44	0.001366	
082 to 083 S03	-0.31874236E-01	0.96253569E-03	-0.53150506E-07	43	0.000775	
084 to 085 S03	-0.22073834E-01	0.95459300E-03	0.38284407E-07	43	0.001037	
086 to 092 S03	-0.68709889E-02	0.95688724E-03	0.42797804E-08	150	0.001549	
093 to 095 S03	0.13907181E-02	0.95680064E-03	0.14985374E-09	65	0.001092	
096 to 097 S03	0.37615123E-02	0.95744099E-03	-0.84529938E-08	40	0.000884	
098 to 099 S03	0.20749048E-01	0.98726272E-03	-0.32570719E-06	48	0.001562	
100 to 101 S03	0.65954377E-02	0.95472218E-03	0.59023049E-08	43	0.001298	
102 to 104 S03	0.57362283E-03	0.95957215E-03	-0.41938467E-07	57	0.000914	
105 to 106 S03	-0.91747190E-02	0.96498194E-03	-0.90946316E-07	28	0.001279	

Table 12: 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.

Station Number	(F_2+F_3.N)	station number	(F_2+F_3.N)	station number	(F_2+F_3.N)
1 TEST	0.98742342E-03	37 S04I	0.95658030E-03	73S03	0.95827468E-03
2 S04I	0.98716526E-03	38 S04I	0.95660218E-03	74S03	0.95823538E-03
3 S04I	0.98725884E-03	39 S04I	0.95504184E-03	75S03	0.95786211E-03
4 S04I	0.98724844E-03	40 S04I	0.95511904E-03	76S03	0.95788886E-03
5 S04I	0.10322266E-02	41 S04I	0.95703805E-03	77S03	0.95842332E-03
6 S04I	0.10322266E-02	42 S04I	0.95703008E-03	78S03	0.95843131E-03
7 S04I	0.98690369E-03	43 S04I	0.95702211E-03	79S03	0.95843929E-03
8 S04I	0.98693532E-03	44 S04I	0.95668522E-03	80S03	0.95732310E-03
9 S04I	0.98789931E-03	45 S04I	0.95668249E-03	81S03	0.95730813E-03
10 S04I	0.98778553E-03	46 S04I	0.95667976E-03	82S03	0.95817735E-03
11 S04I	0.98768450E-03	47 S04I	0.95605761E-03	83S03	0.95812420E-03
12 S04I	0.98766663E-03	48 S04I	0.95576899E-03	84S03	0.95780889E-03
13 S04I	0.98670749E-03	49 S04I	0.95636344E-03	85S03	0.95784717E-03
14 S04I	0.98672818E-03	50 S04I	0.95638381E-03	86S03	0.95725530E-03
15 S04I	0.98805001E-03	51 S04I	0.95640419E-03	87S03	0.95725958E-03
16 S04I	0.98810230E-03	52 S04I	0.95542546E-03	88S03	0.95726386E-03
17 S04I	0.98815459E-03	53 S04I	0.95567894E-03	89S03	0.95726814E-03
18 S04I	0.98820687E-03	54 TEST	0.95835512E-03	90S03	0.95727242E-03
19 S04I	0.95733896E-03	55S03	0.95853942E-03	91S03	0.95727670E-03
20 S04I	0.95746798E-03	56S03	0.95872372E-03	92S03	0.95728098E-03
21 S04I	0.95741133E-03	57S03	0.95490015E-03	93S03	0.95681457E-03
22 S04I	0.95729571E-03	58S03	0.95453358E-03	94S03	0.95681472E-03
23 S04I	0.95832904E-03	59S03	0.95592085E-03	95S03	0.95681487E-03
24 S04I	0.95832197E-03	60S03	0.95599808E-03	96S03	0.95662950E-03
25 S04I	0.95831489E-03	61S03	0.95682575E-03	97S03	0.95662105E-03
26 S04I	0.95830781E-03	62S03	0.95677297E-03	98S03	0.95534341E-03
27 S04I	0.95830074E-03	63S03	0.95695933E-03	99S03	0.95501771E-03
28 S04I	0.95795483E-03	64S03	0.95690192E-03	100S03	0.95531241E-03
29 S04I	0.95804456E-03	65S03	0.95684452E-03	101S03	0.95531831E-03
30 S04I	0.95800507E-03	66S03	0.95733220E-03	102S03	0.95529443E-03
31 S04I	0.95805553E-03	67S03	0.95733546E-03	103S03	0.95525249E-03
32 S04I	0.95757736E-03	68S03	0.95616942E-03	104S03	0.95521055E-03
33 S04I	0.95749279E-03	69S03	0.95618640E-03	105S03	0.95543257E-03
34 S04I	0.97676403E-03	70S03	0.95620339E-03	106S03	0.95534163E-03
35 S04I	0.97657712E-03	71S03	0.95622037E-03		
36 S04I	0.95655843E-03	72S03	0.95831399E-03		

Table 13: 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 scans numbers are not included in the ignore or interpolate actions.

Sta #	Approx. press. (dbar)	raw scan numbers	action taken	reason
1	69	312710-312712	ignore	fouling of cond. cell
2	103	267360-267656; 267704-268141	ignore	wake effect
2	28; 24	274342-274439; 274610-274752	ignore	wake effect
3	110	294797-294846	ignore	wake effect
4	189	326120-326134	ignore	fouling of cond. cell
4	101	331813-332033	ignore	wake effect
17	102	269059-269211; 269417-269509	ignore	wake effect
18	53	300375-300727	ignore	wake effect
20	3704-3718	163056-163405	ignore	fouling of cond. cell
32	600	287236-287282	ignore	fouling of cond. cell
34	110-112	378784-378843	ignore	fouling of cond. cell
35	28; 26	330110-330137; 330166-330192	ignore	fouling of cond. cell
36	131-137	305201-305336	ignore	fouling of cond. cell
41	56-77	262645-262993	ignore	fouling of cond. cell
45	64-67	237753-237801	interpolate	wake effect
47	11	76038-76197	interpolate	wake effect
60	256-258	16896-170036	interpolate	wake effect
60	320	166669-166671	ignore	suspect pressure value
61	259	195087-195110	ignore	wake effect
65	56-72	254997-255277	ignore	fouling of cond. cell
71	213-216	285966-286010	ignore	fouling of cond. cell
94	1012-1039	271068-271531	ignore	fouling of cond. cell
95	828-834	257553-257678	ignore	fouling of cond. cell
103	236	227094-227097	ignore	fouling of cond. cell
105	150; 12	110099-110538; 121628-121631	ignore	fouling of cond. cell

Table 14: Suspect 2 dbar averages. Note: for suspect salinity values, the following are also suspect: sigma-T, specific volume anomaly, and geopotential anomaly.

station number	suspect 2 dbar values (dbar)		reason
	bad	questionable	
Suspect salinity values			
1	60,62	58,64,116,118	salinity spike in steep local gradient
2	24	20,22	salinity spike in steep local gradient
3	34,36	98	salinity spike in steep local gradient
4	-	100,110	salinity spike in steep local gradient
10	-	404	salinity spike in steep local gradient
11	-	120,122,124	salinity spike in steep local gradient
15	38	36,40,42,52,54	salinity spike in steep local gradient
16	38	-	salinity spike in steep local gradient
17	58	56,60	salinity spike in steep local gradient
18	54,96,108	52,56	salinity spike in steep local gradient
25	-	48	salinity spike in steep local gradient
29	-	46	salinity spike in steep local gradient
35	-	34	salinity spike in steep local gradient
55	-	802-812	possible fouling of conductivity cell
60	-	322	salinity spike in steep local gradient
67	-	54	salinity spike in steep local gradient
68	42	-	salinity spike in steep local gradient
71	64	-	salinity spike in steep local gradient
72	-	64	salinity spike in steep local gradient
73	-	52	salinity spike in steep local gradient
74	-	60	salinity spike in steep local gradient
76	-	72	salinity spike in steep local gradient
78	-	78	salinity spike in steep local gradient
Suspect dissolved oxygen values			
64	3230-3258	-	
74	1358	-	
74	3664	-	
74	3760	-	
91	462-474	-	

Table 15a: Suspect 2 dbar-averaged data from near the surface (applies to all parameters other than dissolved oxygen, except where noted).

	suspect 2dbar values (dbar)				suspect 2dbar values (dbar)		
Stn #	bad	questionable	comment	stn #	bad	questionable	comment
13	-	2	temperature ok	71	-	2	temperature ok
14	-	2	temperature ok	72	-	2	temperature ok
16	-	2	temperature ok	73	-	2	temperature ok
18	-	2	temperature ok	74	-	2	temperature ok
63	-	2	temperature ok				

Table 15b: Suspect 2 dbar-averaged dissolved oxygen data from near the surface.

	suspect 2dbar values (dbar)			suspect 2dbar values (dbar)			suspect 2dbar values (dbar)	
Stn #	bad	questionable	Stn #	bad	questionable	Stn #	bad	questionable
19	-	2-24	52	-	2	75	-	2-6
20	-	2-14	53	-	2	84	-	2-10
25	-	2-10	67	-	2-14	85	-	2-10
37	-	2-60	69	-	2-12	95	-	2-10
38	-	2-12	70	-	2-12			

Table 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 defined as in eqn A2.24 in the CTD methodology); n is the number of samples retained for calibration in each station or station grouping.

Stn #	K_1	K_2	K_3	K_4	K_5	K_6	dox	n
19	10.84	6.0000	-1.520	-0.0997	0.5714	0.0001243	0.0836	22
20	11.15	7.0000	-1.498	-0.1347	0.6687	0.0001101	0.0977	22
21	9.50	8.0000	-1.283	-0.0774	0.2524	0.0001077	0.0922	23
22	9.79	6.5000	-1.318	-0.0857	0.5944	0.0001191	0.1631	24
23	9.85	8.0000	-1.327	-0.0834	0.5259	0.0001162	0.0993	24
24	11.31	6.0000	-1.509	-0.1429	0.5847	0.0001015	0.1042	22
25	10.08	5.0000	-1.428	-0.0586	0.1952	0.0001219	0.0943	23
26	10.25	6.0000	-1.331	-0.1175	0.5731	0.0001038	0.1114	22
27	10.82	5.0000	-1.484	-0.1072	0.3868	0.0001021	0.0833	20

Stn #	K_1	K_2	K_3	K_4	K_5	K_6	dox	n
28	-	-	-	-	-	-	-	-
29	10.00	5.0000	-1.421	-0.0584	0.0549	0.0001235	0.0821	22
30	13.27	6.3000	-1.765	-0.1997	0.6450	0.0000960	0.0952	23
31	10.20	5.5000	-1.323	-0.1257	0.6496	0.0001120	0.1202	22
32	11.22	6.1000	-1.513	-0.1274	0.6352	0.0001118	0.1145	23
33	9.90	6.5000	-1.343	-0.0834	0.4733	0.0001193	0.1101	23
34	11.42	5.0000	-1.606	-0.1106	0.4598	0.0001185	0.1193	23
35	9.55	5.0000	-1.274	-0.0870	0.3656	0.0001115	0.0900	23
36	10.62	5.7000	-1.462	-0.0981	0.5355	0.0001164	0.1128	22
37	10.99	5.4000	-1.366	-0.1729	0.6951	0.0000956	0.1161	22
38	9.83	8.5000	-1.300	-0.0998	0.4719	0.0001090	0.1785	24
39	11.85	5.5000	-1.693	-0.0893	0.9384	0.0001481	0.1395	24
40	9.52	5.0000	-1.222	-0.1050	0.4554	0.0000956	0.1988	23
41	10.35	5.0000	-1.321	-0.1407	0.5947	0.0000991	0.1704	22
42	10.19	5.0000	-1.365	-0.1027	0.6043	0.0001209	0.1027	23
43	10.46	5.0000	-1.415	-0.0988	0.7758	0.0001334	0.1264	23
44	9.98	5.0000	-1.276	-0.1154	0.7166	0.0001112	0.1620	23
45	8.59	5.0000	-1.092	-0.0568	0.8185	0.0001261	0.1211	23
46	9.40	7.6000	-1.077	-0.1526	0.7112	0.0000860	0.0937	23
47	4.56	8.0000	-0.129	-0.1478	0.5075	0.0000238	0.1100	24
48	9.82	8.0000	-1.220	-0.1357	0.6939	0.0001045	0.1126	15
49	8.69	5.0000	-0.823	-0.2138	0.7031	0.0000645	0.1851	23
50	10.13	5.0000	-1.288	-0.1417	0.7160	0.0001096	0.1802	21
51	9.92	5.7000	-1.265	-0.1289	0.6950	0.0001095	0.1700	23
52	9.38	5.0000	-0.620	-0.3413	0.7189	0.0000302	0.1431	23
53	9.81	5.0000	-1.182	-0.1388	0.6609	0.0000698	0.1821	11
54	-	-	-	-	-	-	-	-
55	6.97	5.0000	-0.663	-0.0339	0.7479	0.0002265	0.2867	23
56	10.77	5.0000	-0.784	-0.1082	1.7653	0.0002543	0.2701	11
57	7.77	5.0000	-0.893	-0.0376	0.9939	0.0002700	0.1365	9
58	18.99	5.0000	-1.887	-0.3220	1.0860	-0.0000862	0.2016	12
59	7.80	6.5000	-0.828	-0.1463	0.5008	0.0000699	0.2340	23
60	10.74	5.0000	-1.405	-0.1374	0.6837	0.0000890	0.2835	22
61	8.56	5.4000	-0.752	-0.2324	0.7231	0.0000545	0.2215	22
62	6.83	5.0000	-0.702	-0.1088	0.3474	0.0000582	0.2236	23
63	9.99	5.0000	-1.155	-0.1899	0.7218	0.0000761	0.2073	22
64	10.84	6.0000	-1.542	-0.0947	0.5279	0.0001167	0.1488	23
65	-	-	-	-	-	-	-	-
66	-	-	-	-	-	-	-	-
67	9.88	8.1000	-1.358	-0.0693	0.5847	0.0001246	0.0932	22
68	10.37	5.0000	-1.398	-0.0993	0.6389	0.0001149	0.2438	24

Stn #	K_1	K_2	K_3	K_4	K_5	K_6	dox	n
69	10.21	5.0000	-1.507	-0.0230	0.5929	0.0001541	0.0993	22
70	10.13	5.0000	-1.482	-0.0384	0.6813	0.0001547	0.1931	23
71	10.94	5.0000	-1.563	-0.0789	0.6839	0.0001389	0.1362	23
72	10.30	7.0000	-1.405	-0.0978	0.5148	0.0001129	0.1102	22
73	11.69	5.0000	-1.712	-0.0789	0.6026	0.0001338	0.2344	22
74	11.15	5.0000	-1.618	-0.0774	0.7047	0.0001443	0.1594	23
75	11.19	5.0000	-1.548	-0.1200	0.4974	0.0001064	0.1792	22
76	9.81	5.0000	-1.417	-0.0364	0.4576	0.0001436	0.1843	23
77	11.49	5.0000	-1.668	-0.0842	0.6645	0.0001397	0.1952	21
78	15.42	5.0000	-2.300	-0.1429	0.8493	0.0001510	0.2491	24
79	10.63	5.0000	-1.523	-0.0686	0.7043	0.0001431	0.2986	24
80	15.38	4.8000	-2.256	-0.1733	0.8770	0.0001353	0.3505	23
81	12.66	5.0000	-1.843	-0.1084	0.8944	0.0001435	0.1945	23
82	12.32	5.0000	-1.784	-0.1071	0.8816	0.0001374	0.2613	23
83	11.65	5.0000	-1.704	-0.0841	0.7762	0.0001453	0.1655	22
84	12.00	5.0000	-1.788	-0.0758	0.6134	0.0001404	0.2362	24
85	13.74	4.6000	-2.095	-0.0979	0.5523	0.0001431	0.3313	23
86	12.92	5.0000	-1.943	-0.1079	0.9207	0.0001597	0.1862	23
87	11.10	5.0000	-1.617	-0.0748	0.7939	0.0001402	0.2204	23
88	12.15	5.0000	-1.813	-0.0984	0.9811	0.0001700	0.1533	22
89	13.48	5.0000	-2.058	-0.1033	0.7539	0.0001634	0.2285	24
90	12.95	5.0000	-1.975	-0.0904	0.6741	0.0001597	0.1744	23
91	12.49	5.0000	-1.903	-0.0793	0.6989	0.0001619	0.1489	22
92	11.68	5.0000	-1.778	-0.0751	0.8059	0.0001793	0.1691	21
93	11.85	5.0000	-1.822	-0.0711	0.7029	0.0001812	0.1999	24
94	11.56	5.0000	-1.716	-0.0889	0.9086	0.0001596	0.2278	24
95	11.31	5.0000	-1.685	-0.0770	0.8041	0.0001618	0.1031	24
96	13.48	5.0000	-2.135	-0.0747	0.5469	0.0001834	0.2361	22
97	11.53	5.0000	-1.745	-0.0648	0.6549	0.0001629	0.2228	21
98	11.11	5.0000	-1.627	-0.0804	0.8678	0.0001512	0.1764	24
99	11.13	5.0000	-1.686	-0.0721	0.8706	0.0001874	0.1619	22
100	11.73	5.0000	-1.816	-0.0685	0.6922	0.0001936	0.2216	23
101	10.99	5.0000	-1.610	-0.0631	0.6581	0.0001085	0.2108	24
102	11.61	5.0000	-1.805	-0.0742	0.7840	0.0002055	0.2297	23
103	11.13	5.0000	-1.730	-0.0609	0.7031	0.0002107	0.2480	23
104	10.63	5.0000	-1.549	-0.0857	0.9403	0.0001587	0.1744	24
105	10.31	5.0000	-1.342	-0.0749	0.7824	-0.0000437	0.2751	22
106	7.45	9.8000	-0.946	-0.0346	0.8315	0.0000151	0.2323	15

Table 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.

Stn #	K_1	K_2	K_3	K_4	K_5	K_6	coefficients varied	
19	11.9000	6.0000	-1.300	-0.360E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
20	11.5000	7.0000	-1.400	-0.360E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
21	10.1000	8.0000	-1.100	-0.360E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
22	10.5500	6.5000	-1.100	-0.360E-01	0.850	0.15000E-03	K_1	K_3 K_4 K_5 K_6
23	10.7500	8.0000	-1.100	-0.360E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
24	11.5000	6.0000	-1.350	-0.660E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
25	11.3000	5.0000	-1.020	-0.360E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
26	10.5800	6.0000	-1.200	-0.500E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
27	11.2300	5.0000	-1.300	-0.550E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
28	-	-	-	-	-	-	-	
29	11.1000	5.0000	-1.050	-0.380E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
30	13.1500	6.3000	-1.700	-0.400E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
31	10.4000	5.5000	-1.200	-0.360E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
32	11.5000	6.1000	-1.400	-0.400E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
33	10.6700	6.5000	-1.100	-0.360E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
34	12.1000	5.0000	-1.410	-0.500E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
35	10.0000	5.0000	-1.100	-0.400E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
36	11.0000	5.7000	-1.300	-0.370E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
37	10.9000	5.4000	-1.300	-0.500E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
38	10.0000	8.5000	-1.250	-0.360E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
39	12.9000	5.5000	-1.300	-0.360E-01	0.850	0.15000E-03	K_1	K_3 K_4 K_5 K_6
40	9.4000	5.0000	-1.230	-0.360E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
41	10.5500	5.0000	-1.100	-0.700E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
42	11.0000	5.0000	-1.100	-0.400E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
43	11.0000	5.0000	-1.150	-0.360E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
44	10.3500	5.0000	-1.100	-0.360E-01	0.800	0.15000E-03	K_1	K_3 K_4 K_5 K_6
45	8.5000	5.0000	-1.100	-0.360E-01	0.800	0.15000E-03	K_1	K_3 K_4 K_5 K_6
46	9.9000	7.6000	-1.000	-0.360E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
47	4.8500	8.0000	-0.040	-0.360E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
48	10.4000	8.0000	-1.100	-0.360E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
49	8.8500	5.0000	-0.850	-0.360E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
50	10.3500	5.0000	-1.110	-0.360E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
51	10.5000	5.7000	-1.100	-0.370E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
52	10.8000	5.0000	-0.650	-0.600E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
53	9.6000	5.0000	-0.470	-0.700E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
54	-	-	-	-	-	-	-	-
55	7.1000	5.0000	-0.650	-0.360E-01	0.740	0.15000E-03	K_1	K_3 K_4 K_5 K_6

Stn #	K_1	K_2	K_3	K_4	K_5	K_6	coefficients varied	
56	10.2000	5.0000	-0.650	-0.360E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
57	7.8500	5.0000	-0.870	-0.360E-01	0.800	0.15000E-03	K_1	K_3 K_4 K_5 K_6
58	7.6500	5.0000	-0.570	-0.360E-01	0.670	0.15000E-03	K_1	K_3 K_4 K_5 K_6
59	8.4000	6.5000	-0.800	-0.360E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
60	10.8000	5.0000	-1.120	-0.360E-01	0.710	0.15000E-03	K_1	K_3 K_4 K_5 K_6
61	9.0000	5.4000	-0.680	-1.000E-01	0.740	0.15000E-03	K_1	K_3 K_4 K_5 K_6
62	7.1500	5.0000	-0.650	-0.600E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
63	10.4000	5.0000	-1.020	-0.500E-01	0.740	0.15000E-03	K_1	K_3 K_4 K_5 K_6
64	11.4000	6.0000	-1.400	-0.360E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
65	-	-	-	-	-	-	-	-
66	-	-	-	-	-	-	-	-
67	11.4000	8.1000	-1.100	-0.360E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
68	10.7000	5.0000	-1.100	-0.400E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
69	10.1500	5.0000	-1.520	-0.300E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
70	10.4500	5.0000	-1.450	-0.350E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
71	12.5000	5.0000	-1.100	-0.400E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
72	10.7000	7.0000	-1.200	-0.360E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
73	12.9500	5.0000	-1.230	-0.360E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
74	12.6800	5.0000	-1.000	-0.360E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
75	11.3000	5.0000	-1.200	-0.600E-01	0.700	0.15000E-03	K_1	K_3 K_4 K_5 K_6
76	10.1500	5.0000	-1.300	-0.360E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
77	12.4000	5.0000	-1.150	-0.360E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
78	14.0000	5.0000	-1.600	-0.400E-01	0.690	0.15000E-03	K_1	K_3 K_4 K_5 K_6
79	10.4000	5.0000	-1.500	-0.500E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
80	13.5000	4.8000	-1.400	-0.500E-01	0.650	0.10000E-03	K_1	K_3 K_4 K_5 K_6
81	12.5500	5.0000	-1.200	-0.360E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
82	12.0500	5.0000	-1.100	-0.360E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
83	12.5000	5.0000	-1.120	-0.360E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
84	12.7000	5.0000	-1.120	-0.360E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
85	12.5000	4.6000	-1.300	-0.360E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
86	13.3000	5.0000	-1.610	-0.360E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
87	11.8000	5.0000	-1.210	-0.360E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
88	13.0000	5.0000	-1.510	-0.360E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
89	13.5000	5.0000	-1.570	-0.360E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
90	13.3000	5.0000	-1.520	-0.360E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
91	13.9000	5.0000	-1.650	-0.360E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
92	13.2000	5.0000	-1.410	-0.360E-01	0.700	0.15000E-03	K_1	K_3 K_4 K_5 K_6
93	14.1000	5.0000	-1.600	-0.360E-01	0.600	0.15000E-03	K_1	K_3 K_4 K_5 K_6
94	12.7000	5.0000	-1.310	-0.450E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
95	12.3000	5.0000	-1.300	-0.360E-01	0.750	0.15000E-03	K_1	K_3 K_4 K_5 K_6
96	15.4000	5.0000	-1.820	-0.400E-01	0.690	0.15000E-03	K_1	K_3 K_4 K_5 K_6

Stn #	K_1	K_2	K_3	K_4	K_5	K_6	coefficients varied
97	13.4500	5.0000	-1.420	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
98	12.0000	5.0000	-1.200	-0.400E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
99	12.9000	5.0000	-1.300	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
100	14.4000	5.0000	-1.640	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
101	12.5000	5.0000	-1.300	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
102	12.9000	5.0000	-1.200	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
103	14.3000	5.0000	-1.370	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
104	11.8000	5.0000	-1.200	-0.360E-01	0.750	0.15000E-03	K_1 K_3 K_4 K_5 K_6
105	11.3000	5.0000	-1.150	-0.370E-01	0.800	0.20000E-03	K_1 K_3 K_4 K_5 K_6
106	7.2000	9.8000	-1.020	-0.200E-01	0.740	0.20000E-03	K_1 K_3 K_4 K_5 K_6

Table 18: Questionable dissolved oxygen Niskin bottle sample values (not deleted from hydrology data file).

stn no.	rosette position	stn no.	rosette position
1	2,24	44	1
12	1	48	1
15	14	64	13,14
16	14	77	2
17	14	80	9
32	1	101	5

Table 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
		2	2		
4	17	4	4		
7	21,22,23				
14	13	14	13	14	13
17	23				
19	23				
21	23	21	19		
24	22				
25	23				
27	22				
28	whole stn				
30	23				
32	23				

PHOSPHATE		NITRATE		SILICATE	
station number	**rosette position**	**station number**	**rosette position**	**station number**	**rosette position**
34	23				
35	24				
36	24				
37	24			37	2
40	24				
		42	11,12		
		45	1 to 13		
50	24				
51	23				
52	whole stn	52	whole stn		
55	22				
56	22				
		60	whole stn		
64	24				
65	24				
67	23				
68	23,24				
69	23				
71	23			71	11
72	23			72	19
73	23,24				
74	23,24				
75	22,23,24				
76	23,24				
78	24				
83	22				
		103	22 to 24		

Table 20: Laboratory temperatures T_l at the times of nutrient analyses. Note that a mean value of 21.5^{o}C was used for conversion to gravimetric units for WOCE format data (Appendix 2).

stn no.	T_l (^{o}C)	stn no.	T_l (^{o}C)	stn no.	T_l (^{o}C)	stn no.	T_l (^{o}C)	stn no.	T_l (^{o}C)	stn no.	T_l (^{o}C)
1	22	21	21.7	41	21	61	22	81	21.5	101	21.5
2	22	22	22	42	21	62	21	82	21.5	102	21.5
3	22	23	21.5	43	21.5	63	21.5	83	22	103	21
4	23	24	22	44	21	64	21	84	22	104	21.5
5	-	25	20.5	45	22	65	22	85	22	105	21.5

stn no.	T_l (^{o}C)	stn no.	T_l (^{o}C)	stn no.	T_l (^{o}C)	stn no.	T_l (^{o}C)	stn no.	T_l (^{o}C)	stn no.	T_l (^{o}C)
6	21	26	21	46	21	66	22	86	22	106	21.5
7	22	27	21	47	21	67	22	87	23		
8	20.5	28	21	48	21	68	21.5	88	22.5		
9	21	29	21	49	21	69	22	89	22.5		
10	22.5	30	21	50	20.5	70	22	90	23.5		
11	21.5	31	21.5	51	21.5	71	22	91	22.5		
12	21.5	32	21	52	22	72	21.5	92	21.5		
13	21.5	33	20.5	53	21	73	21.5	93	22		
14	22	34	22	54	19.5	74	22	94	22		
15	22	35	21	55	20	75	22	95	21		
16	21.5	36	21	56	19.5	76	21.5	96	21.5		
17	21	37	21.5	57	21	77	21.5	97	21.5		
18	22.5	38	21.5	58	21	78	21.5	98	21.5		
19	21	39	21	59	21	79	22	99	22		
20	22	40	21	60	22	80	21.5	100	22		

Table 21: 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.

Stn #	rosette position	Stn #	rosette position	Stn #	rosette position
19	22	46	22	77	19
20	22	48	1	82	20
21	22	49	23	83	19
24	21	50	1,22,23	85	19
26	21,22	52	23	88	18
27	21,22	55	22	90	18
29	12,22	60	22,24	91	18,22
30	22	61	20,24	92	13,23
31	12,23	62	24	96	10
32	23	63	21,24	97	11
34	23	64	22	99	14,18
35	22	67	24	100	14
36	21,23	69	21,24	102	22
37	23	70	24	105	7,8
40	3	71	21	106	17,18
41	22	72	20,23		
42	21	73	20		
43	24	74	20		
44	1	75	20,23		

Table 22: Stations containing fluorescence (fl) and photosynthetically active radiation (par) 2 dbar-averaged data.

stations with fl data	stations with par data
	2 to 4
5 to 12	5 to 12
	13 to 76

Table 23: Protected and unprotected reversing thermometers used for cruise AU9404 (serial numbers are listed).

protected thermometers			
station numbers	**rosette position 24 thermometers**	**rosette position 12 thermometers**	**rosette position 2 thermometers**
2	-	12094,11973 (pos. 13)	-
3 to 8	12095,12096	12119,12120	12094,11973
9 to 63	12095,12096	12119,12120	12094,11637
64 to 102	12095,12096	12119,12120	12094,11973
103 to 106	11637,11638	12094,11973	12119,12120
107	11638 (pos. 23); 11637 (pos. 20);	12095 (pos. 16); 12094 (pos. 12); 12096 (pos. 8);	12119 (pos. 5); 12120 (pos. 2)

unprotected thermometers			
station numbers		**rosette position 12 thermometers**	**rosette position 2 thermometers**
2		11992 (pos. 13)	-
3 to 35		11993	11992
36 to 107		11992	11993

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APPENDIX 1 CTD Instrument Calibrations

Table A1.1: Calibration coefficients and calibration dates for CTD serial numbers 1103 and 1193 (unit nos 7 and 5 respectively) used during RSV Aurora Australis cruise AU9404. 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 - 13/09/1994		*CSIRO Calibration Facility - 13/09/1994*	
pcal0	-2.043035e+01	pcal0	-9.273027
pcal1	1.002658e-01	pcal1	1.008386e-01
pcal2	6.393209e-9	pcal2	0.0
pcal3	0.0	pcal3	0.0
platinum temperature calibration coefficients		*platinum temperature calibration coefficients*	
CSIRO Calibration Facility - 23/09/1994		*CSIRO Calibration Facility - 23/09/1994 (with additional offset term from cruise thermometer data)*	
Tcal0	0.70500e-02	Tcal0	-0.62088e-02 - 0.007
Tcal1	0.50000e-03	Tcal1	0.49880e-03
Tcal2	0.35049e-11	Tcal2	0.27541e-11
pressure temperature calibration coefficients		*pressure temperature calibration coefficients*	
General Oceanics - July 1993		*General Oceanics - July 1993*	
Tpcal0	1.062859e+02	Tpcal0	2.238391e+02
Tpcal1	-2.117688e-03	Tpcal1	-1.155218e-02
Tpcal2	2.597323e-09	Tpcal2	2.418139e-07
Tpcal3	0.000000	Tpcal3	-2.007116e-12
coefficients for temperature correction to pressure		*coefficients for temperature correction to pressure*	
General Oceanics - July 1993		*General Oceanics - July 1993*	
T_0	21.50	T_0	22.00
S_1	-5.9127e-07	S_1	-2.3599e-06
S_2	-3.2430e-01	S_2	-1.6700e-01

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

f0	-2.699918e+01
f1	8.239746e-04
f2	-2.071294e-22
par0	-4.499860
par1	1.373290e-04
par2	-3.452156e-23

APPENDIX 2: WOCE Data Format Addendum

A2.1 INTRODUCTION

This Appendix is relevant only to data submitted to the WHP Office. For WOCE format data, file format descriptions as detailed earlier in this report should be ignored. Data files submitted to the WHP Office are in the standard WOCE format as specified in Joyce et al. (1991).

A2.2 CTD 2 DBAR-AVERAGED DATA FILES

- CTD 2 dbar-averaged file format is as per Table 3.12 of Joyce et al. (1991), 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 A2.1. Data quality information is detailed in earlier sections of this report.

A2.3 HYDROLOGY DATA FILES

- Hydrology data file format is as per Table 3.7 of Joyce et al. (1991), with quality flags defined in Tables A2.2 and A2.3.
- 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.

A2.4 CONVERSION OF UNITS FOR DISSOLVED OXYGEN AND NUTRIENTS

A2.4.1 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

$$C_k = 1000\, C_l / \rho(\theta,s,0) \qquad \text{(eqn A2.1)}$$

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

$$\theta = \theta(T,s,p) \qquad \text{(eqn A2.2)}$$

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 A2.1 and A2.2 are CTD 2 dbar-averaged data.

A2.4.2 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

$$C_k = 1000\, C_l / \rho(T_l,s,0) \qquad \text{(eqn A2.3)}$$

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 $T_l = 21.5^oC$ was used for all stations. Upcast CTD burst data averages are used for s.

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Table A2.1: Definition of quality flags for CTD data (after Table 3.11 in Joyce et al., 1991). 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 value
7,8	these flags are not used
9	parameter not sampled

Table A2.2: Definition of quality flags for Niskin bottles (i.e. parameter BTLNBR in *.sea files) (after Table 3.8 in Joyce et al., 1991).

flag	definition
1	this flag is not used
2	no problems noted
3	bottle leaking, as noted when rosette package returned on deck
4	bottle did not trip correctly
5	bottle leaking, as noted from data analysis
6	bottle not fired at correct depth, due to misfiring of rosette pylon
7,8	these flags are not used
9	samples not drawn from this bottle

Table A2.3: Definition of quality flags for water samples in *.sea files (after Table 3.9 in Joyce et al., 1991).

flag	definition
1	this flag is not used
2	acceptable measurement
3	questionable measurement
4	bad measurement
5	measurement not reported
7	manual autoanalyser peak measurement
6,8	these flags are not used
9	parameter not sampled

A2.5 STATION INFORMATION FILES

- File format is as per section 2.2.2 of Joyce et al. (1991), 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 ±3 m.
- Lineout (i.e. meter wheel readings of the CTD winch) were unavailable.

REFERENCES

Joyce, T., Corry, C. and Stalcup, M., 1991. *Requirements for WOCE Hydrographic Programme Data Reporting.* WHP Office Report WHPO 90-1, Revision 1, WOCE Report No. 67/91, Woods Hole Oceanographic Institution. 71 pp.

CFC-11 and CFC-12 Measurements on AU9404 (WOCE SR3 and S4)
(John Bullister)
27 April 1997

CFC Sampling Procedures and Data Processing

CFC water samples were usually the first samples collected from the 10 liter bottles. Care was taken to co-ordinate the sampling of CFCs with other gas samples to minimize the time between the inital opening of each bottle and the completion of sample drawing. In most cases, all dissolved gas samples were collected within several minutes of the initial opening of each bottle. CFC samples were collected in 100 ml precision glass syringes and held immersed in a water bath until processing. For air sampling, a ~100 meter length of 3/8" OD Dekaron tubing was run from the CFC lab van to the bow of the ship. Air was sucked through this line into the CFC van using an Air Cadet pump. The air was compressed in the pump, and the downstream pressure held at about 1.5 atm using a back pressure regulator. A tee allowed a flow (~100 cc/min) of the compressed air to be directed to the gas sample valves, while the bulk of the air (>7 liter/minute) was vented through the back pressure regulator.

Concentrations of CFC-11 and CFC-12 in air samples, seawater and gas standards on the cruise were measured by shipboard electron capture gas chromatography, using techniques similiar to those described by Bullister and Weiss (1988). The CFC analytical system functioned well during this expedition.

Analytical blanks for the water stripping process were determined and subtracted from the measured water sample concentrations. Both gas and water sample analytical blanks were very low for most of the expedition. In a few cases, for very low concentration water samples and a higher than average water sample analytical blank, subtraction of the water sample CFC analytical blank from the measured CFC water sample concentration yielded negative reported concentration values.

Concentrations of CFC-11 and CFC-12 in air, seawater samples and gas standards are reported relative to the SIO93 calibration scale (Cunnold, et. al., 1994). CFC concentrations in air and standard gas are reported in units of mole fraction CFC in dry gas, and are typically in the parts-per-trillion (ppt) range. Dissolved CFC concentrations are given in units of picomoles of CFC per kg seawater (pmol/kg). CFC concentrations in air and seawater samples were determined by fitting their chromatographic peak areas to multi-point calibration curves, generated by pressurizing sample loops and injecting known volumes of gas from a CFC working standard (PMEL cylinder 33790) into the analytical instrument. The concentrations of CFC-11 and CFC-12 in this working standard were calibrated versus a primary CFC standard (36743) (Bullister, 1984) before the cruise and a secondary standard (32386) before and after the cruise. No measurable drift between the working standards could be detected during this interval. Full range calibration curves were run 11 times during the cruise. Single injections of a fixed volume of standard gas at one atmosphere were run much more frequently (at intervals of 1 to 2 hours) to monitor short term changes in detector sensitivity. We estimate a precision (1 standard deviation) for dissolved CFC measurements on this cruise of about 1%, or 0.005 pmol/kg, whichever is greater (see listing of replicate samples given at the end of this report).

As expected, low (~0.01 pmol/kg) but non-zero CFC concentrations were measured in deep samples along the northern ends of the SR3 section. Deep and bottom CFC concentrations increased significantly southward along the section. It is likely that most of the deep CFC signals observed on SR3, which are strongly correlated with elevated dissolved oxygen and cold temperatures, are due to deep ventilation processes in this high latitude region, and not simply blanks due of the sampling and analytical procedures. The measured levels of CFC in deep water samples on the northern end of SR3 are considerable higher than those found on WOCE sections in the low latitude Pacific and Indian Oceans. For example, typical measured deep water CFC measurements along WOCE section I2 (at about 8S) were ~0.003 pmol/kg for CFC-11 and <0.001 for CFC-12. Since no "zero" concentration CFC water was present anywhere along SR3 or SR4, and an earlier occupation of SR3 in 1991 showed similar low levels of CFCs along the northern end of this section, no corrections for 'sampling blanks' have been applied to the reported CFC signals for SR3 or S4.

A number of CFC samples (from a total of ~1500) had clearly anomolous CFC-11 and/or CFC-12 concentrations relative to adjacent samples. These appeared to occur more or less randomly, and were not clearly associated with other features in the water column (eg. elevated oxygen concentrations, salinity or temperature features, etc.). This suggests that the high values were due to isolated low-level CFC contamination events. These samples are included in this report and are flagged as either 3 (questionable) or 4 (bad) measurements. 34 analyses of CFC-11 were assigned a flag of 3 and 49 analyses of CFC-12 were assigned a flag of 3. 82 analyses of CFC-11 were assigned a flag of 4 and 70 CFC-12 samples assigned a flag of 4.

In addition to the file of mean CFC concentrations reported for each water sample (keyed to the unique station:sample ID), tables of the following are included in this report:

Table 2a. AU9404 Replicate dissolved CFC-11 analyses
Table 2b. AU9404 Replicate dissolved CFC-12 analyses
Table 3. AU9404 CFC air measurements
Table 4. AU9404 CFC air measurements interpolated to station locations

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

References

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

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

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

Table 2a: AU9404 Replicate dissolved CFC-11 analyses

Stn	Niskin	CFC-11 (pmol/kg)	Stn	Niskin	CFC-11 (pmol/kg)	Stn	Niskin	CFC-11 (pmol/kg)
1	2	0.059	18	204	0.480	35	24	6.310
1	2	0.090	18	204	0.481	35	24	6.268
4	1	1.434	19	24	6.419	35	107	0.150
4	1	1.444	19	24	6.378	35	107	0.155
4	11	0.155	21	13	0.138	37	1	1.546
4	11	0.151	21	13	0.135	37	1	1.560
4	13	0.326	21	24	6.406	37	2	1.226
4	13	0.360	21	24	6.396	37	2	1.261
4	18	6.734	23	1	1.631	37	11	0.073
4	18	6.843	23	1	1.620	37	11	0.078
9	9	0.561	23	20	0.645	37	16	0.195
9	9	0.564	23	20	0.617	37	16	0.202
10	1	1.523	23	24	6.398	37	24	6.379
10	1	1.528	23	24	6.398	37	24	6.371
10	13	0.459	23	204	0.425	38	1	1.499
10	13	0.459	23	204	0.441	38	1	1.501
10	24	6.203	25	23	6.216	39	1	1.784
10	24	6.406	25	23	6.200	39	1	1.784
12	11	0.329	25	204	0.284	39	6	0.221
12	11	0.321	25	204	0.290	39	6	0.222
14	2	1.480	26	11	0.094	39	11	0.105
14	2	1.520	26	11	0.096	39	11	0.107
14	5	0.668	26	11	0.097	39	18	0.334
14	5	0.645	26	11	0.084	39	18	0.340
14	6	0.548	26	12	0.107	39	23	5.562
14	6	0.577	26	12	0.115	39	23	5.529
14	6	0.571	26	12	0.119	40	11	0.095
14	9	0.397	26	12	0.103	40	11	0.097
14	9	0.396	26	13	0.162	41	1	1.390
14	11	0.279	26	13	0.168	41	1	1.385

14	11	0.265	26	13	0.154	41	2	0.886
14	13	0.133	26	15	0.195	41	2	0.879
14	13	0.135	26	15	0.220	41	11	0.092
14	21	0.905	26	15	0.230	41	11	0.084
14	21	0.926	26	15	0.189	41	14	0.104
14	122	3.726	26	15	0.225	41	14	0.103
14	122	3.778	31	5	0.197	41	16	0.176
18	1	1.345	31	5	0.190	41	16	0.201
18	1	1.295	31	24	6.464	41	24	6.387
18	2	0.916	31	24	6.491	41	24	6.397
18	2	0.986	32	11	0.123	41	107	0.091
18	6	0.207	32	11	0.123	41	107	0.092
18	6	0.247	32	11	0.132	41	222	2.998
18	8	0.152	33	1	1.661	41	222	3.009
18	8	0.159	33	1	1.641	42	8	0.062
18	16	0.259	33	12	0.104	42	8	0.061
18	16	0.238	33	12	0.110	43	11	0.078
18	20	0.880	33	24	6.252	43	11	0.079
18	20	0.832	33	24	6.271	43	17	0.224
18	24	6.303	35	1	2.329	43	17	0.225
18	24	6.518	35	1	2.339	43	107	0.140
18	122	4.880	35	11	0.085	43	107	0.144
18	122	4.890	35	11	0.066	45	2	0.631
						45	2	0.596
45	5	0.305	49	107	0.354	61	24	6.306
45	5	0.308	49	107	0.357	61	24	6.250
45	8	0.154	50	1	1.575	62	1	1.815
45	8	0.143	50	1	1.577	62	1	1.805
45	11	0.150	50	6	0.434	63	2	2.139
45	11	0.142	50	6	0.405	63	2	2.135
45	14	0.245	50	11	0.090	63	12	0.337
45	14	0.248	50	11	0.089	63	12	0.334
45	20	0.558	50	16	0.216	63	222	4.159
45	20	0.583	50	16	0.212	63	222	4.140
45	222	3.436	50	24	5.514	65	1	2.221
45	222	3.621	50	24	5.571	65	1	2.220
47	1	0.179	51	1	1.492	65	24	6.235
47	1	0.177	51	1	1.496	65	24	6.264
47	20	4.101	51	5	0.434	67	1	1.857
47	20	4.084	51	5	0.438	67	1	1.848
48	1	0.976	51	10	0.090	67	17	0.242
48	1	1.014	51	10	0.089	67	17	0.225
48	2	0.901	51	17	0.377	67	107	0.121
48	2	0.900	51	17	0.375	67	107	0.123
48	6	0.333	51	24	5.237	68	9	0.064
48	6	0.335	51	24	5.206	68	9	0.061
48	9	0.170	51	103	1.036	68	11	0.071
48	9	0.168	51	103	1.028	68	11	0.068
48	11	0.170	54	1	0.104	69	1	1.501
48	11	0.175	54	1	0.102	69	1	1.503
48	11	0.173	54	6	0.104	69	6	0.160
48	11	0.172	54	6	0.105	69	6	0.151
48	13	0.211	54	11	0.105	69	11	0.065
48	13	0.210	54	11	0.118	69	11	0.066
48	15	4.573	54	12	0.106	69	17	0.312
48	15	4.615	54	12	0.108	69	17	0.313
48	204	0.564	54	18	0.109	69	20	1.206
48	204	0.566	54	18	0.106	69	20	1.221

49	1	1.147	54	23	0.110	69	23	6.537
49	1	1.150	54	23	0.109	69	23	6.488
49	5	0.618	54	24	0.112	69	103	0.593
49	5	0.616	54	24	0.108	69	103	0.593
49	9	0.211	54	24	0.129	71	1	1.288
49	9	0.209	54	24	0.105	71	1	1.284
49	11	0.129	55	11	4.834	71	11	0.051
49	11	0.129	55	11	4.862	71	11	0.055
49	13	0.201	55	18	4.124	71	20	1.296
49	13	0.198	55	18	4.110	71	20	1.289
49	15	0.254	55	24	6.432	71	24	6.049
49	15	0.250	55	24	6.405	71	24	6.020
49	17	0.429	60	1	2.348	73	1	0.269
49	17	0.425	60	1	2.384	73	1	0.271
49	21	1.756	60	1	2.360	73	8	0.050
49	21	1.755	61	6	1.094	73	8	0.050
49	24	4.649	61	6	1.099	73	10	0.061
49	24	4.692	61	11	0.430	73	10	0.058
49	103	1.021	61	11	0.433	73	11	0.071
49	103	1.034				73	11	0.069
73	17	0.705	85	20	4.731	97	1	0.005
73	17	0.701	85	20	4.735	97	1	0.005
73	23	5.624	86	8	0.061	97	14	3.392
73	23	5.676	86	8	0.064	97	14	3.393
73	103	0.130	86	11	0.209	97	18	3.762
73	103	0.128	86	11	0.230	97	18	3.768
74	1	0.246	86	17	2.235	97	204	0.008
74	1	0.246	86	17	2.221	97	204	0.010
74	12	0.123	86	23	4.428	98	1	0.004
74	12	0.120	86	23	4.491	98	1	0.006
74	24	5.503	89	6	0.026	98	105	0.006
74	24	5.531	89	6	0.024	98	105	0.006
75	1	0.239	89	24	4.559	99	10	0.691
75	1	0.267	89	24	4.549	99	10	0.689
75	5	0.081	89	105	0.022	99	15	3.683
75	5	0.080	89	105	0.021	99	15	3.662
75	11	0.083	89	204	0.027	99	20	3.845
75	11	0.084	89	204	0.021	99	20	3.839
75	16	0.554	91	10	0.085	99	105	0.037
75	16	0.559	91	10	0.083	99	105	0.041
75	23	5.604	91	15	0.911	101	10	0.632
75	23	5.605	91	15	0.915	101	10	0.625
76	1	0.135	91	105	0.011	101	15	3.559
76	1	0.137	91	105	0.010	101	15	3.556
76	19	1.163	92	204	0.030	101	20	3.655
76	19	1.184	92	204	0.029	101	20	3.667
76	24	5.573	93	6	0.012	101	105	0.113
76	24	5.583	93	6	0.020	101	105	0.118
77	1	0.137	93	16	2.203	103	1	0.006
77	1	0.153	93	16	2.181	103	1	0.003
77	6	0.090	93	20	3.621	103	6	0.009
77	6	0.077	93	20	3.607	103	6	0.007
77	18	1.569	94	6	0.026	103	16	0.972
77	18	1.556	94	6	0.025	103	16	0.976
77	24	5.500	95	1	0.006	103	21	2.974
77	24	5.472	95	1	0.005	103	21	2.981
79	1	0.073	95	1	0.006	105	23	2.988
79	1	0.068	95	9	0.143	105	23	2.983

79	10	0.069	95	9	0.143
79	10	0.064	95	16	3.227
81	13	0.499	95	16	3.242
81	13	0.494	95	19	3.687
81	19	4.397	95	19	3.664
81	19	4.412	95	23	3.732
83	2	0.041	95	23	3.736
83	2	0.037	95	103	0.011
83	5	0.034	95	103	0.012
83	5	0.035	95	105	0.024
85	2	0.022	95	105	0.026
85	2	0.017	96	105	0.009
85	8	0.039	96	105	0.013
85	8	0.042	96	204	0.006
85	15	1.043	96	204	0.008
85	15	1.041			

Table 2b: AU9404 Replicate dissolved CFC-12 analyses

Stn	Niskin	CFC-12 (pmol/kg)	Stn	Niskin	CFC-12 (pmol/kg)	Stn	Niskin	CFC-12 (pmol/kg)
1	2	0.037	18	204	0.226	29	2	0.462
1	2	0.045	18	204	0.208	29	2	0.449
4	1	0.638	21	1	0.840	29	11	0.074
4	1	0.647	21	1	0.817	29	11	0.076
4	13	0.167	21	10	0.055	29	24	3.066
4	13	0.185	21	10	0.058	29	24	3.078
4	18	3.199	21	13	0.090	31	1	0.486
4	18	3.283	21	13	0.085	31	1	0.483
9	9	0.252	21	24	3.285	31	5	0.104
9	9	0.266	21	24	3.219	31	5	0.097
10	1	0.680	23	1	0.719	31	14	0.068
10	1	0.693	23	1	0.753	31	14	0.061
10	24	2.856	23	12	0.046	31	18	0.144
10	24	2.916	23	12	0.050	31	18	0.141
12	11	0.150	23	12	0.054	31	24	3.068
12	11	0.165	23	16	0.116	31	24	3.008
14	2	0.659	23	16	0.130	32	11	0.077
14	2	0.684	23	16	0.120	32	11	0.068
14	5	0.288	23	20	0.292	32	11	0.072
14	5	0.303	23	20	0.275	33	1	0.764
14	6	0.257	23	24	3.308	33	1	0.752
14	6	0.242	23	24	3.414	33	11	0.082
14	6	0.240	23	204	0.227	33	11	0.051
14	9	0.164	23	204	0.197	33	12	0.069
14	9	0.166	23	204	0.204	33	12	0.061
14	11	0.107	25	1	0.565	33	18	0.147
14	11	0.116	25	1	0.580	33	18	0.153
14	21	0.410	25	12	0.058	33	24	3.058
14	21	0.426	25	12	0.060	33	24	3.061
14	122	1.776	25	23	3.166	35	1	1.077
14	122	1.772	25	23	3.150	35	1	1.092
18	1	0.590	25	107	0.048	35	11	0.040
18	1	0.610	25	107	0.053	35	11	0.040
18	2	0.391	25	204	0.132	35	24	3.030
18	2	0.432	25	204	0.123	35	24	2.954

18	6	0.111	26	11	0.043	35	107	0.071
18	6	0.110	26	11	0.041	35	107	0.091
18	8	0.072	26	11	0.040	37	1	0.696
18	8	0.069	26	11	0.031	37	1	0.691
18	10	0.049	26	12	0.066	37	2	0.567
18	10	0.043	26	12	0.063	37	2	0.553
18	14	0.057	26	12	0.060	37	11	0.043
18	14	0.061	26	12	0.066	37	11	0.043
18	16	0.118	26	13	0.065	37	16	0.100
18	16	0.110	26	13	0.058	37	16	0.107
18	18	0.156	26	13	0.062	37	24	3.055
18	18	0.158	26	15	0.105	37	24	3.017
18	20	0.371	26	15	0.093	38	1	0.658
18	20	0.379	26	15	0.095	38	1	0.667
18	24	3.035	26	15	0.124	39	1	0.820
18	24	3.170	26	15	0.105	39	1	0.799
18	122	2.350	29	1	1.007	39	6	0.104
18	122	2.291	29	1	1.027	39	6	0.113
39	11	0.054	48	9	0.080	54	1	0.051
39	11	0.061	48	9	0.086	54	1	0.050
39	18	0.164	48	11	0.084	54	6	0.056
39	18	0.163	48	11	0.082	54	6	0.053
39	23	2.607	48	11	0.082	54	11	0.050
39	23	2.630	48	11	0.082	54	11	0.067
40	11	0.050	48	13	0.095	54	12	0.059
40	11	0.065	48	13	0.102	54	12	0.059
41	1	0.614	48	15	2.234	54	18	0.063
41	1	0.604	48	15	2.221	54	18	0.062
41	2	0.391	48	204	0.264	54	23	0.059
41	2	0.392	48	204	0.252	54	23	0.054
41	11	0.055	49	1	0.509	54	24	0.062
41	11	0.043	49	1	0.506	54	24	0.062
41	14	0.060	49	5	0.276	54	24	0.062
41	14	0.056	49	5	0.276	54	24	0.062
41	16	0.100	49	9	0.094	55	11	2.284
41	16	0.088	49	9	0.106	55	11	2.294
41	24	3.075	49	11	0.060	55	18	1.943
41	24	3.062	49	11	0.057	55	18	1.979
41	107	0.050	49	13	0.089	55	24	3.090
41	107	0.051	49	13	0.079	55	24	3.129
41	222	1.408	49	15	0.116	60	1	1.104
41	222	1.413	49	15	0.112	60	1	1.089
42	8	0.035	49	17	0.196	60	1	1.097
42	8	0.037	49	17	0.201	61	1	0.805
43	1	0.270	49	21	0.818	61	1	0.792
43	1	0.274	49	21	0.809	61	6	0.489
43	11	0.047	49	24	2.191	61	6	0.490
43	11	0.034	49	24	2.206	61	11	0.207
43	17	0.109	49	103	0.451	61	11	0.208
43	17	0.104	49	103	0.465	61	24	3.113
43	107	0.068	49	107	0.161	61	24	3.112
43	107	0.067	49	107	0.180	62	1	0.832
45	2	0.283	50	1	0.698	62	1	0.832
45	2	0.290	50	1	0.728	63	2	1.000
45	5	0.150	50	6	0.198	63	2	1.021
45	5	0.132	50	6	0.190	63	12	0.164
45	8	0.078	50	11	0.042	63	12	0.173
45	8	0.069	50	11	0.039	63	222	2.007

45	14	0.116	50	16	0.100	63	222	2.019
45	14	0.113	50	16	0.109	65	1	1.044
45	20	0.253	50	24	2.689	65	1	1.041
45	20	0.242	50	24	2.652	65	24	3.014
45	222	1.728	51	1	0.660	65	24	3.030
45	222	1.694	51	1	0.658	67	1	0.869
47	1	0.089	51	5	0.205	67	1	0.871
47	1	0.081	51	5	0.207	67	17	0.119
47	20	2.099	51	17	0.180	67	17	0.113
47	20	2.109	51	17	0.180	67	107	0.066
48	1	0.443	51	24	2.552	67	107	0.070
48	1	0.434	51	24	2.563	68	9	0.036
48	6	0.160	51	103	0.465	68	9	0.037
48	6	0.174	51	103	0.456			
68	11	0.032	76	19	0.542	91	105	0.011
68	11	0.043	76	19	0.556	91	105	0.013
69	1	0.711	76	24	2.701	92	204	0.025
69	1	0.693	76	24	2.702	92	204	0.019
69	6	0.077	77	1	0.084	93	2	0.015
69	6	0.077	77	1	0.082	93	2	0.024
69	11	0.034	77	6	0.049	93	6	0.013
69	11	0.035	77	6	0.046	93	6	0.015
69	17	0.145	77	18	0.734	93	16	1.066
69	17	0.145	77	18	0.737	93	16	1.077
69	20	0.537	77	24	2.680	93	20	1.884
69	20	0.561	77	24	2.675	93	20	1.838
69	23	3.136	79	1	0.047	94	6	0.024
69	23	3.109	79	1	0.043	94	6	0.017
69	103	0.292	79	10	0.040	95	1	0.014
69	103	0.276	79	10	0.037	95	1	0.014
71	1	0.587	81	13	0.228	95	1	0.013
71	1	0.600	81	13	0.228	95	9	0.067
71	5	0.095	81	19	2.149	95	9	0.074
71	5	0.093	81	19	2.136	95	16	1.625
71	11	0.027	83	2	0.025	95	16	1.619
71	11	0.034	83	2	0.026	95	19	1.831
71	20	0.589	83	5	0.024	95	19	1.823
71	20	0.580	83	5	0.023	95	23	1.839
71	24	2.921	83	11	0.041	95	23	1.914
71	24	2.923	83	11	0.036	95	103	0.014
73	1	0.142	83	222	2.767	95	103	0.015
73	1	0.142	83	222	2.754	95	105	0.018
73	8	0.043	85	2	0.018	95	105	0.017
73	8	0.040	85	2	0.005	96	105	0.013
73	10	0.040	85	15	0.496	96	105	0.009
73	10	0.039	85	15	0.477	96	204	0.007
73	11	0.048	85	20	2.238	96	204	0.007
73	11	0.048	85	20	2.237	97	1	0.006
73	17	0.329	86	8	0.036	97	1	0.010
73	17	0.335	86	8	0.033	97	18	1.936
73	23	2.734	86	11	0.107	97	18	1.888
73	23	2.662	86	11	0.103	97	204	0.007
73	103	0.076	86	17	1.070	97	204	0.013
73	103	0.070	86	17	1.032	98	1	0.009
74	1	0.132	86	23	2.230	98	1	0.011
74	1	0.140	86	23	2.215	98	105	0.013
74	12	0.068	89	6	0.012	98	105	0.008
74	12	0.066	89	6	0.003	99	10	0.326

75	1	0.129	89	24	2.240	99	10	0.304
75	1	0.135	89	24	2.232	99	15	1.821
75	5	0.058	89	105	0.006	99	15	1.855
75	5	0.061	89	105	0.008	99	20	2.027
75	16	0.264	89	204	0.006	99	20	1.998
75	16	0.267	89	204	0.003	99	105	0.025
75	23	2.687	91	10	0.050	99	105	0.024
75	23	2.698	91	10	0.047	101	10	0.306
76	1	0.076	91	15	0.435	101	10	0.307
76	1	0.077	91	15	0.421			
101	15	1.787	103	16	0.478			
101	15	1.761	103	16	0.483			
101	20	1.857	103	21	1.542			
101	20	1.887	103	21	1.569			
101	105	0.058	105	23	1.599			
101	105	0.061	105	23	1.615			
103	1	0.011						
103	1	0.008						

Table 3: AU9404 CFC Air Measurements

Date	Time (hhmm)	Latitude	Longitude	F11 PPT	F12 PPT
19 Dec 94	2338	57 26.6 S	127 53.5 E	257.0	515.0
19 Dec 94	2350	57 26.6 S	127 53.5 E	257.3	507.3
20 Dec 94	0015	57 26.6 S	127 53.5 E	257.0	509.7
20 Dec 94	0033	57 26.6 S	127 53.5 E	257.3	511.4
22 Dec 94	0704	62 00.3 S	118 00.4 E	257.7	510.3
22 Dec 94	0716	62 00.3 S	118 00.4 E	258.0	508.3
22 Dec 94	0729	62 00.3 S	118 00.4 E	257.5	511.3
22 Dec 94	0741	62 00.3 S	118 00.4 E	258.1	508.5
5 Jan 95	0335	63 16.0 S	113 13.0 E	258.4	509.5
5 Jan 95	0347	63 16.0 S	113 13.0 E	259.8	507.2
5 Jan 95	0359	63 16.0 S	113 13.0 E	257.4	508.8
5 Jan 95	0412	63 16.0 S	113 13.0 E	257.7	509.2
12 Jan 95	0146	62 52.7 S	144 51.1 E	258.8	511.1
12 Jan 95	0157	62 52.7 S	144 51.1 E	257.2	512.4
12 Jan 95	0213	62 52.7 S	144 51.1 E	257.9	510.7
12 Jan 95	0227	62 52.7 S	144 51.1 E	256.4	511.8
14 Jan 95	0751	63 26.0 S	156 39.0 E	259.8	511.5
14 Jan 95	0803	63 26.0 S	156 39.0 E	259.2	510.3
20 Jan 95	0938	65 04.9 S	139 51.5 E	261.5	508.7
20 Jan 95	0952	65 04.9 S	139 51.5 E	260.1	507.6
20 Jan 95	1008	65 04.9 S	139 51.5 E	260.1	506.7
20 Jan 95	1021	65 04.9 S	139 51.5 E	260.8	-9.0
20 Jan 95	1035	65 04.9 S	139 51.5 E	260.5	507.2
22 Jan 95	1424	60 36.0 S	139 51.0 E	259.0	507.1
22 Jan 95	1435	60 36.0 S	139 51.0 E	258.8	510.4
22 Jan 95	1449	60 36.0 S	139 51.0 E	259.3	508.4
27 Jan 95	1107	51 35.9 S	143 03.1 E	255.6	-9.0
27 Jan 95	1118	51 35.9 S	143 03.1 E	257.8	501.9
27 Jan 95	1130	51 35.9 S	143 03.1 E	256.2	499.6
27 Jan 95	1145	51 35.9 S	143 03.1 E	258.0	497.5
27 Jan 95	1157	51 35.9 S	143 03.1 E	259.0	497.4
1 Feb 95	0353	44 07.0 S	146 13.0 E	256.9	502.0
1 Feb 95	0404	44 07.0 S	146 13.0 E	257.4	500.5

1 Feb 95	0416	44 07.0 S	146 13.0 E	257.3	498.8
1 Feb 95	0427	44 07.0 S	146 13.0 E	256.2	496.9

Table 4: AU9404 CFC Air values (interpolated to station locations)

Stn #	Latitude	Longitude	Date	F11 PPT	F12 PPT
1	57 32.1 S	127 49.5 E	20 Dec 94	257.5	510.2
2	61 59.1 S	120 01.7 E	21 Dec 94	257.6	510.2
3	62 00.7 S	119 02.1 E	21 Dec 94	257.6	510.2
4	62 00.3 S	118 01.6 E	22 Dec 94	257.6	510.2
6	65 59.3 S	109 55.0 E	2 Jan 95	258.3	506.6
7	65 23.1 S	112 33.2 E	3 Jan 95	258.3	506.6
8	65 18.5 S	112 32.2 E	3 Jan 95	258.3	506.6
9	64 57.7 S	112 09.6 E	4 Jan 95	258.3	506.6
10	64 44.9 S	111 55.1 E	4 Jan 95	258.3	506.6
11	64 30.9 S	111 25.8 E	4 Jan 95	258.3	506.6
12	64 06.1 S	112 05.9 E	4 Jan 95	258.3	506.6
13	63 40.8 S	112 36.5 E	4 Jan 95	258.3	506.6
14	63 16.5 S	113 13.0 E	5 Jan 95	258.3	506.6
15	62 50.8 S	113 49.1 E	5 Jan 95	258.3	506.6
16	62 25.3 S	114 25.7 E	5 Jan 95	258.3	506.6
17	62 00.0 S	115 01.0 E	6 Jan 95	258.0	510.1
18	61 59.7 S	116 30.5 E	6 Jan 95	258.0	510.1
19	62 00.3 S	120 01.4 E	6 Jan 95	258.0	510.1
20	61 59.8 S	121 26.9 E	7 Jan 95	258.0	510.1
21	62 00.2 S	122 50.4 E	7 Jan 95	258.0	510.1
22	62 00.1 S	124 15.4 E	7 Jan 95	258.0	510.1
23	62 00.2 S	125 39.6 E	7 Jan 95	258.0	510.1
24	62 00.4 S	127 05.5 E	8 Jan 95	258.4	509.9
25	62 00.7 S	128 31.6 E	8 Jan 95	258.4	509.9
26	62 00.2 S	129 56.7 E	8 Jan 95	258.4	509.9
27	62 00.6 S	131 20.0 E	9 Jan 95	258.4	509.9
28	61 59.9 S	132 45.6 E	9 Jan 95	258.4	509.9
29	62 01.4 S	134 11.1 E	9 Jan 95	258.4	509.9
30	62 00.3 S	135 35.1 E	9 Jan 95	258.7	510.9
31	61 59.9 S	137 01.3 E	10 Jan 95	258.7	510.9
32	62 09.5 S	138 27.2 E	10 Jan 95	258.7	510.9
33	62 21.5 S	139 53.4 E	10 Jan 95	258.7	510.9
34	62 28.1 S	141 03.3 E	11 Jan 95	258.7	510.9
35	62 35.9 S	142 12.4 E	11 Jan 95	258.7	510.9
36	62 45.8 S	143 36.2 E	11 Jan 95	258.7	510.9
37	62 54.2 S	145 03.3 E	12 Jan 95	258.7	510.9
38	63 03.1 S	146 28.0 E	12 Jan 95	258.7	510.9
39	63 10.7 S	147 50.9 E	12 Jan 95	258.7	510.9
40	63 18.6 S	149 12.6 E	13 Jan 95	258.2	511.3
41	63 25.9 S	150 39.8 E	13 Jan 95	258.2	511.3
42	63 25.6 S	152 10.8 E	13 Jan 95	258.2	511.3
43	63 26.2 S	153 41.4 E	13 Jan 95	258.2	511.3
44	63 26.1 S	155 10.9 E	14 Jan 95	258.2	511.3
45	63 25.8 S	156 39.1 E	14 Jan 95	258.2	511.3
46	63 26.0 S	158 09.9 E	14 Jan 95	258.2	511.3
47	63 25.6 S	159 26.4 E	14 Jan 95	258.2	511.3
48	64 00.9 S	160 10.7 E	15 Jan 95	258.2	511.3
49	64 37.3 S	160 44.3 E	15 Jan 95	258.2	511.3
50	65 18.0 S	161 23.8 E	15 Jan 95	258.2	511.3

51	65 56.0 S	162 03.3 E	16 Jan 95	258.2	511.3
52	66 06.7 S	162 14.2 E	16 Jan 95	258.2	511.3
53	66 09.1 S	162 15.3 E	16 Jan 95	258.2	511.3
54	64 13.9 S	155 19.7 E	18 Jan 95	258.2	511.3
55	66 36.3 S	144 09.6 E	19 Jan 95	259.3	509.5
56	66 00.5 S	142 39.2 E	19 Jan 95	259.3	509.5
57	65 50.6 S	141 25.6 E	19 Jan 95	259.3	509.5
58	65 35.1 S	139 50.4 E	19 Jan 95	259.3	509.5
59	65 32.5 S	139 51.1 E	20 Jan 95	260.0	508.0
60	65 26.3 S	139 50.7 E	20 Jan 95	260.0	508.0
61	65 04.8 S	139 51.6 E	20 Jan 95	260.0	508.0
62	64 49.4 S	139 49.4 E	20 Jan 95	260.0	508.0
63	64 17.2 S	139 51.3 E	20 Jan 95	260.0	508.0
64	63 51.6 S	139 52.2 E	21 Jan 95	260.0	508.0
65	63 21.7 S	139 50.5 E	21 Jan 95	260.0	508.0
66	62 50.8 S	139 51.1 E	21 Jan 95	260.0	508.0
67	62 20.4 S	139 49.7 E	21 Jan 95	260.0	508.0
68	61 51.1 S	139 51.2 E	22 Jan 95	260.0	508.0
69	61 21.9 S	139 53.3 E	22 Jan 95	260.0	508.0
70	60 36.2 S	139 49.9 E	22 Jan 95	260.0	508.0
71	59 50.9 S	139 51.8 E	22 Jan 95	260.0	508.0
72	59 05.7 S	139 51.6 E	23 Jan 95	260.0	508.0
73	58 21.1 S	139 51.7 E	23 Jan 95	259.0	504.8
74	57 38.8 S	139 52.7 E	23 Jan 95	258.0	503.2
75	56 56.1 S	139 49.7 E	24 Jan 95	258.0	503.2
76	56 12.0 S	140 17.5 E	24 Jan 95	258.0	503.2
77	55 30.1 S	140 44.3 E	24 Jan 95	258.0	503.2
78	55 00.5 S	141 00.9 E	25 Jan 95	258.0	503.2
79	54 31.3 S	141 19.1 E	25 Jan 95	258.0	503.2
80	54 03.3 S	141 36.0 E	25 Jan 95	258.0	503.2
81	53 35.0 S	141 53.1 E	25 Jan 95	258.0	503.2
82	53 07.5 S	142 08.5 E	26 Jan 95	258.0	503.2
83	52 40.3 S	142 24.4 E	26 Jan 95	257.6	501.9
84	52 15.8 S	142 38.7 E	26 Jan 95	257.6	501.9
85	51 51.4 S	142 51.8 E	26 Jan 95	257.6	501.9
86	51 25.9 S	143 03.7 E	27 Jan 95	257.1	499.3
87	50 33.1 S	142 43.1 E	27 Jan 95	257.1	499.3
88	51 02.6 S	143 13.9 E	28 Jan 95	257.1	499.3
89	50 43.2 S	143 24.4 E	28 Jan 95	257.1	499.3
90	50 25.2 S	143 33.0 E	28 Jan 95	257.1	499.3
91	50 04.8 S	143 44.9 E	28 Jan 95	257.1	499.3
92	49 43.1 S	143 54.1 E	29 Jan 95	257.1	499.3
93	49 15.5 S	144 07.8 E	29 Jan 95	257.1	499.3
94	48 46.6 S	144 19.2 E	29 Jan 95	257.1	499.3
95	48 18.4 S	144 31.9 E	30 Jan 95	257.1	499.3
96	47 47.9 S	144 46.1 E	30 Jan 95	257.1	499.3
97	47 27.2 S	144 53.7 E	30 Jan 95	257.1	499.3
98	47 09.0 S	145 03.1 E	30 Jan 95	257.1	499.3
99	46 38.2 S	145 15.4 E	31 Jan 95	257.1	499.3
100	46 09.2 S	145 27.9 E	31 Jan 95	257.1	499.3
101	45 41.6 S	145 40.4 E	31 Jan 95	257.1	499.3
102	45 13.4 S	145 50.4 E	31 Jan 95	257.1	499.3
103	44 42.6 S	146 01.9 E	31 Jan 95	257.1	499.3
104	44 23.0 S	146 11.0 E	1 Feb 95	257.1	499.3
105	44 07.2 S	146 13.2 E	1 Feb 95	257.1	499.3
106	43 59.9 S	146 18.9 E	1 Feb 95	257.1	499.3
107	44 11.7 S	146 55.0 E	1 Feb 95	257.1	499.3

Data Quality Evaluations

DQ Evaluation of WOCE P12/S04I/PR12/SR03

(Arnold Mantyla)
10 Feb. 1999

Two WOCE sections were completed on this cruise. The first, labeled S04 in the .sum file, completed the gap in the circumpolar line of stations between S04P and S04I, mostly in the Australian- Antarctic Basin. The second line, listed as SR03 in the .sum file, provided another season crossing of the Antarctic Circumpolar Current system between the Adelie Coast and Tasmania. This is a very useful data set, and should help elucidate the fate of abyssal waters originating from the Adelie coast and the Ross Sea.

The data were taken with a 24 place rosette system, and even though the deep water coverage was reasonably good, the WOCE standard 36 place rosette would have been better for improving shallow and intermediate depth coverage and to place extra samples near deep-water inversions often seen near Antarctica. The quality of salinity and oxygen data were first rate and should have been listed to one more decimal place to meet WOCE requirements. An excessive number of CTD and bottle salinities were flagged as "bad" data, even in cases where the two were in perfect agreement. The majority of my QUALT2 changes were in restoring those cases to acceptable data codes. I am reluctant to throw out useful data, knowing how poor subsequent fill-in inter- polations can be when the data are put to use. Most of the seemingly poor quality salinities were in the strong halocline just below the surface mixed layer. In these strong gradient regions, a statistical time average will naturally have a high standard deviation, but the resulting mean is a valid estimate of the local salinity, and should be accepted as such, especially when confirmed by the water sample salinity.

The few oxygen uncertainties were most likely due to sample drawing errors (2 from one niskin, none from another). One station, 78 appears to be systematically high by about 6%; the standard factor calculation should be verified to see if the data can be corrected.

The nutrient data had the most uncertainty, although that isn't reflected in the quality flags. Either the PO4 or the NO3 profiles would often shift independently of the other for groups of stations, unlike the consistent nitrate/phosphate slopes and intercepts seen on other expeditions. Although I could tell where shifts occurred, I could not at this time tell which data set was likely to be correct or doubtful. Perhaps a careful evaluation of the standards and blanks used to calculate the data might result in improved consistency in the N/P ratio. Comparisons with other cruises were inconclusive, showing no clear overall bias for the data in this cruise, although differences between specific cruise crossings or overlaps did occur.

The first 34 stations had the number 12 and 24 phosphates flagged as poor because these samples followed a wash cycle and were suppressed by a few percent. Later stations ran double samples to eliminate the problem. Lou Gordon in his WOCE nutrient guide describes a technique for correcting for this source of error; I would encourage the data originators to try the method to see if most of the lost phosphates could be recovered.

The following are comments on specific stations with problems that should be looked into:

Sta. 62: The phosphates and nitrates are coded "4" for bad data, but the silicates are coded "7", which I thought was reserved for gas chromatograph data. Does this mean the silicates are bad (and should be coded 4) also?

Sta. 78: All of the oxygens are systematically higher by about 6% than the bracketing stations. I suspect that an error has occurred in the standard factor and the data should be corrected. If not, list all of the O2's for this station as uncertain.

Sta. 80, 1300db: All of the water samples are questionable at this depth, but would be ok at the usually sampled depth of 1200db. Could this be a depth mistake (with incorrect CTD data as well)?

Sta. 96, 1600db: The water samples, bad at this depth, appear to be from about 1400db unsampled depth. Could this be a depth error also?

Sta. 97, 1800 and 2000db: These water samples appear to be from the data gap between 1200 and 1800db. Were there attempts to trip bottles at abut 1400 and 1600db where these samples appear to belong? If so, it would be worth salvaging the data.

Sta. 103, 110-502db: The nitrates appear to be tabulated one depth too deep, there are no other water samples listed at 502db. If so, the NO3's would be ok at one depth shallower.

Sta. 103, 66-200db: According to the CTD, the bottle salinities listed at 66 and 111db are actually from 111 and 200db. This is not a mis-trip, per the oxygen data, so it must be a sample drawing error. Since the CTD confirm the correct location for these samples, why not list them as ok at their correct depths?

PI Response to Bottle Data Quality Evaluation
(Mark Rosenberg)
1999.DEC.10

Answer as per the order of the DQE report:

1. "An excessive number of CTD and bottle salinities were flagged as bad..."

   In my own version of the data (i.e. before converting it to WOCE format), flags for the CTD burst data in the bottle file (used for comparison with bottles) are automatically downgraded when the CTD burst data exceeds a certain standard deviation (I'm typically not too concerned as plenty of good CTD salinity values remain for the conductivity calibration). I've then automatically carried these flags through to the WOCE format files without giving due thought to upgrading flags. I agree with you though, if the CTD and bottle values agree then may as well resurrect the CTD values with a good flag, so there isn't so many gaps in the strong gradients. I'd be reluctant to resurrect them if there isn't a good bottle value for them to agree with, or if they don't agree - a flag "3" might be a compromise in such cases, so that at least there's a clear distinction between these values and values where there's no problem at all (i.e. no strong gradient, or no rolling ship). For bottle salinities, I could only spot 3 values that might be worth resurrecting:

station	bottle	difference between CTD and bottle
45	21	.004
47	13	.004
77	18	.002

2. "The first 34 stations had the number 12 and 24 phosphates flagged as poor because... ...WOCE nutrient guide describes a technique for correcting..."

   I always get confused between the countless errors and possible corrections in the nutrient analyses, particularly as I'm not a chemist, but it's possible there's 2 different errors here:

   (a) the carrryover error referred to in the WOCE nutrient manual i.e. from the "more or less incomplete flushing of the flow system between samples"
   (b) the suppression of phosphate peaks run after a wash cycle, described in our data report for cruise 09AR9407 as :
   "...suppressed by, on average, 2%. It is suspected that this was due to sorption of the phosphomolybdate complex produced by the presence of phosphate in the sample onto the walls of the instrument tubing, after having been exposed to the cleaning action of the low nutrient seawater wash." Our bottle 12 and 24 samples are due to error (b), and as this seems to me to be different to error (a), I wouldn't be game to apply the WOCE guide correction to the relevant phosphates. Guess I'm more comfortable to accept the loss of data. On a happy note, a couple of years after this cruise our nutrient guy successfully "fixed" the problem, or at least made it no longer significant, just in time for our last WOCE cruise.

3. "Sta. 62: ...phosphates and nitrates are coded "4"...silicates coded "7"..."

   The silicates for bottles 1 to 23 are okay, but the peaks were measured manually from the strip charts rather than by automatic peak integration in the software. I used the 7 flag to reflect this, not noticing that it was already reserved for gas chromatograph data (oops). Probably okay to change these flags to "2".

4. "Sta. 78: ...oxygens...higher by about 6%..."

   There's no hope of correcting it unfortunately: I'd prefer flag "4". I've also flagged the CTD oxygen as bad in the *.ctd file for this station.

5. "Sta. 80 1300db..."
6. "sta. 96, 1600 db..."
7. "sta. 97, 1800 and 2000 db..."

   Misfire problems at all 3 of these stations. As it happens the CTD 2 dbar averaged data for all these stations is upcast, making it easy to compare CTD salinity in the .ctd files to bottle salinities to confirm where the bottle samples come from. You're right in all 3 cases, and I've put in the correct CTD values and changed the flags for the bottle values.

8. "Sta. 103, 110-502db: nitrates..."

   Post-processing of the nitrate autoanalyser results for this station got rather messy, so despite the apparently better appearance moving the samples one depth up, I still can't help feeling it's a bit of a "fudge" - I'd feel better leaving them where they are and flagged as bad.

9. "Sta. 103, 66-200db: ...bottle salinities..."

   The salinity bottle at 66 dbar is still fairly scattered from the CTD value at 111dbar, though the bottle at 111dbar matches the 200dbar CTD value. But the salinity bottle at 200 dbar doesn't seem to match anything. So I'm not sure it's conclusive that the 66 and 111 dbar bottles come from 1 depth down, but I'm happy to move them down and flag them as "3".

Rosenberg, continued
1999.DEC.12

I've done the flag changes for cruise AR9404 bottle data file, plus I've added in parameters 7,8 (CFC's) for the appropriate stations in the sum file. Also changed CTD oxygen flags to 4 in a94045078.ctd.

stn 62	bottle 1-23	• changed QUALT1 from 7 to 3 for silicate • changed QUALT2 from 7 to 3 for silicate
stn 78	bottle 1-24	• changed QUALT1 from 2 to 4 for CTD and bottle oxygen • changed QUALT2 from 2 to 3 for CTD oxygen
stn 80	bottle 9	• changed all CTD values for the new pressure • changed QUALT1 to 2 for bottle sal,ox,nuts • changed QUALT2 to 2 for bottle sal,ox,nuts
stn 96	bottle 10	• changed all CTD values for the new pressure bottle oxygen • changed by .1 due to new density in conversion to umol/kg • changed QUALT1 to 2 for bottle sal,ox,nuts • changed QUALT2 to 2 for bottle sal,ox,nuts
stn 97	bottle 111,10	• changed all CTD values for the new pressure • changed QUALT1 to 2 for bottle sal,ox,nuts • changed QUALT2 to 2 for bottle sal,ox,nuts
stn 103	bottle 222,21,20	• moved bottle salinity for 222 and 21 down one depth, and made bottle salinity for 222 equal to -9.0000 • changed QUALT1 for bottle salinity to, respectively, 5,3,3 for the 3 bottles • changed QUALT2 to 5 for bottle 222 bottle sal

CTD salinity in steep gradients for most stations - I didn't resurrect any QUALT1 flags as it looks like you got it covered in the QUALT2 flags. So the QUALT1 cautions will reflect the high standard deviations.

CTD Contents and Consistency Check (S03/S04I 09AR9404_1)
(WHPO Staff)
2002.JAN.03

The WHP-Exchange format bottle and/or CTD data from this cruise have been examined by a computer application for contents and consistency. The parameters found for the files are listed, a check is made to see if all CTD files for this cruise contain the same CTD parameters, a check is made to see if there is a one-to-one correspondence between bottle station numbers and CTD station numbers, a check is made to see that pressures increase through each file for each station, and a check is made to locate multiple casts for the same station number in the bottle data. Results of those checks are reported in this '_check.txt' file.

When both bottle and CTD data are available, the CTD salinity data (and, if available, CTD oxygen data) reported in the bottle data file are subtracted from the corresponding bottle data and the differences are plotted for the entire cruise. Those plots are the' _sal.ps' (figure 1) and '_oxy.ps' (figure 2) files.

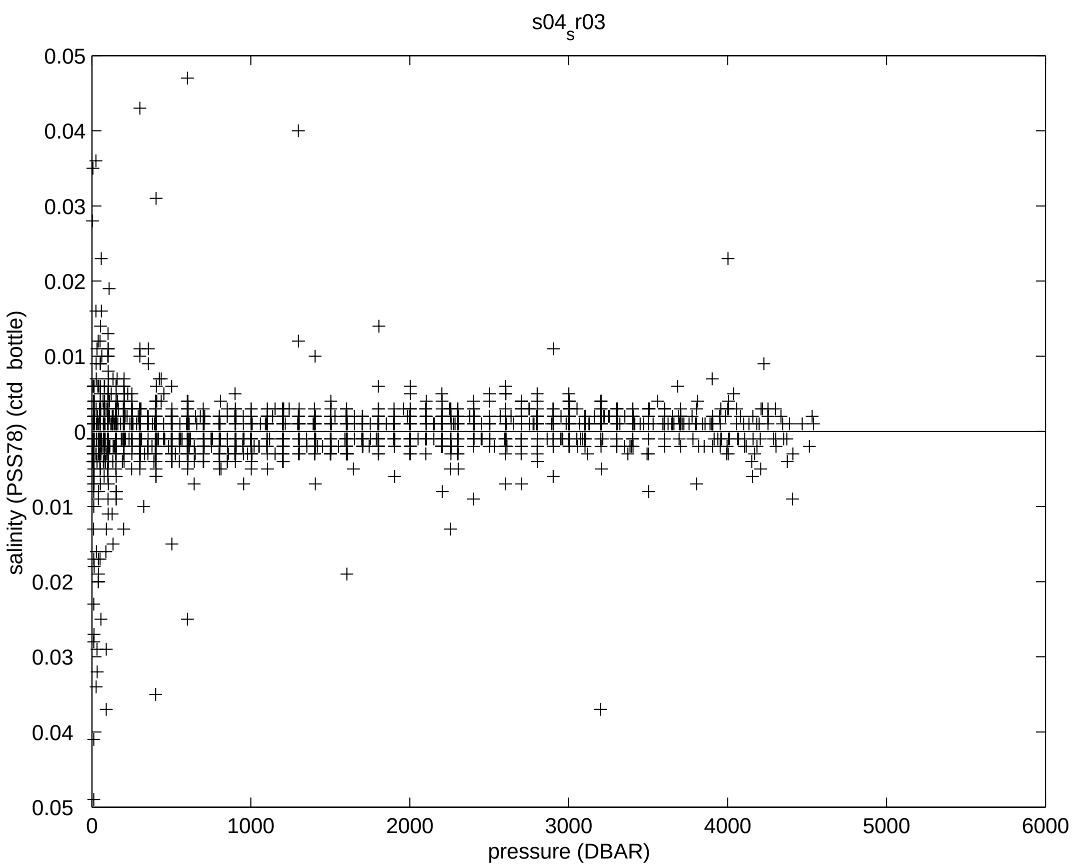

figure 1

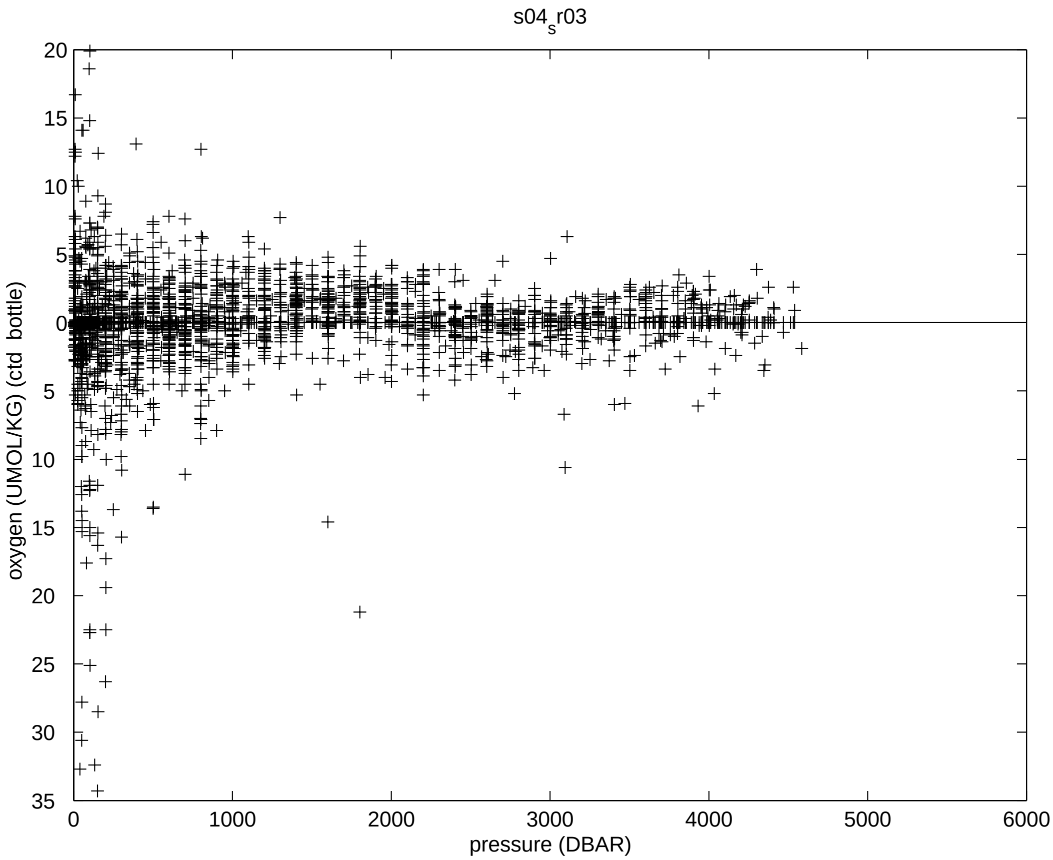

figure 2

Following parameters found for bottle file:

EXPOCODE	DEPTH	SILCAT
SECT_ID	CTDPRS	SILCAT_FLAG_W
STNNBR	CTDTMP	NO2+NO3
CASTNO	CTDSAL	NO2+NO3_FLAG_W
SAMPNO	CTDSAL_FLAG_W	PHSPHT
BTLNBR	SALNTY	PHSPHT_FLAG_W
BTLNBR_FLAG_W	SALNTY_FLAG_W	CFC-11
DATE	CTDOXY	CFC-11_FLAG_W
TIME	CTDOXY_FLAG_W	CFC-12
LATITUDE	OXYGEN	CFC-12_FLAG_W
LONGITUDE	OXYGEN_FLAG_W	

s04_sr03_hy1.csv -> NO2+NO3_FLAG_W found without matching parameter.

- All ctd parameters match the parameters in the reference station.
- Station #5 has a CTD file, but does not exist in s04_sr03_hy1.csv.
- No bottle pressure inversions found.
- Bottle file pressures are increasing.
- No multiple casts found in bottle data.

S04I Final Report for AMS 14C Samples

(Robert M. Key)

April 19, 1999

1.0 General Information

WOCE cruise S04I was carried out aboard the R/V N.B. Palmer in the southern Indian Ocean. The WHPO designation for this cruise was 320696_3. Thomas Whitworth III (TAMU) and James H. Swift (SIO) were the co-chief scientists. The cruise constituted the Indian Ocean portion of WOCE line S4, a meridional circumnavigation of Antarctica at a nominal latitude of 60°S. This segment covered the longitudes 20°E to 120°E. A total of 108 full depth CTD/Rosette stations were carried out. The cruise departed Cape Town, South Africa on May 3 and ended at Hobart Tasmania on July 4, 1996. On June 8, science operations were suspended for seven days when the Palmer was diverted to Mirnyy Station in the Davis Sea to deliver emergency food supplies. The reader is referred to cruise documentation provided by the chief scientists as the primary source for cruise information. This report covers details of the small volume radiocarbon samples. The AMS station locations are shown in Figure 1 and summarized in Table 1. A total of 816 $\Delta^{14}C$ samples were collected at 31 stations

TABLE 1. S4I $\Delta^{14}C$ station locations.

Station	Month	Latitude	Longitude	Bottom Depth (m)
1	5/16/96	-58.008	20.006	5412
7	5/18/96	-61.399	25.749	5243
13	5/20/96	-64.000	30.017	5135
23	5/22/96	-65.134	37.349	4874
26	5/24/96	-64.465	41.619	4435
29	5/25/96	-63.736	46.408	4270
35	5/28/96	-65.456	53.363	501
36	5/28/96	-65.371	53.264	1303
38	5/28/96	-65.104	53.018	2468
40	5/29/96	-64.435	53.072	4200
42	5/29/96	-63.498	53.682	4790
46	5/30/96	-63.501	58.335	4566
51	6/1/96	-62.361	64.406	4365
55	6/3/96	-61.962	70.017	4165
58	6/4/96	-61.806	74.982	4000
62	6/5/96	-61.417	80.489	2480
66	6/6/96	-59.696	84.850	2024
68	6/7/96	-59.660	85.248	4494
70	6/7/96	-59.520	86.221	4304

TABLE 1. S4I $\Delta^{14}C$ station locations.

Station	Month	Latitude	Longitude	Bottom Depth (m)
73	6/14/96	-65.330	91.475	553
76	6/15/96	-64.859	93.004	1808
78	6/16/96	-64.464	92.481	3060
80	6/16/96	-63.653	91.737	3629
84	6/18/96	-63.092	86.007	3809
87	6/20/96	-62.001	90.001	4020
90	6/22/96	-62.286	94.670	3848
93	6/23/96	-62.335	99.558	4316
98	6/24/96	-62.104	105.269	4297
102	6/26/96	-62.244	110.607	3986
105	6/26/96	-62.002	115.331	4255
108	6/27/96	-62.000	120.000	4194

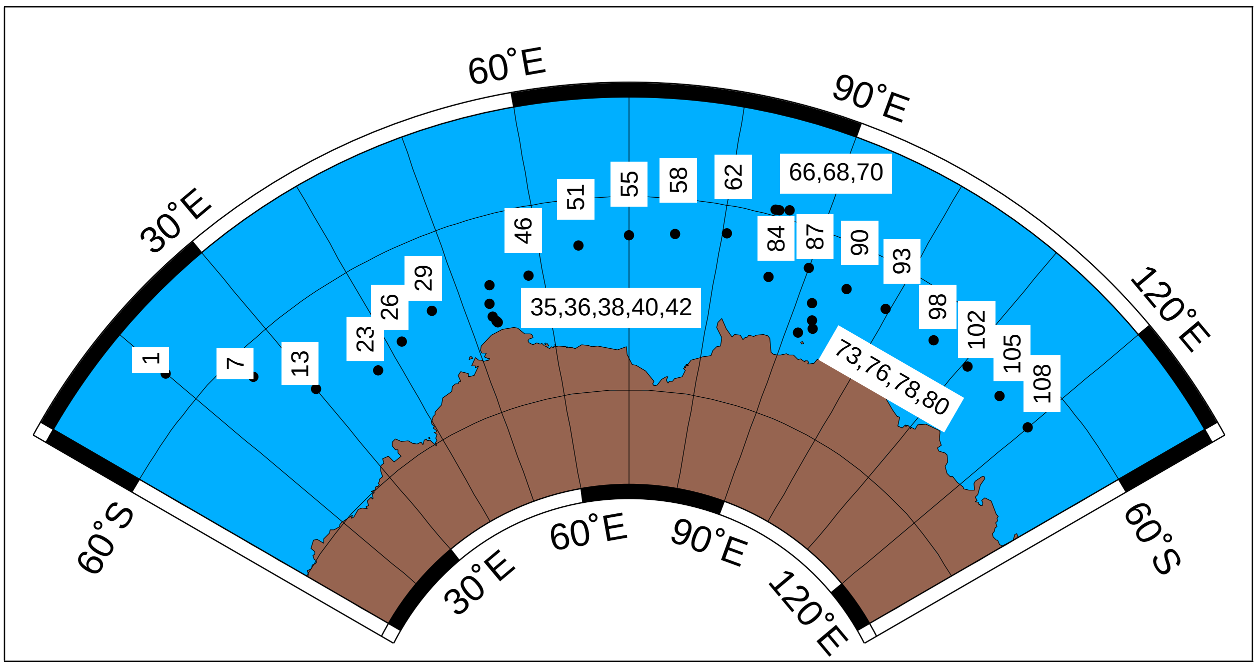

Figure 1: AMS ^{14}C station map for WOCE S04I.

2.0 Personnel

^{14}C sampling for this cruise was carried out by Robert M. Key (Princeton University). ^{14}C (and accompanying 13C) analyses were performed at the National Ocean Sciences AMS Facility (NOSAMS) at Woods Hole Oceanographic Institution. R. Key collected the data from the originators, merged the files, assigned quality control flags to the ^{14}C and submitted the data files to the WOCE office (4/99). R. Key is P.I. for the ^{14}C data and NOSAMS for the ^{13}C data.

3.0 Results

This ^{14}C data set and any changes or additions supersedes any prior release.

3.1 Hydrography

Hydrography from this leg has been submitted to the WOCE office by the chief scientist and described in the hydrographic report.

3.2 ^{14}C

The $\Delta^{14}C$ values reported here were originally distributed in a NOSAMS data report (NOSAMS, 1999), February 16, 1999. That reports included results which had not been through the WOCE quality control procedures. This report supersedes that data distribution. All of the AMS samples from this cruise have been measured. Replicate measurements were made on 4 water samples. These replicate analyses are tabulated in Table 2. The table shows

Table 2: Summary of Replicate Analyses

Sta-Cast-Bottle	$\Delta^{14}C$	Err	E.W.Mean[a]	Uncertainty[b]
51-1-9	-161.31	2.92	-167.40	2.62
	-176.84	2.91		
51-1-10	-167.33	3.26	-167.40	2.59
	-167.51	4.29		
58-1-26	-151.72	5.74	-155.78	3.49
	-156.65	2.67		
70-1-5	-176.29	4.42	-176.06	3.46
	-175.69	5.55		

a. Error weighted mean reported with data set

b. Larger of the standard deviation and the error weighted standard deviation of the mean.

the error weighted mean and uncertainty for each set of replicates. Uncertainty is defined here as the larger of the standard deviation and the error weighted standard deviation of the mean. For these replicates, the simple average of the normal standard deviations for the replicates is 1.0‰. This precision estimate is lower than the average error for the time frame over which these samples were measured (Jul. 1996 - Dec. 1998) and lower than the overall mean error for Pacific WOCE samples (Elder,*et. al*., 1998). Note that the errors given for individual measurements in the final data report (with the exception of the replicates) include only counting errors, and errors due to blanks and backgrounds. The uncertainty obtained for replicate analyses is generally a better estimate of the true error since it includes errors due to sample collection, sample degassing, *etc*. Close examination of the data along 67°S in the deep water indicates that 4‰ is a more realistic of the true error associated with this data set.

4.0 Quality Control Flag Assignment

Quality flag values were assigned to all $\Delta^{14}C$ measurements using the code defined in

Table 0.2 of WHP Office Report WHPO 91-1 Rev. 2 section 4.5.2. (Joyce,*et al.*,1994*)*.Measurement flags values of 2, 3, and 6 have been assigned. The choice between values 2 (good) and 3 (questionable) involves some interpretation. There is little overlap between this data set and any existing^{14}C data, so that type of comparison was difficult. In general the lack of other data for comparison led to a more lenient grading on the ^{14}C data.

When using this data set for scientific application, any ^{14}C datum which is flagged with a “3” should be carefully considered. When flagging^{14}C data, the measurement error was taken into consideration. That is, approximately one-third of the^{14}C measurements are expected to deviate from the true value by more than the measurement precision. No measured values have been removed from this data set. Table3 summarizes the quality control flags assigned to this data set. For a detailed description of the flagging procedure see Key, *et al*. (1996).

Table 3: Summary of Assigned Quality Control Flags

Flag	Number
2	803
3	6
4	0
5	4
6	3[a]

a. Some replicates flagged 3 or 4

5.0 Data Summary

Figures 2-6 summarize the Δ^{14}C data collected on this leg. Only Δ^{14}C measurements with a quality flag value of 2 (“good”) or 6 (“replicate”) are included in each figure. Figure 2 shows the Δ^{14}C values with 2σ error bars plotted as a function of pressure. The mid depth Δ^{14}C minimum which normally occurs around 2500 meters in most of the Pacific is absent in this section. In fact, there is very little variation in the deep and bottom water. All of the samples for the entire cruise collected at a depth greater than 1000 meters have a meanΔ14C = -153.8±7.2‰ with a substantial fraction of this variance due to the samples collected very near the Antarctic slope. This result compares remarkably well with the mean of -156.0±8.5‰ calculated for the WOCE Pacific Antarctic section (S4P). Figure 3 shows the Δ14C values plotted against silicate.The straight line shown in the figure is the least squares regression relationship derived by Broecker*et al.* (1995) based on the GEOSECS global data set. According to their analysis, this line (Δ^{14}C = -70 - Si) represents the relationship between naturally occurring radiocarbon and silicate for most of the ocean. They interpret deviations inΔ14C above this line to be due to input of bomb-produced radiocarbon, however, they note that the technique can not be applied at high latitudes as confirmed by this data set. With the exception of the very near surface waters, this region of the Pacific shows no change since GEOSECS which strongly implies that the data in Figure 3 indicates a failure of the technique in this area rather than bomb-produced contamination throughout the water column.

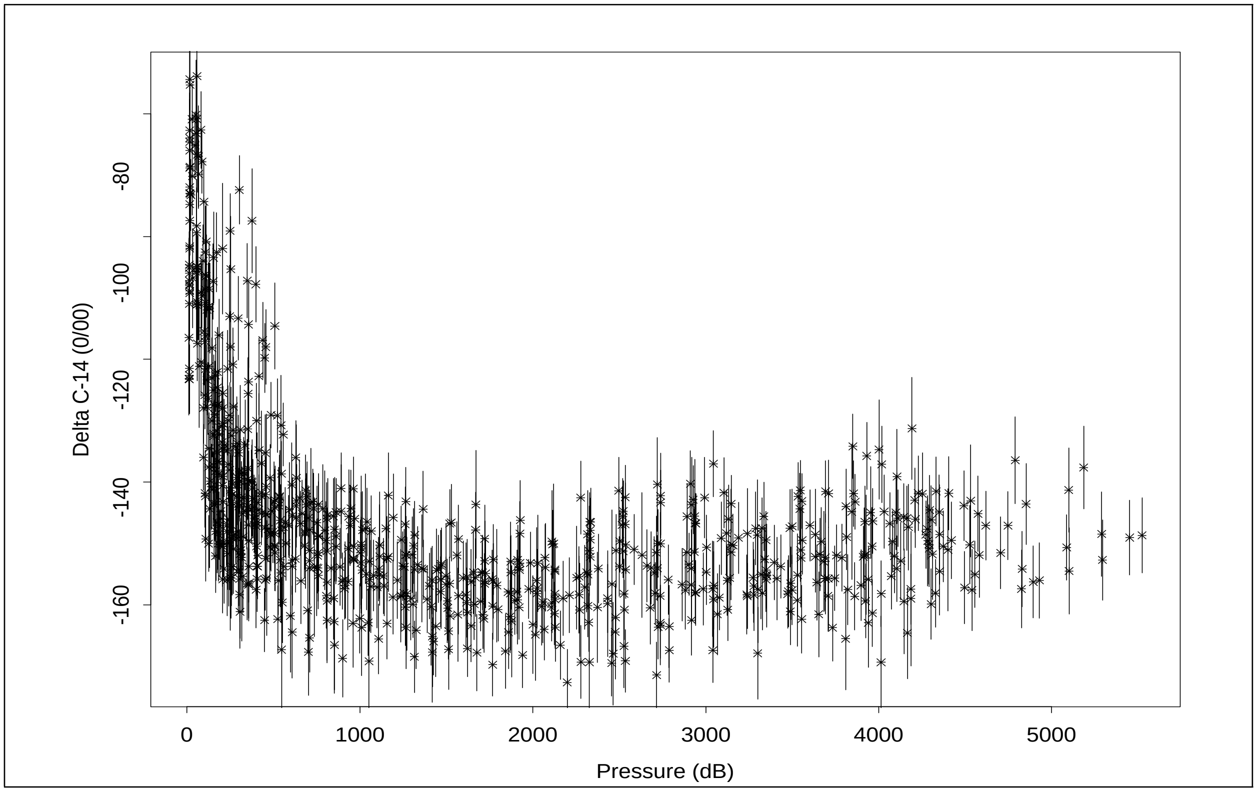

Figure 2: $\Delta^{14}C$ results for S4I stations shown with 2σ error bars.Only those measurements having a quality control flag value of 2 or 6 are plotted.

Figure 4 shows all of the S4I radiocarbon values plotted against potential alkalinity normalized to a salinity of 35 (defined as [alkalinity + nitrate]*35/salinity). The straight line is the regression fit (^{14}C = -68 -(PALK_35 - 2320) derived by S. Rubin (LDEO) to all of the GEOSECS results for waters which were assumed to have no bomb-produced ^{14}C (depths greater than 1000 meters, but including high latitude samples). Preliminary investigation indicates that this new method for separating bomb-produced and natural ^{14}C works in high latitude waters. For this data set it appears that the regression intercept derived from the GEOSECS data may be a bit too low. Regardless, if the function is valid, then for these data, waters which have alkalinity values less than ~2400µmole/kg have a significant amount of bomb-produced radiocarbon. If this is true, and if the values have changed little since GEOSECS, then most of the bomb contamination had to have been distributed throughout most of the water column even as early as the mid 1970's.

Figures 5-7 show gridded sections of the $\Delta^{14}C$ data. The data were gridded using the "loess" methods described in Chambers *et al.* (1983), Chambers and Hastie (1991), Cleveland (1979) and Cleveland and Devlin (1988).

Figure 5 shows the main zonal cruise section along ~62°S. The colors in the image indicate $\Delta^{14}C$ while the contours are CFC-11 concentration (pmol/kg; preliminary data from Bill Smethie (LDEO) and Mark Warner (UW)). Significant resolution is lost in the deep water $\Delta^{14}C$ since most of the variability is near the surface. Nevertheless, a strong correlation in the two distributions is immediately apparent. The bottom waters both east and west of the Kerguelen Ridge (~80°E) have appreciable chlorofluorocarbon concentrations and are most likely contaminated with bomb-produced radiocarbon. The highest near bottom (pressure >3750dB) $\Delta^{14}C$ values

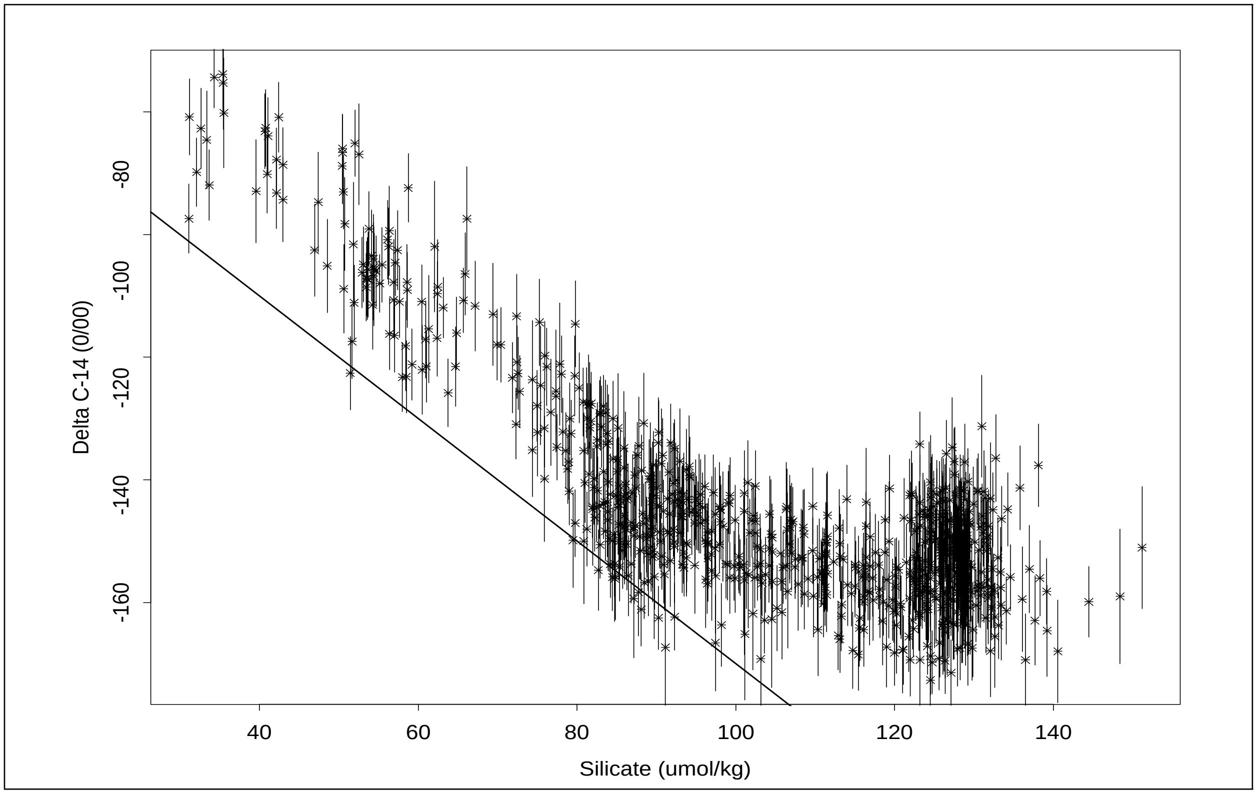

Figure 3: $\Delta^{14}C$ as a function of silicate for S4I AMS samples. The straight line shows the relationship proposed by Broecker, *et al.*, 1995 ($\Delta^{14}C$ = -70 - Si with radiocarbon in ‰ and silicate in µmol/kg). Two-sigma error bars are given for the $\Delta^{14}C$ measurements.

along this section range between -140‰ and -130‰ and are comparable to near bottom waters at similar latitudes in the Pacific (Key and Schlosser, 1999). Figure 6 and Figure 7 show contoured sections of the $\Delta^{14}C$ distribution along 65°E and 90°E respectively. Note that the contour interval used in the two figures is different. The 65°E and 90°E sections clearly show penetration of bomb radiocarbon along the Antarctic continental slope.

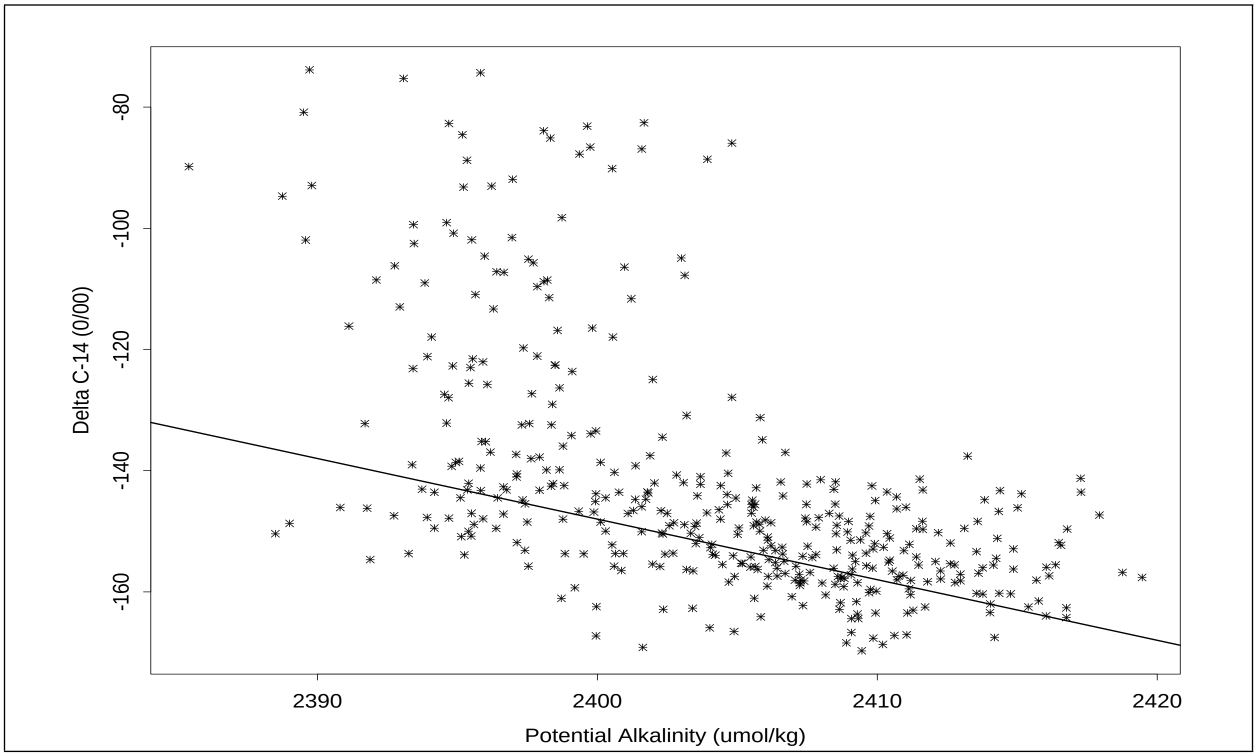

Figure 4: Based on the new method devised by S. Rubin, the samples which plot above the line and have potential alkalinity values less than about 2400 μmole/kg are contaminated with bomb-produced ^{14}C..

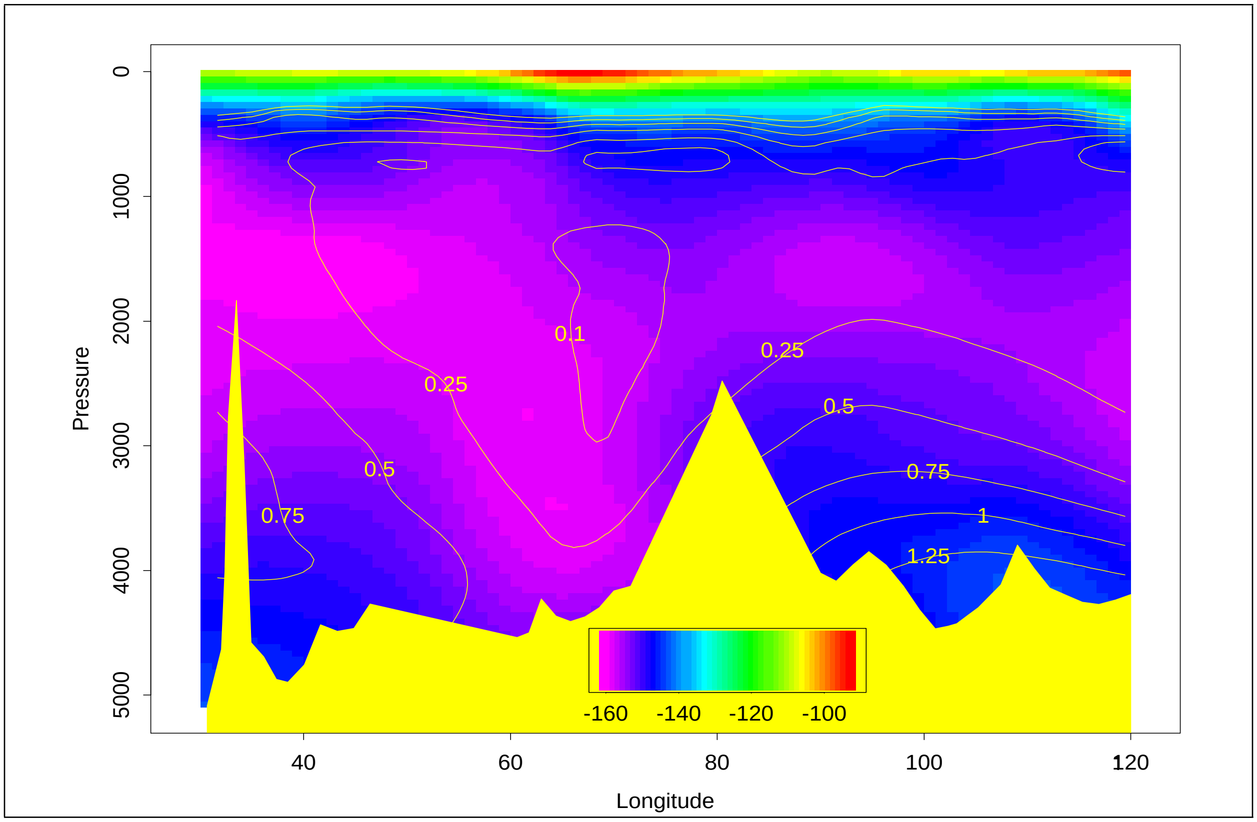

Figure 5: $\Delta^{14}C$ concentrations, along main east-west section of S4I at approximately 62°S, are indicated by color. Contour lines are preliminary CFC-11 concentrations (pmol/kg).

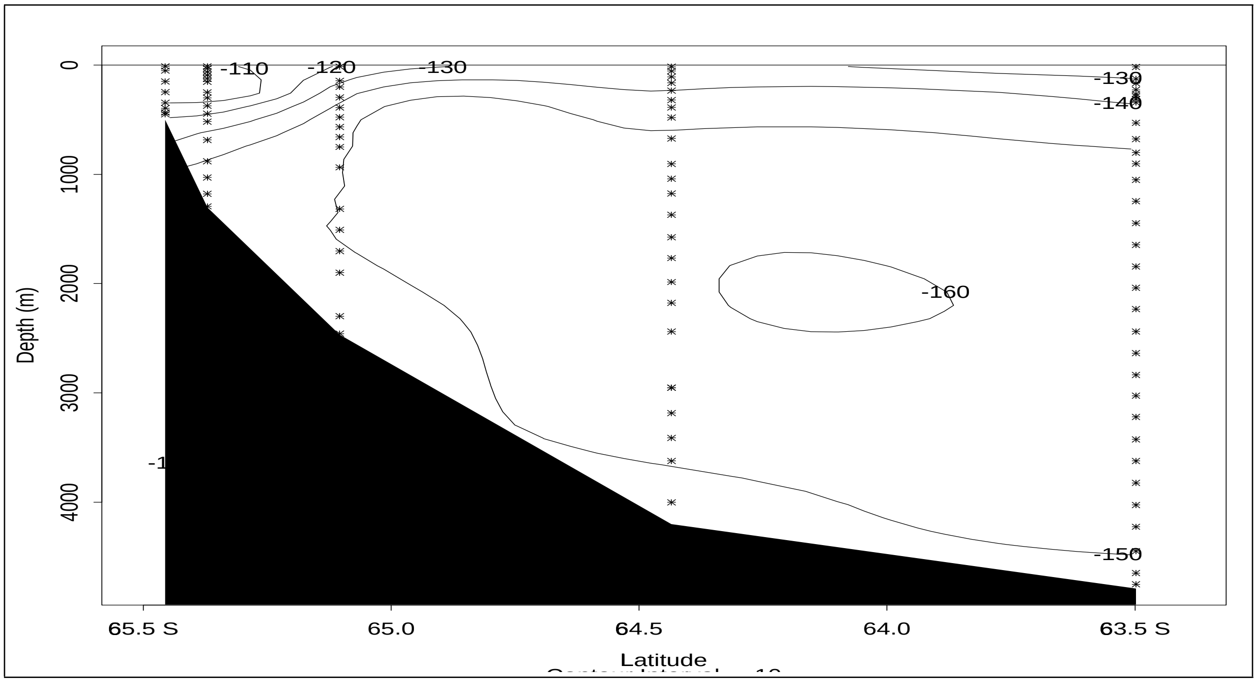

Figure 6: $\Delta^{14}C$ along ~65°E near the Antarctic slope. The near bottom values along the lower slope indicate entrainment of "new" bottom water.

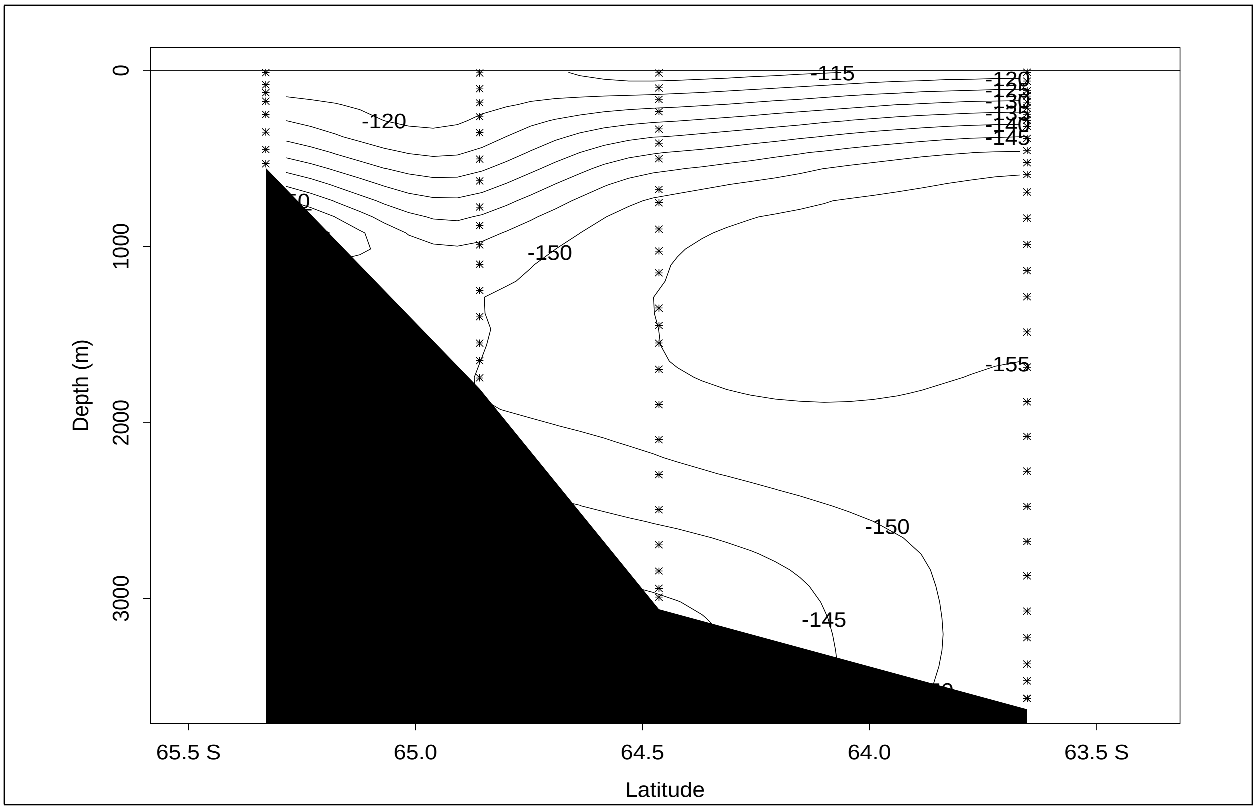

Figure 7: .$\Delta^{14}C$ along ~90°E near the Antarctic slope. The near bottom values along the lower slope indicate entrainment of "new" bottom water.

6.0 References and Supporting Documentation

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NOSAMS, National Ocean Sciences AMS Facility Data Report #99-043, Woods Hole Oceanographic Institution, Woods Hole, MA, 02543, 2/16/1999.

DATA PROCESSING NOTES

Date	Contact	Data Type	Data Status
04/25/98	Rosenberg	DOC	CFC Rpt/Cruise Rpt Rcvd @ WHPO
09/11/98	Diggs	CTD/BTL/SUM	Data Updated and corrected
09/16/98	Rintoul	CTD/BTL/SUM	Submitted for DQE
	"I have just corrected and updated all records pertaining to P12/S04I. This line is also know as SR03 and PR12, the *correct* expocode is 09AR9404_1 (not 09AR9508/1), but all references to the previous expocode should be retained in our records. The data files to date are NON-PUBLIC and the password is the same as P12."		
01/04/99	Anderson	BTL/CTD	Ready to Reformat
02/07/99	Mantyla	NUTs/S/O	DQE Begun
02/10/99	Anderson	SUM/BTL	Data Reformatted
	I have reformatted P12 (S04, SR03, PR12). Arnold is DQEing that line now. I have reformatted P14N. George will DQE that line next. The .sea, .sum, and readme files for these cruises are on whpo in /usr/export/ftp/pub/WHPO/S_ANDERSON/P12 or P14N."		
02/10/99	Mantyla	NUTs/S/O	DQE Report rcvd @ WHPO
09/14/99	Rosenberg	NO2+NO3	no separate nitrite data
	"For P11A (09AR9391_2), there's no separate nitrite data, only total nitrate+nitrite. In fact the same applies to all our Aurora Australis WOCE cruises."		
09/20/99	Rintoul	CTD	Data are Public
	"All the CTD data associated with me should be made public. I thought we had taken care of this earlier, but it appears not. I'm a little unsure how the DQE process is supposed to work. I think only two of our cruises have so far been DQE'd; if your policy is to not release data publicly until it has been DQE'd, then that is OK too."		
12/10/99	Rosenberg	BTL	First PI Response to DQE Report
12/17/99	Rosenberg	BTL	Changes made by PI following DQE
12/23/99	Rosenberg	CFCs/NUTs/TSO	Data are Public
	Submitted new CFC data file. "You can also make all the data for that cruise public."		
03/24/00	Schlosser	He/Tr	Data are Public
	as mentioned in my recent message, we will release our data with a flag that indicates that they are not yet final. We started the process of transferring the data and we will continue with the transfer during the next weeks. I had listed the expected order of delivery in my last message."		

04/26/00	Bartolacci	Cruise ID	p12 designation changed to s03

After DPC meeting April, 2000 it was decided to delete P12 from Pacific table and move data to S03. this was done and S03 was added to the southern onetime lines."

09/06/00	Uribe	BTL/SUM	Data Update

There is a version online of S. Anderson's revised data. However Mark Rosenberg submitted more recent files that contain Quality 2 data."

12/04/00	Tilbrook	ALKALI/TCARBN	Submitted

A comma separated file is attached that contains the DIC and alkalinity data for the SR3 line and the part of the S4 line we did from about 120E to meet the S4P line near the Ross Sea (CTD2 - 57). The SR3 line starts about CTD 58.

Missing data is represented by -9, the nitrite column shows all ""-9"". The quality control flags conform to the WOCE standard, but are in individual columns.

This file was used by the US carbon group in their crossover analysis for the Pacific. According to Chris Sabine (who put the quality control flags in WOCE standards format), our data are in good shape. As far as I am aware there are no corrections applied to our DIC or alkalinity data. By the way, Chris sent me a file where he had combined the carbon and CFC data from John Bullister and Mark Warner. I guess Mark and John are giving you their data and if so, I can send the file with the CFC data in it.

I will try and get the P11S carbon data to you in the next few weeks. For now, please do not make these data public access."

12/05/00	Diggs	ALKALI/TCARBN	Reformatting Needed; given to S. Anderson

"I have received the Carbon data for S04-SR03 (09AR9404_1) from Bronte Tilbrook (CSIRO) via Lynne Talley yesterday.

Although the data are not in the WOCE format, there's enough information in them to make a WOCE-style bottle file which will enable us to merge these data into the existing bottle file."

12/05/00	Diggs	DOC	New DOC online

"I have updated the very outdated DOC file with updated MS Word docs that were just sitting around. Now, the docs look better and I've added J. Bullister's 1997 CFC docs to the new PDF file online."

06/21/01	Uribe	BTL	Website Updated; CSV File Added

Bottle file in exchange format was put online.

10/15/01	Diggs	CTD	Data Reformatted

CTD had duplicate files in the ZIP archive and I have removed the extra files. Re-zipped the remainder and replaced the online zip CTD archive file.

12/24/01	Uribe	CTD	Website Updated; CSV File Added

CTD has been converted to exchange using the new code and put online.

Empty section ID's were filled in with AUR from R/V AURORA AUSTRALIS.

01/03/02	Hajrasuliha	CTD	Internal DQE completed

made .ps files. & *check.txt file.

01/31/02	Kozyr	ALKALI/TCARBN	Final data rec'd @WHPO

I have put 3 data files in WHPO ftp INCOMING area. These files are the final CO2-related data and quality flags for WOCE sections A14 (L'ATALANTE 35A3CITHER3/1), A13 (L'ATALANTE 35A3CITHER3/2), and SR03/S04 (P12, 09AR9404_1)."

05/14/02	Anderson	ALKALI	Data Merged into BTL file

Here are my notes on merging TCARBN and ALKALI for S03:

Added TCARBN and ALKALI from file sent by Bronte Tilbrook to Lynne Talley.

Found in:

whpo.ucsd.edu/data/onetime/southern/s03/original/2000.12.04_SR03_CARBON_TILBROOK.DIR/s04-sr03_carbon.csv

Merged into online file s03hy.txt 19900105WHPOSIOSA

05/14/02	Anderson	TCARBN	Data Merged into BTL file

• New CSV file added"

• Merged TCARBN and ALKALI into online file.

• Made new exchange file.

Added TCARBN and ALKALI from file sent by Bronte Tilbrook to Lynne Talley.

Found in:

whpo.ucsd.edu/data/onetime/southern/s03/original/2000.12.04_SR03 _CARBON_TILBROOK.DIR/s04-sr03_carbon.csv

Merged into online file s03hy.txt 19900105WHPOSIOSA

06/11/02	Kozyr	ALKALI	Alkalinity and quality flags submitted

Bronte Tilbrook from CSIRO has sent me new (corrected) Total Alkalinity values and quality flags for the Section SR03_S04 cruise

(EXPOCODE 09AR9404_1 WHP-ID P12 (S04/SR03) DATES 121394 TO 020295.

I've made a merging of new data into the CDIAC data set for this cruise. I've put the final data file into your ftp /INCOMING area for you to change your data set alk numbers and quality flags.

06/12/02	Anderson	ALKALI	BTL, csv & exchange files updated

Data merged into online file, new CSV file online (20020514WHPOSIOSA).

• Merged new ALKALI data submitted by Kozyr into online file

• Made new exchange file.

10/03/02	Kappa	DOC	Compiled final PDF/TXT files

New DOCs online. I have updated the very outdated DOC files with new PDF and Text docs that were just sitting around. Now, the docs look better and I've added CTD, BTL and 14C DQE reports, as well as PI response to the BTL DQE report and his corrections.

Apparently the text version was not previously put online as stated above. Old PDF doc required extensive reformatting because the bottom lines of many pages were cut off.

In addition to the new reports I reformatted and added, both the PDF and TXT docs now have a first page summary of the cruise; a table of contents; and these data processing notes.

The new PDF doc also has links between the figures, tables and appendices and each text reference to them.

There are also links from each item in the table of contents to the related text passages.

As a final navigation aid I've added "thumbnails" for each page.