ACE CRC unpublished draft report, with CTD data processing and data quality information - final report including historical comparisons and mooring data still to come

Kerguelen Deep Western Boundary Current Experiment and CLIVAR I9 Transect, Marine Science Cruises AU0304 and AU0403 - Oceanographic Field Measurements and Analysis

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Kerguelen Deep Western Boundary Current Experiment and CLIVAR I9S Transect, Marine Science Cruises AU0304 and AU0403 - Oceanographic Field Measurements and Analysis

ABSTRACT

Oceanographic measurements in the Southern Ocean Indian Sector to the southwest of Australia were conducted on two cruises, during the southern summers of 2002/2003 and 2004/2005. A CTD transect up the northeastern flank of the Kerguelen Plateau, south across the Princess Elizabeth Trough and onward to the Antarctic continenl shelf was occupied on both cruises. Additional CTD stations were occupied around an experimental krill survey area in the vicinity of Mawson on the first cruise. A full occupation of CLIVAR meridional section I9S was completed on the second cruise. A total of 179 CTD vertical profile stations were taken over the two cruises, most to within 30 m of the bottom. Over 3500 Niskin bottle water samples were collected for the measurement of salinity, dissolved oxygen, nutrients, CFC's, dissolved inorganic carbon, alkalinity, ^{18}O, methane, selenium and biological parameters, using a 24 bottle rosette sampler. Full depth current profiles were collected by an LADCP attached to the CTD package, while near surface current data were collected by a ship mounted ADCP. An array of 8 moorings comprising current meters and thermosalinographs were deployed up the northeastern slope of the Kerguelen Plateau in February 2003 during the first cruise, and retrieved on the second cruise in January 2005. A summary of all data and data quality is presented in this report.

PART 1 OCEANOGRAPHIC FIELD MEASUREMENTS AND ANALYSIS

1.1 INTRODUCTION

Two Southern Ocean oceanographic projects were undertaken and completed aboard the Australian Antarctic Division vessel RSV Aurora Australis on marine science cruises AU0304 and AU0403. The first project was the Kerguelen Deep Western Boundary Current (DWBC) Experiment, a joint Australian/Japanese project comprising of mooring and CTD work, and conducted over both cruises. The primary oceanographic aim of this experiment is:

* to estimate the transport of the Kerguelen Western Boundary Current, including the northward transport of Antarctic Bottom Water east of the Kerguelen Plateau.

The second project was a reoccupation of CLIVAR-I9S meridional CTD transect. This transect was initially occupied by the RV Knorr ten years previously (P.I. Mike McCartney, WHOI). The primary oceanographic aims of the I9S repeat are:

* to measure changes in water mass properties and inventories throughout the full ocean depth between Australia and Antarctica along 115E;

* to estimate the transport of mass, heat and other properties south of Australia, and to compare the results to previous occupations of the I9S line and other sections in the Australian sector;

* to identify mechanisms responsible for variability in ocean climate south of Australia;

* to use repeat measurements to assess the skill of ocean and coupled models.

Part 1 of this reports describes the CTD, Niskin bottle, hull mounted ADCP and underway data and data quality. Part 2 describes the mooring data.

AU0304

Cruise AU0304 took place from January to March 2003 (Figure 1.2a), commencing the Kerguelen DWBC Experiment. The first major constituent of the cruise was a krill flux survey north of Mawson (principal investigators Steve Nicol, Graham Hosie and Tim Pauly, Australian Antarctic Division). CTD profiles were measured as part of the survey (Figure 1.2b) (see Voyage 4 2002/2003 Voyage Leader's report for a summary of the programs and work completed on the cruise). The second major constituent of the cruise was the Kerguelen DWBC program. An array of 8 current meter/thermosalinograph moorings was deployed in a line commencing to the northeast of the Kerguelen Plateau, then traversing up the slope to the plateau (Figure 1.1). A CTD transect was done over the mooring array, and then continuing south across the Princess Elizabeth Trough to the Antarctic continental shelf, approximating the WOCE-I8S transect from 1994 (P.I. Mike McCartney, WHOI).

AU0403

Cruise AU0403 took place from December 2004 to February 2005 (Figure 1.3). Two CTD transects were completed: CLIVAR-I9S, and a repeat of the Kerguelen Plateau/Princess Elizabeth Trough transect initially done on cruise AU0304. The Kerguelen DWBC mooring array was successfully recovered.

1.2 CRUISE ITINERARIES AND SUMMARIES

CTD station details are summarised in Table 1.3; sampling at each station is summarised in Table 1.4; mooring deployment and recovery details are summarised in Table 1.5; drifter deployment details are summarised in Table 1.6. Principal investigators for CTD and water sampling measurements are listed in Table 1.7, while cruise participants are listed in Table 1.8.

AU0304

The ship departed south from Hobart on January 3rd 2003, with 3 test/calibration CTD casts taken en route at ~62^{o} 15'S. The first test cast was aborted just below 600 dbar due to an electrical fault in the termination. After retermination, a second test was taken to 1000 dbar. For both these casts an RDI LADCP was fitted to the rosette frame. The third CTD cast, down to 4300 dbar, was a calibration cast for 12 of the microcats to be deployed on the Kerguelen DWBC mooring array. These 12 microcats were attached to the rosette frame, and 6 calibration stops of 30 minutes duration each were made on the upcast, to provide calibration correction data for the microcat temperatures. A Sontek LADCP was also fitted to the rosette frame for this cast to provide a deep water test for the instrument prior to commencement of the scientific programs.

The krill/hydroacoustics survey work commenced in the vicinity of Mawson, with a series of repeated north/south transects across a survey box ~50 nautical miles north to south by ~60 miles east to west (Figure 1.2b). Two small CTD transects of 5 stations each were completed along the eastern and western sides of the box. A floating sediment trap (P.I.'s Stéphane Pesant and Anya Waite, University of Western Australia) was deployed on three occasions, doing a CTD at both the deployment and recovery locations. CTD's were repeated around the southeastern part of the box, upstream and downstream from a large iceberg, then the ship proceeded to Mawson.

The ship was not supplied with sufficient fuel in Hobart prior to sailing, so additional fuel was taken on from the Polar Bird, also at Mawson. While at anchor in Horseshoe Harbour, a cold water calibration of the sounders was completed, including a shallow CTD to 46 dbar. The ship departed Mawson after four and a half days, and the krill/hydroacoustics was recommenced ENE of Mawson, with a fine scale survey around a krill swarm. A further 9 CTD's were done around this survey area, including CTD's at the deployment and recovery locations of a third floating sediment trap deployment. During this work, 4 of the acoustic releases (the Kaiyo Denshi units) required for the mooring deployments were tested - for each of 2 CTD casts, 2 of the acoustic releases were attached to the CTD package and tested when the package was at depth. On one of the hydroacoustic transects a whale acoustics "ARP" mooring was deployed (P.I. John Hildebrand, Scripps Institution of Oceanography), to be recovered the following season. After completion of the krill program, the ship steamed north to the Kerguelen Plateau region for commencement of the Kerguelen DWBC program.

Mooring and CTD work were interleaved over the next few days. Prior to commencement of the mooring work, bathymetry information from the mooring locations was sent to the ship from the RTV Umitaka Maru (P.I. Takashi Ishimaru, Tokyo University of Fisheries). For 2 of the mooring locations in particular, these depths showed significant variation from the Smith and Sandwell topography (Smith and Sandwell, 1997) used for pre cruise planning. Mooring deployments commenced at the southwestern end of the array (Figure 1.1, Table 1.5), with a bathymetric survey conducted at each location prior to deployment. Final adjustments were made to mooring line lengths according to depths found from these surveys. CTD casts were also taken at each mooring location.

By this stage of the cruise, significant time had been lost to bad weather, so it was decided to leave the 3 northeasternmost CTD stations (Figure 1.2a) for the transit home. CTD work was continued along the transect line, completing all stations along the mooring array and onto the plateau. Several planned CTD stations on the southward leg across the plateau then across the Princess Elizabeth Trough were omitted due to time constraints. The section was completed on the shelf to the northeast of Davis. After retrieving personnel and cargo from Davis then Mawson, the ship returned to Hobart. En route the 3 CTD's were completed at the northeastern end of the transect.

AU0403

The ship departed Fremantle on December 23rd 2004. After a test CTD to ~1000 dbar, the CLIVAR-I9S transect was commenced south of Cape Leeuwin (Figure 1.3). Station 10 down to 5675 dbar was the deepest CTD done by the Aurora Australis to date. No significant time was lost to weather during the transect, however some time was lost due to equipment malfunction, including CTD winch spooling problems and CTD communication problems. 11 Argo floats were deployed on the transect (Table 1.6). Additional instruments were deployed from the trawl deck at some of the CTD stations, including a "fluoromap" fluorometer (P.I. Mark Doubell, Flinders University), a turbulence probe (P.I.

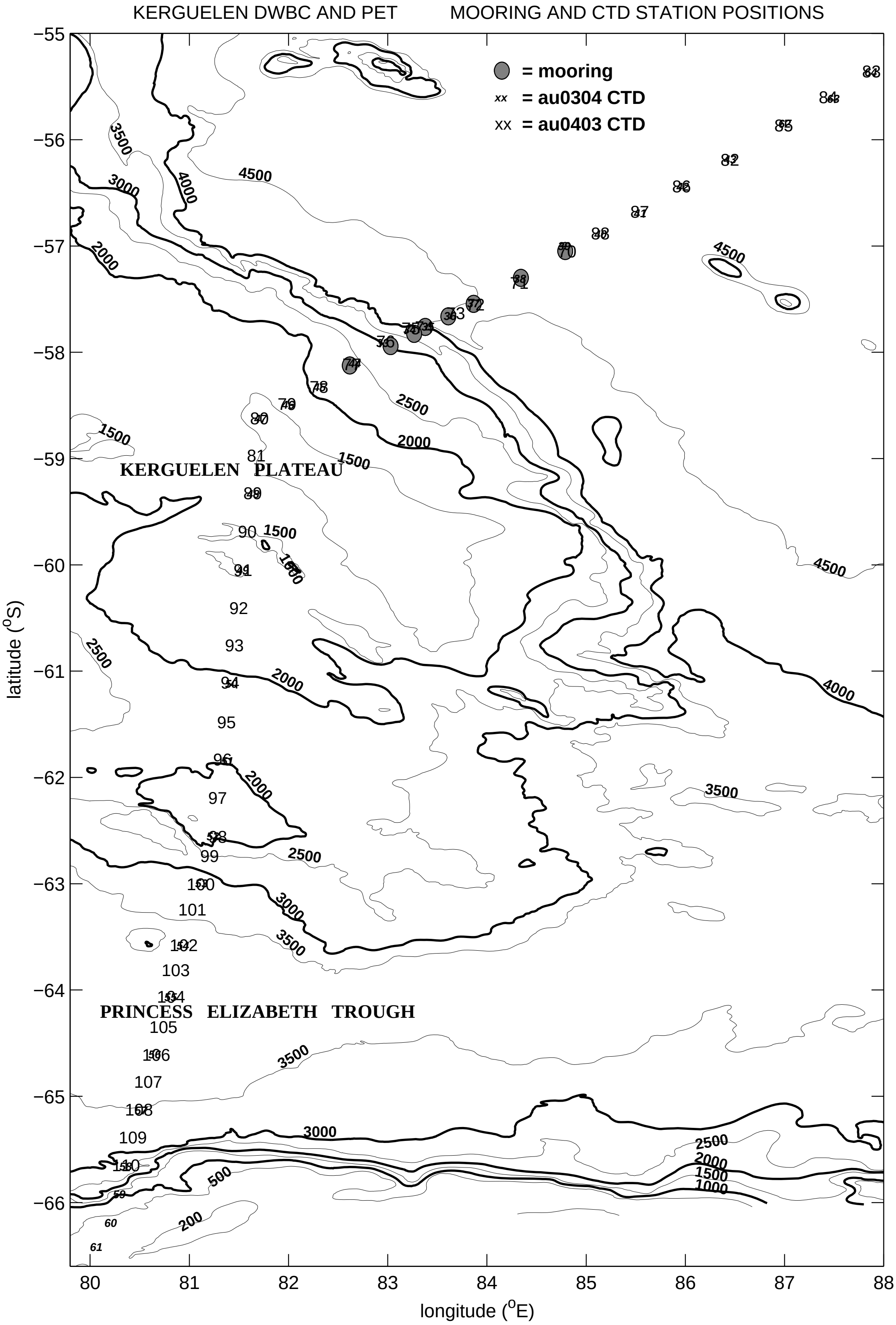


Figure 1.1: Kerguelen DWBC Experiment mooring locations, and Kerguelen/Princess Elizabeth Trough CTD stations for cruises AU0304 and AU0403.

Table 1.1: Summary of cruise itineraries

	AU0304	AU0403
Expedition Designation	AU0304, voyage 4 2002/2003 (cruise acronym KAOS)	AU0403, voyage 3 2004/2005 (cruise acronym)
Chief Scientist	John Church (CSIRO) Steve Nicol (Antarctic Division)	Steve Rintoul (CSIRO)
Ship	RSV Aurora Australis	RSV Aurora Australis
Ports of Call	Hobart Mawson Davis Mawson (again)	Hobart Davis
Cruise Dates	Jan 3rd – Mar 17th, 2003	Dec 23rd 2004 – Feb 17th 2005

Kevin Speer, Florida State University), and 10x10 bacteria/virus sampler (P.I. Justin Seymour, Flinders University) (Table 1.4b). Weather conditions during the transect south were mostly good enough for CTD operations, however conditions were frequently unsuitable for the fluoromap and turbulence probe work. The number of turbulence profile measurements in particular was not as high as desired. The transect was finished ~6 miles into the pack ice, in ~460 m water depth. The heavy pack ice prevented further CTD's to the south.

After completion of the I9S transect, the ship steamed northwest to the Kerguelen Plateau region for commencement of the Kerguelen DWBC work. A window of good weather allowed successful and complete recovery of the 8 DWBC moorings in three and a half days. CTD's were done at each mooring location, and the transect was continued to the station at 59^{o}S. At this stage the forecast showed some bad weather approaching, so it was decided to steam back to the northeast to complete the stations at the northeast end of the transect. After completing these, the transect was resumed south of 59^{o}S, continuing southward across the Kerguelen Plateau and Princess Elizabeth Trough, completing all planned stations down to 65.6^{o}S. Heavy pack ice prevented further CTD's along the planned transect. 3 CTD's were done up the slope and onto the shelf ~60 nautical miles west of the planned transect, and an additonal shallow CTD was done on the way in to Davis for the phytoplankton program. Fluoromap and turbulence probe deployments were done at several stations along the whole transect (Table 1.4b), and an ARP mooring was deployed on the northern slope of the Princess Elizabeth Trough (P.I. Jason Gedamke, Australian Antarctic Division).

By this stage of the cruise the ship was over a week ahead of schedule, due to the generally good weather conditions and timely recovery of the moorings, and so the port call to Davis was rescheduled to an earlier date. After retrieving personnel and cargo from Davis, a second ARP mooring was deployed on the way out, on the southern slope of the Princess Elizabeth Trough at ~66.2^{o}S. After deploying the ARP, 5 krill trawls were done to catch live krill for return to Hobart. En route back to Hobart, a further 8 Argo floats were deployed. At the last Argo deployment location, close to the proposed "PULSE" mooring site (P.I. Tom Trull) to the southwest of Tasmania, the Argo float included an oxygen sensor. A final CTD was done here for comparison with the Argo oxygen data.

1.3 FIELD DATA COLLECTION METHODS

1.3.1 CTD instrumentation

AU0304

This was the first cruise on the Aurora Australis using the newly purchased Sea-Bird CTD system. SBE9plus CTD serial 703, with dual temperature and conductivity sensors and a single SBE43

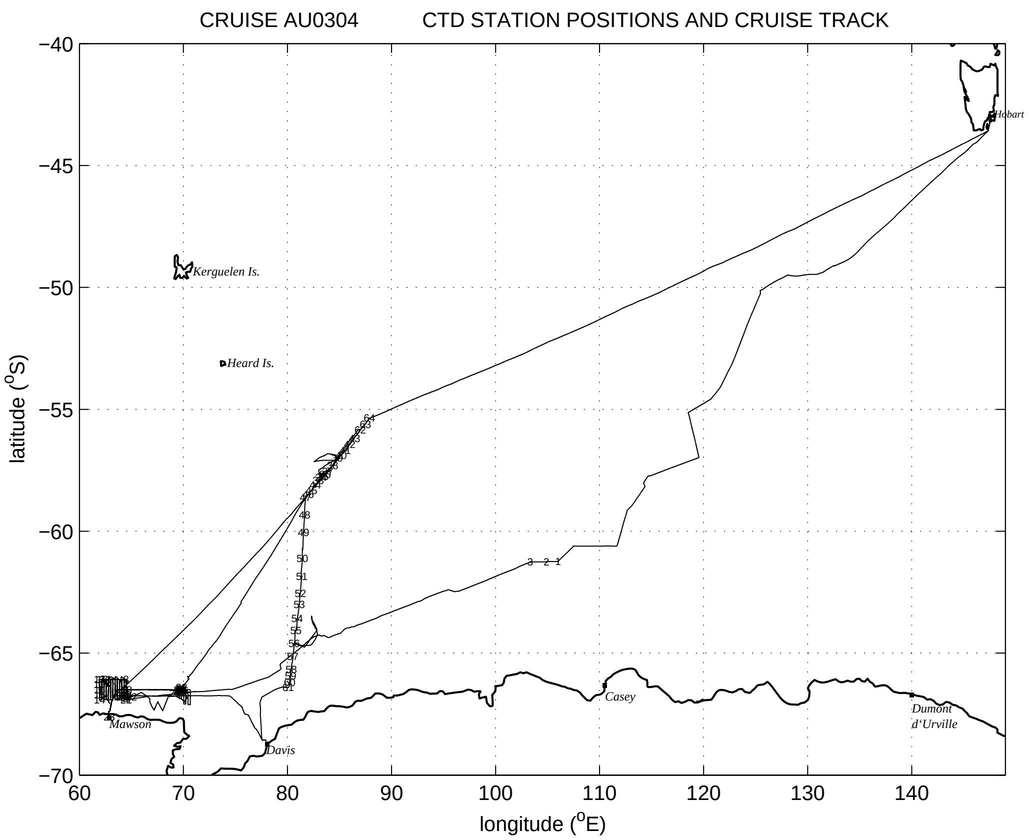


Figure 1.2a: CTD station positions and cruise track for cruise AU0304.

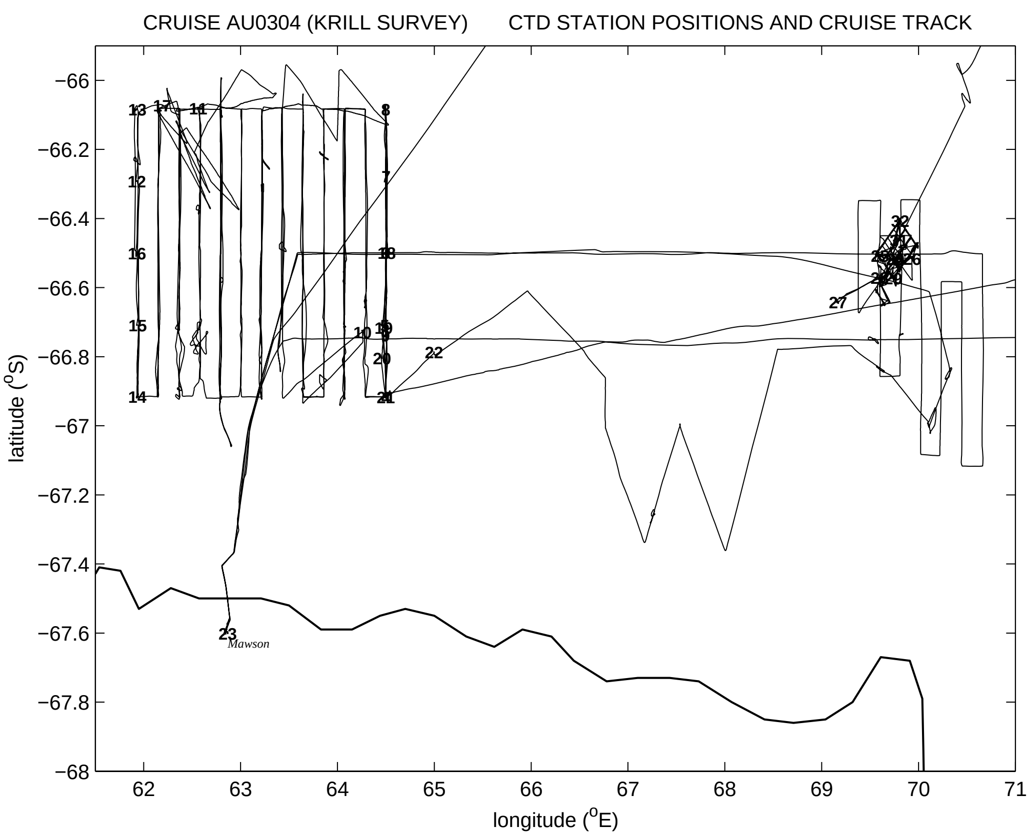


Figure 1.2b: Cruise track and CTD station positions for krill survey on cruise AU0304.

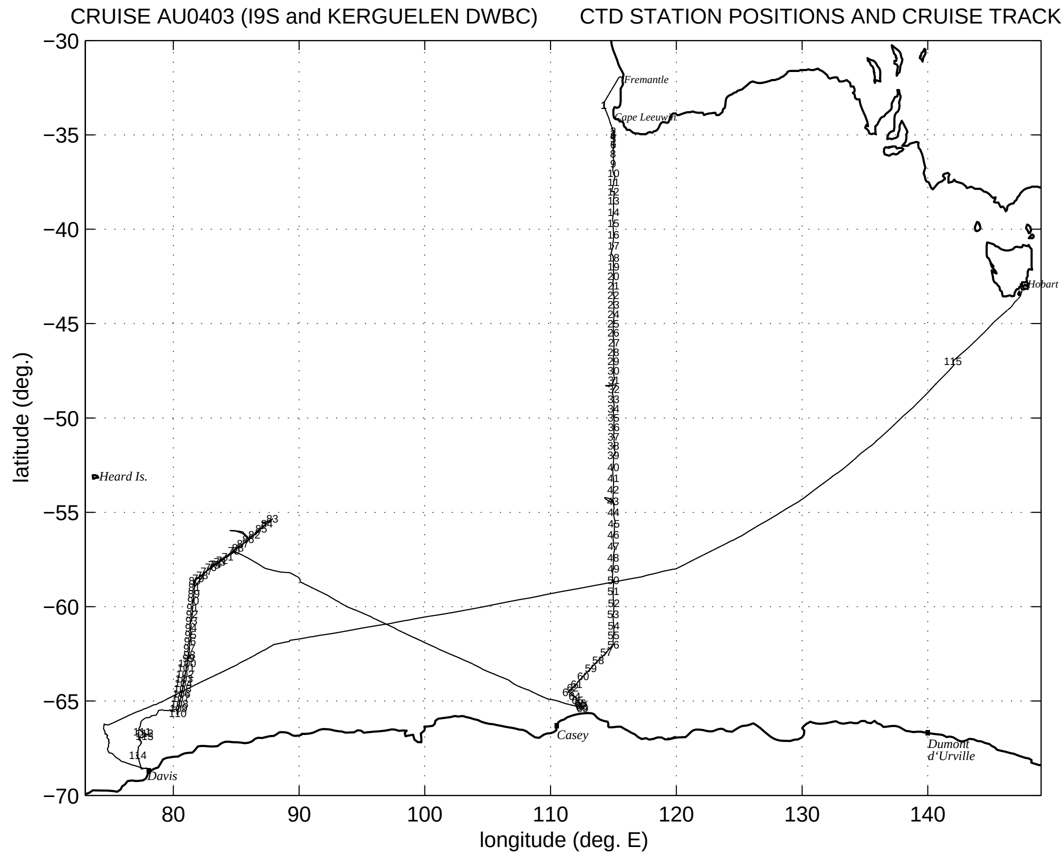


Figure 1.3: CTD station positions and cruise track for cruise AU0403.

dissolved oxygen sensor (on the primary sensor pump line), was used for the entire cruise, mounted on a Sea-Bird 24 bottle rosette frame, together with a SBE32 24 position pylon (Table 1.2). 10 litre General Oceanics Niskin bottles were used for sample collection. Benthos model PSA-900 altimeters, serials 1007 and 1008, were used one at a time throughout the cruise. A Wetlabs fluorometer serial 013 was also mounted on the frame for all casts. CTD data were transmitted up a 6 mm seacable to a SBE11plusV2 deck unit, at a rate of 24 Hz, and data were logged simultaneously on 2 PC's using Sea-Bird data acquisition software "Seasave". Two LADCP's, an RDI and a Sontek, were used in different combinations throughout the cruise, attached to the rosette frame. The Sontek had two transducer sets, looking upward and downward, while the RDI had a single downward looking set. Both LADCP's were powered by a separate battery pack, and data were logged internally and downloaded after each CTD cast. For casts with the Sontek LADCP fitted, 2 Niskin bottles had to be removed for the upward looking transducer set. When both LADCP's were fitted (Table 1.4a) 2 additional Niskin bottles had to be removed, due to weight limitations for the rosette package, leaving 20 bottles. For station 33 onwards, the package was stopped for 5 minutes on the upcast at ~100 m above the bottom, for logging of LADCP bottom track data. LADCP data from the 2 instruments are compared in Thurnherr (2003a and b).

With the new pumped CTD system, the CTD deployment method was changed from previous cruises. The new deployment method for both cruises AU0304 and AU0403 was as follows:

* CTD initially deployed to ~20 m
* after confirmation of pump operation, CTD returned to just below the surface (depth dependent on sea state)
* after returning to just below the surface, downcast proper commenced

Bottle samples for salinity, dissolved oxygen and nutrients (phosphate, nitrate+nitrite, silicate) were collected on most stations (Table 1.4). Samples for various biological parameters were collected from Niskin bottles throughout the cruise.

AU0403
SBE9plus CTD serial 703, with the same setup as for AU0304, was used for stations 1 to 41 (Table 1.2); CTD serial 704 was used for station 42 onwards. The frame, pylon and fluorometer were as for AU0304. Older model Benthos 2110 altimeters were used for most of the cruise (Table 1.2) due to unreliability of the newer PSA-900 model. For station 115, the the PSA-900 was tested again through the fluorometer channel (i.e. no fluorescence data). A Sontek LADCP was fitted to the package for most casts (Table 1.4), with both the upward and downward looking transducers fitted up to station 25. With both transducers fitted, only 22 Niskin bottles were on the package, as for AU0304. After station 35 the upward looking transducers were removed (discussed later in the report), and there were 24 bottles on the package for the remainder of the cruise. For most casts, the package was stopped for 5 minutes on the upcast at ~50 m above the bottom, for logging of LADCP bottom track data.

The various bottle samples collected at each station are listed in Table 1.4.

CTD sensor calibrations
Pre cruise manufacturer supplied calibrations were used for all CTD sensors (March and September 2002 for AU0304, July to August 2004 for AU0403), including the fluorometer (Table 1.10). Complete conductivity and dissolved oxygen calibrations derived from in situ Niskin bottle samples are listed later in the report. Hydrochemistry laboratory methods are discussed in Appendix 1.1. Full details of CTD processing and calibration techniques are given in Appendix 1.2.

Table 1.2: CTD sensors, serial numbers and manufacturer specifications.

parameter	sensor	accuracy	resolution
AU0304			
CTD underwater unit	SBE9plus serial 703		
pressure	Paroscientific Digiquartz serial 88903	1.5 dbar	0.1 dbar
primary temperature	SBE3plus serial 4208	0.001^{o}C	0.0002^{o}C
primary conductivity	SBE4C serial 2788	0.003mS/cm	0.0004mS/cm
primary pump	SBE5T serial 3456	-	-
oxygen	SBE43 serial 0191	-	-
secondary temperature	SBE3plus serial 4245	0.001^{o}C	0.0002^{o}C
secondary conductivity	SBE4C serial 2821	0.003mS/cm	0.0004mS/cm
secondary pump	SBE5T serial 3471	-	-
fluorometer	Wetlabs ECO-AFL serial 013	-	-
altimeter *(station 1-39, 52)*	Benthos PSA-900 serial 1007	-	0.1 m
altimeter *(station 40-51, 53-64)*	Benthos PSA-900 serial 1008	-	0.1 m
AU0403			
station 1 to 41			
CTD underwater unit	SBE9plus serial 703		
pressure, temperature, conductivity, oxygen, pump as above for AU0304			
station 42 to 115			
CTD underwater unit	SBE9plus serial 704		
pressure	Paroscientific Digiquartz serial 89084	1.5 dbar	0.1 dbar
primary temperature	SBE3plus serial 4248	0.001^{o}C	0.0002^{o}C
primary conductivity	SBE4C serial 2977	0.003mS/cm	0.0004mS/cm
primary pump	SBE5T serial 3478	-	-
oxygen	SBE43 serial 0178	-	-
secondary temperature	SBE3plus serial 4246	0.001^{o}C	0.0002^{o}C
secondary conductivity	SBE4C serial 2808	0.003mS/cm	0.0004mS/cm
secondary pump	SBE5T serial 3951	-	-
fluorometer	Wetlabs ECO-AFL serial 013	-	-
altimeter *(station 1-6, and 115)*	Benthos PSA-900 serial 137	-	0.1 m
altimeter *(station 7-40)*	Benthos 2110 serial 115	±5%	0.1 m
altimeter *(station 41-115)*	Benthos 2110 serial 142	±5%	0.1 m

Table 1.3a: **Summary of station information for cruise AU0304. All times are UTC. In the station naming, "cat" is the cast with microcats attached, "krill" is the krill survey area, "sed" is the floating sediment trap, "swarm" is the krill swarm study, "cal" is the cold water acoustic calibration at Mawson, and "DWBC/PET" is the Kerguelen Deep Western Boundary Current experiment and the Princess Elizabeth Trough section. Note that "maxP" is the maximum pressure of each CTD cast. Values in brackets in the altimeter column are derived from LADCP data.**

station	START						BOTTOM					END			
number	date	time	latitude	longitude	depth (m)	maxP (dbar)	time	latitude	longitude	depth (m)	altimeter (m)	time	latitude	longitude	depth (m)
001 test	11 Jan 2003	0715	61 14.28S	106 01.04E	4240	627	0740	61 14.09S	106 01.39E	-	-	0740	61 14.09S	106 01.39E	-
002 test	11 Jan 2003	1111	61 15.05S	104 53.47E	4250	1008	1142	61 14.94S	104 53.78E	-	-	1218	61 15.15S	104 54.00E	-
003 cat	11 Jan 2003	1642	61 15.84S	103 20.83E	4280	4307	1807	61 15.65S	103 19.88E	4280	(<4)	2150	61 15.78S	103 18.94E	4280
004 krill	15 Jan 2003	1730	66 55.03S	064 30.13E	341	313	1751	66 55.06S	064 29.73E	336	17.9	1819	66 55.05S	064 28.94E	326
005 krill	15 Jan 2003	2044	66 42.55S	064 29.40E	2199	2185	2136	66 42.55S	064 28.35E	2221	27.8	2249	66 42.46S	064 26.86E	2178
006 krill	16 Jan 2003	0120	66 29.95S	064 29.83E	2687	2678	0217	66 29.98S	064 29.76E	2690	23.7	0318	66 29.99S	064 29.41E	2697
007 krill	16 Jan 2003	0459	66 16.66S	064 30.21E	2637	2610	0553	66 16.51S	064 29.99E	2600	26.8	0640	66 16.33S	064 29.93E	2570
008 krill	16 Jan 2003	0806	66 05.05S	064 30.00E	2805	2810	0858	66 05.02S	064 29.62E	2820	26.2	0954	66 05.03S	064 29.17E	2800
009 sed	16 Jan 2003	1925	66 44.26S	064 29.85E	1789	502	1935	66 44.22S	064 29.81E	1808	-	2003	66 44.21S	064 29.58E	1858
010 sed	19 Jan 2003	0914	66 43.76S	064 15.54E	2111	502	0935	66 43.59S	064 15.24E	2090	-	0958	66 43.49S	064 15.27E	2094
011 sed	21 Jan 2003	1412	66 04.88S	062 33.69E	2970	510	1428	66 04.96S	062 33.72E	2976	-	1505	66 04.92S	062 33.40E	2980
012 krill	24 Jan 2003	1026	66 17.53S	061 55.65E	2772	2762	1124	66 17.45S	061 55.43E	2770	28.0	1233	66 17.46S	061 55.05E	2794
013 krill	24 Jan 2003	1545	66 05.01S	061 55.98E	3086	3059	1638	66 05.10S	061 55.22E	3069	27.8	1754	66 05.26S	061 54.68E	3062
014 krill	25 Jan 2003	0119	66 54.93S	061 56.04E	454	421	0127	66 54.94S	061 56.13E	448	23.1	0205	66 54.95S	061 55.81E	464
015 krill	25 Jan 2003	0358	66 42.50S	061 56.27E	359	363	0406	66 42.48S	061 56.15E	373	18.1	0433	66 42.51S	061 55.61E	399
016 krill	25 Jan 2003	0625	66 30.04S	061 55.85E	1370	1336	0658	66 30.31S	061 55.58E	1303	17.4	0741	66 30.54S	061 55.27E	1204
017 sed	25 Jan 2003	1206	66 04.30S	062 11.50E	3061	503	1222	66 04.29S	062 11.69E	3063	-	1249	66 04.33S	062 11.83E	3061
018 krill	30 Jan 2003	1248	66 29.94S	064 30.50E	2682	2655	1340	66 29.74S	064 31.06E	2650	22.4	1444	66 29.75S	064 31.27E	2641
019 krill	30 Jan 2003	1652	66 42.95S	064 28.68E	2183	1003	1719	66 42.95S	064 28.56E	2193	-	1756	66 42.90S	064 28.29E	2194
020 krill	30 Jan 2003	1933	66 48.24S	064 27.58E	924	935	1955	66 48.29S	064 27.57E	928	29.2	2043	66 48.00S	064 27.60E	912
021 krill	30 Jan 2003	2205	66 55.01S	064 29.97E	340	312	2212	66 54.99S	064 29.98E	339	18.6	2230	66 54.97S	064 29.84E	341
022 swarm	31 Jan 2003	0041	66 47.17S	064 59.77E	1605	1559	0114	66 47.34S	064 59.75E	1557	18.5	0202	66 47.52S	065 00.00E	1481
023 cal	04 Feb 2003	1428	67 36.06S	062 51.95E	36	46	1430	67 36.05S	062 51.95E	36	5.9	1433	67 36.05S	062 51.95E	37
024 swarm/sed	08 Feb 2003	2002	66 31.00S	069 45.72E	1974	1937	2040	66 31.02S	069 45.20E	1957	19.5	2133	66 31.17S	069 44.57E	1938
025 swarm	09 Feb 2003	0023	66 30.46S	069 36.16E	1881	505	0033	66 30.41S	069 36.07E	1894	-	0104	66 30.30S	069 35.85E	1891
026 swarm	09 Feb 2003	0415	66 30.99S	069 55.96E	2034	507	0428	66 30.95S	069 55.75E	2034	-	0458	66 30.87S	069 55.57E	2038
027 sed	12 Feb 2003	0608	66 38.49S	069 10.13E	1629	502	0623	66 38.48S	069 10.06E	1633	-	0645	66 38.42S	069 09.78E	1639
028 swarm	12 Feb 2003	1130	66 34.27S	069 36.01E	1761	608	1150	66 34.20S	069 35.59E	-	-	1222	66 34.38S	069 35.22E	-
029 swarm	12 Feb 2003	1740	66 34.37S	069 44.28E	1839	503	1757	66 34.43S	069 43.89E	-	-	1821	66 34.29S	069 43.17E	1821
030 swarm	12 Feb 2003	1932	66 31.08S	069 45.59E	1965	1925	2012	66 31.07S	069 44.88E	1945	19.0	2053	66 31.24S	069 44.24E	1926
031 swarm	12 Feb 2003	2159	66 27.80S	069 47.80E	2130	504	2215	66 27.84S	069 47.94E	2129	-	2237	66 27.72S	069 48.03E	2131
032 swarm	12 Feb 2003	2339	66 24.33S	069 48.68E	2192	507	2356	66 24.27S	069 48.82E	2194	-	0017	66 24.24S	069 48.91E	2201
033 DWBC/PET	16 Feb 2003	0128	57 54.61S	082 57.00E	2842	2851	0229	57 54.44S	082 57.58E	2853	17.6	0356	57 53.82S	082 58.35E	-
034 DWBC/PET	16 Feb 2003	1146	57 47.02S	083 13.28E	3821	3927	1257	57 46.72S	083 13.11E	3873	12.0	1502	57 46.02S	083 13.51E	3985

Table 1.3a: (continued)

station number	START					maxP	BOTTOM					END			
	date	time	latitude	longitude	depth (m)	(dbar)	time	latitude	longitude	depth (m)	altimeter (m)	time	latitude	longitude	depth (m)
035 DWBC/PET	16 Feb 2003	1756	57 45.19S	083 24.30E	4495	4571	1927	57 44.55S	083 24.36E	4479	18.6	2115	57 44.61S	083 24.90E	4445
036 DWBC/PET	17 Feb 2003	1510	57 39.32S	083 37.71E	4277	4415	1700	57 38.52S	083 38.94E	-	12.8	1903	57 37.55S	083 39.52E	-
037 DWBC/PET	18 Feb 2003	1228	57 32.16S	083 51.84E	-	4503	1350	57 32.42S	083 52.45E	-	12.5	1520	57 32.52S	083 53.10E	-
038 DWBC/PET	19 Feb 2003	0013	57 18.16S	084 19.92E	4632	4725	0141	57 18.87S	084 21.52E	4631	(<4)	0342	57 19.12S	084 23.12E	4632
039 DWBC/PET	21 Feb 2003	0720	56 59.71S	084 46.77E	4720	4706	0902	56 58.95S	084 47.22E	4721	(108)	1116	56 58.39S	084 47.66E	4717
040 DWBC/PET	21 Feb 2003	1322	56 53.23S	085 08.70E	4530	4599	1436	56 53.21S	085 08.62E	4541	13.0	1606	56 53.08S	085 08.96E	4517
041 DWBC/PET	21 Feb 2003	1849	56 41.41S	085 32.65E	4752	4832	2010	56 42.28S	085 34.33E	4752	17.7	2210	56 43.36S	085 36.65E	4749
042 DWBC/PET	22 Feb 2003	0030	56 26.28S	085 58.46E	4739	4827	0152	56 26.33S	085 59.20E	4739	18.0	0352	56 26.71S	086 00.20E	4739
043 DWBC/PET	22 Feb 2003	0626	56 10.85S	086 27.07E	4741	4824	0801	56 10.11S	086 27.59E	4739	13.9	1017	56 09.09S	086 28.01E	4735
044 DWBC/PET	23 Feb 2003	1134	58 06.09S	082 40.10E	2330	2321	1219	58 05.91S	082 39.60E	2323	8.0	1320	58 05.61S	082 39.24E	2317
045 DWBC/PET	23 Feb 2003	1516	58 19.57S	082 18.77E	2141	2130	1543	58 19.37S	082 18.85E	2142	14.6	1640	58 19.02S	082 19.07E	2151
046 DWBC/PET	23 Feb 2003	1858	58 29.43S	081 59.71E	1653	1623	1933	58 29.46S	081 59.76E	1653	26.1	2042	58 29.05S	082 00.08E	1663
047 DWBC/PET	23 Feb 2003	2237	58 37.19S	081 43.11E	1465	1425	2310	58 37.17S	081 43.83E	1458	(28)	0006	58 37.25S	081 44.64E	1447
048 DWBC/PET	24 Feb 2003	0423	59 19.67S	081 38.52E	1813	1774	0501	59 19.59S	081 38.74E	1814	-	0608	59 19.32S	081 39.13E	1813
049 DWBC/PET	24 Feb 2003	1024	60 03.04S	081 32.14E	1575	1537	1055	60 03.05S	081 32.08E	1573	30.3	1153	60 02.87S	081 32.09E	1573
050 DWBC/PET	24 Feb 2003	2118	61 06.93S	081 25.48E	2100	2101	2159	61 06.62S	081 25.95E	2102	0.0	2308	61 06.32S	081 26.56E	2103
051 DWBC/PET	25 Feb 2003	0534	61 50.64S	081 23.06E	2100	2083	0618	61 50.55S	081 23.09E	2100	20.0	0718	61 50.30S	081 23.29E	2100
052 DWBC/PET	25 Feb 2003	1118	62 33.09S	081 14.22E	2003	1971	1152	62 33.12S	081 14.21E	2002	(36)	1253	62 32.90S	081 14.21E	2008
053 DWBC/PET	25 Feb 2003	1533	62 59.66S	081 07.31E	3283	3304	1643	62 59.87S	081 07.63E	3285	14.1	1825	63 00.35S	081 08.28E	3294
054 DWBC/PET	25 Feb 2003	2248	63 34.73S	080 56.13E	3645	3670	2358	63 34.99S	080 55.88E	3651	25.5	0136	63 35.04S	080 56.81E	3655
055 DWBC/PET	26 Feb 2003	0420	64 03.83S	080 48.68E	3670	3700	0537	64 04.17S	080 48.03E	3671	15.6	0723	64 04.74S	080 47.19E	3678
056 DEBC/PET	28 Feb 2003	0622	64 36.04S	080 38.99E	3638	3668	0737	64 36.27S	080 39.07E	3639	16.3	0915	64 36.43S	080 39.51E	3640
057 DWBC/PET	28 Feb 2003	1205	65 07.83S	080 30.80E	3509	3523	1306	65 07.97S	080 31.44E	3510	17.9	1451	65 08.18S	080 32.24E	3510
058 DWBC/PET	28 Feb 2003	1858	65 39.56S	080 21.55E	2533	2503	1935	65 39.62S	080 21.30E	2555	(132)	2052	65 39.93S	080 20.93E	2612
059 DWBC/PET	28 Feb 2003	2303	65 55.13S	080 17.65E	1122	1081	2323	65 55.19S	080 17.50E	1109	24.5	0007	65 55.53S	080 17.45E	1112
060 DWBC/PET	01 Mar 2003	0240	66 11.31S	080 12.48E	358	342	0249	66 11.28S	080 12.51E	360	11.5	0319	66 11.12S	080 12.82E	362
061 DWBC/PET	01 Mar 2003	0558	66 24.87S	080 03.79E	228	208	0602	66 24.87S	080 03.74E	226	13.6	0625	66 24.71S	080 03.79E	228
062 DWBC/PET	09 Mar 2003	0041	55 50.74S	087 00.08E	4716	4835	0209	55 50.16S	087 01.62E	-	19.2	0351	55 49.32S	087 03.62E	4759
063 DWBC/PET	09 Mar 2003	0637	55 36.80S	087 29.45E	4554	4741	0810	55 36.28S	087 30.23E	-	17.7	1001	55 36.09S	087 30.15E	4670
064 DWBC/PET	09 Mar 2003	1217	55 21.62S	087 52.24E	4457	4543	1347	55 22.11S	087 52.84E	-	18.0	1538	55 22.47S	087 52.95E	4470

Table 1.3b: **Summary of station information for cruise AU0403. All times are UTC. In the station naming, "I9S" is the CLIVAR I9S transect, "DWBC/PET" is the Kerguelen Deep Western Boundary Current experiment and the Princess Elizabeth Trough section, "fluoro" is a cast for fluorescence data, and "PULSE" is near the future PULSE mooring site. Note that "maxP" is the maximum pressure of each CTD cast.**

station	START						BOTTOM					END			
number	date	time	latitude	longitude	depth (m)	maxP (dbar)	time	latitude	longitude	depth (m)	altimeter (m)	time	latitude	longitude	depth (m)
001 test	24 Dec 2004	0535	33 26.12S	114 14.69E	980	974	0601	33 26.24S	114 14.45E	985	20.2	0702	33 26.27S	114 14.02E	992
002 I9S	24 Dec 2004	1827	34 49.15S	114 59.74E	144	131	1831	34 49.17S	114 59.70E	144	17.1	1901	34 49.15S	114 59.01E	143
003 I9S	24 Dec 2004	2125	34 57.58S	114 59.78E	274	261	2134	34 57.62S	114 59.74E	283	17.8	2204	34 57.68S	114 59.35E	323
004 I9S	24 Dec 2004	2349	35 02.87S	114 59.96E	-	575	0006	35 02.88S	114 59.89E	-	-	0040	35 02.90S	114 59.67E	-
005 I9S	25 Dec 2004	0212	35 11.81S	115 00.08E	1507	1471	0243	35 11.66S	114 59.96E	1481	75.4	0342	35 11.59S	114 59.73E	1461
006 I9S	25 Dec 2004	2020	35 30.71S	114 59.90E	2380	2455	2117	35 30.93S	114 59.48E	2405	0.0	2245	35 31.10S	114 59.07E	2433
007 I9S	26 Dec 2004	0148	35 38.95S	115 00.40E	-	5180	0337	35 39.31S	114 59.65E	5099	18.1	0543	35 39.31S	114 59.20E	5040
008 I9S	26 Dec 2004	0931	36 00.37S	114 59.21E	5197	5348	1122	36 01.19S	114 59.15E	5249	6.2	1325	36 01.73S	114 58.92E	5212
009 I9S	26 Dec 2004	1828	36 31.85S	114 59.81E	5334	5118	2017	36 33.64S	114 59.57E	5023	3.8	0103	36 37.46S	114 58.74E	4687
010 I9S	27 Dec 2004	0456	37 02.42S	115 00.93E	-	5675	0714	37 03.09S	115 01.25E	5596	37.0	1122	37 04.52S	115 02.62E	5440
011 I9S	27 Dec 2004	1549	37 29.92S	115 00.43E	5056	5273	1742	37 30.38S	115 00.87E	5161	40.2	0016	37 32.33S	115 01.20E	5190
012 I9S	28 Dec 2004	0442	38 00.02S	114 59.60E	4786	4909	0616	38 00.17S	114 59.94E	4786	35.5	0927	38 00.60S	115 00.42E	4799
013 I9S	28 Dec 2004	1420	38 29.75S	115 00.37E	4665	4760	1534	38 29.41S	115 00.29E	4683	36.4	1820	38 28.68S	115 00.22E	4696
014 I9S	28 Dec 2004	2252	39 06.44S	115 00.19E	4721	4862	0027	39 05.65S	114 59.89E	4681	28.2	0250	39 04.63S	114 59.71E	4594
015 I9S	29 Dec 2004	0737	39 41.91S	114 59.95E	4743	4813	0909	39 42.02S	114 59.68E	4712	15.9	1120	39 42.50S	114 59.57E	4665
016 I9S	29 Dec 2004	1501	40 17.77S	115 00.03E	4665	4861	1636	40 17.51S	115 00.36E	4727	23.5	1855	40 16.97S	115 00.55E	4721
017 I9S	30 Dec 2004	0018	40 52.79S	115 00.38E	4612	4711	0131	40 52.81S	115 00.31E	4612	21.8	0429	40 52.63S	115 00.34E	4620
018 I9S	30 Dec 2004	1407	41 31.16S	115 00.27E	4569	4662	1529	41 31.44S	115 00.40E	4563	18.8	1724	41 31.75S	115 00.71E	4529
019 I9S	30 Dec 2004	2049	41 59.89S	115 00.30E	4454	4642	2211	41 59.44S	115 00.53E	4532	23.0	0022	41 58.76S	115 00.78E	4459
020 I9S	31 Dec 2004	0339	42 30.13S	114 59.87E	4304	4403	0444	42 30.08S	114 59.82E	4301	25.0	0633	42 30.34S	114 59.68E	4282
021 I9S	31 Dec 2004	0958	42 59.82S	115 00.10E	4286	4473	1111	42 59.85S	115 00.20E	4281	8.1	1304	43 00.02S	114 59.92E	4278
022 I9S	31 Dec 2004	1613	43 29.75S	115 00.03E	4433	4451	1746	43 29.66S	115 01.18E	4353	41.6	1940	43 29.62S	115 02.44E	4294
023 I9S	31 Dec 2004	2342	43 59.59S	115 00.20E	4299	4403	0055	43 59.56S	115 01.36E	4350	19.1	0235	43 59.62S	115 02.80E	4270
024 I9S	01 Jan 2005	0552	44 29.59S	115 00.29E	4307	4460	0711	44 29.35S	115 01.33E	4400	16.6	0911	44 28.96S	115 02.37E	4314
025 I9S	01 Jan 2005	1225	45 00.44S	114 59.27E	4188	4312	1341	45 00.14S	114 59.27E	4179	18.0	1519	44 59.33S	114 59.50E	4242
026 I9S	01 Jan 2005	1833	45 30.05S	114 59.77E	4164	4242	1946	45 29.90S	114 59.51E	4167	28.3	2138	45 30.07S	114 58.75E	4221
027 I9S	02 Jan 2005	0045	46 01.19S	115 02.58E	4119	4246	0155	46 01.03S	115 02.95E	4093	27.0	0322	46 00.63S	115 03.34E	4132
028 I9S	02 Jan 2005	0637	46 31.09S	114 59.63E	4008	4067	0804	46 31.09S	115 00.91E	4002	19.0	0958	46 30.74S	115 02.41E	3966
029 I9S	02 Jan 2005	1340	47 00.34S	114 59.33E	3848	3873	1450	47 00.03S	114 59.90E	3832	22.8	1617	46 59.76S	115 00.26E	3868
030 I9S	02 Jan 2005	1946	47 30.61S	115 00.12E	3788	3912	2056	47 30.29S	115 00.23E	3726	25.6	2238	47 30.07S	115 00.55E	3718
031 I9S	03 Jan 2005	0213	48 00.12S	115 01.04E	3597	3654	0335	47 59.44S	115 01.84E	3628	25.8	0459	47 58.60S	115 02.08E	3618
032 I9S	04 Jan 2005	0645	48 28.52S	115 01.75E	3948	4022	0803	48 28.10S	115 01.83E	3908	19.0	0944	48 27.80S	115 01.81E	3887
033 I9S	04 Jan 2005	1352	48 59.99S	115 00.47E	3830	3737	1519	48 59.53S	115 00.83E	3680	32.4	1650	48 59.05S	115 01.23E	3943
034 I9S	04 Jan 2005	2038	49 30.58S	115 00.11E	3383	3454	2139	49 30.42S	115 00.88E	3437	19.0	0004	49 30.26S	115 02.83E	3419
035 I9S	05 Jan 2005	0421	49 59.68S	115 00.73E	3756	3855	0540	49 59.36S	115 01.91E	3951	-	0726	49 59.29S	115 02.78E	3971
036 I9S	05 Jan 2005	1054	50 29.18S	115 01.65E	2980	3054	1150	50 29.08S	115 02.59E	3116	22.5	1313	50 29.08S	115 03.23E	3042
037 I9S	05 Jan 2005	1722	51 00.13S	115 00.46E	3977	4030	1843	51 00.37S	115 02.19E	4005	19.4	2025	51 00.74S	115 04.19E	4303

Table 1.3b: continued

station	START						BOTTOM					END			
number	date	time	latitude	longitude	depth (m)	maxP (dbar)	time	latitude	longitude	depth (m)	altimeter (m)	time	latitude	longitude	depth (m)
038 I9S	06 Jan 2005	0259	51 28.73S	114 59.93E	3535	3586	0417	51 28.51S	115 00.23E	3495	15.7	0623	51 28.04S	115 00.43E	3535
039 I9S	06 Jan 2005	1157	51 58.67S	114 59.78E	3640	3699	1313	51 58.68S	115 00.41E	3663	29.2	1409	51 58.74S	115 00.52E	3637
040 I9S	06 Jan 2005	1821	52 36.63S	114 59.66E	3832	3840	2000	52 36.50S	115 00.40E	3785	0.0	2203	52 36.44S	115 00.52E	3810
041 I9S	07 Jan 2005	0318	53 12.04S	114 59.83E	3955	3985	0438	53 11.99S	114 59.94E	3960	28.6	0650	53 12.19S	115 00.64E	3991
042 I9S	07 Jan 2005	1055	53 48.55S	114 59.20E	-	4151	1211	53 48.73S	114 58.99E	4096	22.2	1350	53 48.93S	114 59.09E	4041
043 I9S	08 Jan 2005	1357	54 24.20S	114 58.24E	-	4248	1515	54 23.75S	114 58.50E	4194	25.7	1651	54 23.26S	114 59.06E	4213
044 I9S	08 Jan 2005	2105	54 59.94S	115 00.32E	4431	4484	2218	54 59.39S	115 00.62E	4424	16.1	0009	54 59.04S	115 01.17E	4423
045 I9S	09 Jan 2005	0426	55 35.86S	115 02.28E	4573	4704	0557	55 35.81S	115 02.90E	4535	17.4	0742	55 35.79S	115 04.06E	4466
046 I9S	09 Jan 2005	1117	56 11.17S	114 59.85E	-	4586	1244	56 11.49S	114 59.64E	4520	24.2	1436	56 11.87S	114 59.47E	4575
047 I9S	09 Jan 2005	1813	56 48.14S	115 00.78E	4494	4598	1943	56 48.63S	115 03.41E	4530	12.6	2212	56 49.25S	115 05.56E	4530
048 I9S	10 Jan 2005	0130	57 24.05S	114 59.12E	4547	4622	0251	57 24.31S	115 00.08E	4557	16.1	0457	57 24.74S	115 00.85E	4547
049 I9S	10 Jan 2005	0826	57 59.95S	115 00.22E	4557	4628	0955	58 00.29S	115 00.78E	4560	22.6	1157	58 00.67S	115 00.56E	4568
050 I9S	10 Jan 2005	2005	58 36.17S	114 59.68E	4547	4611	2140	58 36.86S	114 59.30E	4540	14.9	2337	58 37.55S	114 58.73E	4537
051 I9S	11 Jan 2005	0520	59 11.91S	114 59.89E	4525	4592	0651	59 12.11S	114 59.02E	4524	22.8	0850	59 12.07S	114 58.21E	4520
052 I9S	11 Jan 2005	1237	59 48.54S	115 02.07E	4475	4562	1352	59 48.64S	115 01.60E	4485	22.2	1608	59 48.71S	115 00.49E	4485
053 I9S	11 Jan 2005	2358	60 23.95S	114 59.11E	4455	4532	0116	60 23.68S	114 59.06E	4460	13.4	0316	60 23.35S	114 58.34E	4455
054 I9S	12 Jan 2005	0718	61 00.55S	115 01.10E	4385	4464	0845	61 00.46S	115 01.69E	4385	13.9	1116	61 00.28S	115 02.18E	4375
055 I9S	12 Jan 2005	1427	61 30.11S	115 00.87E	4315	4403	1539	61 30.48S	115 00.67E	4325	14.4	1735	61 31.21S	115 00.04E	4340
056 I9S	12 Jan 2005	2100	62 00.43S	114 59.66E	4305	4289	2221	62 00.65S	114 58.84E	4225	14.9	0007	62 01.04S	114 58.04E	4215
057 I9S	13 Jan 2005	0328	62 25.06S	114 25.66E	4040	4103	0445	62 25.02S	114 26.41E	4050	12.7	0630	62 24.88S	114 27.56E	4040
058 I9S	13 Jan 2005	0932	62 50.80S	113 47.68E	3790	3842	1035	62 50.83S	113 46.82E	3790	23.4	1223	62 50.73S	113 46.21E	3810
059 I9S	13 Jan 2005	1526	63 16.25S	113 12.24E	3570	3595	1625	63 16.22S	113 12.14E	3560	13.9	1814	63 16.13S	113 11.89E	3580
060 I9S	13 Jan 2005	2113	63 41.40S	112 35.95E	3300	3338	2213	63 41.33S	112 35.65E	3315	14.2	0002	63 41.43S	112 35.83E	3315
061 I9S	14 Jan 2005	0431	64 06.45S	112 04.29E	2285	2295	0512	64 06.42S	112 03.99E	2290	14.6	0627	64 06.79S	112 03.43E	2320
062 I9S	14 Jan 2005	0808	64 17.03S	111 46.11E	2545	2513	0858	64 17.12S	111 45.92E	2488	14.1	1028	64 17.33S	111 46.07E	2510
063 I9S	14 Jan 2005	1243	64 31.30S	111 25.22E	2895	2894	1330	64 31.25S	111 25.16E	2865	12.8	1526	64 30.79S	111 23.90E	2905
064 I9S	14 Jan 2005	1821	64 45.01S	111 55.13E	2260	2279	1903	64 45.01S	111 55.04E	2280	13.9	2039	64 45.20S	111 55.46E	2275
065 I9S	14 Jan 2005	2256	64 57.73S	112 09.60E	2300	2317	2332	64 57.91S	112 09.47E	2320	14.2	0105	64 58.18S	112 09.71E	2350
066 I9S	15 Jan 2005	0233	65 07.78S	112 22.55E	1800	1802	0302	65 07.87S	112 22.39E	1795	14.5	0427	65 08.30S	112 21.79E	1825
067 I9S	15 Jan 2005	0541	65 13.39S	112 27.47E	1405	1329	0606	65 13.54S	112 27.27E	1335	19.0	0705	65 13.87S	112 26.30E	1365
068 I9S	15 Jan 2005	0838	65 17.26S	112 29.29E	1165	1117	0858	65 17.30S	112 28.85E	1090	10.2	0944	65 17.45S	112 27.70E	1105
069 I9S	15 Jan 2005	1131	65 23.54S	112 32.02E	460	435	1143	65 23.62S	112 31.66E	440	10.6	1219	65 23.96S	112 30.56E	400
070 DWBC/PET	20 Jan 2005	1100	57 03.04S	084 48.52E	4717	4806	1222	57 03.66S	084 50.68E	4719	12.9	1441	57 04.41S	084 53.77E	4719
071 DWBC/PET	20 Jan 2005	1916	57 20.78S	084 19.55E	4609	4680	2032	57 20.89S	084 19.70E	4607	17.2	2254	57 20.70S	084 19.96E	4609
072 DWBC/PET	21 Jan 2005	1033	57 33.10S	083 53.02E	4426	4474	1148	57 33.33S	083 53.01E	4420	20.8	1354	57 33.41S	083 52.63E	4420
073 DWBC/PET	21 Jan 2005	1523	57 37.76S	083 41.11E	4403	4449	1636	57 37.66S	083 40.65E	4397	19.0	1858	57 37.10S	083 40.09E	4405
074 DWBC/PET	22 Jan 2005	0856	57 45.79S	083 22.16E	4579	4637	1013	57 45.35S	083 21.00E	4568	15.8	1211	57 44.56S	083 19.13E	4558
075 DWBC/PET	22 Jan 2005	1329	57 46.53S	083 13.97E	3902	3959	1436	57 46.09S	083 12.48E	3914	19.7	1629	57 45.04S	083 10.40E	4000
076 DWBC/PET	22 Jan 2005	1826	57 53.74S	082 58.79E	2908	2903	1920	57 53.54S	082 58.38E	2901	18.2	2100	57 53.16S	082 58.11E	2917

Table 1.3b: (continued)

station	START						BOTTOM					END			
number	date	time	latitude	longitude	depth (m)	maxP (dbar)	time	latitude	longitude	depth (m)	altimeter (m)	time	latitude	longitude	depth (m)
077 DWBC/PET	23 Jan 2005	1012	58 06.77S	082 38.30E	2296	2279	1056	58 06.55S	082 38.27E	2297	22.8	1209	58 06.34S	082 37.77E	2287
078 DWBC/PET	23 Jan 2005	1405	58 19.52S	082 18.45E	2136	2126	1445	58 19.33S	082 18.55E	2140	17.8	1606	58 19.12S	082 18.35E	2141
079 DWBC/PET	23 Jan 2005	1756	58 29.06S	081 59.06E	1648	1624	1829	58 28.88S	081 58.82E	1646	17.6	1941	58 28.39S	081 58.69E	1650
080 DWBC/PET	23 Jan 2005	2124	58 37.09S	081 42.43E	1478	1452	2154	58 36.93S	081 42.28E	1476	18.6	2305	58 36.84S	081 42.53E	1473
081 DWBC/PET	24 Jan 2005	0526	58 58.14S	081 40.52E	1588	1559	0602	58 58.08S	081 41.10E	1577	17.0	0658	58 58.18S	081 41.19E	1574
082 DWBC/PET	25 Jan 2005	1052	56 11.17S	086 26.94E	4742	4817	1208	56 11.44S	086 27.71E	4736	23.0	1425	56 11.94S	086 29.92E	4744
083 DWBC/PET	25 Jan 2005	2211	55 21.43S	087 52.61E	4495	4572	2330	55 21.10S	087 52.65E	4530	21.5	0152	55 21.12S	087 53.32E	4611
084 DWBC/PET	26 Jan 2005	1250	55 35.86S	087 26.40E	4574	4681	1407	55 35.69S	087 26.47E	4601	21.8	1600	55 35.79S	087 26.88E	4607
085 DWBC/PET	26 Jan 2005	1945	55 51.88S	086 59.47E	4680	4792	2126	55 51.62S	086 58.97E	4701	18.0	2338	55 51.30S	086 58.00E	4737
086 DWBC/PET	28 Jan 2005	0848	56 26.39S	085 57.71E	4745	4831	1012	56 26.31S	085 57.83E	4747	14.4	1219	56 26.35S	085 58.01E	4745
087 DWBC/PET	28 Jan 2005	1426	56 40.58S	085 32.42E	4749	4828	1552	56 40.49S	085 32.80E	4753	22.0	1754	56 40.48S	085 33.68E	4749
088 DWBC/PET	28 Jan 2005	2027	56 52.92S	085 08.68E	4530	4661	2140	56 52.00S	085 08.35E	4545	11.8	2345	56 51.13S	085 07.78E	4561
089 DWBC/PET	29 Jan 2005	1545	59 19.49S	081 38.32E	1811	1789	1624	59 19.46S	081 38.29E	1815	18.6	1733	59 19.17S	081 37.99E	1815
090 DWBC/PET	29 Jan 2005	2037	59 41.23S	081 35.17E	1805	1798	2106	59 41.14S	081 35.26E	1815	13.9	2205	59 41.06S	081 34.96E	1790
091 DWBC/PET	30 Jan 2005	0022	60 02.83S	081 32.45E	1570	1554	0049	60 02.88S	081 32.33E	1572	9.7	0141	60 02.84S	081 32.13E	1559
092 DWBC/PET	30 Jan 2005	0348	60 24.27S	081 29.91E	1596	1577	0419	60 24.28S	081 29.96E	1595	13.9	0513	60 24.30S	081 30.06E	1595
093 DWBC/PET	30 Jan 2005	0710	60 45.49S	081 27.25E	1717	1691	0746	60 45.45S	081 27.35E	1715	21.9	0849	60 45.49S	081 27.51E	1719
094 DWBC/PET	30 Jan 2005	1233	61 06.53S	081 24.64E	2107	2080	1313	61 06.52S	081 24.52E	2103	23.5	1417	61 06.76S	081 24.56E	2103
095 DWBC/PET	30 Jan 2005	1645	61 28.72S	081 22.46E	2182	2172	1734	61 28.83S	081 22.44E	2178	13.0	1902	61 28.95S	081 23.15E	2182
096 DWBC/PET	30 Jan 2005	2147	61 49.81S	081 20.12E	2093	2084	2221	61 50.02S	081 19.93E	2091	9.2	2352	61 50.51S	081 19.43E	2088
097 DWBC/PET	31 Jan 2005	0205	62 11.64S	081 17.15E	1732	1718	0239	62 11.71S	081 17.28E	1731	8.2	0347	62 12.00S	081 17.59E	1730
098 DWBC/PET	31 Jan 2005	0547	62 33.50S	081 17.27E	2021	1997	0629	62 33.64S	081 17.39E	2001	17.1	0738	62 33.53S	081 17.14E	2011
099 DWBC/PET	31 Jan 2005	1042	62 44.33S	081 12.20E	2587	2582	1129	62 44.31S	081 11.89E	2591	22.8	1258	62 44.00S	081 11.48E	2510
100 DWBC/PET	31 Jan 2005	1508	63 00.34S	081 06.94E	3291	3314	1554	63 00.37S	081 06.56E	3291	13.4	1727	63 00.93S	081 05.66E	3306
101 DWBC/PET	31 Jan 2005	1943	63 14.54S	081 01.87E	3410	3437	2045	63 14.69S	081 02.13E	3412	12.8	2235	63 14.43S	081 01.97E	3412
102 DWBC/PET	01 Feb 2005	0117	63 34.70S	080 56.63E	3645	3678	0213	63 34.67S	080 56.35E	3645	10.6	0357	63 34.11S	080 56.49E	3636
103 DWBC/PET	01 Feb 2005	0530	63 48.67S	080 51.84E	3685	3721	0637	63 48.41S	080 51.98E	3682	12.1	0809	63 48.16S	080 51.08E	3685
104 DWBC/PET	01 Feb 2005	0941	64 03.64S	080 49.00E	3670	3705	1042	64 03.43S	080 48.82E	3674	14.0	1231	64 03.17S	080 47.90E	3676
105 DWBC/PET	01 Feb 2005	1416	64 20.82S	080 44.33E	3655	3692	1515	64 20.61S	080 44.11E	3659	11.5	1641	64 20.26S	080 45.17E	3661
106 DWBC/PET	01 Feb 2005	1915	64 36.51S	080 39.94E	3647	3675	2019	64 36.50S	080 40.33E	3639	10.9	2204	64 36.52S	080 40.47E	3641
107 DWBC/PET	01 Feb 2005	2354	64 51.86S	080 35.19E	3626	3657	0055	64 52.16S	080 34.98E	3624	11.3	0230	64 52.37S	080 34.10E	3624
108 DWBC/PET	02 Feb 2005	0411	65 07.57S	080 29.57E	3505	3532	0510	65 07.67S	080 29.51E	3509	10.9	0636	65 07.64S	080 30.04E	3507
109 DWBC/PET	02 Feb 2005	0828	65 23.18S	080 25.78E	3282	3294	0921	65 23.05S	080 25.92E	3283	14.1	1102	65 22.66S	080 26.20E	3283
110 DWBC/PET	02 Feb 2005	1327	65 38.89S	080 21.77E	2671	2731	1412	65 38.91S	080 20.86E	2696	9.4	1527	65 39.45S	080 20.38E	2720
111 DWBC/PET	03 Feb 2005	1101	66 38.23S	077 31.65E	1120	1154	1122	66 38.22S	077 31.46E	1109	6.3	1212	66 38.25S	077 31.07E	1113
112 DWBC/PET	03 Feb 2005	1327	66 42.28S	077 42.74E	652	627	1341	66 42.31S	077 42.58E	648	14.1	1412	66 42.47S	077 42.29E	634
113 DWBC/PET	03 Feb 2005	1607	66 51.15S	077 42.75E	245	227	1613	66 51.17S	077 42.77E	245	14.4	1636	66 51.08S	077 42.94E	246
114 fluoro	04 Feb 2005	0457	67 52.80S	077 10.55E	424	401	0507	67 52.79S	077 10.60E	423	14.6	0538	67 52.70S	077 10.22E	422
115 PULSE	15 Feb 2005	0235	46 59.95S	142 00.25E	3453	3533	0328	46 59.99S	142 00.40E	3452	28.7	0510	46 59.92S	142 00.62E	3476

Table 1.4a: **Cruise AU0304 summary of samples drawn from Niskin bottles at each station, including salinity (sal), dissolved oxygen (do), and nutrients (nut). Note that 1=samples taken, 0=no samples taken. Additional sensors fitted to the package are also listed, including Sontek LADCP (Son), and RDI LADCP (RDI). For these, 1=instrument switched on, 0=instrument switched off or not fitted. A fluorometer was fitted to the package for all casts.**

station	sal	do	nut	Son	RDI	station	sal	do	nut	Son	RDI
1 test	0	0	0	0	1	33 DWBC/PET	1	1	1	1	1
2 test	1	0	0	0	1	34 DWBC/PET	1	1	1	0	0
3 cat	1	0	0	1	0	35 DWBC/PET	1	1	1	1	1
4 krill	1	1	1	0	0	36 DWBC/PET	1	1	1	1	1
5 krill	1	1	1	1	0	37 DWBC/PET	1	1	1	0	0
6 krill	1	1	1	1	1	38 DWBC/PET	1	1	1	1	1
7 krill	1	1	1	0	1	39 DWBC/PET	1	1	1	1	1
8 krill	1	1	1	1	1	40 DWBC/PET	1	1	1	1	1
9 sed	1	1	1	0	0	41 DWBC/PET	1	1	1	1	0
10 sed	1	1	1	0	0	42 DWBC/PET	1	1	1	1	0
11 krill	1	1	1	0	0	43 DWBC/PET	1	1	1	1	0
12 krill	1	1	1	1	1	44 DWBC/PET	1	1	1	1	1
13 krill	1	1	1	1	1	45 DWBC/PET	1	1	1	1	1
14 krill	1	1	1	1	1	46 DWBC/PET	1	1	1	1	1
15 krill	1	1	1	1	1	47 DWBC/PET	1	1	1	1	1
16 krill	1	1	1	1	1	48 DWBC/PET	1	1	1	0	0
17 sed	1	1	1	1	0	49 DWBC/PET	1	1	1	1	0
18 krill	1	1	1	1	0	50 DWBC/PET	1	1	1	1	0
19 krill	1	1	1	1	0	51 DWBC/PET	1	1	1	1	0
20 krill	1	1	1	1	0	52 DWBC/PET	1	1	1	1	0
21 krill	1	1	1	0	1	53 DWBC/PET	1	1	1	1	0
22 swarm	1	1	1	0	1	54 DWBC/PET	1	1	1	1	0
23 cal	0	0	0	0	0	55 DWBC/PET	1	1	1	1	0
24 swarm	1	1	1	0	1	56 DWBC/PET	1	1	1	1	0
25 swarm	1	1	1	0	1	57 DWBC/PET	1	1	1	1	0
26 swarm	1	1	1	0	1	58 DWBC/PET	1	1	1	1	0
27 sed	1	1	1	1	1	59 DWBC/PET	1	1	1	1	0
28 swarm	1	1	1	0	1	60 DWBC/PET	1	1	1	1	0
29 swarm	1	1	1	0	1	61 DWBC/PET	1	1	1	1	0
30 swarm	1	1	1	1	1	62 DWBC/PET	1	1	1	1	0
31 swarm	1	1	1	0	1	63 DWBC/PET	1	1	1	1	0
32 swarm	1	1	1	0	1	64 DWBC/PET	1	1	1	1	0

Table 1.4b: **Cruise AU0403 summary of samples drawn from Niskin bottles at each station, including salinity (sal), dissolved oxygen (do), nutrients (nut), chlorofluorocarbons (CFC), dissolved inorganic carbon and alkalinity (dic/alk), oxygen-18 (^{18}O), methane (CH_4), selenium species (SE), and biological parameters/pigments (pig). Note that 1=samples taken, 0=no samples taken. The Sontek LADCP (LADCP) status is also listed: 2=both transducer sets fitted and logging, 1=downward looking transducer set only fitted and logging, 0=instrument not logging or not fitted. The fluorometer was fitted to the package for all casts (not connected for CTD 115). Additional profiling casts done from the trawl deck at each station include fluoromap fluorometer (flmap), turbulence probe (turbo), and 10x10 bacteria/virus sampler (10x10).**

station	sal	do	nut	CFC	dic/alk	^{18}O	CH_4	sel	pig	LADCP	flmap	turbo	10x10
1 test	1	1	1	0	0	0	0	0	1	2	0	0	0
2 I9S	1	1	1	0	1	0	0	1	0	2	0	0	0
3 I9S	1	1	1	1	1	0	0	0	1	2	0	0	0
4 I9S	1	1	1	0	0	0	0	0	1	2	0	0	0
5 I9S	1	1	1	1	1	0	0	0	0	2	0	0	0
6 I9S	1	1	1	0	0	0	0	0	1	2	0	0	0

Table 1.4b: **(continued)**

station	sal	do	nut	CFC	dic/alk	^{18}O	CH_4	sel	pig	LADCP	flmap	turbo	10x10
7 I9S	1	1	1	1	1	0	0	1	0	2	0	0	0
8 I9S	1	1	1	0	0	0	0	0	1	2	0	0	0
9 I9S	1	1	1	1	1	0	0	0	0	2	0	0	0
10 I9S	1	1	1	0	0	0	0	0	1	2	0	0	0
11 I9S	1	1	1	1	1	0	0	0	1	2	0	0	0
12 I9S	1	1	1	0	0	0	0	0	1	2	1	0	0
13 I9S	1	1	1	1	1	0	0	0	0	2	0	0	0
14 I9S	1	1	1	0	0	0	0	0	1	2	0	0	0
15 I9S	1	1	1	1	1	0	0	1	0	2	0	0	0
16 I9S	1	1	1	0	0	0	0	0	1	2	0	0	0
17 I9S	1	1	1	1	1	0	0	0	0	2	0	0	0
18 I9S	1	1	1	0	0	0	0	0	1	2	0	0	0
19 I9S	1	1	1	1	1	0	0	0	0	2	0	0	0
20 I9S	1	1	1	0	0	0	0	1	1	2	0	0	0
21 I9S	1	1	1	1	1	0	0	0	0	2	0	0	0
22 I9S	1	1	1	0	0	0	0	0	0	2	0	0	0
23 I9S	1	1	1	1	1	0	0	0	0	0	0	0	0
24 I9S	1	1	1	0	0	0	0	0	1	0	0	0	0
25 I9S	1	1	1	1	1	0	0	0	0	2	0	0	0
26 I9S	1	1	1	0	0	0	0	0	1	0	0	0	0
27 I9S	1	1	1	1	1	0	0	0	0	0	0	0	0
28 I9S	1	1	1	0	0	0	0	1	1	0	0	0	0
29 I9S	1	1	1	1	1	0	0	0	0	0	0	0	0
30 I9S	1	1	1	0	0	0	0	0	1	0	0	0	0
31 I9S	1	1	1	1	1	0	0	0	0	0	0	0	0
32 I9S	1	1	1	0	0	0	0	1	1	0	0	0	0
33 I9S	1	1	1	1	1	0	0	0	0	0	0	0	0
34 I9S	1	1	1	0	0	0	0	0	1	0	1	1	0
35 I9S	1	1	1	1	1	0	0	1	0	0	0	0	0
36 I9S	1	1	1	0	0	0	0	0	1	0	0	0	0
37 I9S	1	1	1	1	1	0	0	1	1	0	0	0	0
38 I9S	1	1	0	0	0	0	0	0	1	0	0	0	0
39 I9S	1	0	0	0	0	0	0	0	0	0	0	0	0
40 I9S	1	1	1	1	1	0	0	0	1	1	1	1	0
41 I9S	1	1	1	1	1	0	0	1	0	1	0	0	0
42 I9S	1	1	1	0	0	0	0	1	1	1	0	0	0
43 I9S	1	1	1	1	1	0	0	0	0	1	0	0	0
44 I9S	1	1	1	0	0	0	0	0	1	1	0	0	0
45 I9S	1	1	1	1	1	0	0	0	0	1	0	0	0
46 I9S	1	1	1	0	0	0	0	1	1	1	0	0	0
47 I9S	1	1	1	1	1	0	0	0	0	1	0	0	0
48 I9S	1	1	1	0	0	0	0	0	1	0	0	0	0
49 I9S	1	1	1	1	1	0	0	0	0	1	0	0	0
50 I9S	1	1	1	0	0	0	0	1	1	1	1	1	0
51 I9S	1	1	1	1	1	0	0	0	0	1	0	0	0
52 I9S	1	1	1	0	0	0	0	0	1	1	1	1	0
53 I9S	1	1	1	1	1	0	0	1	0	1	0	0	0
54 I9S	1	1	1	0	0	0	0	0	1	1	0	0	0
55 I9S	1	1	1	1	1	0	0	0	0	1	0	0	0
56 I9S	1	1	1	0	0	0	0	0	1	1	0	0	0
57 I9S	1	1	1	1	1	0	0	1	0	1	0	0	0
58 I9S	1	1	1	0	0	0	0	0	1	1	0	0	0
59 I9S	1	1	1	1	1	1	0	0	0	1	0	0	0
60 I9S	1	1	1	0	0	1	0	1	1	1	1	1	1
61 I9S	1	1	1	1	1	1	0	0	0	1	0	0	0
62 I9S	1	1	1	0	0	1	0	0	1	1	1	0	1
63 I9S	1	1	1	1	1	1	0	0	0	1	0	0	0

Table 1.4b: (continued)

station	sal	do	nut	CFC	dic/alk	^{18}O	CH_4	sel	pig	LADCP	flmap	turbo	10x10
64 I9S	1	1	1	0	0	1	0	1	1	1	1	0	0
65 I9S	1	1	1	1	1	1	0	0	0	1	0	0	0
66 I9S	1	1	1	0	0	1	0	0	1	1	1	0	1
67 I9S	1	1	1	1	1	1	0	1	0	1	0	0	0
68 I9S	1	1	1	1	1	1	0	0	0	1	0	0	0
69 I9S	1	1	1	1	1	1	0	0	1	1	1	0	1
70 DWBC/PET	1	1	1	0	0	0	1	0	1	1	1	1	1
71 DWBC/PET	1	1	1	1	0	0	0	0	0	1	0	0	0
72 DWBC/PET	1	1	1	1	1	0	0	0	1	1	0	0	0
73 DWBC/PET	1	1	1	1	0	0	0	0	0	1	1	1	0
74 DWBC/PET	1	1	1	1	0	0	1	1	1	1	0	0	0
75 DWBC/PET	1	1	1	1	1	0	0	0	0	1	0	0	0
76 DWBC/PET	1	1	1	0	0	0	0	0	1	1	0	0	0
77 DWBC/PET	1	1	1	1	1	0	0	1	0	1	0	0	0
78 DWBC/PET	1	1	1	0	0	0	0	0	1	1	0	0	0
79 DWBC/PET	1	1	1	1	1	0	0	0	0	1	0	0	0
80 DWBC/PET	1	1	1	0	0	0	0	0	1	1	0	1	0
81 DWBC/PET	1	1	1	0	0	0	0	1	0	1	0	0	0
82 DWBC/PET	1	1	1	1	1	0	0	0	0	1	0	0	0
83 DWBC/PET	1	1	1	1	1	0	0	0	0	1	0	0	0
84 DWBC/PET	1	1	1	1	0	0	1	1	1	1	0	0	0
85 DWBC/PET	1	1	1	1	0	0	0	0	0	1	0	0	0
86 DWBC/PET	1	1	1	1	0	0	0	0	1	1	0	0	0
87 DWBC/PET	1	1	1	1	0	0	0	0	0	1	0	0	0
88 DWBC/PET	1	1	1	1	1	0	0	1	0	1	0	0	0
89 DWBC/PET	1	1	1	1	1	0	0	0	0	1	0	0	0
90 DWBC/PET	1	1	1	0	0	0	0	0	1	1	0	0	0
91 DWBC/PET	1	1	1	0	0	0	0	0	0	1	0	0	0
92 DWBC/PET	1	1	1	1	1	0	0	0	0	1	0	0	0
93 DWBC/PET	1	1	1	0	0	0	0	0	0	1	1	1	0
94 DWBC/PET	1	1	1	0	0	0	0	0	0	1	0	0	0
95 DWBC/PET	1	1	1	1	1	0	0	0	0	1	0	0	0
96 DWBC/PET	1	1	1	0	0	0	0	0	1	1	0	0	0
97 DWBC/PET	1	1	1	0	0	0	0	0	0	1	0	0	0
98 DWBC/PET	1	1	1	1	1	0	0	0	0	1	0	0	0
99 DWBC/PET	1	1	1	0	0	0	0	0	1	1	1	0	0
100 DWBC/PET	1	1	1	0	0	0	0	0	0	1	0	0	0
101 DWBC/PET	1	1	1	1	1	0	0	0	0	1	0	0	0
102 DWBC/PET	1	1	1	0	0	0	0	0	1	1	0	0	0
103 DWBC/PET	1	1	1	0	0	0	0	0	0	1	0	0	0
104 DWBC/PET	1	1	1	1	1	1	0	0	0	1	0	0	0
105 DWBC/PET	1	1	1	0	0	1	0	1	1	1	0	0	0
106 DWBC/PET	1	1	1	0	0	1	1	0	0	1	0	0	0
107 DWBC/PET	1	1	1	1	1	1	0	0	0	1	0	0	0
108 DWBC/PET	1	1	1	0	0	1	0	0	1	1	0	0	0
109 DWBC/PET	1	1	1	0	0	1	0	0	0	1	0	1	0
110 DWBC/PET	1	1	1	1	1	1	0	0	1	1	1	0	1
111 DWBC/PET	1	1	1	1	1	1	0	0	1	1	0	0	0
112 DWBC/PET	1	1	1	1	1	1	0	0	1	1	1	0	1
113 DWBC/PET	1	1	1	1	1	1	0	0	0	1	0	0	0
114 fluoro	1	1	1	0	0	1	0	0	1	1	1	0	0
115 PULSE	1	1	0	0	0	0	0	0	0	1	0	0	0

Table 1.5: **Summary of Kerguelen DWBC mooring deployments and recoveries. Note: for deployments, "release time" is the time the final component was released from the trawl deck; for recoveries, "release time" is the time the release command was sent to the acoustic release at the base of the mooring. Mooring positions are the estimated landing sites.**

DEPLOYMENTS (AU0304)

mooring	*position* *latitude*	*longitude*	*depth (m)*	*release time (UTC)*	*CTD*
KERGUELEN1	57° 03.120'S	84° 47.676'E	4725	1804, 19/02/2003	39
KERGUELEN2	57° 17.754'S	84° 20.550'E	4639	1217, 19/02/2003	38
KERGUELEN3	57° 32.520'S	83° 52.182'E	4433	1938, 18/02/2003	37
KERGUELEN4	57° 39.684'S	83° 37.050'E	4273	0050, 18/02/2003	36
KERGUELEN5	57° 45.864'S	83° 23.238'E	4575	0746, 18/02/2003	35
KERGUELEN6	57° 49.596'S	83° 16.038'E	3480	1035, 16/02/2003	34
KERGUELEN7	57° 56.520'S	83° 01.878'E	2858	0024, 16/02/2003	33
KERGUELEN8	58° 07.614'S	82° 37.374'E	2259	1800, 15/02/2003	44

RECOVERIES (AU0403)

mooring	*position* *latitude*	*longitude*	*depth (m)*	*release time (UTC)*	*CTD*
KERGUELEN1	57° 03.120'S	84° 47.676'E	4725	0133, 20/01/2005	70
KERGUELEN2	57° 17.754'S	84° 20.550'E	4639	0054, 21/01/2005	71
KERGUELEN3	57° 32.520'S	83° 52.182'E	4433	0712, 21/01/2005	72
KERGUELEN4	57° 39.684'S	83° 37.050'E	4273	0016, 22/01/2005	73
KERGUELEN5	57° 45.864'S	83° 23.238'E	4575	0439, 22/01/2005	74
KERGUELEN6	57° 49.596'S	83° 16.038'E	3480	2341, 22/01/2005	75
KERGUELEN7	57° 56.520'S	83° 01.878'E	2858	0403, 23/01/2005	76
KERGUELEN8	58° 07.614'S	82° 37.374'E	2259	0752, 23/01/2005	77

Table 1.6: **Summary of drifter deployments.**

AU0403

drifter	*position* *latitude*	*longitude*	*depth (m)*	*release time (UTC)*	*CTD*
ARGO1679	36° 01.74'S	114° 58.92'E	5212.4	1325, 26/12/2004	8
ARGO1680	38° 00.59'S	115° 00.30'E	4799.0	0927, 28/12/2004	12
ARGO1681	44° 59.32'S	114° 59.51'E	4286.7	1528, 01/01/2005	25
ARGO1682	47° 58.39'S	115° 01.58'E	3610.7	0515, 03/01/2005	31
ARGO1683	49° 59.25'S	115° 02.41'E	3986.5	0735, 05/01/2005	35
ARGO1684	51° 58.52'S	114° 59.93'E	3618.9	1429, 06/01/2005	39
ARGO1685	53° 48.77'S	114° 58.98'E	4082.2	1400, 07/01/2005	42
ARGO1686	56° 12.76'S	114° 58.81'E	4568.0	1445, 09/01/2005	46
ARGO1687	58° 00.23'S	114° 59.57'E	4560.5	1230, 10/01/2005	49
ARGO1688	59° 48.96'S	115° 00.83'E	4478.9	1615, 11/01/2005	52
ARGO1845	61° 00.50'S	115° 02.86'E	4384.6	1125, 12/01/2005	54
ARGO1689	57° 59.21'S	120° 00.13'E	4602.5	2040, 11/02/2005	-
ARGO1798	56° 30.30'S	124° 26.51'E	4673.1	0730, 12/02/2005	-
ARGO1799	54° 52.59'S	128° 36.19'E	4449.9	2040, 12/02/2005	-
ARGO1800	53° 06.17'S	132° 23.48'E	3716.5	0950, 13/02/2005	-
ARGO1801	51° 13.39'S	135° 53.72'E	3253.6	2220, 13/02/2005	-
ARGO1807	49° 15.30'S	139° 05.81'E	3083.5	1157, 14/02/2005	-
ARGO1808	47° 12.05'S	142° 03.59'E	4261.6	0059, 15/02/2005	-
ARGO1844	46° 59.28'S	142° 00.58'E	3741.5	0529, 15/02/2005	115
Technocean met-buoy serial 46020	62° 00.03'S	88° 02.61'E	3903	2143, 08/02/2005	-

Table 1.7: Principal investigators (*=cruise participant) for CTD water sampling programs.

measurement	*name*	*affiliation*
AU0304		
CTD, salinity, O_2, nutrients	*John Church	CSIRO
biological sampling	Simon Wright	Antarctic Division
AU0403		
CTD, salinity, O_2, nutrients	*Steve Rintoul, John Church	CSIRO
D.I.C., alkalinity	Bronte Tilbrook	CSIRO
CFC	Shuichi Watanabe	JAMSTEC
^{18}O	Shigeru Aoki	Hokkaido University
methane	Osamu Yoshida	Tokyo Institute of Technology
selenium	*Bronwyn Wake	CSIRO
biological sampling	Laurent Seuront, *Raechel Waters	Flinders University

Table 1.8a: Scientific personnel (cruise participants) for cruise AU0304.

Shigeru Aoki	CTD, moorings	National Institute of Polar Research, Japan
John Church	CTD	CSIRO
Clodagh Curran	hydrochemistry	Antarctic CRC
Yasu Fukamachi	CTD, moorings	Hokkaido University
Neale Johnston	hydrochemistry	CSIRO
Dan McLaughlan	CTD, moorings	CSIRO
Mark Rosenberg	CTD, moorings	Antarctic CRC
Serguei Sokolov	CTD, LADCP	CSIRO
Andreas Thurnherr	CTD, LADCP	Florida State University
Shinsuke Toyoda	CTD, moorings	Hokkaido University
Bronwyn Wake	hydrochemistry	Antarctic CRC
Luke Finley	krill	Antarctic Division
Edwina Hollander	krill	Antarctic Division
Brian Hunt	krill, CPR	Antarctic Division
So Kawaguchi	krill	Antarctic Division
John Kitchener	krill, CPR	Antarctic Division
Ichwan Nasution	krill	Agency for Marine and Fisheries Research, Indonesia
Steve Romaine	hydroacoustics	IOS, Canada
Patti Virtue	krill	IASOS
David Wanless	hydroacoustics	Antarctic Division
Mahadi Mohammad	phytoplankton	Universiti Sains Malaysia
Wan Maznah Wan Omar	phytoplankton	Universiti Sains Malaysia
Sazlina Salleh	phytoplankton	Universiti Sains Malaysia
Vera Subariah	phytoplankton	State University of Papua
Zul Yasin	phytoplankton	Universiti Sains Malaysia
Catherine Bell	whales	University of Adelaide
Paul Hodda	whales	Australian Whale Conservation Society
Shannon McKay	whales	Deakin University
Julie Oswald	whale hydroacoustics	Scripps Institute of Oceanography
Vic Peddemors	whales	University of Durban-Westville, South Africa
Kate Stafford	whale hydroacoustics	NOAA
Alice Ewing	birds	IASOS
Peter Lansley	birds	IASOS
Christel Heeman	floating sediment traps, diatoms	Alfred Wegener Institute, Germany
Stephane Pesant	floating sediment traps, diatoms	University of Western Australia
Maya Whiteley	floating sediment traps, diatoms	University of Western Australia

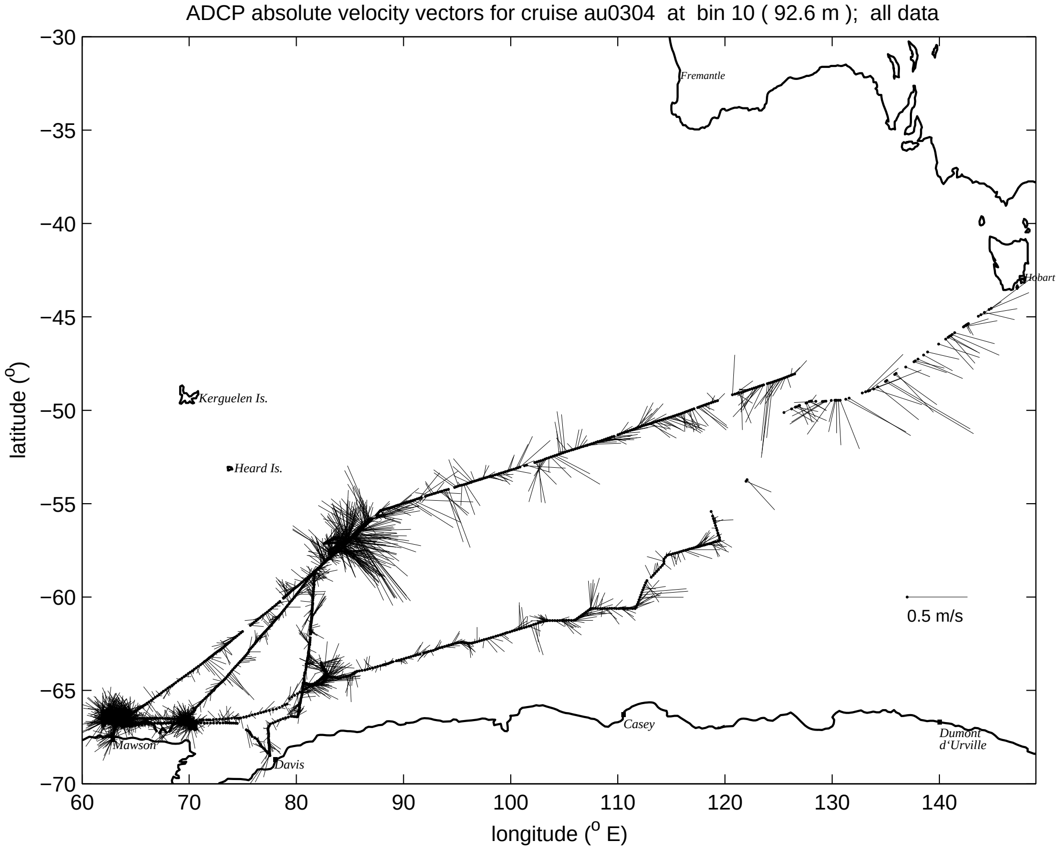
Table 1.8a: (continued)

John Birss	doctor	Antarctic Division
Andrew Cawthorn	gear officer	Antarctic Division
Mirjana Jambrecina	dotzapper	Antarctic Division
Ruth Lawless	deputy voyage leader	Antarctic Division
Steve Nicol	voyage leader, krill	Antarctic Division
Alan Poole	electronics	Antarctic Division
Bryan Scott	computing	Antarctic Division
Graeme Snow	communications	Antarctic Division
Tony Veness	electronics	Antarctic Division

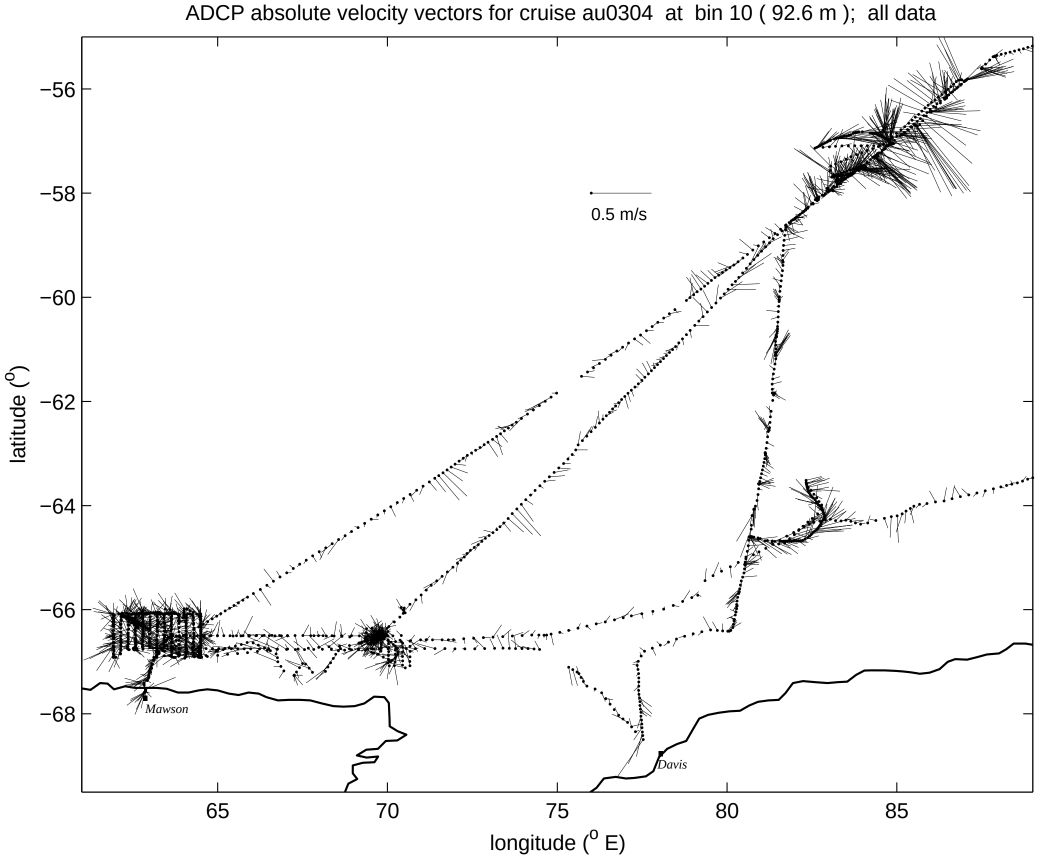
Table 1.8b: Scientific personnel (cruise participants) for cruise AU0403.

Kate Berry	hydrochemistry	CSIRO
Jacqui Foster	carbon, krill	Marine Discovery Centre, Woodbridge
Yasu Fukamachi	CTD, moorings, LADCP	Hokkaido University
Judy Horsburgh	carbon	IASOS
Eric Howarth	CTD, turbulence probe	Florida State University
Kazu Kusahara	CTD, moorings	Hokkaido University
Anna Kuswardani	CTD	Agency for Marine and Fisheries Research, Indonesia
Peter Lazarevich	CTD, turbulence probe	Florida State University
Lusia Manu	CTD	Sam Ratulangi University, Indonesia
Andrew Moy	hydrochemistry	ACE CRC
Clodagh Moy	hydrochemistry	ACE CRC
Steve Rintoul	CTD, voyage leader	CSIRO
Mark Rosenberg	CTD, moorings, deputy voyage leader	ACE CRC
Katsunori Sagishima	CFC	Marine Works Japan
Ken'ichi Sasaki	CFC	JAMSTEC, Japan
Rick Smith	CTD, Argo floats	CSIRO
Serguei Sokolov	CTD, LADCP	CSIRO
Bronwyn Wake	selenium, krill	CSIRO
Mark Doubell	phytoplankton	Flinders University
David Poulsen	phytoplankton	Flinders University
Justin Rowntree	phytoplankton, krill	Flinders University
Justin Seymour	phytoplankton	Flinders University
Raechel Waters	phytoplankton, krill	Flinders University
David Andrew	birds	free agent
Andrew Stafford	birds	free agent
Cath Deacon	doctor	Antarctic Division
Chris Kuplis	communications	Antarctic Division
Tim Shaw	electronics	ACE CRC
Graeme Snow	communications	Antarctic Division
Peter Wiley	computing	Antarctic Division

(a)

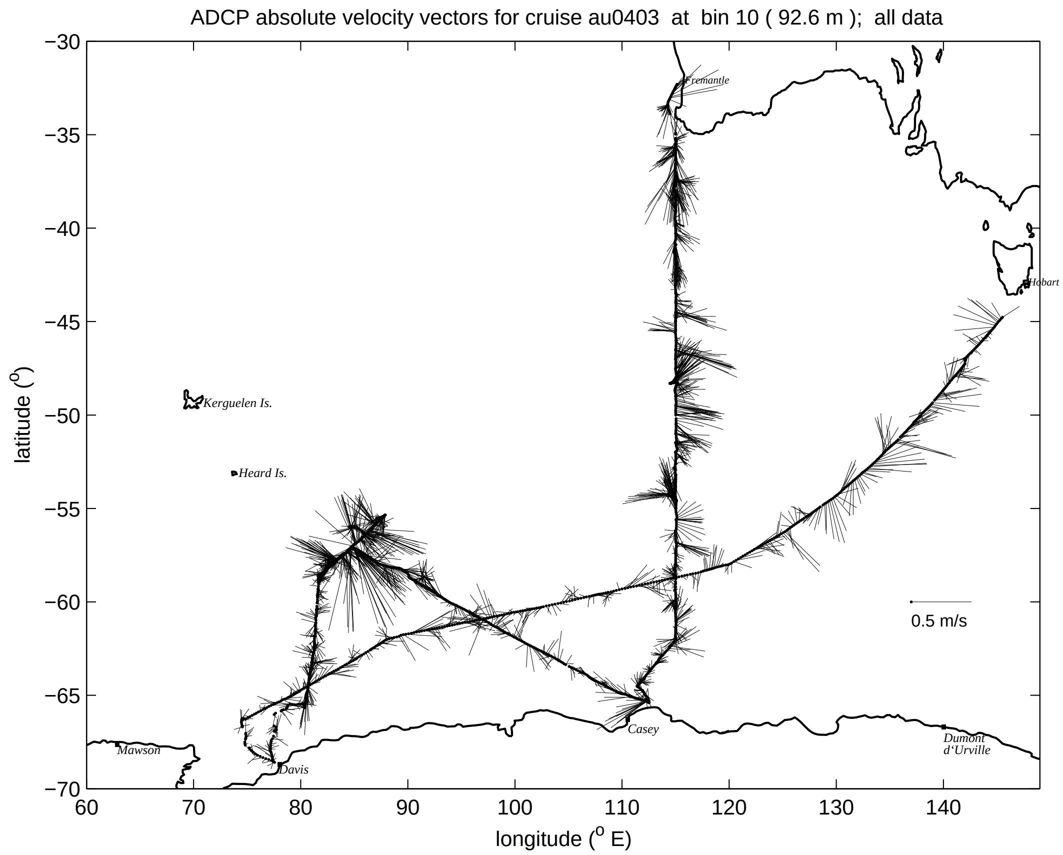


(b)



<u>Figure 1.4a and b:</u> AU0304 hull mounted ADCP 30 minute ensemble data, for (a) whole cruise track, and (b) Kerguelen DWBC, PET and krill survey.

(c)



(d)

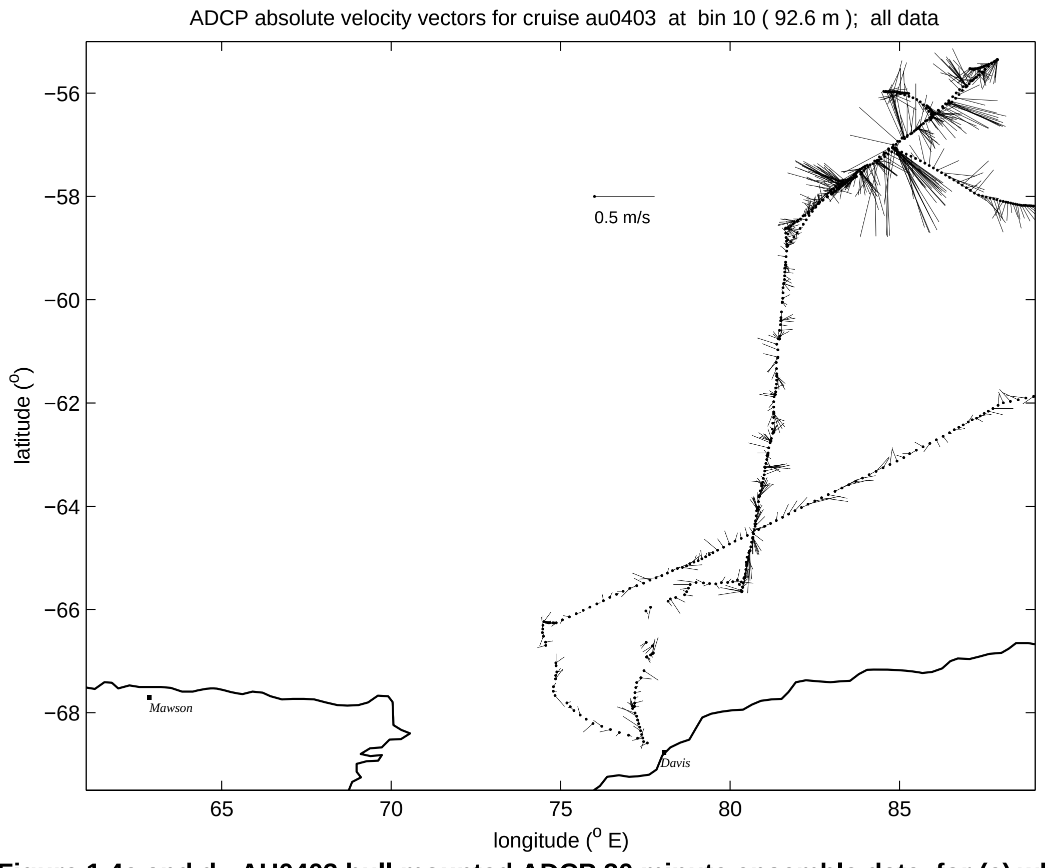
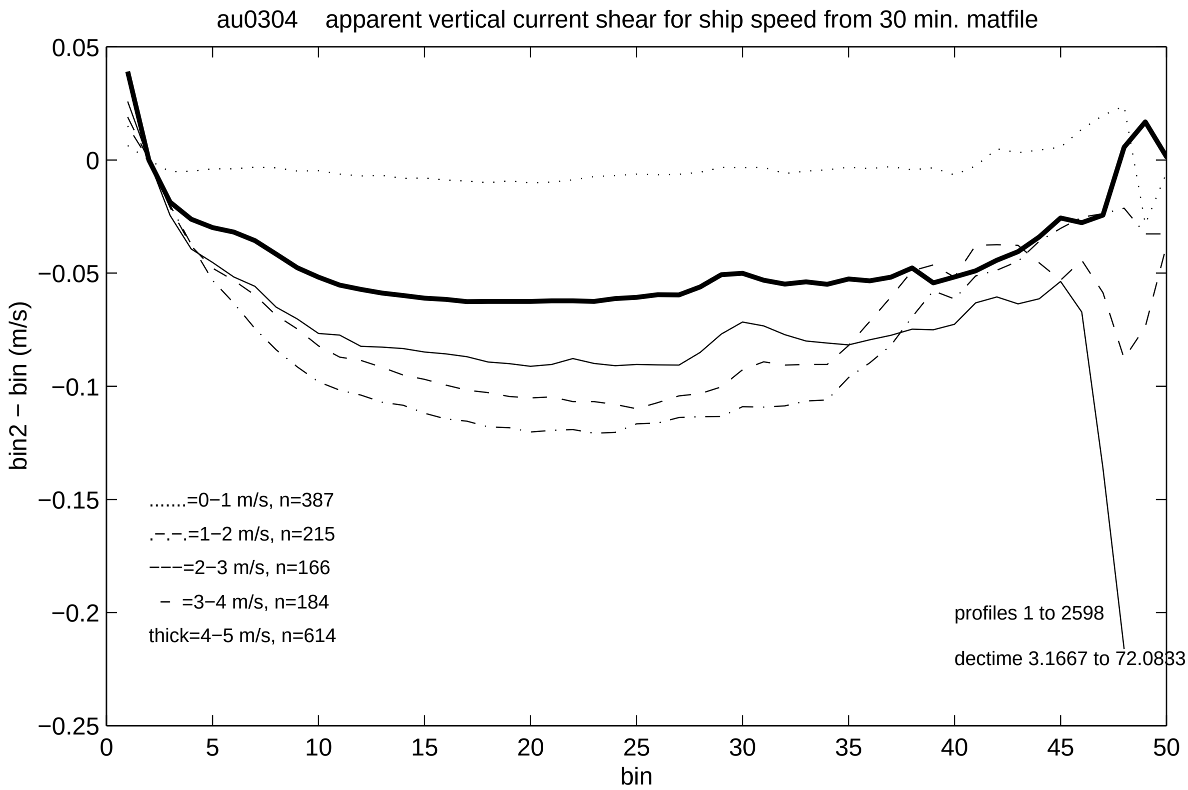
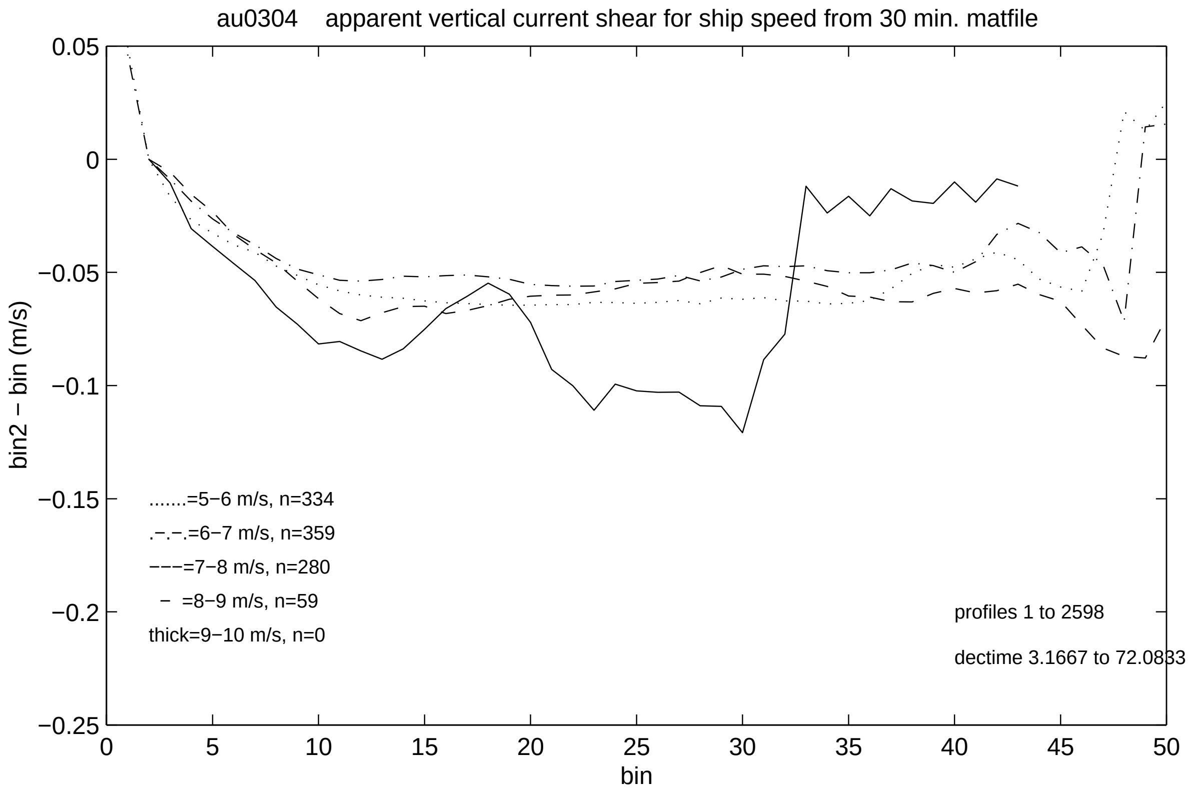
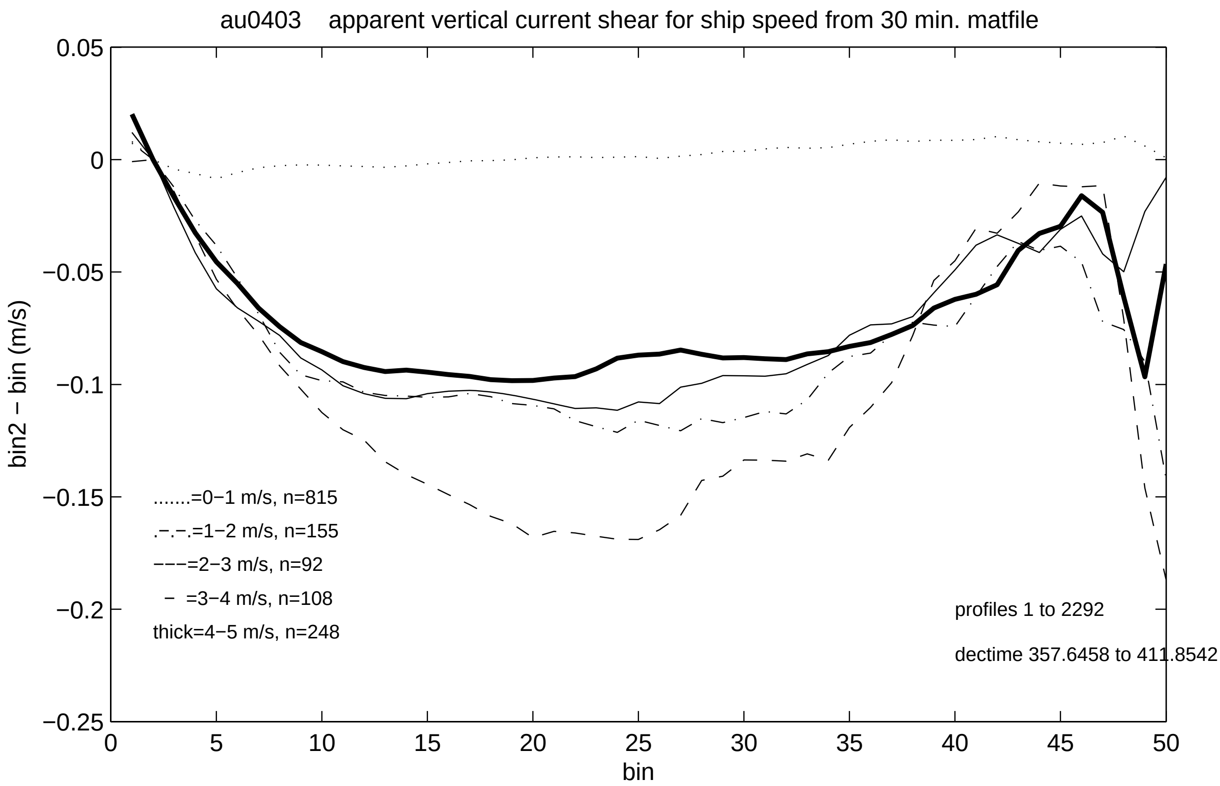


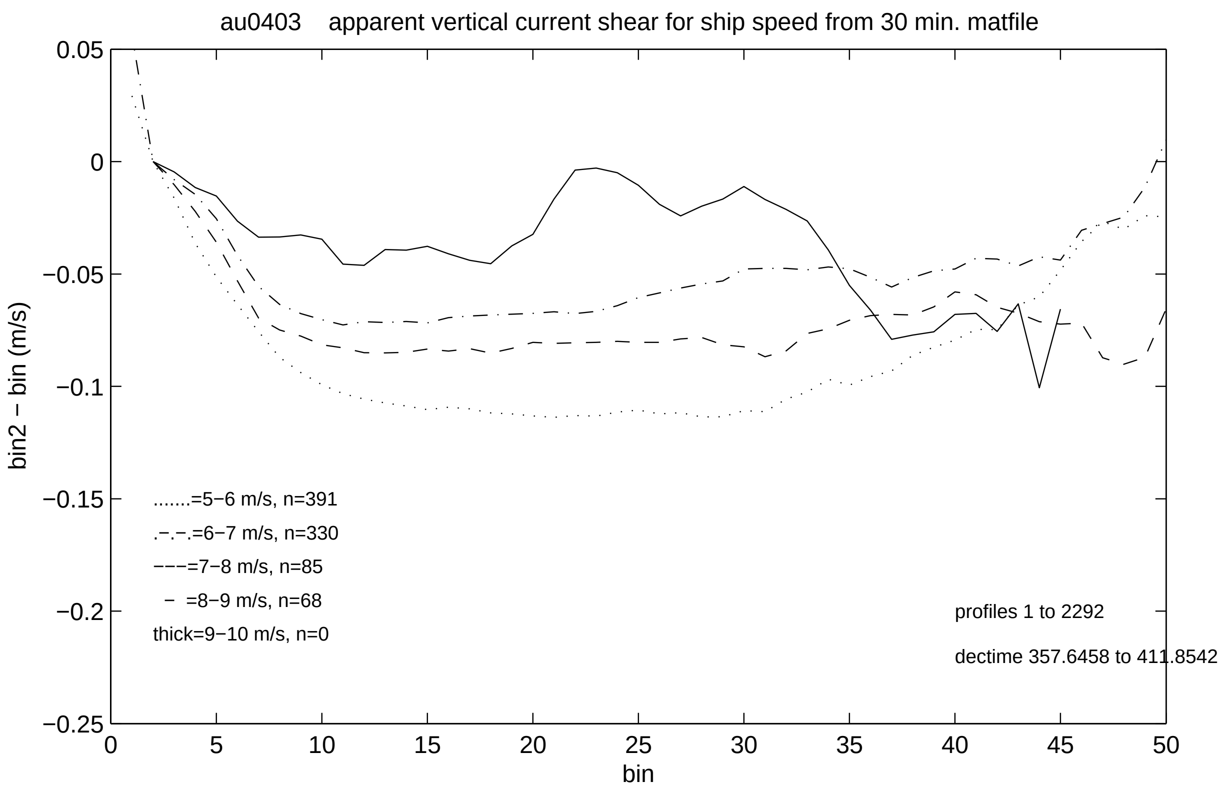
__Figure 1.4c and d:__ **AU0403 hull mounted ADCP 30 minute ensemble data, for (c) whole cruise track, and (d) Kerguelen DWBC and PET.**





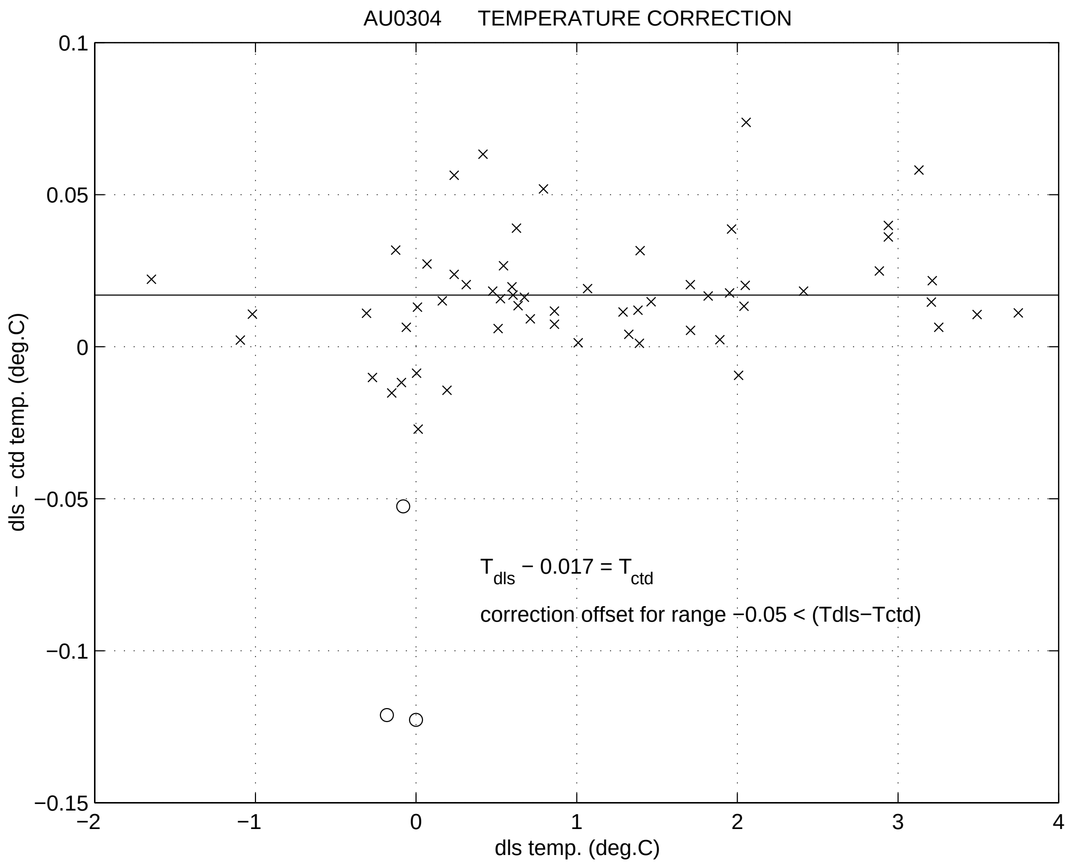
<u>Figure 1.5a:</u> AU0304 apparent ADCP vertical current shear, calculated from uncorrected (i.e. ship speed included) ADCP velocities. The data are divided into different speed classes, according to ship speed during the 30 minute ensembles. For each speed class, the profile is an average over the entire cruise.





<u>Figure 1.5b:</u> AU0403 apparent ADCP vertical current shear, calculated from uncorrected (i.e. ship speed included) ADCP velocities. The data are divided into different speed classes, according to ship speed during the 30 minute ensembles. For each speed class, the profile is an average over the entire cruise.

(a)



(b)

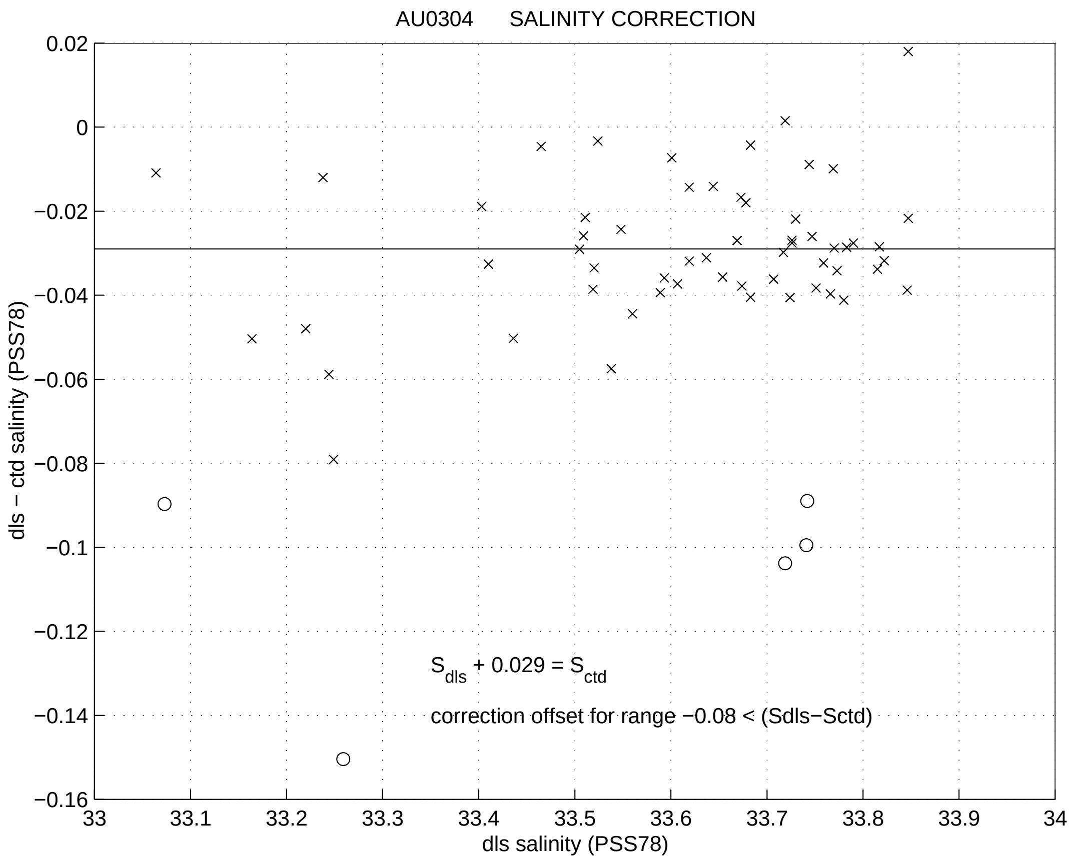
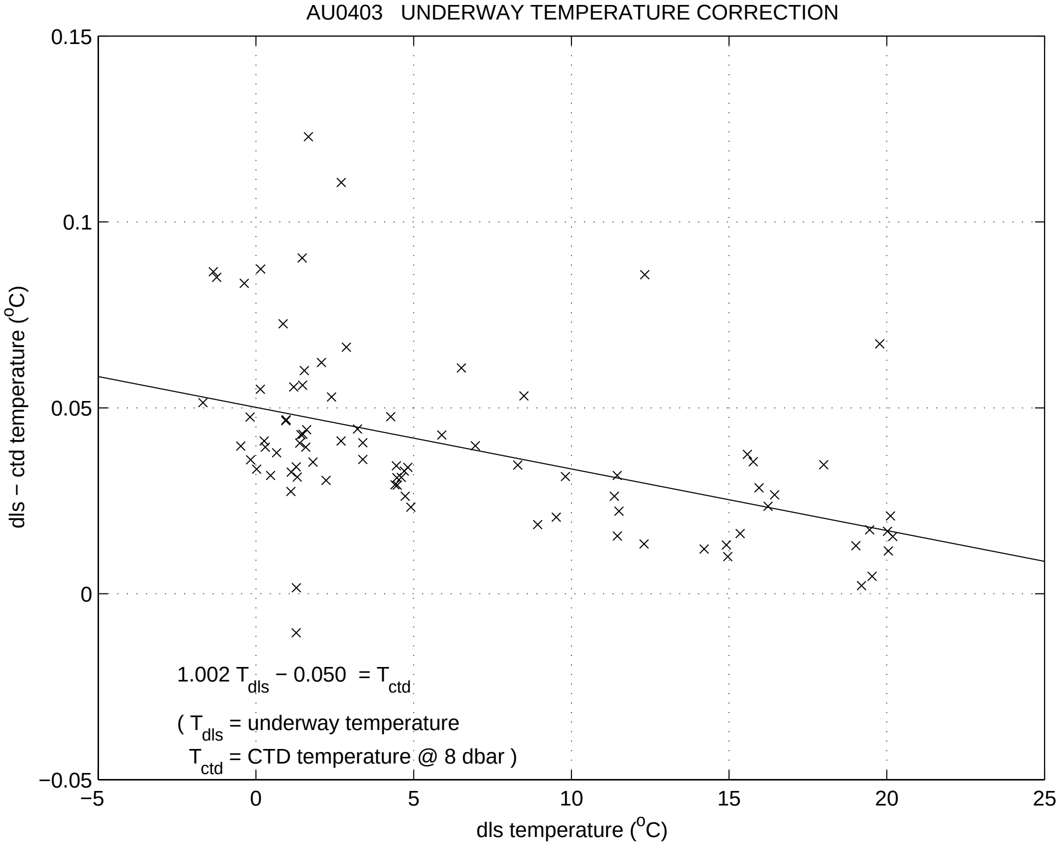


Figure 1.6a and b: AU0304 comparison between (a) CTD and underway temperature data, and (b) CTD and underway salinity data, including bestfit lines. Note: dls refers to underway data.

(c)



(d)

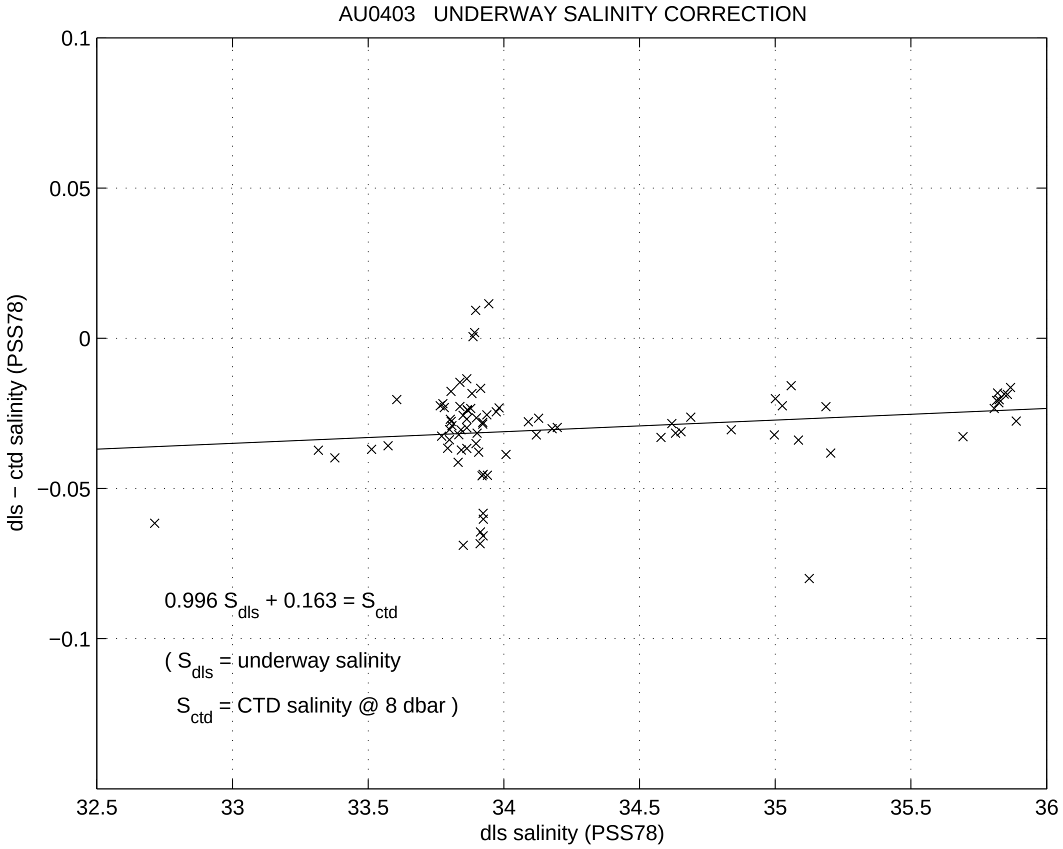


Figure 1.6c and d: AU0403 comparison between (c) CTD and underway temperature data, and (d) CTD and underway salinity data, including bestfit lines. Note: dls refers to underway data.

1.3.2 ADCP

The hull mounted ADCP on the Aurora Australis is described in Rosenberg (unpublished report, 1999), with the following updates:

(i) There is no longer a Fugro differential GPS system - all GPS data, including heading, come from the Ashtech 3D system.

(ii) Triggering of the 12 kHz sounder and the higher frequency hydroacoustics array are now separate, resulting in a higher ping rate for the ADCP (linked to the higher frequency hydroacoustics array).

Logging parameters for both cruises are summarised in Table 1.9. Current vectors for both cruises are plotted in Figures 1.4a to d; the apparent vertical current shear error for different ship speed classes, discussed in Rosenberg (unpublished report, 1999), is plotted in Figures 1.5a and b.

Table 1.9: ADCP logging and calibration parameters for cruises AU0304 and AU0403.

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

reference layer averaging:	bins 8 to 20
XROT:	822
ensemble averaging duration:	3 min. (for logged data) 30 min. (for final processed data)

calibration

cruise	α ($\pm$ standard deviation)	$1+\beta$ ($\pm$ standard deviation)	no. of calibration sites
AU0304	2.346 ± 0.568	1.0712 ± 0.011	375
AU0403	2.408 ± 0.535	1.0687 ± 0.011	183

1.3.3 Underway measurements

Underway data were logged to an Oracle database on the ship. For more information, see the AADC (Antarctic Division Data Centre) website, and the cruise dotzapper (i.e. data quality controller) report for AU0304:

Marine Science Support Data Quality Report, RSV Aurora Australis Season Voyage 4 2002-2003, Mim Jambrecina, January 2003, Antarctic Division unpublished report.
(report at web address http://aadc-maps.aad.gov.au/metadata/mar_sci/Dz200203040.html)

Note that AU0403 underway data have not been dotzapped (except for the 12 kHz depth data). For both cruises, a sound speed of 1490 ms^{-1} was used for ocean depth calculation, and the ship's draught of 7.3 m was accounted for.

For AU0304, underway data were dumped from the AADC website. Underway data for AU0403 were supplied by Peter Wiley (AAD Marine Science Support). Data are in the following files:

AU0304	
1 min. instantaneous values, text format:	kaos.ora
1 min. instantaneous values, matlab format:	kaosora.mat

AU0403
1 min. average values, text format: i9_unzapped.ora
1 min. average values, matlab format: i9_unzappedora.mat
(except for depth, which is 1 min. instantaneous values)

Note that for AU0403 data, all wind data are suspect due to anemometer vane damage.

A correction was applied to the underway sea surface temperature and salinity data, derived by comparing the underway data with CTD temperature and salinity data at 8 dbar (Figure 1.6a to d). The following corrections were applied:

for AU0304:

$T = T_{dls} - 0.017$ (eqn 1.1)

$S = S_{dls} + 0.029$ (eqn 1.2)

for AU0403:

$T = 1.002\ T_{dls} - 0.050$ (eqn 1.3)

$S = 0.996\ S_{dls} + 0.163$ (eqn 1.4)

for corrected underway temperature and salinity T and S respectively, and uncorrected values T_{dls} and S_{dls}.

1.3.4 Moorings and drifters

Mooring deployments and recoveries are summarised in Table 1.5. Mooring data are described in detail in Part 2 of this report. Drifter deployments are summarised in Table 1.6.

1.4 PROBLEMS ENCOUNTERED

AU0304

* Significant time was lost to bad weather, and to shortage of fuel and the resulting time spent obtaining fuel from the Polar Bird at Mawson. Many of the planned CTD's southward across the southern Kerguelen Plateau and Princess Elizabeth Trough were omitted due to the resulting time constraints.

* Logging of 12 kHz sounder data seized up on several occasions. As a result, some of the bathymetry during the deployments of moorings 4 and 5 is missing.

* The CTD seacable electric termination failed during the downcast of the first test cast (CTD 1), and electric retermination was required.

* During the inital deployment attempt for CTD 39, overtensioning of the winch resulted in slippage of the mechanical termination and breakage of the electric termination; a full retermination was required.

* There was difficulty throughout the cruise obtaining stable data from the Benthos PSA-900 altimeters. On two occasions, at CTD 38 and CTD 50, altimeter problems resulted in the package touching the bottom.

* Unstable altimeter readings prevented a confirmed approach to the bottom for several stations (details given section 1.5 of this report).

* For the first 9 stations, the top Niskin caps were cocked incorrectly, preventing sufficient flushing of the bottles during the cast. This was obvious from the shallower bottle samples in the steep vertical gradients (details given in section 1.5).

* Some CTD winch spooling problems occurred throughout the cruise. After CTD 43, the spooler from the aft winch was installed for use on the forward winch.

AU0403
* CTD winch spooling problems were significant throughout the cruise, with a cumulative time loss of one full day.

* For the first part of the cruise the CTD gantry was problematic, due to a badly adjusted proximity switch. This caused significant delays at several stations.

* Severe rolling of the ship during CTD operations was experienced for much of the I9S transect, due to offset of current and wind headings. CTD deployments and recoveries were difficult on occasion, and the CTD wire was often kinked due to wire snatching with the ship roll as the CTD entered the water. The CTD room flooded on occasion due to the rolling, most seriously during CTD 49 - on this occasion, much of the CTD room electronics were shorted, including the gantry, and CTD recovery at the end of the cast was delayed for an hour while the gantry electronics were repaired.

* A full seacable retermination was required before CTD 18, when a broken strand was noticed near the top of the wire during the initial deployment attempt. Two further full reterminations were carried out after CTD's 28 and 39. An electrical retermination only was carried out after CTD 38.

* Both available CTD frame lifting bridles were bent during the cruise, during either the deployment or recovery operations. Repeat straightening was not possible, and as a result most CTD's for the cruise were carried out with the frame hanging at an angle (~5 to 10 degrees).

* For many CTD stations, difficulties communicating with the rosette pylon were experienced. The fault was traced to a faulty pylon-to-CTD cable, and then again to the first replacement pylon-to-CTD cable. Details of data losses and data degradation due to this problem are given in section 1.5.

* During CTD 9, the ship's thrusters struggled to maintain heading, and vessel drift was fast. At the bottom of the cast the bathymetry changed rapidly, with the sea bed "chasing" the package on the upcast from ~5200 dbar up to ~4900 dbar.

* During CTD 13 and CTD 48, the ship lost heading, resulting in a large wire angle and towing of the CTD behind the ship. On each occasion a Niskin bottle was lost from the package.

* During CTD 4, 5 and 35, downcasts were stopped early due to hazard from the rapidly changing bathymetry over steep slopes. CTD 5 was stopped at 75 m above the bottom. For CTD 4, the bottom of the downcast was an elevation greater than 192 m above the sea bed i.e. out of range of the LADCP. For CTD 35, there were no LADCP data so it is not known where the sea bed was relative to the bottom of the cast.

* The PSA-900 altimeter used for the first few CTD's failed by station 6. The package touched the bottom during station 6, with no response from the altimeter.

* The package touched the bottom again during station 40, due to a winch driving error.

* The upper and lower bottle locating rings on the CTD frame were slightly out of adjustment, and on several occasions bottles returned to the deck hanging from the frame by the saftey rope. Samples from these bottles were bad (see section 1.5).

* The LADCP battery housing leaked on two occasions, first during CTD 22, then again during CTD 25 after an initial repair attempt. The leakage caused battery shorting and damage to a bulkhead connector. The LADCP could not be used for stations 26 to 39, during the second repair attempt. When reinstalled for CTD 40 there was no spare bulkhead connector, so the remaining casts were done with the downward looking transducers only.

* A new Lachat nutrient analyser was used for the first time on this cruise, and data quality problems were encountered. Further details are given in section 1.5 and Appendix 1.1.

1.5 CTD AND BOTTLE DATA RESULTS

CTD and Niskin bottle data quality are discussed in this section. Full details of the CTD data processing and calibration techniques are described in Appendix 1.2. Data file formats are described in Appendix 1.3. When using the data, the following data quality tables are important:

Table 1.15 – questionable CTD data
Table 1.16 – questionable nutrient data

In general, the CTD data quality for these cruises using the Sea-Bird CTD system is improved compared to previous cruises using the Neil Brown type CTD's, in particular for CTD dissolved oxygen data. A small disadvantage of the new CTD system is the required deployment methodology (described above in section 1.3), which means the top few dbar of data are missed. However this near surface data was often suspect anyway for the old Neil Brown type CTD's, due to transient sensor errors when entering the water.

1.5.1 CTD data

1.5.1.1 Conductivity/salinity

The conductivity calibration and equivalent salinity results for both cruises are plotted in Figures 1.7 and 1.8, and the derived conductivity calibration coefficients are listed in Tables 1.12 and 1.13.

AU0304
The conductivity cell on CTD703 (used for the entire cruise) calibrated very well (Figures 1.7a and 1.8a), with CTD salinity accurate to well within 0.002 (PSS78). Note that the primary conductivity/temperature sensor pair was used for the final data. Close inspection of the vertical profiles of the bottle-CTD salinity difference values reveals a slight negative biasing of the order 0.001 (PSS78) for stations 39 and 53, and a slight positive biasing of the same magnitude for station 48. TS plot comparisons for these stations with surrounding stations indicates the biasing is most likely due to salinometer instabilities.

For stations 38 and 50 where the CTD touched the bottom, close inspection of conductivity and temperature data does not show any significant difference before and after touchdown.

AU0403
The conductivity cells on CTD703 (stations 1 to 41) and CTD704 (stations 42 to 115) calibrated very well (Figures 1.7b and 1.8b), with CTD salinity accurate to well within 0.0015 (PSS78). For this cruise, a small calibration drift over the cruise was evident for the primary conductivity sensor, so the secondary conductivity/temperature sensor pair was used for the final data. Inspection of vertical profiles of the bottle-CTD salinity difference values reveals a slight negative biasing of the order 0.001 (PSS78) for stations 35, 42 and 53, and of the order 0.002 (PSS78) for station 54; and a slight positive biasing of the order 0.001 (PSS78) for station 36. As for AU0304, this is most likely due to salinometer instabilities.

During the downcast of CTD 9, 11 and 14, transmission faults resulted in bad conductivity/salinity data from 222 to 246 dbar for CTD 9, 208 to 218 dbar for CTD 11, and 202 to 224 dbar for CTD 14.

For stations 6 and 40 where the CTD touched the bottom, there is no significant offset in conductivity and temperature data before and after bottom contact.

1.5.1.2 Temperature

As mentioned above, primary temperature was used for final AU0304 data, while secondary temperature was used for final AU0403 data. Primary and secondary temperature data (t_p and t_s respectively) are compared for both cruises in Figures 1.9a and b. CTD upcast burst data, obtained at each Niskin bottle stop, are used for the comparison. From the figures, there is a very small pressure dependency of t_p-t_s for CTD704 (of the order 0.0005°C over 5000 dbar) , and a much stronger dependency for CTD703 (of the order 0.002°C over 5000 dbar). Without some temperature standard for comparison, it cannot be determined which of the 2 CTD703 temperature sensors has the strong pressure dependency; and indeed for CTD704, it cannot be determined whether the 2 temperature sensors have the same pressure dependency, or no pressure dependency. As a result, all temperature data from below ~2000 dbar for both cruises can only be considered accurate to 0.002°C. For shallower data (above ~1500 dbar), temperature accuracy is 0.001°C. Clearly, use of an independent temperature standard such as an SBE35 would improve temperature accuracy e.g. CTD work by the RV Mirai (Uchida and Fukasawa, 2005).

For CTD704 (AU0403 stations 42 to 115), several bad data scans occurred for secondary temperature during each cast, due to a hardware problem. The problem was manifest as 2 consecutive data scans being plus and minus the expected value. These bad scans (typicaly 5 or 10 per station) were removed by a despiking routine.

1.5.1.3 Pressure

On previous cruises using General Oceanics Neil Brown type CTD's, noise in the pressure signal often resulted in pressure spiking up to 1 dbar in magnitude, resulting in vertical "jumps" when removing pressure reversals in preparation for 2 dbar averaging. There was no equivalent pressure noise for the Sea-Bird CTD's, and when creating 2 dbar bin averages using a minimum required attendance of 8 data scans per bin, there were no missing 2 dbar bins for the data from cruises AU0304 and AU0403.

Surface pressure offsets for each cast (Table 1.11) were obtained from inspection of the data before the package entered the water.

1.5.1.4 Dissolved oxygen

The CTD oxygen calibration results for both cruises are plotted in Figure 1.10, and the derived calibration coefficients are listed in Table 1.18. CTD oxygen data using the new SBE43 sensors are significantly improved compared with previous cruises, and overall the calibrated CTD oxygen agrees with the bottle data to well within 1% of full scale (where full scale is ~380 µmol/l above 750 dbar, and ~270 µmol/l below 750 dbar), with exceptions discussed below. Near surface CTD oxygen data, typically suspect for previous cruises, is much improved, owing to the pumped system of the Sea-Bird CTD's.

When calibrating the CTD oxygen data, in the case of deeper stations, calibrating the whole profile as a single fit against bottle data in general leaves small residuals between calibrated CTD and bottle oxygen near the bottom of the profile. This suggests there is a subtle difference in response of the oxygen sensor according to depth, not accounted for by any of the calibration coefficients. Consequently, for casts deeper than 1400 dbar the profiles were split into a shallow and deep part for separate calculation of calibration coefficients, with a linear interpolation between the 2 calibrations around the split point. Casts shallower than 1400 dbar were calibrated as whole profile fits. Complete details of this calibration methodology are given in Appendix 1.2.

AU0304

* For most stations, there is a suspicious increase in CTD oxygen data from the surface down to the base of the mixed layer. This increase is mostly of the order ~4 µmol/l, and is assumed to be an equilibration issue with the sensor, with insufficient time given for the sensor to "warm up" after turning on the power prior to each cast. As a result, near surface CTD oxygen data for this cruise should only be considered accurate to 2%.

* For station 4, CTD oxygen data for the top part of the profile could not be fitted against the bottle samples, and data were rejected for 2 to 118 dbar.

* For station 24, there were insufficient bottles below 50 dbar, and the CTD oxygen data were therefore rejected for 52 to 1936 dbar.

* For station 28, CTD oxygen data were rejected for 180 to 606 dbar, again due to lack of bottle samples.

* For station 56, CTD oxygen data were rejected for 1000 to 1002 dbar, due to a kink in the data resulting from power cycling of the deck unit.

* Additional near surface CTD oxygen data rejected were for station 6 (2 to 12 dbar), station 150 (2 to 150 dbar), and station 59 (2 to 98 dbar). Suspect near surface data retained in the data files are listed in Table 1.15.

AU0403
* For several stations, pylon communication problems resulted in missing bottle samples, and in the worst cases sections of vertical CTD oxygen profile data could not be calibrated. As a result, CTD oxygen data are missing for:

station 38, 2 to 78 dbar
station 39, whole profile
station 41, 2 to 342 dbar
station 51, 2 to 100 dbar
station 63, 2 to 984 dbar
station 68, 2 to 296 dbar
station 73, 2 to 478 dbar

* For station 7, CTD oxygen sensor data were bad below 3222 dbar. For station 44, oxygen sensor data were bad below 4396 dbar.

* For station 38, not enough samples were available for a split profile calibration fit (Appendix 1.2), so a whole profile fit was done.

* For stations 75, 110 and 114, the CTD to bottle oxygen fit is not so good near the surface, with a difference of ~2 to 3% at the shallowest bottle.

1.5.1.5 Fluorescence

All fluorescence data have a calibration as supplied by the manufacturer (Table 1.10). In general, these data should only be used quantitatively if linked to primary productivity data derived from Niskin bottles samples.

For AU0403 station 29, the sensor cover was accidentally left on the fluorometer, and fluorescence values are very high. The profile shape however appears to be okay.

1.5.1.6 Additional CTD data processing/quality notes

AU0304
* For stations 3, 39, 47, 48, 52 and 58, downcasts had to be stopped before "seeing" the bottom with the altimeter, due to unreliability of the altimeter. For most of these stations, the elevation above the bottom at the bottom of the cast was determined from post-processing of the LADCP data (Table 1.3a). For station 48 there were no LADCP data, and the final elevation above the bottom is unknown.

* Station 56 - The downcast was paused at 1000 dbar and the power was cycled to try and get the altimeter to work. The altimeter came on again and logging was recommenced as a different file.

AU0403
* Station 4 - The final elevation above the bottom at the bottom of the cast is > 192 m (i.e. outside LADCP range).

* Station 10 - The cast was started 2 miles south of the planned location, to avoid the steep slope and to give maximum depth for attempts at fixing the CTD winch spooling.

* Station 16 - At the 1250 dbar bottle stop on the upcast, data acquisition was accidentally stopped (instead of firing the bottle). Logging was restarted to a new file.

* Station 22 - After inital deployment to 20 dbar and commencement of pump operation, the CTD was not brought back to just below the surface - the top 20 dbar of data are therefore missing.

* Station 35 - The final elevation above the bottom at the bottom of the cast is unknown.

* Station 61 - The cast was commenced ~1 mile southwest of the planned location, due to the presence of an iceberg.

* Station 81 - The CTD was lifted out of the water prematurely, before bottle 24 was fired. It was lowered back down to 10 dbar to fire the bottle.

* Data losses/degradation due to communication problems with the rosette pylon are as follows. One or more Niskin bottles didn't close for stations 41, 51, 63, 68, 73, 75 and 76. For several stations, some bottle samples are bad due to uncertainty of bottle closing depth, stations 38 and 39 being the worst affected. Given the generally stable performance of the CTD conductivity cell, the number of good salinity samples obtained from these and surrounding stations means that CTD salinity data quality is not degraded. The more significant data degradation is the poorer vertical definition of CFC and nutrient profiles. For CTD oxygen, data cannot be calibrated for sections of the profile where several oxygen samples are missing, and as a result some CTD oxygen data is missing for several stations, as detailed in section 1.5.1.4 above.

1.5.2 Niskin bottle data

Questionable nutrient samples are listed in Table 1.16, and questionable bottle oxygen samples are listed in Table 1.17. International Standard Seawater batch numbers used for salinity analyses are detailed in Appendix 1.1.

Nitrate+nitrite versus phosphate data are shown in Figure 1.11. For AU0304, and for southern stations for AU0403, shallow samples are clearly depleted in phosphate. This feature has been observed on previous cruises during the austral summer (Part 4 in Rosenberg et al., 1997), and is believed to be real.

AU0304
* For the first 9 stations, several bottle samples were bad for all parameters, due to inadequate flushing of the Niskin bottles caused by incorrect cocking of the Niskin top caps. The following samples were affected:

station 4, Niskin 24, 23, 22, 21, 18 and 16
station 6, Niskin 24, 21, 20, 29, 18 and 16
station 7, Niskin 24 and 21
station 8, Niskin 20, 19, 18, 17, 16, 15
station 9, Niskin 9.

* From intercruise comparisons (*relevant Appendix not yet completed*), phosphate data for AU0304 appears to be mostly low, by ~2 to 4%.

* Problems were encountered with the nitrate channel on the Alpkem autoanalyser, and a significant number of nitrate+nitrate values have been flagged as questionable (Table 1.16).

AU0403
* At station 1, the last 2 rosette positions were not fired due to operator error - thus there were no samples for Niskin 24 (no Niskin 23 due to LADCP).

* For station 8, unstable salinometer behaviour resulted in suspect salinity samples for rosette positions 5 to 18.

* For station 26, salinity bottle samples are suspect for rosette positions 15 to 20, most likely due to the salinometer.

* For stations 31 to 55, a problem occurred with the dissolved oxygen instrument standardisation. The oxygen values for these stations were corrected after sample analysis (details given in Appendix 1.1).

* Duplicate oxygen samples were taken at several stations, as follows:

station 6 to 23 - bottom 8 bottles
station 24 to 31 - 8 bottles, spanning the oxygen minimum
station 35 to 37 and 40 to 49 - 4 bottles, spanning the oxygen minimum
station 58 to 61 - bottom 4 bottles

The duplicate samples were analysed using a different technique, on the Lachat nutrient analyser. These results did not warrant further analysis (R. Cowley, CSIRO, personal communication).

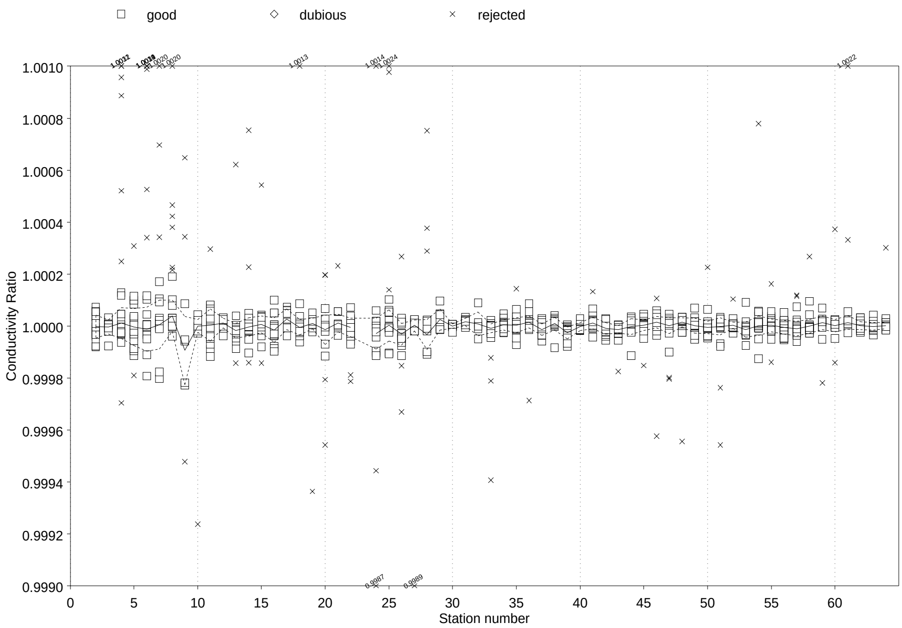
* At several stations, 1 or more Niskins were dislodged from the frame. On 2 occasions bottles were lost (station 13 Niskin 17, and station 48 Niskin 108). For remaining cases, the bottles returned to deck hanging from a safety rope, and samples were taken. All these samples were bad for all paramaters, as follows:

station 17, Niskin 16
station 19, Niskin 12
station 20, Niskin 16 and 12
station 31, Niskin 104
station 48, Niskin 24 (oxygen data retained for this bottle, but flagged as questionable)

* For station 82, the endcaps were lost from Niskin 107 when a spring lanyard broke during the cast.

* Problems were encountered with accuracy of nutrient measurments using the new Lachat analyser, particularly for phosphate, and at low concentrations. After much experimentation with the equipment and a marked improvement in data accuracy, many samples were rerun using the duplicates. See Appendix 1.1 for further details.

(a)



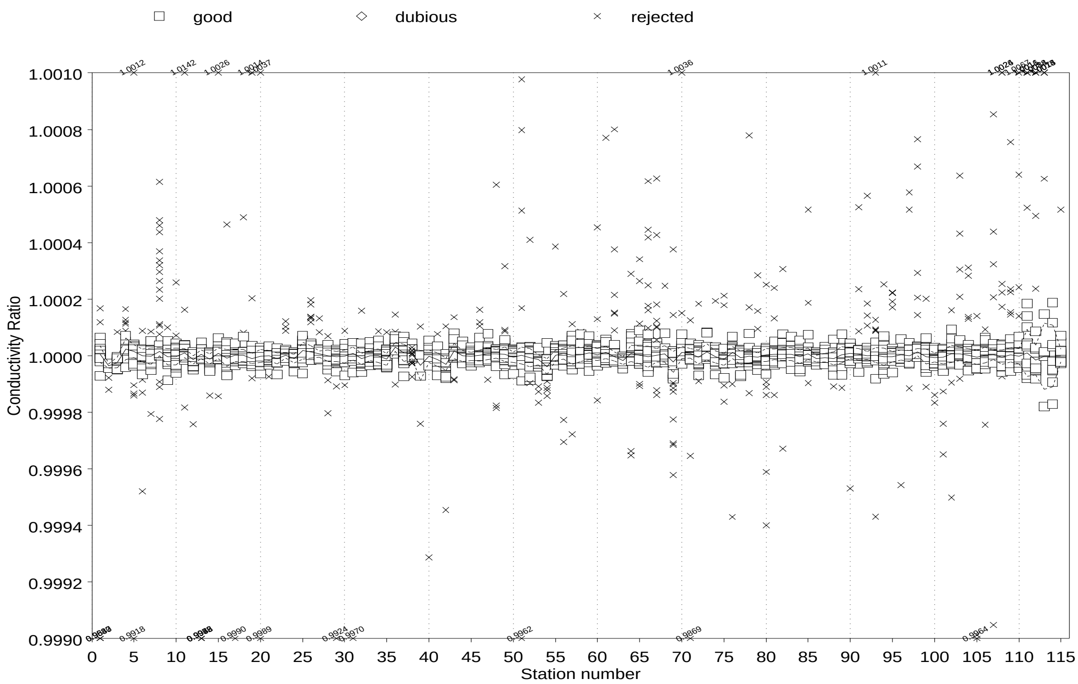
Calibration data for cruise : au0304

Calibration file : a0304.bot

Conductivity s.d. = 0.00003

Number of bottles used = 967 out of 1054 Mean ratio for all bottles = 1.00000

(b)



Calibration data for cruise : au0403

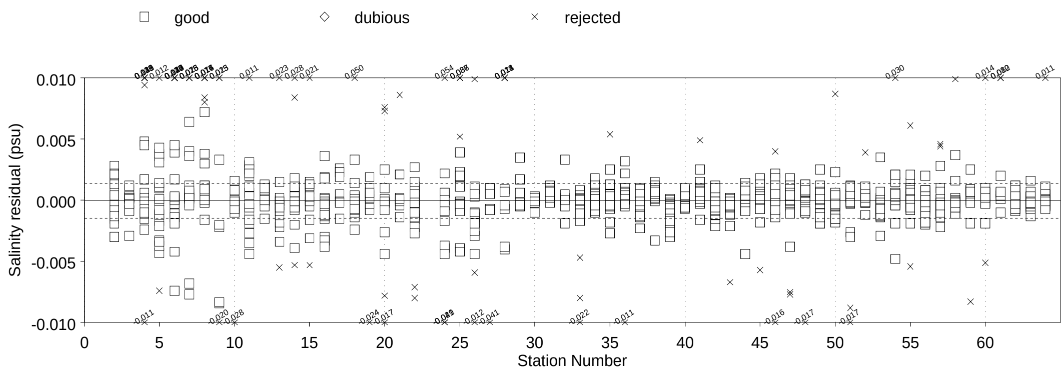
Calibration file : a0403.bot

Conductivity s.d. = 0.00002

Number of bottles used = 2164 out of 2470 Mean ratio for all bottles = 1.00000

<u>Figure 1.7a and b:</u> Conductivity ratio c_{btl}/c_{cal} versus station number for (a) cruise AU0304, and (b) cruise AU0403. The solid line follows the mean of the residuals for each station; the broken lines are $\pm$ the standard deviation of the residuals for each station. c_{cal} = calibrated CTD conductivity from the CTD upcast burst data; c_{btl} = 'in situ' Niskin bottle conductivity, found by using CTD pressure and temperature from the CTD upcast burst data in the conversion of Niskin bottle salinity to conductivity.

(a)



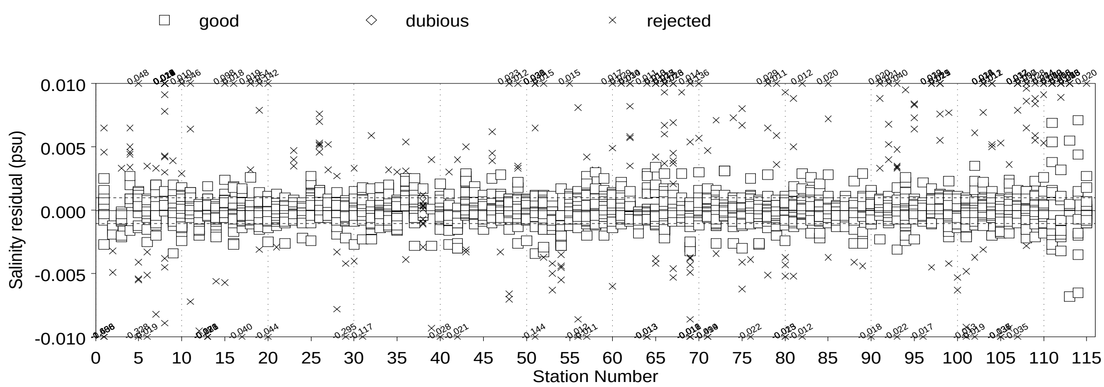
Calibration data for cruise : au0304

Calibration file : a0304.bot

Mean offset salinity = -0.0001psu (s.d. = 0.0014 psu)

Number of bottles used = 967 out of 1054

(b)



Calibration data for cruise : au0403

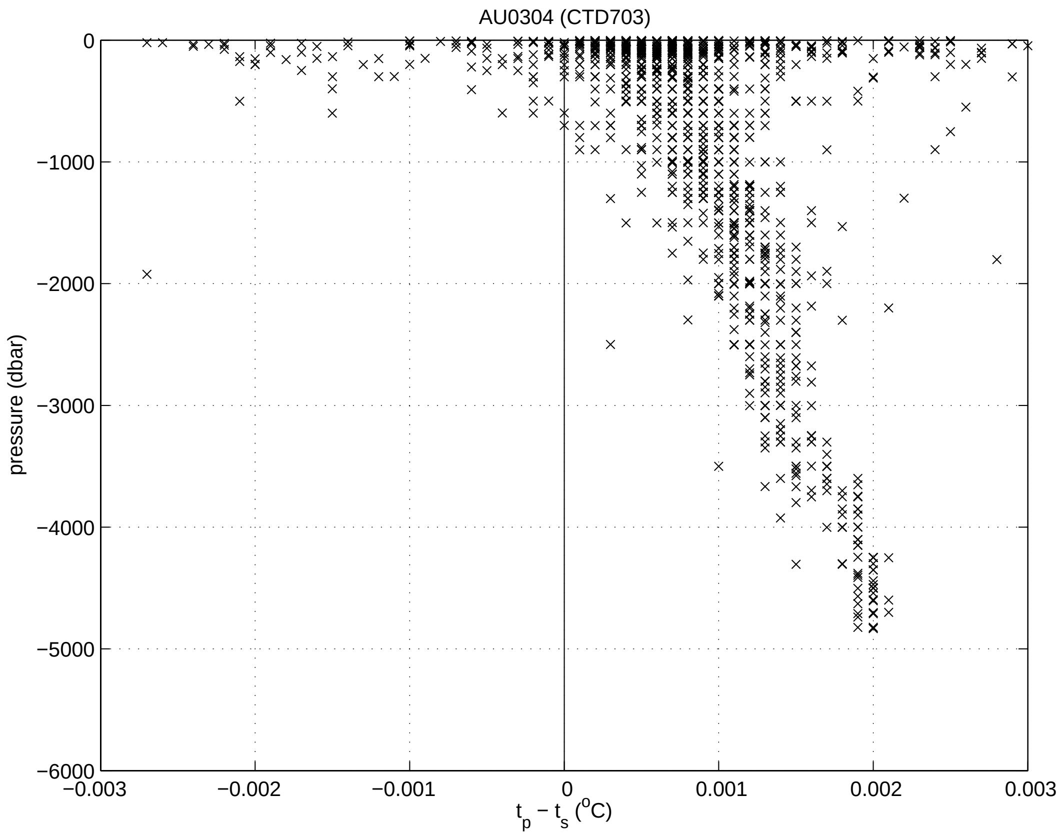
Calibration file : a0403.bot

Mean offset salinity = 0.0000psu (s.d. = 0.0010 psu)

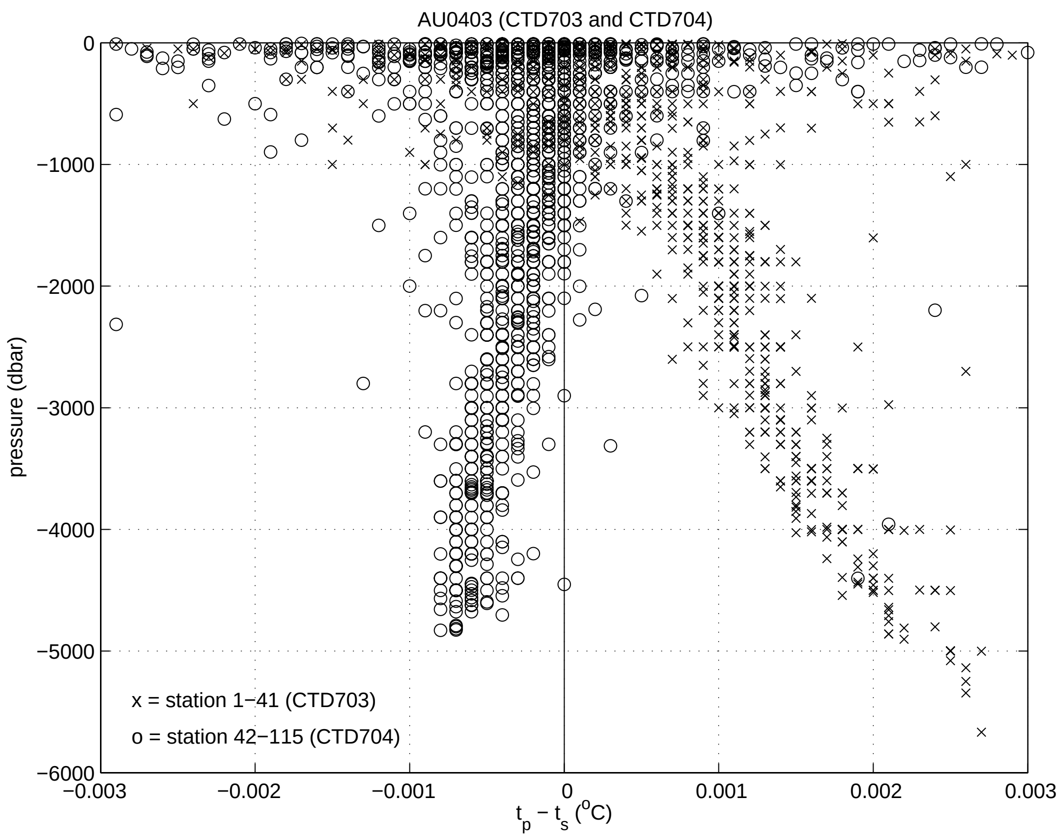
Number of bottles used = 2164 out of 2470

<u>Figure 1.8a and b:</u> Salinity residual (s_{btl} - s_{cal}) versus station number for (a) cruise AU0304, and (b) cruise AU0403. The solid line is the mean of all the residuals; the broken lines are $\pm$ the standard deviation of all the residuals. s_{cal} = calibrated CTD salinity; s_{btl} = Niskin bottle salinity value.

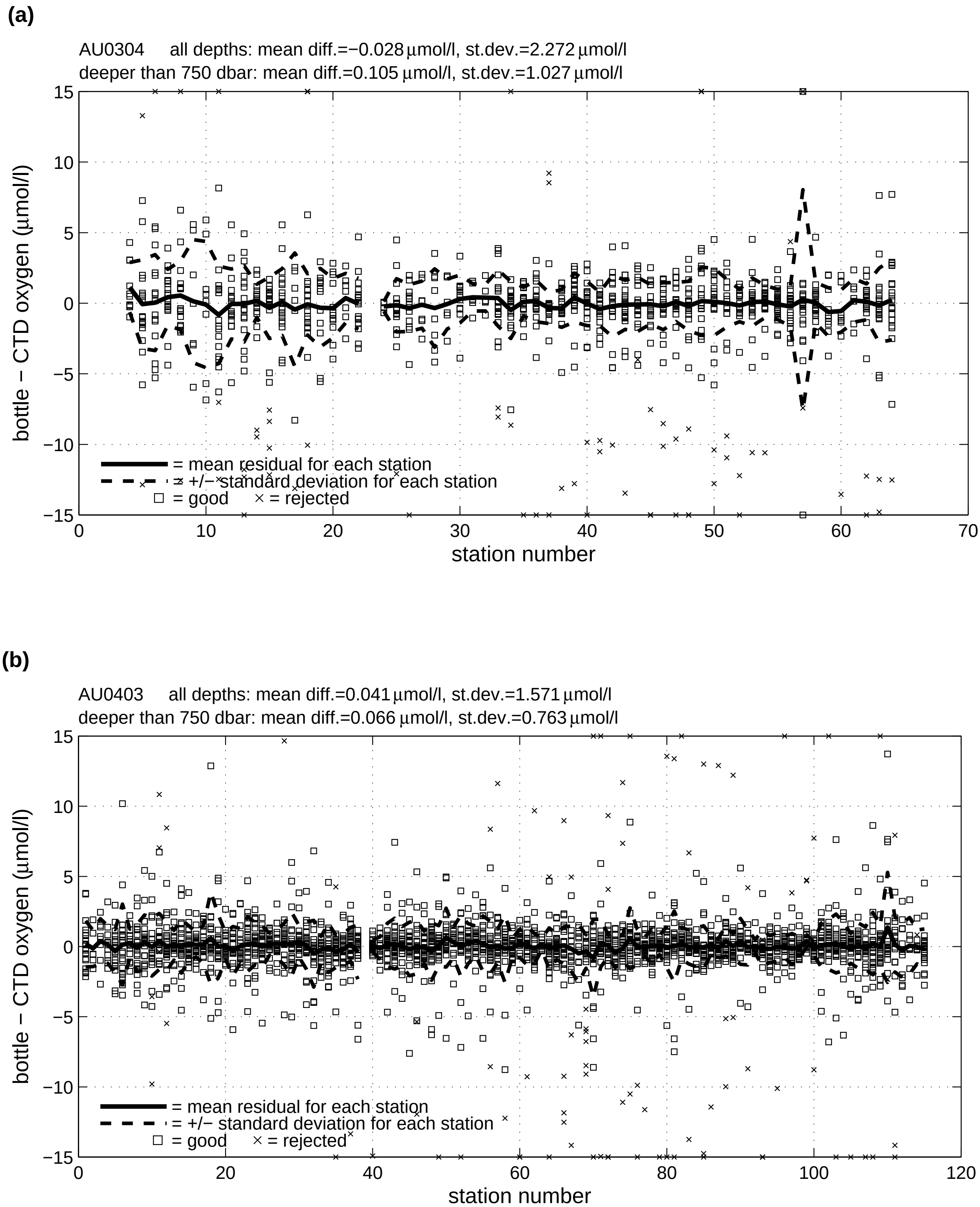
(a)



(b)

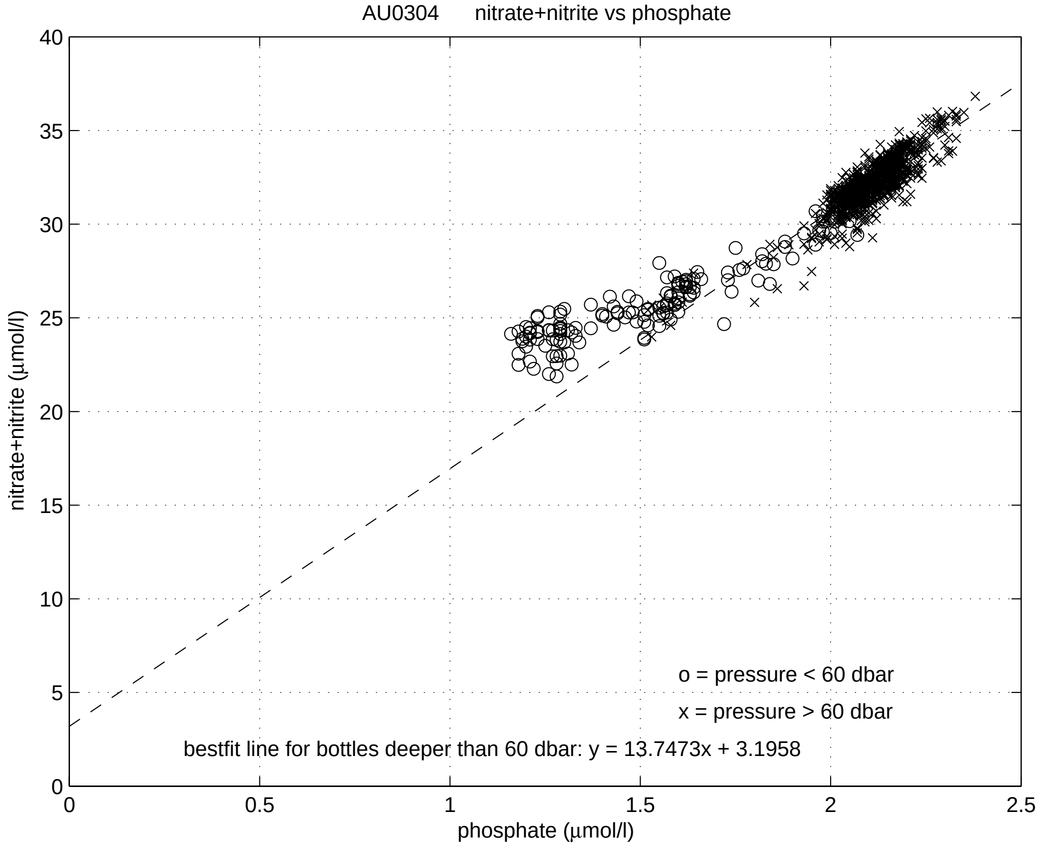


<u>Figure 1.9:</u> Difference between primary and secondary temperature sensor (t_p - t_s) for CTD upcast burst data from Niskin bottle stops, for (a) cruise AU0304, and (b) cruise AU0403.



<u>Figure 1.10a and b:</u> Dissolved oxygen residual (o_{btl} - o_{cal}) versus station number for (a) cruise AU0304, and (b) cruise AU0403. The solid line follows the mean residual for each station; the broken lines are ± the standard deviation of the residuals for each station. o_{cal}=calibrated downcast CTD dissolved oxygen; o_{btl}=Niskin bottle dissolved oxygen value. Note: values outside vertical axes plotted on axes limits.

(a)



(b)

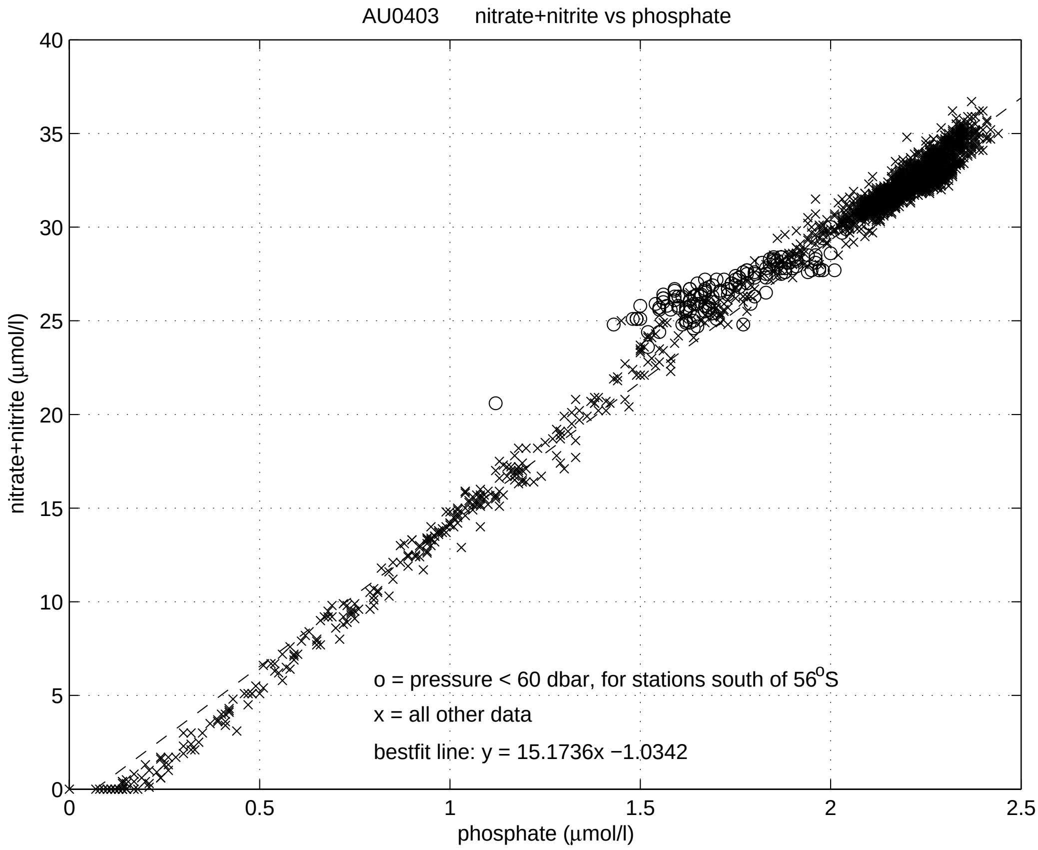


Figure 1.11: Nitrate+nitrite versus phosphate data for AU0304 and AU0403.

<u>Table 1.10:</u> Calibration coefficients and calibration dates for CTD's used during cruises AU0304 and AU0403. Note that platinum temperature calibrations are for the ITS-90 scale.

AU0304, CTD serial number 703 (all calibrations supplied by manufacturer)

Primary Temperature, serial 4208, 18/09/2002

coefficient	value of coefficient
G	: 4.36431101e-003
H	: 6.46864899e-004
I	: 2.24097114e-005
J	: 1.78556443e-006
F0	: 1000.000
Slope	: 1.00000000
Offset	: 0.0000

Secondary Temperature, serial 4245, 04/09/2002

coefficient	value of coefficient
G	: 4.38201522e-003
H	: 6.45520809e-004
I	: 2.25045727e-005
J	: 1.85646207e-006
F0	: 1000.000
Slope	: 1.00000000
Offset	: 0.0000

Primary Conductivity, serial 2788, 18/09/2002

coefficient	value of coefficient
G	: -9.73289151e+000
H	: 1.43026028e+000
I	: -1.27776424e-003
J	: 1.76869992e-004
CTcor	: 3.2500e-006
CPcor	: -9.57000000e-008
Slope	: 1.00000000
Offset	: 0.00000

Secondary Conductivity, serial 2821, 24/09/2002

coefficient	value of coefficient
G	: -1.05979689e+001
H	: 1.43865878e+000
I	: -4.12365989e-004
J	: 1.06979561e-004
CTcor	: 3.2500e-006
CPcor	: -9.57000000e-008
Slope	: 1.00000000
Offset	: 0.00000

Pressure, serial 88903, 22/03/2002

coefficient	value of coefficient
C1	: -4.989485e+004
C2	: -1.030675e+000
C3	: 1.388810e-002
D1	: 3.863300e-002
D2	: 0.000000e+000
T1	: 3.010350e+001
T2	: -5.657137e-004
T3	: 3.998260e-006
T4	: 2.345400e-009
T5	: 0.000000e+000
Slope	: 1.00000000
Offset	: 0.40000
AD590M	: 1.276320e-002
AD590B	: -9.834109e+000

Oxygen, serial 0191, 24/09/2002

coefficient	value of coefficient
Soc	: 4.7260e-001
Boc	: 0.0000
Offset	: -0.4841
Tcor	: 0.0046
Pcor	: 1.35e-004
Tau	: 0.0

Fluorometer, serial 013, 27/11/2002

coefficient	value of coefficient
Vblank	: 0.0970
Scale factor	: 1.28667000e+001

AU0403, CTD serial number 703 (all calibrations supplied by manufacturer)

Primary Temperature, serial 4208, 23/07/2004

coefficient	value of coefficient
G	: 4.36424125e-003
H	: 6.46711671e-004
I	: 2.23037791e-005
J	: 1.76166534e-006
F0	: 1000.000
Slope	: 1.00000000
Offset	: 0.0000

Secondary Temperature, serial 4245, 23/07/2004

coefficient	value of coefficient
G	: 4.38186967e-003
H	: 6.45201467e-004
I	: 2.22699049e-005
J	: 1.80088365e-006
F0	: 1000.000
Slope	: 1.00000000
Offset	: 0.0000

Primary Conductivity, serial 2788, 23/07/2004

coefficient	value of coefficient
G	: -9.73488518e+000
H	: 1.42981499e+000
I	: -9.36650117e-004
J	: 1.55796390e-004
CTcor	: 3.2500e-006
CPcor	: -9.57000000e-008
Slope	: 1.00000000
Offset	: 0.00000

Secondary Conductivity, serial 2821, 23/07/2004

coefficient	value of coefficient
G	: -1.05940111e+001
H	: 1.43567822e+000
I	: 6.80159176e-004
J	: 3.43281772e-005
CTcor	: 3.2500e-006
CPcor	: -9.57000000e-008
Slope	: 1.00000000
Offset	: 0.00000

Table 1.10: **(continued)**

coefficient	value of coefficient	coefficient	value of coefficient
AU0403, CTD serial number 703 (continued)			
Pressure, serial 88903, 23/07/2004		*Oxygen, serial 0191, 11/08/2004*	
C1	: -4.989485e+004	Soc	: 4.7130e-001
C2	: -1.030675e+000	Boc	: 0.0000
C3	: 1.388810e-002	Offset	: -0.4921
D1	: 3.863300e-002	Tcor	: 0.0012
D2	: 0.000000e+000	Pcor	: 1.35e-004
T1	: 3.010350e+001	Tau	: 0.0
T2	: -5.657137e-004		
T3	: 3.998260e-006	*Fluorometer, serial 013, 27/11/2002*	
T4	: 2.345400e-009	Vblank	: 0.0970
T5	: 0.000000e+000	Scale factor	: 1.28667000e+001
Slope	: 1.00013000		
Offset	: -0.14160		
AD590M	: 1.276320e-002		
AD590B	: -9.834109e+000		
AU0403, CTD serial number 704 (all calibrations supplied by manufacturer)			
Primary Temperature, serial 4248, 04/08/2004		*Secondary Temperature, serial 4246, 23/07/2004*	
G	: 4.38733870e-003	G	: 3.97919382e-003
H	: 6.51075969e-004	H	: 6.21868034e-004
I	: 2.33753796e-005	I	: 1.87739784e-005
J	: 1.88807486e-006	J	: 1.60756924e-006
F0	: 1000.000	F0	: 1000.000
Slope	: 1.00000000	Slope	: 1.00000000
Offset	: 0.0000	Offset	: 0.0000
Primary Conductivity, serial 2977, 29/07/2004		*Secondary Conductivity, serial 2808, 23/07/2004*	
G	: -1.07267718e+001	G	: -9.29883054e+000
H	: 1.48472457e+000	H	: 1.43077133e+000
I	: 3.84843342e-006	I	: -1.73862736e-003
J	: 7.45463011e-005	J	: 2.09562861e-004
CTcor	: 3.2500e-006	CTcor	: 3.2500e-006
CPcor	: -9.57000000e-008	CPcor	: -9.57000000e-008
Slope	: 1.00000000	Slope	: 1.00000000
Offset	: 0.00000	Offset	: 0.00000
Pressure, serial 89084, 23/07/2004		*Oxygen, serial 0178, 26/07/2004*	
C1	: -5.337692e+004	Soc	: 5.2230e-001
C2	: -5.768735e-001	Boc	: 0.0000
C3	: 1.541700e-002	Offset	: -0.4914
D1	: 3.853800e-002	Tcor	: 0.0021
D2	: 0.000000e+000	Pcor	: 1.35e-004
T1	: 2.984003e+001	Tau	: 0.0
T2	: -4.090591e-004		
T3	: 3.693030e-006	*Fluorometer, serial 013, 27/11/2002*	
T4	: 3.386020e-009	Vblank	: 0.0970
T5	: 0.000000e+000	Scale factor	: 1.28667000e+001
Slope	: 1.00002000		
Offset	: -0.2038		
AD590M	: 1.283280e-002		
AD590B	: -9.705663e+000		

<u>Table 1.11:</u> Surface pressure offsets (i.e. poff, in dbar). For each station, these values are subtracted from the pressure calibration "offset" value from Table 1.10.

stn	poff	stn	poff	stn	poff	stn	poff	stn	poff	stn	poff
AU0304											
1	0.40	12	0.54	23	0.49	34	0.75	45	0.84	56	0.51
2	0.61	13	0.63	24	0.60	35	0.76	46	0.78	57	0.58
3	0.54	14	0.52	25	0.80	36	0.43	47	0.71	58	0.41
4	0.38	15	0.56	26	0.73	37	0.45	48	0.60	59	0.70
5	0.56	16	0.65	27	0.49	38	0.59	49	0.51	60	0.73
6	0.62	17	0.62	28	0.52	39	0.50	50	0.58	61	0.70
7	0.63	18	0.60	29	0.58	40	0.58	51	0.56	62	0.20
8	0.62	19	0.78	30	0.50	41	0.58	52	0.54	63	0.51
9	0.50	20	0.72	31	0.61	42	0.60	53	0.42	64	0.55
10	0.45	21	0.74	32	0.58	43	0.75	54	0.55		
11	0.48	22	0.73	33	0.59	44	0.68	55	0.69		
AU0403											
1	-0.23	21	-0.39	41	-0.46	61	-0.71	81	-0.72	101	-0.84
2	-0.35	22	-0.31	42	-0.57	62	-0.75	82	-0.63	102	-0.91
3	-0.31	23	-0.38	43	-0.70	63	-0.62	83	-0.65	103	-0.81
4	-0.32	24	-0.51	44	-0.70	64	-0.67	84	-0.57	104	-0.92
5	-0.39	25	-0.47	45	-0.68	65	-0.76	85	-0.90	105	-0.85
6	-0.31	26	-0.49	46	-0.78	66	-0.77	86	-0.65	106	-0.77
7	-0.33	27	-0.47	47	-0.69	67	-0.77	87	-0.70	107	-0.80
8	-0.29	28	-0.56	48	-0.91	68	-0.85	88	-0.72	108	-0.84
9	-0.38	29	-0.53	49	-0.88	69	-0.82	89	-0.75	109	-0.80
10	-0.33	30	-0.55	50	-0.96	70	-0.91	90	-0.65	110	-0.80
11	-0.31	31	-0.55	51	-0.93	71	-0.94	91	-0.66	111	-0.76
12	-0.42	32	-0.41	52	-0.98	72	-0.85	92	-0.65	112	-0.78
13	-0.40	33	-0.41	53	-0.88	73	-0.98	93	-0.65	113	-0.76
14	-0.44	34	-0.47	54	-0.88	74	-0.90	94	-0.65	114	-0.67
15	-0.39	35	-0.43	55	-0.91	75	-0.95	95	-0.54	115	-0.50
16	-0.41	36	-0.53	56	-0.85	76	-0.97	96	-0.70		
17	-0.37	37	-0.60	57	-0.79	77	-0.75	97	-0.70		
18	-0.32	38	-0.54	58	-0.80	78	-0.81	98	-0.78		
19	-0.25	39	-0.36	59	-0.74	79	-0.80	99	-0.81		
20	-0.30	40	-0.50	60	-0.75	80	-0.92	100	-0.90		

<u>Table 1.12:</u> 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.

stn grouping	F_1	F_2	F_3	n	σ
AU0304					
001 to 005	0.26824171E-01	0.99934872E-03	-0.40325085E-07	64	0.001526
006 to 011	0.31760098E-01	0.99902297E-03	0.48684554E-08	68	0.002284
012 to 017	0.72281193E-02	0.99978699E-03	0.10257699E-07	92	0.000972
018 to 022	0.15168448E-01	0.99975290E-03	-0.53038789E-08	62	0.000890
023 to 037	0.91014635E-02	0.99991884E-03	-0.51725072E-09	162	0.000733
038 to 041	-0.21634762E-01	0.10004787E-02	0.99194221E-08	75	0.000624
042 to 053	-0.28794659E-02	0.10003642E-02	-0.13906388E-08	221	0.000603
054 to 061	0.64509870E-02	0.99993332E-03	0.12626363E-08	128	0.000689
062 to 064	-0.12962177E-01	0.10008478E-02	-0.34637609E-08	64	0.000392
AU0403					
001 to 012	0.36219872E-03	0.10000481E-02	-0.71998658E-08	172	0.001039
013 to 042	-0.45210967E-02	0.10001321E-02	0.81030400E-09	544	0.000617
043 to 047	-0.97050752E-02	0.10005678E-02	-0.53223310E-08	106	0.000447
048 to 060	0.43608906E-02	0.99991775E-03	-0.13633889E-08	264	0.000645
061 to 080	0.76180204E-02	0.99975569E-03	-0.14602137E-09	342	0.000543
081 to 100	0.13750652E-02	0.99993603E-03	0.50105062E-09	379	0.000485
101 to 110	0.15500617E-01	0.99975569E-03	-0.24143746E-08	196	0.000715
111 to 115	0.11337715E-02	0.10009367E-02	-0.81076349E-08	60	0.001910

Table 1.13: **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.**

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station number	($F_2 + F_3 . N$)	station number	($F_2 + F_3 . N$)	station number	($F_2 + F_3 . N$)	station number	($F_2 + F_3 . N$)
1	0.99930839E-03	17	0.99994624E-03	33	0.99992059E-03	49	0.10002536E-02
2	0.99926807E-03	18	0.99960116E-03	34	0.99991854E-03	50	0.10002521E-02
3	0.99922774E-03	19	0.99959536E-03	35	0.99991648E-03	51	0.10002506E-02
4	0.99918742E-03	20	0.99958957E-03	36	0.99991443E-03	52	0.10002491E-02
5	0.99914709E-03	21	0.99958377E-03	37	0.99991237E-03	53	0.10002476E-02
6	0.99905218E-03	22	0.99957797E-03	38	0.10007687E-02	54	0.99987974E-03
7	0.99905705E-03	23	0.99994114E-03	39	0.10007757E-02	55	0.99987824E-03
8	0.99906192E-03	24	0.99993909E-03	40	0.10007827E-02	56	0.99987674E-03
9	0.99906679E-03	25	0.99993703E-03	41	0.10007897E-02	57	0.99987523E-03
10	0.99907166E-03	26	0.99993498E-03	42	0.10002640E-02	58	0.99987373E-03
11	0.99907653E-03	27	0.99993292E-03	43	0.10002625E-02	59	0.99987222E-03
12	0.99989590E-03	28	0.99993087E-03	44	0.10002610E-02	60	0.99987072E-03
13	0.99990597E-03	29	0.99992881E-03	45	0.10002595E-02	61	0.99986922E-03
14	0.99991604E-03	30	0.99992676E-03	46	0.10002580E-02	62	0.10007126E-02
15	0.99992611E-03	31	0.99992470E-03	47	0.10002566E-02	63	0.10007090E-02
16	0.99993617E-03	32	0.99992265E-03	48	0.10002551E-02	64	0.10007054E-02

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station number	($F_2 + F_3 . N$)	station number	($F_2 + F_3 . N$)	station number	($F_2 + F_3 . N$)	station number	($F_2 + F_3 . N$)
1	0.10000409E-02	30	0.10001715E-02	59	0.99976759E-03	88	0.99999276E-03
2	0.10000337E-02	31	0.10001725E-02	60	0.99976555E-03	89	0.99999336E-03
3	0.10000265E-02	32	0.10001734E-02	61	0.99972952E-03	90	0.99999396E-03
4	0.10000193E-02	33	0.10001744E-02	62	0.99972967E-03	91	0.99999457E-03
5	0.10000121E-02	34	0.10001753E-02	63	0.99972983E-03	92	0.99999517E-03
6	0.10000049E-02	35	0.10001763E-02	64	0.99972998E-03	93	0.99999577E-03
7	0.99999772E-03	36	0.10001773E-02	65	0.99973013E-03	94	0.99999638E-03
8	0.99999052E-03	37	0.10001782E-02	66	0.99973029E-03	95	0.99999698E-03
9	0.99998332E-03	38	0.10001792E-02	67	0.99973044E-03	96	0.99999758E-03
10	0.99997612E-03	39	0.10001801E-02	68	0.99973059E-03	97	0.99999819E-03
11	0.99996893E-03	40	0.10001811E-02	69	0.99973074E-03	98	0.99999879E-03
12	0.99996173E-03	41	0.10001820E-02	70	0.99973090E-03	99	0.99999939E-03
13	0.10001552E-02	42	0.10001830E-02	71	0.99973105E-03	100	0.99999999E-03
14	0.10001562E-02	43	0.10005414E-02	72	0.99973120E-03	101	0.99961286E-03
15	0.10001572E-02	44	0.10005382E-02	73	0.99973136E-03	102	0.99961083E-03
16	0.10001581E-02	45	0.10005350E-02	74	0.99973151E-03	103	0.99960881E-03
17	0.10001591E-02	46	0.10005318E-02	75	0.99973166E-03	104	0.99960678E-03
18	0.10001600E-02	47	0.10005285E-02	76	0.99973182E-03	105	0.99960475E-03
19	0.10001610E-02	48	0.99979003E-03	77	0.99973197E-03	106	0.99960273E-03
20	0.10001619E-02	49	0.99978799E-03	78	0.99973212E-03	107	0.99960070E-03
21	0.10001629E-02	50	0.99978595E-03	79	0.99973228E-03	108	0.99959867E-03
22	0.10001639E-02	51	0.99978391E-03	80	0.99973243E-03	109	0.99959665E-03
23	0.10001648E-02	52	0.99978187E-03	81	0.99998853E-03	110	0.99959462E-03
24	0.10001658E-02	53	0.99977983E-03	82	0.99998914E-03	111	0.10000368E-02
25	0.10001667E-02	54	0.99977779E-03	83	0.99998974E-03	112	0.10000287E-02
26	0.10001677E-02	55	0.99977575E-03	84	0.99999034E-03	113	0.10000206E-02
27	0.10001686E-02	56	0.99977371E-03	85	0.99999095E-03	114	0.10000125E-02
28	0.10001696E-02	57	0.99977167E-03	86	0.99999155E-03	115	0.10000044E-02
29	0.10001706E-02	58	0.99976963E-03	87	0.99999215E-03		

Table 1.14: Missing data points in 2 dbar-averaged files. "1" indicates missing data for the indicated parameters: T=temperature; S=salinity and conductivity; O=oxygen; F=fluorescence.

station no.	pressure (dbar) where data missing	T	S	O	F
AU0304					
1-3	whole station			1	
4	2-118			1	
6	2-12			1	
11-12	2	1	1	1	1
14	2	1	1	1	1
18	2	1	1	1	1
23	2-44			1	
24	2	1	1	1	1
24	52-1936			1	
26	2-24	1	1	1	1
28	2	1	1	1	1
28	180-606		1		
29	2	1	1	1	1
35	2	1	1	1	1
39	2	1	1	1	1
41-42	2	1	1	1	1
50	2	1	1	1	1
52	2	1	1	1	1
52	1862				1
56	1000-1002			1	
56	1004	1	1	1	1
58	2-150			1	
59	2-98			1	
AU0403					
1	2-4	1	1	1	1
2	2	1	1	1	1
3	2-6	1	1	1	1
4-5	2-4	1	1	1	1
6	2, 888-890	1	1	1	1
7	2-4, 162, 174-176	1	1	1	1
7	3222-5180			1	
8	2	1	1	1	1
9	2-4	1	1	1	1
9	222-246		1		
11	2-4	1	1	1	1
11	208-218		1		
12	2-4, 4910	1	1	1	1
13	2	1	1	1	1
14	2-4	1	1	1	1
14	202-224		1		
15-18	2	1	1	1	1
19	2-4	1	1	1	1
20	2-8	1	1	1	1
21	2, 4474	1	1	1	1
22	2-20	1	1	1	1
23	2-8	1	1	1	1
24	2	1	1	1	1
26	2-6	1	1	1	1
27	2-4	1	1	1	1
28-29	2	1	1	1	1
30	2-4	1	1	1	1
31	2-8	1	1	1	1
32	2	1	1	1	1
33-34	2-4	1	1	1	1
35-38	2	1	1	1	1
38	4-78			1	
39	2-12	1	1	1	1
39	whole station			1	

Table 1.14: **(continued)**

station no.	pressure (dbar) where data missing	T	S	O	F
40	2-4	1	1	1	1
41	2	1	1	1	1
41	4-342			1	
42-43	2-4	1	1	1	1
44	2	1	1	1	1
44	4396-4484			1	
45-46	2-4	1	1	1	1
47	2-6	1	1	1	1
48	2	1	1	1	1
49	2-8	1	1	1	1
50-52	2-4	1	1	1	1
51	6-100			1	
53	2-6	1	1	1	1
54	2-4	1	1	1	1
55	2-8	1	1	1	1
56	2-6	1	1	1	1
57	2	1	1	1	1
58	2-6	1	1	1	1
59	2-6, 3596	1	1	1	1
60	2-4	1	1	1	1
61	2	1	1	1	1
62	2-6	1	1	1	1
63	2-4	1	1	1	1
63	6-984			1	
64	2-4	1	1	1	1
65	2	1	1	1	1
66	2-4	1	1	1	1
67	2	1	1	1	1
68	2-4	1	1	1	1
68	6-296			1	
69-70	2-4	1	1	1	1
71	2-12	1	1	1	1
72-78	2-4	1	1	1	1
73	6-478			1	
80-81	2-4	1	1	1	1
82	2-10	1	1	1	1
83	2-4	1	1	1	1
84	2-8	1	1	1	1
85	2-4	1	1	1	1
86-87	2-8	1	1	1	1
88	2-4	1	1	1	1
89	2-8	1	1	1	1
90-92	2-4	1	1	1	1
93-95	2-8	1	1	1	1
96-97	2-4	1	1	1	1
98	2-8, 1998	1	1	1	1
99	2-10	1	1	1	1
100	2-8	1	1	1	1
101	2	1	1	1	1
102	2-4	1	1	1	1
103	2-6	1	1	1	1
104-105	2-8	1	1	1	1
106	2	1	1	1	1
107	2-4	1	1	1	1
109-111	2-8	1	1	1	1
112	2-12	1	1	1	1
113	2	1	1	1	1
114	2-4	1	1	1	1
115	2-4	1	1	1	1
115	whole station				1

<u>Table 1.15:</u> Suspect CTD 2 dbar averages (not deleted from the CTD 2dbar average files) for the indicated parameters: T=temperature; S=salinity and conductivity; O=oxygen; F=fluorsecence.

station number	questionable 2 dbar value(dbar)	parameters
AU0304		
5	2-46	O
8	2-10	O
10	2-30	O
11	2-24	O
12	2-44	O
15	2	S
18	2-50	O
25	2	S
26	26-40	O
36	2	S
48	2	S
AU0403		
29	whole station	F

<u>Table 1.16a:</u> Suspect nutrient sample values (not deleted from bottle data file) for cruise AU0304, out by ~2 to 4% of full scale value. Note additionally that from intercruise comparisons, AU0304 phosphates appear to be mostly low by ~2 to 4%.

PHOSPHATE		NITRATE		SILICATE	
station number	rosette position	station number	rosette position	station number	rosette position
		5	whole station		
		6	whole station		
11	15				
		17	whole station		
		20	5		
		30	17		
		33	1,4,9,15		
		34	4		
		35	whole station		
		36	5,6		
		38	18		
		39	6,9		
		40	5,11		
		44	6,9		
		45	5		
		47	whole station		
		49	whole station		
50	5	50	whole station		
		51	4,5		
		54	3,8		
55	5	55	1		
		58	whole station		
63	11				

Table 1.16b: Suspect nutrient sample values (not deleted from bottle data file) for cruise AU0403. Note: listing is by rosette position, not Niskin bottle number.

PHOSPHATE		NITRATE		SILICATE	
station number	rosette position	station number	rosette position	station number	rosette position
				11	4
				12	6
		13	9		
24	20				
				37	10
40	9				
				42	3
		48	19		
50	17	50	2,3,15	50	12
				56	7,8
				65	15
90	9				
		102	8		
		103	3		
		105	1	105	12
		106	7,15		

Table 1.17: Suspect dissolved oxygen bottle values (not deleted from bottle data file).

station number	rosette position
AU0304	
11	21
60	1
AU0403	
48	24

Table 1.18a: CTD dissolved oxygen calibration coefficients for cruise AU0304: slope, bias, tcor (= temperature correction term), and pcor (= pressure correction term). dox is equal to 2.8σ , for σ as defined in Appendix 1.2. Note that coefficients are given for both the shallow and deep part of the profile, according to the profile split used for calibration (see Appendix 1.2 for methodology).

	----------shallow----------					----------deep----------				
stn	slope	bias	tcor	pcor	dox	slope	bias	tcor	pcor	dox
1	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-
4	0.164465	0.434553	-0.020273	0.000030	0.111125	0.164465	0.434553	-0.020273	0.000030	0.111125
5	0.591783	-0.478937	0.021298	0.000174	0.206837	0.199493	0.253860	-0.126415	0.000065	0.032301
6	0.483370	-0.266693	-0.015773	0.000141	0.221302	0.414866	-0.091854	-0.065904	0.000074	0.042642
7	0.565883	-0.413125	0.013840	0.000169	0.147084	0.534069	-0.274655	-0.087431	0.000069	0.027401
8	0.747892	-0.784341	0.026249	0.000275	0.159305	0.564617	-0.245300	-0.222759	0.000003	0.058158
9	0.620084	-0.515371	0.002871	0.000120	0.253182	0.620084	-0.515371	0.002871	0.000120	0.253182
10	0.797408	-0.867825	0.042757	0.000294	0.281813	0.797408	-0.867825	0.042757	0.000294	0.281813
11	0.840665	-1.019923	-0.000941	0.000741	0.238001	0.840665	-1.019923	-0.000941	0.000741	0.238001
12	0.254008	0.215361	-0.090502	0.000028	0.172637	0.706026	-0.585963	0.037058	0.000109	0.109880
13	0.648545	-0.551958	0.017475	0.000186	0.182479	0.712024	-0.495660	-0.146131	0.000034	0.024061
14	0.706402	-0.679651	-0.000525	0.000080	0.086629	0.706402	-0.679651	-0.000525	0.000080	0.086629
15	0.316592	0.225089	0.054649	0.000065	0.111702	0.316592	0.225089	0.054649	0.000065	0.111702
16	0.694956	-0.630198	0.016248	0.000161	0.153623	0.694956	-0.630198	0.016248	0.000161	0.153623
17	0.826580	-0.912457	0.013722	0.000415	0.231529	0.826580	-0.912457	0.013722	0.000415	0.231529
18	0.506080	-0.298977	-0.016447	0.000138	0.067146	0.704009	-0.594369	-0.023405	0.000100	0.078726
19	0.781771	-0.840607	0.004906	0.000326	0.137162	0.781771	-0.840607	0.004906	0.000326	0.137162
20	0.618077	-0.509751	0.043047	0.000192	0.127267	0.618077	-0.509751	0.043047	0.000192	0.127267
21	0.411513	0.019539	0.047804	0.000087	0.106108	0.411513	0.019539	0.047804	0.000087	0.106108
22	0.698139	-0.623850	0.012253	0.000168	0.135608	1.008015	-1.086143	-0.128956	0.000034	0.064799
23	-	-	-	-	-	-	-	-	-	-
24	0.730531	-0.699200	0.029755	0.001292	0.023989	0.698416	-0.602454	0.019449	0.000134	0.051476
25	0.719139	-0.680359	0.006835	0.000244	0.113209	0.719139	-0.680359	0.006835	0.000244	0.113209
26	0.892388	-1.010245	0.020243	0.000426	0.100122	0.892388	-1.010245	0.020243	0.000426	0.100122
27	0.712366	-0.637307	0.018220	0.000185	0.097229	0.712366	-0.637307	0.018220	0.000185	0.097229
28	0.736709	-0.670287	0.006560	0.000093	0.177979	0.736709	-0.670287	0.006560	0.000093	0.177979
29	0.801689	-0.797691	0.009859	0.000218	0.102628	0.801689	-0.797691	0.009859	0.000218	0.102628
30	0.712044	-0.624114	-0.002095	0.000148	0.103813	1.282525	-1.676573	0.329698	0.000332	0.026386
31	0.786994	-0.826490	0.002738	0.000414	0.062255	0.786994	-0.826490	0.002738	0.000414	0.062255
32	0.785535	-0.822121	0.003683	0.000401	0.063664	0.785535	-0.822121	0.003683	0.000401	0.063664
33	0.628794	-0.476235	0.004340	0.000148	0.188891	0.508064	-0.288628	0.047871	0.000118	0.046844
34	0.538314	-0.354858	0.053439	0.000144	0.108975	0.560588	-0.340210	0.000372	0.000102	0.035858
35	0.594355	-0.408541	0.013758	0.000117	0.088204	0.580283	-0.394331	0.033635	0.000117	0.030665
36	0.632093	-0.431718	-0.010804	0.000102	0.100138	0.463238	-0.169716	0.005093	0.000085	0.017513
37	0.620869	-0.445488	0.036509	0.000121	0.089635	0.466477	-0.166484	-0.003569	0.000081	0.016934
38	0.636835	-0.469608	0.013746	0.000120	0.118347	0.474856	-0.201355	0.008722	0.000091	0.023035
39	0.634398	-0.446498	0.008881	0.000111	0.134757	0.673711	-0.539202	0.045459	0.000131	0.036286
40	0.630468	-0.447082	-0.006792	0.000115	0.106360	0.618746	-0.441339	0.021675	0.000115	0.040158
41	0.481707	-0.310467	0.071194	0.000172	0.133679	0.618096	-0.464283	0.040371	0.000129	0.034260
42	0.578361	-0.417485	0.029807	0.000148	0.188705	0.701665	-0.597057	0.035186	0.000142	0.037021
43	0.614754	-0.444552	0.016952	0.000124	0.136641	0.571559	-0.372529	0.016964	0.000113	0.051503
44	0.638302	-0.520284	0.057262	0.000183	0.141687	0.598007	-0.403376	0.023015	0.000115	0.024050
45	0.628812	-0.508133	0.052525	0.000181	0.107167	0.794380	-0.707851	0.011249	0.000130	0.017285
46	0.621056	-0.501226	0.049831	0.000204	0.125788	0.596839	-0.406052	0.022117	0.000117	0.019175
47	0.632124	-0.499421	0.026768	0.000190	0.103366	0.521464	-0.442252	0.145860	0.000299	0.013560
48	0.652279	-0.562205	0.038681	0.000245	0.155750	0.797417	-0.703913	-0.005566	0.000127	0.014116
49	0.558937	-0.488090	0.125640	0.000299	0.155283	0.797243	-0.704198	-0.002106	0.000126	0.016200
50	0.666948	-0.541150	0.027069	0.000158	0.159580	0.595568	-0.406992	0.022675	0.000119	0.017310
51	0.662750	-0.500146	0.014725	0.000118	0.131057	0.394650	-0.108807	0.041633	0.000112	0.028019
52	0.661303	-0.537564	0.042947	0.000150	0.072802	0.394670	-0.108757	0.041353	0.000110	0.031043
53	0.672956	-0.551897	0.050186	0.000132	0.139343	0.708890	-0.586981	0.026370	0.000127	0.030298
54	0.630695	-0.491693	0.042219	0.000148	0.097875	0.507536	-0.289908	0.057826	0.000118	0.034234
55	0.615743	-0.537644	0.119796	0.000209	0.092330	0.517412	-0.273392	0.011453	0.000098	0.038544
56	0.707454	-0.746200	0.207747	0.000310	0.100185	0.807623	-0.681252	-0.019230	0.000096	0.042046
57	0.774917	-0.762243	0.096391	0.000217	0.087275	0.056481	0.530054	-0.063496	0.000020	0.089434
58	0.488164	-0.210709	-0.039804	0.000093	0.080119	0.734774	-0.610204	-0.075524	0.000103	0.044503
59	0.280125	0.173253	-0.081488	0.000033	0.111412	0.280125	0.173253	-0.081488	0.000033	0.111412
60	0.104132	0.866672	0.120603	0.000001	0.091614	0.104132	0.866672	0.120603	0.000001	0.091614
61	0.740391	-0.892195	-0.179166	0.000024	0.115308	0.740391	-0.892195	-0.179166	0.000024	0.115308
62	0.523299	-0.327477	0.049909	0.000145	0.127904	0.207066	0.247635	-0.009254	0.000051	0.041979
63	0.630011	-0.438406	0.016675	0.000106	0.244034	0.551870	-0.319826	0.019229	0.000100	0.036045
64	0.656355	-0.477715	0.001211	0.000112	0.174852	0.620450	-0.430754	0.013645	0.000110	0.046200

Table 1.18b: CTD dissolved oxygen calibration coefficients for cruise AU0403 (definitions as per Table 1.18a).

	shallow					deep				
stn	slope	bias	tcor	pcor	dox	slope	bias	tcor	pcor	dox
1	0.455224	-0.242060	0.008951	0.000287	0.111315	0.455224	-0.242060	0.008951	0.000287	0.111315
2	0.647529	-0.689988	0.009215	0.000270	0.088685	0.647529	-0.689988	0.009215	0.000270	0.088685
3	0.654540	-0.549864	0.000476	0.000059	0.098137	0.654540	-0.549864	0.000476	0.000059	0.098137
4	0.425036	-0.049252	0.002865	0.000034	0.074939	0.425036	-0.049252	0.002865	0.000034	0.074939
5	0.467746	-0.207165	0.006237	0.000177	0.112375	0.491721	-0.220927	0.006103	0.000133	0.033557
6	0.479152	-0.187529	0.003622	0.000128	0.142692	0.348902	-0.216781	0.133405	0.000303	0.079216
7	0.490931	-0.208037	0.003073	0.000138	0.068831	0.307821	0.009759	0.010005	0.000132	0.039836
8	0.579704	-0.278918	0.001755	0.000164	0.113936	0.389052	0.007181	-0.024681	0.000102	0.075983
9	0.571178	-0.233728	0.002752	0.000133	0.147652	0.552676	-0.152542	-0.037563	0.000108	0.042532
10	0.590116	-0.245772	0.002444	0.000137	0.140882	0.623528	-0.352290	0.049722	0.000183	0.044671
11	0.683350	-0.349296	-0.004127	0.000154	0.156095	0.721983	-0.441982	0.032029	0.000186	0.028380
12	0.643945	-0.293554	-0.000859	0.000146	0.161540	0.706982	-0.332937	-0.017208	0.000129	0.037702
13	0.697776	-0.352383	-0.004332	0.000152	0.080708	0.708435	-0.377599	0.010934	0.000154	0.026728
14	0.640653	-0.278001	-0.000312	0.000137	0.140627	0.657442	-0.366766	0.042733	0.000182	0.033512
15	0.654989	-0.299939	-0.000917	0.000145	0.094725	0.753871	-0.374546	-0.017601	0.000130	0.049476
16	0.686381	-0.319138	-0.004715	0.000131	0.072024	0.769820	-0.479334	0.028494	0.000186	0.009194
17	0.675952	-0.318696	-0.003485	0.000142	0.145403	0.747815	-0.405635	0.002753	0.000150	0.029861
18	0.684500	-0.334235	-0.003011	0.000149	0.133178	0.761064	-0.390680	-0.013598	0.000133	0.048750
19	0.726566	-0.375571	-0.006653	0.000149	0.135502	0.741702	-0.392567	-0.002360	0.000146	0.030577
20	0.699265	-0.352845	-0.004821	0.000159	0.081000	0.709094	-0.346311	-0.003694	0.000136	0.052106
21	0.636967	-0.231258	-0.003774	0.000090	0.129243	0.689579	-0.327512	-0.001874	0.000137	0.040089
22	0.698725	-0.345072	-0.004900	0.000150	0.086831	0.688278	-0.315222	-0.005983	0.000130	0.046434
23	0.699301	-0.350417	-0.005026	0.000154	0.149369	0.727160	-0.333541	-0.019721	0.000118	0.068561
24	0.713576	-0.352606	-0.006888	0.000137	0.103434	0.638471	-0.211756	-0.026440	0.000099	0.072375
25	0.672401	-0.304653	-0.003474	0.000131	0.096769	0.683019	-0.317936	-0.004166	0.000135	0.037279
26	0.700833	-0.340212	-0.005479	0.000138	0.062249	0.786165	-0.444992	-0.002732	0.000151	0.027413
27	0.706370	-0.359121	-0.004837	0.000157	0.076687	0.681482	-0.337050	0.010007	0.000145	0.037868
28	0.696476	-0.331940	-0.005645	0.000132	0.075092	0.690826	-0.281713	-0.025473	0.000109	0.034746
29	0.718616	-0.367561	-0.006348	0.000151	0.139418	0.590611	-0.216612	0.001489	0.000129	0.052383
30	0.727175	-0.374917	-0.007569	0.000150	0.051170	0.779562	-0.426080	-0.008223	0.000142	0.032667
31	0.773194	-0.413146	-0.013848	0.000143	0.076225	0.687773	-0.316613	-0.006086	0.000132	0.038853
32	0.695566	-0.333853	-0.003604	0.000140	0.116712	0.590112	-0.211067	0.005611	0.000124	0.028003
33	0.704955	-0.359812	-0.003520	0.000162	0.078193	0.784802	-0.417419	-0.015307	0.000135	0.044369
34	0.776663	-0.438838	-0.012209	0.000172	0.108014	0.689217	-0.314949	-0.008760	0.000132	0.037067
35	0.695799	-0.335660	-0.004437	0.000143	0.070250	0.772312	-0.388623	-0.022209	0.000124	0.034364
36	0.727924	-0.370560	-0.008716	0.000149	0.076952	0.592579	-0.210530	0.002370	0.000129	0.029637
37	0.712101	-0.353056	-0.007921	0.000147	0.087546	0.844048	-0.526277	-0.002074	0.000170	0.026348
38	0.567260	-0.305702	0.098200	0.000221	0.047889	0.567260	-0.305702	0.098200	0.000221	0.047889
39	0.829221	-0.440073	-0.090244	0.000078	1.527730	0.600683	-0.160160	-0.040466	0.000101	0.298201
40	0.707933	-0.345682	-0.007165	0.000145	0.035549	0.691056	-0.309723	-0.011320	0.000127	0.031284
41	0.597767	-0.221713	0.000712	0.000143	0.061633	0.606084	-0.185015	-0.019756	0.000104	0.023630
42	0.534136	-0.260247	0.003256	0.000144	0.099443	0.498130	-0.201567	0.001247	0.000133	0.013785
43	0.550737	-0.280405	-0.001969	0.000144	0.084171	0.498618	-0.202408	-0.000173	0.000133	0.013242
44	0.544226	-0.272138	-0.000760	0.000142	0.099344	0.495999	-0.203312	0.001810	0.000135	0.011926
45	0.550171	-0.283740	-0.000811	0.000148	0.111551	0.496530	-0.202470	0.001238	0.000134	0.023482
46	0.531531	-0.257415	0.004232	0.000142	0.136868	0.500212	-0.200432	-0.002961	0.000131	0.037829
47	0.530896	-0.252814	0.003108	0.000139	0.077233	0.492789	-0.204663	0.006334	0.000140	0.048044
48	0.555602	-0.294382	-0.000737	0.000153	0.132678	0.497005	-0.202379	0.002695	0.000134	0.029071
49	0.539488	-0.265925	0.001554	0.000143	0.076056	0.497940	-0.203397	0.001938	0.000134	0.034319
50	0.549889	-0.279155	-0.003666	0.000147	0.119519	0.492471	-0.205166	0.010208	0.000140	0.035856
51	0.515380	-0.202744	-0.019163	0.000121	0.070243	0.405181	-0.095368	0.031519	0.000134	0.032198
52	0.551618	-0.282959	-0.001500	0.000147	0.138877	0.502438	-0.199688	-0.004856	0.000129	0.013578
53	0.548278	-0.281666	0.003833	0.000150	0.087136	0.502290	-0.199580	-0.005755	0.000130	0.027484
54	0.554180	-0.282513	-0.001751	0.000145	0.068942	0.502494	-0.199387	-0.001488	0.000129	0.026302
55	0.554111	-0.290755	0.004068	0.000151	0.139962	0.499786	-0.201475	0.000836	0.000133	0.022866
56	0.566456	-0.328267	0.020524	0.000170	0.116246	0.497248	-0.203304	0.012568	0.000137	0.032201
57	0.568051	-0.313974	0.004977	0.000158	0.086296	0.590597	-0.312314	-0.029454	0.000132	0.067221
58	0.513687	-0.169791	-0.048663	0.000097	0.076721	0.501801	-0.198826	-0.003509	0.000130	0.021089
59	0.580363	-0.346485	0.025894	0.000172	0.048722	0.500714	-0.200485	0.001400	0.000135	0.027665
60	0.584073	-0.361613	0.034480	0.000185	0.053835	0.412312	-0.085746	0.044692	0.000137	0.059432
61	0.578588	-0.335231	0.017254	0.000168	0.090093	0.520287	-0.144641	-0.174129	0.000053	0.021136
62	0.643653	-0.486365	0.078697	0.000250	0.041225	0.209786	0.261151	-0.015459	0.000081	0.069417
63	0.885718	-0.929763	0.176822	0.000398	0.005963	0.500574	-0.199147	0.002004	0.000135	0.023526
64	0.610624	-0.403360	0.049940	0.000196	0.116761	0.502860	-0.197189	-0.000902	0.000132	0.025604
65	0.646474	-0.471180	0.059967	0.000224	0.075792	0.297300	0.095962	0.052544	0.000130	0.034858
66	0.596926	-0.360745	0.014445	0.000173	0.087870	0.096463	0.395124	0.056491	0.000133	0.020478
67	0.539652	-0.241473	-0.009578	0.000120	0.086672	0.539273	-0.240762	-0.009698	0.000120	0.087000
68	0.216020	0.319022	-0.069516	0.000014	0.084413	0.216020	0.319022	-0.069516	0.000014	0.084413

Table 1.18b: (continued)

	shallow					deep				
stn	slope	bias	tcor	pcor	dox	slope	bias	tcor	pcor	dox
69	0.709666	-0.587211	0.005579	0.000252	0.077977	0.709666	-0.587211	0.005579	0.000252	0.077977
70	0.574408	-0.312803	-0.005889	0.000149	0.143732	0.509075	-0.197269	-0.013139	0.000122	0.029349
71	0.567755	-0.285630	-0.005918	0.000138	0.078649	0.502553	-0.199081	0.008539	0.000132	0.028743
72	0.545454	-0.276088	0.017129	0.000151	0.057328	0.505958	-0.197323	-0.001155	0.000129	0.022006
73	0.670958	-0.296197	-0.119198	0.000049	0.046910	0.586499	-0.388230	0.098258	0.000201	0.071340
74	0.563011	-0.267075	-0.008502	0.000127	0.068071	0.505812	-0.196265	0.007454	0.000129	0.032346
75	0.482058	-0.137622	-0.018146	0.000108	0.050532	0.380967	0.023668	-0.029241	0.000086	0.041574
76	0.551317	-0.287923	0.014802	0.000165	0.084661	0.592640	-0.309421	-0.020151	0.000134	0.037241
77	0.547953	-0.251322	-0.005852	0.000130	0.055534	0.500008	-0.199668	0.012116	0.000139	0.014927
78	0.538636	-0.279480	0.032013	0.000157	0.090875	0.500430	-0.199348	0.010281	0.000136	0.009841
79	0.547560	-0.287823	0.026904	0.000155	0.048481	0.501248	-0.198168	0.008303	0.000135	0.013795
80	0.559534	-0.290721	0.008132	0.000158	0.098499	0.499817	-0.198679	0.011998	0.000135	0.022599
81	0.562045	-0.308331	0.017339	0.000174	0.176953	0.503019	-0.198077	0.009951	0.000130	0.023113
82	0.568468	-0.290304	-0.006495	0.000144	0.082744	0.326587	0.071307	0.004445	0.000091	0.035544
83	0.554353	-0.277444	0.002752	0.000147	0.085432	0.505397	-0.197998	0.003512	0.000129	0.026921
84	0.513629	-0.234855	0.022097	0.000143	0.110991	0.504642	-0.197817	0.001379	0.000130	0.010122
85	0.509093	-0.229020	0.019243	0.000161	0.121645	0.636419	-0.445674	0.055846	0.000203	0.035537
86	0.554810	-0.270419	-0.000377	0.000140	0.046687	0.506312	-0.197874	0.001746	0.000128	0.027913
87	0.556403	-0.264527	-0.004537	0.000132	0.058725	0.378488	0.010982	-0.011293	0.000093	0.024861
88	0.553666	-0.265969	-0.002596	0.000137	0.057976	0.580216	-0.306725	-0.004301	0.000145	0.035206
89	0.549181	-0.266636	0.006188	0.000140	0.053301	0.503339	-0.195234	0.001562	0.000135	0.039751
90	0.569747	-0.294977	-0.002564	0.000150	0.096326	0.503131	-0.196889	0.006189	0.000130	0.009269
91	0.555158	-0.292485	0.020121	0.000156	0.085408	0.500328	-0.198917	0.011155	0.000137	0.020386
92	0.562602	-0.286247	0.004606	0.000145	0.031452	0.501828	-0.197904	0.009966	0.000134	0.016907
93	0.564857	-0.322011	0.036258	0.000168	0.095914	0.501268	-0.198908	0.012384	0.000134	0.014821
94	0.556055	-0.315099	0.040842	0.000170	0.075959	0.501276	-0.198445	0.008151	0.000135	0.012502
95	0.556100	-0.288784	0.014948	0.000151	0.071594	0.500820	-0.199396	0.010339	0.000136	0.018808
96	0.563048	-0.303435	0.016720	0.000159	0.050074	0.504163	-0.195555	0.000592	0.000132	0.017161
97	0.553779	-0.297370	0.031691	0.000149	0.076029	0.807620	-0.588251	-0.044973	0.000134	0.045034
98	0.558122	-0.289230	0.013731	0.000150	0.053339	0.801349	-0.596137	-0.046273	0.000154	0.014669
99	0.578842	-0.319928	0.011039	0.000151	0.042213	0.500283	-0.199424	0.010379	0.000136	0.010412
100	0.564341	-0.309293	0.021542	0.000157	0.032680	0.500483	-0.200664	0.010703	0.000137	0.021075
101	0.563344	-0.284508	-0.002485	0.000148	0.115782	0.976664	-0.864653	-0.049588	0.000206	0.047911
102	0.571524	-0.296747	-0.002905	0.000150	0.130189	0.506124	-0.194975	0.002469	0.000129	0.033498
103	0.553123	-0.259748	-0.005418	0.000132	0.123599	0.504052	-0.195933	0.006414	0.000132	0.022921
104	0.573906	-0.317006	0.016846	0.000161	0.127765	0.589423	-0.310438	-0.013350	0.000138	0.025052
105	0.575003	-0.293738	-0.007192	0.000141	0.130551	0.503769	-0.194284	0.002154	0.000131	0.025007
106	0.570248	-0.313088	0.013484	0.000168	0.107875	0.504847	-0.194241	0.001899	0.000130	0.028634
107	0.565393	-0.289341	0.007462	0.000144	0.108955	0.507999	-0.191848	-0.008782	0.000126	0.034845
108	0.537817	-0.230634	-0.004715	0.000118	0.138037	0.505489	-0.193466	-0.001698	0.000129	0.051044
109	0.573872	-0.309529	0.002589	0.000162	0.105308	0.410790	-0.035973	-0.024129	0.000103	0.039840
110	0.499832	-0.167327	-0.017377	0.000113	0.109564	0.592103	-0.309097	-0.028209	0.000132	0.036409
111	0.516802	-0.188138	-0.007852	0.000096	0.098296	0.516802	-0.188138	-0.007852	0.000096	0.098296
112	0.394353	-0.001832	-0.042050	0.000128	0.122009	0.394353	-0.001832	-0.042050	0.000128	0.122009
113	0.565776	-0.321734	-0.031486	0.000170	0.138440	0.565776	-0.321734	-0.031486	0.000170	0.138440
114	0.590920	-0.321274	0.003933	0.000158	0.074437	0.590920	-0.321274	0.003933	0.000158	0.074437
115	0.543490	-0.278874	0.003946	0.000163	0.110781	0.496588	-0.208467	0.009673	0.000136	0.025507

APPENDIX 1.1 HYDROCHEMISTRY CRUISE LABORATORY REPORTS

A1.1.1 AU0304 HYDROCHEMISTRY LABORATORY REPORT

Clodagh Moy, Neale Johnston and Bronwyn Wake

Seawater samples from the CTD were analysed for salinity, dissolved oxygen and nutrients (nitrate plus nitrite, silicate and orthophosphate). Samples were collected from 64 stations in total. Additional samples were also analysed for some scientists on board, as described below. The methods used are described in the CSIRO hydrochemistry manual (Cowley, 2001).

Personnel
Clodagh Curran, Hydrochemist, Antarctic CRC
Neale Johnston, Hydrochemist, CSIRO
Bronwyn Wake, Volunteer, PhD student IASOS.

Number of samples analysed
Salinities : 1060
Dissolved Oxygen : 1028
Nutrients : 1021

Salinity

Salinity analyses were performed by Clodagh Curran in lab 3, next to the electronics lab. Guildline salinometer SN62549 was initially setup in the lab, however due to a faulty transformer it was replaced by SN62548 shortly after leaving Hobart. SN62548 was used for the remainder of the cruise.

Ocean Scientific IAPSO standard seawater was used to standardise the salinometer. Two sets of standards, P140 and P141, were used to standardise the instrument. P140 was used for most of the cruise. Measured against its nominal value, P140 showed no difference (i.e. 2R of <0.0 0000) for 10 out of 12 standardisations. There were two occasions where there was a significant change in the measured value during a run.

Some problems occurred between stations 23 and 24, where there was a break in analysis for a number of days. There was a significant jump in the standardisation set value, and P140 at the end of the run had changed considerably from its standardisation value at the beginning of the run i.e. a change from 1.99982 to 1.99992, equivalent to a salinity change of 0.002 (PSS78) over the run. After discovering some growth on the cell, it was thoroughly cleaned with 4% bleach from the ship's galley, flushing 4 times till clean. The following day a run was done, and the standard at the end of the run showed no change from the initial standardisation. The salinometer remained stable for the rest of the cruise.

Near the end of the cruise P141 was introduced, as P140 was low in stock. The standards were compared on two occasions by standardising the instrument with one standard, and measuring the other standard. Results for both P140 and P141 agreed with their nominal values.

A PID temperature controller was used to control the temperature of the lab. On a number of occasions the temperature in the lab rose above 20 degrees. When this occurred analysis was stopped, and the chief Engineer was notified immediately. The temperature of the air entering the lab from the ship's vents was then decreased. A close eye was kept on the lab temperature at all times.

* Files updated:
A0304_equipment.xls,
Extra_samples_a0304.xls
sal_std_check.xls
sal62548.xls

sal62549.xls

Dissolved oxygen

Dissolved oxygen analyses were performed by Bronwyn Wake (and Neale Johnston on a number of occasions) in the photo lab. There were no major problems with the DO system, apart from some temperature problems in the lab. The temperature varied between 13 and 18 degrees over the course of the cruise. Standardisation and blank values were collated and plotted from this and previous cruises, to help identify outlying or suspicious values.

The average standardisation value and average standard deviation was 4.484 ±0.001 ml of thiosulfate, equivalent to 237.8 μmol/l of oxygen. The average blank value and average standard deviation was 0.007 ±0.001 ml of thiosulfate.

* Files updated:
A0304_DO chemical cal.xls,
DO_reag_use_stocktake.xls,
do_std&blank.xls,
do.xls

Nutrients

Nutrients were analysed by Neale Johnston, and Clodagh Curran where necessary, to keep the instrument running over a 24 hour period. Phosphate, silicate and nitrate plus nitrite were analysed as per CSIRO methods. CSIRO's solenoid switching valve system was used to alternate the carrier between artificial seawater, low nutrient seawater and MQ (i.e. Milli-Q) water as well as from colour reagents to MQ for each chemistry for baseline correction. Standards were made up every couple of days in low nutrient seawater (collected from Maria Island, filtered and autoclaved before going on the cruise). If standards were stored for longer than about 3 days, the silicate polymerisation was a problem. The carrier for the standard runs was artificial seawater (39g sodium chloride per litre in MQ). The software used for data collection was Winflow, and the software used for processing was written by Rebecca Cowley (CSIRO). A standard run included baseline correction using the switching valves (which took approximately 45 mins), a carryover correction, a set of standards, low and high SRM's (Standard Reference Material from Ocean Scientific prepared in autoclaved seawater) and QC's (LNSW spiked with nutrients) followed by samples, and then the standards, SRM's and QC's were repeated. A run normally took about 3 hours to complete.

The A/D converter caused a problem when a LTC1047 chip on the phosphate channel malfunctioned. This A/D converter was originally a detector for the digital detectors, and included both a cell and a reference channel. The reference channel is redundant when the system is used as an A/D converter, thus a spare chip was available (from this reference channel).

On occasion the phosphate channel did not register a signal when a run was first started. When this occured the power to the A/D box was turned off for about 10 seconds and then the run restarted. This solved the problem each time. It is not known whether this was related to the problem with the LTC1047 chip.

On several occasions the software failed to activate the sampler, but on each occasion stopping and restarting the run fixed the problem.

The nitrate/nitrite channel seemed to truncate the baseline. It was possible to overcome this by starting the run on an artificially low baseline, however this is not a satisfactory solution. Investigation is required as to whether the problem is caused by the detector, or by the nitrate/nitrite channel on the A/D converter.

The phosphate analysis had problems due to inconsistent flow in the ascorbic acid line. This may have been caused by some of the platen holders being acid damaged in the past. It was overcome by changing the pump tube from orange yellow to an orange white to ensure the ascorbic acid was in excess. It is recommended that new platen holders be put in, and also that the side rails be checked in case they are slightly bent. It has been noted by some users that there is a problem with the rails on the larger pumps, and Ismatec now produce some pumps with heavier gauge rails.

Towards the end of the cruise it was noted that one of the cadmium coils could not be conditioned to work to a satisfactory level, possibly due to it being exposed to the atmosphere over time after each new coil was removed, even though originally all coils were stored under nitrogen. It is recommended that the cadmium lengths are stored under nitrogen in individual whirlpak bags.

There were problems running some of Stephane’s samples that were in fresh water. This was due to the source of the fresh water - from the ship's urn (not MQ water).

General data handling

Plots were made of analyte versus station to check for suspicious data or wrongly entered data. They were based on the data in the csv file, and could be opened via the macro CSV in A0304.XLM. Data were backed up to 250MB Iomega zip disk.

Laboratories

The salinometer and nutrient systems were both in lab 3. The salinometer was on the forward bench near the door, with enough space for two salinity crates next to the bulkhead. The data computer was on the other side of the salinometer. The nutrient system was next to the computer along the forward bench towards the starboard side. There was bench space free in front of the porthole for sample preparation, and the fume cupboard was used to make reagents etc. The wet lab was used to make standards, as the fridge containing them was conveniently located in there together with the small freezer. The DO system was on the starboard bench in the photo lab, and the MQ system was as usual on the forward bulkhead of the photo lab.

Temperature monitoring and control

Temperature in lab 3 was controlled by a CAL Controls Ltd ‘CAL 9900’ proportional derivative plus integral (PID) temperature controller. The temperature from the air vents fluctuated between 11 and 18 degrees, however due to the small size of lab 3 and the heat from the instruments, the temperature on some occasions reach above the set temperature of 20 degrees. During most of the cruise the lab door was open, which helped maintain the temperature at or below 20 degrees. On a few occasions the lab temperature exceeded this and analysis was halted till the chief engineer reduced the ship's air temperature entering the lab via the air vents.

The photo lab had no temperature controller. The photo lab was heated by the ships air conditioning, however regular access to the trawl deck by other groups allowed a lot of cold air to accumulate in and around the photo lab. Thus the temperature fluctuated between 13 and 18 degrees over the cruise. As long as both the standardisation and sample analyses were performed at the same temperature, the low temperature did not effect the results. On a number of occasions the photo lab light was turned off and the sample box lid was removed to help speed up stabilization of the samples to room temperature. For future cruises a temperature controller similar to the one used for lab 3 is recommended.

Temperature in the laboratories was also recorded by two Tinytalk units. One was positioned beside the salinometer, while the other was positioned beside the DO system. A digital thermometer was used to estimate the temperature of the dissolved oxygen samples during stabilization to room temperature. 'Indoor/outdoor' electronic thermometers were used to measure the fridge and freezer. The air temperature about the salinometer was generally 20.0 ±1 °C.

Purified water

The MQ system was set up in the photo lab, as usual. The system appeared to function ok, however air locks were experienced from time to time, slowing the process of reaching optimum quality. A number of groups used the MQ system, and about 400 l of water were produced for this cruise. The filters did not require changing.

Additional samples analysed.

The following additional samples were analysed for other scientists on board au0304:

salinity:	5 samples (Stephane Pesant)
nutrients:	~50 samples (Stephane Pesant) 30 samples (Christel Heeman)

A1.1.2 AU0403 HYDROCHEMISTRY LABORATORY REPORT

Clodagh Moy, Kate Berry and Andrew Moy

Seawater samples from the CTD were analysed for salinity, dissolved oxygen and nutrients (nitrate plus nitrite, silicate and orthophosphate). Samples were collected from 115 stations in total. Additional nutrient samples were also analysed for scientists from IASOS and the Australian Antarctic Division. Analysis procedures, except for procedures developed for the new Lachat nutrient system, are described in Eriksen (1997), Cowley and Johnston (1999) and Cowley (2001), with general updates described in Moy (in prep.).

Personnel
Clodagh Moy (nee Curran), Hydro Chemist, ACE CRC
Kate Berry, Hydro Chemist, CSIRO
Andrew Moy, Volunteer, PhD student IASOS.

Number of samples analysed
Salinities : 2448
Dissolved Oxygen : 2436
Nutrients : 2704

Salinity

Clodagh Moy analysed salinities with a Guildine Autosal Salinometer, SN62549, setup in the wet lab on the aft bench near the starboard side porthole. This salinometer was used throughout the whole voyage.

The spare salinometer, SN62548 was setup on the aft bench on the port side in case it was needed. A new multi-wrist shaker for shaking the salinity samples was purchased before the cruise to reduce repetitive strain injuries. It was setup between the two salinometers on the aft bench. Four salinity crates were stacked two high, each side of SN62549, to help equilibrate to room temperature.

Ocean Scientific IAPSO standard seawater was used to standardise the salinometer. A batch of 10 standards, together with the protective packaging they came in, were setup behind one side of the salinity crates to equilibrate to room temperature. A total of 90 bottles of IAPSO standard seawater over 32 standardisations were used on the voyage. Samples were analysed from shallowest to deepest in a CTD cast i.e. from bottle 24 to bottle 1.

The trim value, or standardisation value, is set on the salinometer during standardisation with IAPSO standard seawater. If the instrument and temperature control is stable there should be minimal change to the trim value day to day. During AU0403 the trim value remained a constant 2.43 ± 0.02 (std dev) over 32 standardisations. The trim value however has decreased significantly since the last voyage. This needs to be investigated by an electrician in Hobart.

Standard Seawater batch number P141 (12th Jun 2002), which was near the end of its shelf life, was used to standardise the instrument from station 1 to 10. P143 (26th Feb 2003) was used from station 10-16, and for the rest of the voyage P144 (23rd Sep 2003) was used. The salinometer remained very stable during the voyage due to good lab temperature control. However on two occasions, analysing stations 16 and 41, it was difficult to control the temperature and analysis was stopped overnight while the lab temperature stabilised.

During analysis of station 27, there were flow problems in the cell. There seemed to be a blockage in the tubing from the pump into the cell causing low flow through the cell. After checking the pump tubing and tubing into the salinometer for blockage, a blockage was found on the inlet to the salinometer. The tubing from the inlet to the pump to the inlet to the salinometer was changed and analysis continued.

Low flow through the cell occurred again during station 57, with the pump motor fluctuating, in turn causing a fluctuation in the flow. The spare pump was installed, but again the motor fluctuated. The power plug was changed, but still no change. Tim Shaw (the AAD electronics person on board) had a look at the two pumps and power plugs, and the only noticeable problem with the pumps was slight corrosion on the power inlet. Tim installed a power controller box to maintain a constant power supply and monitor any drawing of current by the pumps if they were failing. The power controller was used for the rest of the voyage with no further pump problems.

There were a number of samples with leaking lids. This was caused either by a loose sample bottle lid (not tightened by the sampler), or by a chip in the thread of the sample bottle. Where there was a damaged bottle, it was replaced with a new one together with a new lid. On a few occasions there were also samples with either too little or too much sample in them due to samplers either over or under filling the bottles.

The multi-wrist shaker went well during the voyage. It was set on continuous shaking at speed 4. Sixteen samples from the first crate to be analysed at the beginning of the shift were screwed in place before standardization. Then as the samples were analysed the next sample in the crate was screwed in place and so on till the day's crates were analysed. This meant that each sample was shaken for about 45 minutes. Samples were well homogenised, and stability of the readings was improved, without slowing down the overall analysis.

* Files updated:
A0403_equipment.xls,
Salinometer_stability.xls.

Dissolved oxygen

Dissolved oxygen analyses were performed by Andrew Moy using the automated oxygen titration DODO. The DODO system was setup on the starboard sink nearest the portholes in the wet lab. A new peristaltic pump was used to flush waste to drain from the burettes in the hydraulic ram. It worked well.

Standardisations were conducted every second day of analysis, or when a new batch of Sodium Thiosulphate was used. A record of Standardisations and Blanks was maintained during the voyage together with a comparison of duplicate titrations. They can be found in the files *DO_std&blank_timeseries.xls* and *DO_duplicate_samples.xls*.

The mean Blank from Station 1-114 was 0.005±0.001ml of Sodium Thiosulphate. Standardisations changed minimally from station 1 to 30, the average being 4.454±0.027ml of Sodium Thiosulphate. However there was a significant shift in the standardisations from station 31 to 55, the average being 4.401±0.007ml of Sodium Thiosulphate. This corresponded to a 1.3% shift in results. Mark and Steve brought the dissolved oxygen offset to our attention, when they compared the voyage data to a previous WOCE I9S Voyage on the Knorr, 10 years previous. Due to the tight dissolved oxygen profiles produced on the voyage thus far, this small offset was very noticeable.

Every aspect of the Dissolved oxygen analysis was examined for any obvious reason to explain the offset. It was quickly realized that the Biiodate Standard was changed after Station 30. Immediately, the suspect Biiodate Standard was changed to a new batch and a Standardisation completed. The Standardisation shifted back to where it was before Station 31.

During the CLIVAR I9S transect, Kate was also running duplicate DO samples on the Lachat nutrient autoanalyser to compare the two methods for Rebecca Cowley at CSIRO. There were two crates of DO sample bottles set aside for this as their volumes were calibrated accurately by Rebecca before departure. During stations 23-27, 2 other crates were used to collect the duplicate samples by mistake, 8 samples per station. The samples were of no use to Kate as there were no sample bottle volumes for them.

Andrew happened to analyse these duplicates during the low Biiodate Standardisation. After examination of the results for both the original samples taken before the low standardization and comparing them with the duplicates which happened to be analysed during the low standardization, there was a difference of 1.3% similar to the offset in standardizations. The results can be seen in *DO_duplicate crates.xls*. It was decided then to correct Stations 31-55 with this offset of 1.3%, since the profiles were so tight. After correction of the data, the profiles compared very well to the Knorr data.

During analysis of the samples, duplicate aliquots were analysed for 1-2 samples in a cast. For 193 duplicates analysed, the mean % difference was 0.07±0.13%.

A new Metrohm Dosimat was purchased before the voyage, but due to problems with the old DODO system prior to the voyage a comparison of the two systems was unable to be completed in time. The old DODO system was fixed prior to shipping to Fremantle to meet the Aurora Australis. The comparison could not be performed on the voyage due to time constraints and lack of reagents.

* Files updated:
A0403_NUTS&DO_reagcal.xls,
DO_std&blank_timeseries.xls,
DO_duplicate samples.xls,
DO_duplicate crates.xls

Nutrients

The Lachat nutrient analyser from CSIRO in Hobart was used to analyse 2452 samples for silicate, phosphate and nitrate + nitrite (NOx) in the ranges

Si	0-140µM
P	0-3µM
NOx	0-35µM

Lachat operation

The silicate and NOx channels ran well at first, but the phosphate results showed poor precision, with peak areas for replicates see-sawing up and down by up to 5%. - this problem could not be fixed for some time. The phosphate problem seemed to be flow related, but changing pump tubes, checking flows and trimming the ends from tubing produced only limited improvement. The phosphate also spiked badly at first, and this problem was fixed by adding an extra 2m of backpressure coil after the detector. After CTD 69, the pump tubes were moved to different positions on the pump and the phosphate improved markedly, and was reliable for the rest of the voyage. The nitrate had begun to show the same problem at about CTD 50 and remained unreliable, with some runs showing problems with variability.

The position of the pump tubes on the pump appears to be crucial, and some scoring on the rollers of the first pump was noticed where the green pump tube had been positioned. The pump was changed to the spare at CTD 80, and later, after making more space, both pumps were used, with the tubes well spaced out along the rollers. However the nitrate remained variable. Changing pump tubes sometimes made the variability worse. No difference was found between using the green pump tube to push or pull the sample through the solenoid valves. It was used to pull, so that the sample was in contact with only teflon tubing before analysis.

Once the phosphate was working well, all the affected runs were repeated except where the spare sample had already been used. The worst of the nitrate runs were repeated too. Variability in the remaining wobbly nitrate runs (CTDs 55-57, 76-78, 82, 84,105-110) is of the order of 1%. One wobbly phosphate run remained, CTD 9.

Tip: If the phosphate baseline is noisy or wavering, it may be due to a small blockage in the mixer for the two reagents - pull out the ends of teflon tubing one by one and let them flow or trim the ends. On some days, twice as much colour reagent as ascorbic acid was consumed, and on others the amounts were even. This made no difference to response, but a different design for mixing the reagents might be more reliable.

Diluter

The diluter was used at first but the valve leaked, introducing bubbles into the samples, especially for phosphate. As there was no spare valve, standards were prepared manually from CTD43. The main advantage of the diluter was the ability to quantify on two standard ranges in the same run, which was useful early on when profiles included very low and high silicate samples. As the cruise proceeded to the south, there were no very low samples, so only the 0-140µM standard range was used for silicate.

Hydro

An old version of Hydro was used to be sure of getting the right results for the DODO dissolved oxygen method. A separate hydro version was used at first to enter the results from the Lachat, but once repeat runs were started this could no longer be done as the format of the .csv files used in hydro does not support this. A format such as Omnion 2 may be more useful, where the data is in columns in the .csv file and can be easily replaced with repeat data if necessary.

Accuracy

Hiski Kippo's nutstats program worked well, though it was hard to print out, but no doubt this will be improved in future. None of the SRMs (Standard Reference Materials) reflected their true value, as can be seen in the table below. Perhaps this is due to mixing effects, as Bec has proposed. The standards used on this trip were prepared and tested on October 26, and they were acceptably similar to the last batch of standards. The LNSW that was provided for this trip contained 4.1µM Si, 0.1µM P and 0µM NOx, and this was used to prepare all standards and SRMs as well as the Bulk QC sample. As Bec has pointed out, the % error in Hiski's program has the sign reversed. I have corrected this in the following table.

				Accuracy				
	Si high SRM 30µM			P high SRM 3µM			NOx high SRM 30µM	
Batch	mean	%error	Batch	mean	%error	Batch	mean	%error
1-69	30.1	0.34	1-69	2.929	-2.41	1-69	29.91	-0.29
70-114	31.04	3.37	70-114	2.88	-4.16	70-114	29.78	-0.74
			repeats	2.881	-4.12	repeats	29.84	-0.53
	Si low SRM 10µM			P low SRM 1µM			NOx low SRM 10µM	
Batch	mean	%error	Batch	mean	%error	Batch	mean	%error
1-69	10.3	3.03	1-69	0.963	-3.88	1-69	9.92	-0.76
70-114	10.56	5.26	70-114	0.957	-4.55	70-114	9.90	-1.02
			repeats	0.967	-3.42	repeats	9.97	-0.33

In future, the SRM result should be used in the stats (value plus LNSW value) without subtracting a blank - subtracting a blank introduces twice the error into the results.

Precision

10L of LNSW were spiked with standards to make a Bulk QC sample for precision measurements. Hiski's statistics for the Bulk QC are below:

			Precision			
Batch		Mean			CV%	
	Si	P	NOx	Si	P	NOx
1_69	30.09	2.619	28.82	0.62	3.27	0.92
70_114	30.98	2.581	28.84	0.35	1.45	0.48
Repeats		2.590	28.78		1.56	0.54

The problems with phosphate precision are reflected in the higher CV% for runs 1-69.

Detection limits

Detection limits were calculated from 14 replicates of a Cal 0 standard.
Silicate: 0.060μM
Phosphate: 0.032μM
NOx: 0.036μM

DO experiments

DOs on the Lachat were easy to do, although changing back to nutrients always produced a problem of some sort. 230 samples were analysed for DO both on the Lachat and by DODO (Andrew Moy). Andrew also analysed a batch of samples and standards immediately after they had been run on the Lachat. The results have been given to Bec for analysis.

Conclusions

While the Lachat analyser used on AU0403 was generally easy to use, the precision of the data needs to be examined carefully. Variability was exaggerated by the high concentrations of the samples on AU0403, so that a 3% difference was very noticeable. A comparison between the Lachat and the Alpkem will require accuracy and precision data from Alpkem runs. This should be available for AU0304 and AU0103, but it may not have been processed. These data should be processed using Hiski's nutstats program, to provide a meaningful comparison of the two instruments. Future work will also include comparing precision data from AU0403 with that for other Lachat runs, for example from the Southern Surveyor.

The phosphate problem was first noticed when Steve Rintoul plotted I9 data against data from the Knorr for the same transect 10 years ago. The silicate and nitrate data for the early stations matched well, but the phosphate varied widely around the Knorr values. Once the phosphate problem was solved, phosphate analyses were repeated for all of I9 and some of PET, and nitrate analyses were repeated for many stations to include the best data possible.

Temperature monitoring and control

The salinometer remained very stable during the voyage. This was mainly due to good temperature control of the laboratory with an AAD PID temperature controller, an AAD Atlas Air – Mini air-conditioner permanently installed in the wet lab, and the ship's steam heater. The steam heater fan was used to circulate air around the lab, without opening the steam valve. A wall fan was also installed near the floor on the portside island bench near the salinometer to help air flow circulation.

On two occasions there was however difficultly in maintaining good temperature control. This was due to changes in the ship's heating/cooling system, which affected the laboratory temperature. Before analysis of station 16, the air temperature in the laboratory was above 21°C. This affected the salinometer bath temperature causing fluctuations in the 2R readings. Analysis was stopped overnight while the air conditioner temperature was lowered. The air vents in the ceiling were taped off to prevent further fluctuations by the ship's air temperature controller.

During analysis of station 41, the reading again began to fluctuate and the water bath temperature rose. The air conditioner's lowest set temperature was 17 °C, thus as the air temperature outside dropped significantly the air conditioner became a source of heat rather than cold. As it was no longer needed to cool the laboratory, it was switched off. Analysis was stopped overnight till the temperature stabilized.

Two new Easylog USB temperature loggers recorded the laboratory temperature. One was positioned beside the pump on the salinometer, while the other was positioned on the hydraulic ram of the DO system. The Easylog temperature loggers were easy to use as they were USB compatible and were easy to setup and download. A temperature profile was printed out every 11 days and showed the laboratory temperature to be stable at 20.0 +/- 1 °C. 'Indoor/outdoor' electronic thermometers were used to measure the fridge and freezer temperature.

Purified water

The MQ system was set up on Voyage 1 in the photo lab without filter cartridges in it. Before departing Fremantle the filter cartridges were installed and the system was primed, however there was a problem with the RO system, with a lack of reject flow. The problem was eventually traced to a blockage in the needle valve.

Overall the pre-treatment and carbon filters were changed twice during the voyage when the RO product water quality red light was on for over 5mins. The total about of water used was 1400L.

Additional samples analysed.

Apart from the oceanographic program, a number of nutrient samples were also analysed on board the ship, as follows:

Donna Roberts (IASOS): 20 Heard Island samples.
Krystina (IASOS student): 118 Lagoon samples.
Imojen Pearce (AAD student): 157 samples from Davis Station.

APPENDIX 1.2 CTD AND HYDROCHEMISTRY DATA PROCESSING AND CALIBRATION TECHNIQUES

A1.2.1 INTRODUCTION

This Appendix details the data processing and calibration techniques used in the production of the final CTD data set i.e. the CTD 2 dbar-averaged data, and the bottle data file. Logging of the data at sea is discussed in the main text of this report. The different sections in this Appendix, and the description within each section, are ordered to match the steps in the data processing flow. The data processing software is in Fortran and Matlab, plus preliminary stages using Sea-Bird post processing routines.

The data processing methodology described here is a major update to the processing for previous cruises (Rosenberg et al., 1995), due to replacement of the old Neil Brown type CTD's with a Sea-Bird CTD system. Despite this change in instrumentation, many of the central processing methods remain unchanged.

A1.2.2 DATA FILE TYPES

The various data files used throughout the data processing/calibration (and produced by it) are outlined below. A complete description of final data file formats is given in Appendix 1.3.

A1.2.2.1 CTD data files

Several types of CTD data file are referred to in this Appendix:

(i) cnv CTD files, which contain 25 Hz CTD data extracted from the complete raw binary 25 Hz data logged by the data acquisition software, converted to engineering units, and then with initial data processing steps applied using the Sea-Bird post processing software;

(ii) cnn CTD files, as above for the cnv files, and then with the conductivity calibration applied;

(iii) 2 dbar-averaged CTD files, with the CTD data averaged over 2 dbar bins, starting at 2 dbar and centered on each even 2 dbar value.

CTD filenames are of the form *vyyccusss.xxx* (e.g. a04034090.all), where:

v = vessel (e.g. "a" for Aurora Australis)
yy = year (e.g. "04" for 2004)
cc = cruise number (e.g. 03)
u = CTD instrument number ("3" for serial 703, "4" for serial 704)
sss = station number (e.g. 090)
xxx = file type, as follows:
cnv = 24 Hz CTD data
cnn = 24 Hz CTD data after initial conductivity calibration
all = CTD 2 dbar-averaged data

A1.2.2.2 Bottle data file

The final bottle data file contains the Niskin bottle data (salinity, nutrients and dissolved oxygen) output from the hydrochemistry data processing programs (see Appendix 1.1), merged with the averages calculated from upcast CTD burst data from each Niskin bottle stop. The file is named *vyycc.bot* (e.g. a0403.bot), where *v*, *yy* and *cc* are as above. During the CTD data calibration procedure, intermediate bottle data files are produced, named *calibx.dat:nn*, where *x* = 1 or 2 (primary or secondary sensors respectively), and *nn* (e.g. 01) is the file version number. In general, later version numbers are for more advanced stages in the bottle data file quality control.

A1.2.2.3 Station information file

This file contains station information, including position, time, depth, maximum pressure etc. The file is named *vyycc.sta* (e.g. a0403.sta), where *v*, *yy* and *cc* are as above.

A1.2.3 CALCULATION OF PARAMETERS

Raw temperature, conductivity and pressure counts output by the CTD are converted to engineering units in the initial processing stage (see section A1.2.5.1 below), with the calibration coefficients in Table 1.10 of the main text applied in the conversion formulae (see Sea-Bird manual). All temperature values are in terms of the International Temperature Scale of 1990 (ITS-90). Raw oxygen sensor signal values are voltages.

Salinity is calculated from the conductivity, temperature and pressure using the practical salinity scale of 1978 (PSS78), via the algorithm SAL78 (Fofonoff and Millard, 1983). The Fofonoff and Millard routines are also used for back-calculation of conductivity from salinity, temperature and pressure (for calculation of Niskin bottle sample conductivities). Note that temperatures expressed on the ITS-90 scale must first be converted to IPTS-68 (International Practical Temperature Scale of 1968) for input into these routines. The conversion factor used is (Saunders, 1990):

$$T_{68} = 1.00024\ T_{90} \qquad \text{(eqn A1.2.1)}$$

CTD oxygen calculations are described in section A1.2.10 below. For additional sensors (e.g. altimeter, fluorometer, P.A.R., transmissometer), manufacturer supplied sensor calibrations are applied. No further calibration is applied to these additional sensor values.

A1.2.4 STATION HEADER INFORMATION

The following station information is contained in both the station information file, and in the header of each 2 dbar-averaged CTD file:

Position: All station position information is derived from the JRC GPS receiver data in the quality controlled underway measurement data set (see reports referenced in section 1.3.3 of the main text).

Bottom depth: Depth data come from the quality controlled Simrad EA200 12 kHz sounder data.

Times: All times are ultimately derived from a central time server on the ship. For each CTD:
start time = time at commencement of downcast proper (see section 1.3.1 in the main text)
bottom time = time at the maximum pressure of the cast
end time = time when CTD leaves the water

Maximum pressure: This the maximum pressure value reached during the cast.

Altimeter: This is the minimum reliable altimeter value measured near the bottom of the cast. Note that the due to variations in bottom topography, time of minimum altimeter reading does not necessarily correspond exactly with the time of maximum pressure reading.

A1.2.5 INITIAL PROCESSING STEPS USING SEA-BIRD POST PROCESSING PROGRAMS

The complete binary CTD files logged at 24 Hz during data acquisition are initially run through a series of data processing steps on a PC, using the Sea-Bird post processing software. Raw data counts are converted to engineering units, surface pressure offsets applied, various sensor lags, corrections and filters are applied, and pressure reversals are flagged. Programs and processing steps applied are as follows.

A1.2.5.1 Program 1: "Data Conversion"

This program is used to extract the desired parameters from the raw logged data files, and to convert data counts to engineering units. Parameters extracted are scan number, pressure, primary and secondary temperature and conductivity, oxygen signal voltage, and any additional sensors (e.g. altimeter 1 and 2, fluorometer, P.A.R., transmissometer). For cruises AU0304 and AU0403 in this report, the additional sensors were an altimeter and a fluorometer.

Initially, the program is run on the first ~30,000 scans of data (or a sufficient number to include data up to commencement of the downcast). Surface pressure offset at the start of the cast (i.e. just prior to entering the water) is determined from the output file, and the scan number for the commencement of the downcast proper (as noted on the CTD sheet at the time of logging) is checked and ammended if necessary. For each station, the pressure offset coefficient in the configuration file is ammended to include the surface pressure offset, and the program is run again to convert the desired data to engineering units. Data scans prior to commencement of the downcast proper are omitted. A cnv CTD data file for each station is output. For application of the remaining Sea-Bird post processing programs, this cnv file is updated with each processing step.

A1.2.5.2 Program 2: "Align CTD"

This program is used to apply a sensor lag adjustment to the oxygen sensor data of +5 seconds, relative to the pressure data. Note that no conductivity sensor lags are applied here: both primary and secondary conductivity data are advanced +0.073 seconds relative to temperature by the deck unit at the time of logging.

A1.2.5.3 Program 3: "Cell Thermal Mass"

This program removes conductivity cell thermal mass effects from the measured conductivity values. See the SBE Data Processing help information for details of the recursive filter used. Input constant values used were alpha (thermal anomaly amplitude) = 0.03, and 1/beta (thermal anomaly time constant) = 7.0.

A1.2.5.4 Program 4: "Filter"

This program applies a low pass filter with a time constant of 0.15 seconds to the pressure data. For a full description of the filter, see the SBE Data Processing software help information.

A1.2.5.5 Program 5: "Loop Edit"

This program is used to flag (not remove) pressure reversals. A minimum CTD velocity of 0 is used to find pressure reversals. Note also that for the downcast and upcast, pressure values equal to the previous value are also flagged. At a later stage of the processing, when 2 dbar averages are formed, these flagged values are omitted to form a pressure monotonic file.

A1.2.5.6 Program 6: "Derive"

This program is used for an initial calculation of uncalibrated salinity and oxygen. These values are all recalculated at a later stage of the processing, after calibration against Niskin bottle data.

A1.2.5.7 Program 7: "Sea Plot"

This program is used for a quick look at cnv file data, to identify any obvious data spikes/sensor malfunctions. The most obvious spikes are flagged.

All remaining data processing is performed in a unix envirnoment, using fortran and matlab programs.

A1.2.6 FORMATION OF CTD UPCAST BURST DATA

Upcast CTD burst data files for each station are formed from the upcast part of the cnv CTD file. For each bottle firing, 10 seconds of data centered around the bottle firing time are extracted and written to a file *vyyccusss.ros* (for *vyyccusss* defined as above). For 24 Hz data, there are 240 data scans in each upcast burst. Note that bottle firing times are derived from scan numbers recorded by the data acquisition software at each firing. Scan numbers at firing times are also recorded on the CTD log sheet at each station, as a backup in case of data acquisition problems.

The mean of each upcast burst of CTD data is calculated and written to the file *vyyccusss.btl* for each station. These mean values from the burst data are used for comparison with the salinity and dissolved oxygen bottle samples, for the subsequent calibration of the CTD conductivity and dissolved oxygen sensors.

A1.2.7 FORMATION OF INTERMEDIATE BOTTLE DATA FILE

The averaged upcast CTD burst data from all stations are collected in the template bottle data files *calib1.dat* and *calib2.dat*, for respectively primary and secondary temperature/conductivity (and calculated salinity) sensor data. Note that CTD salinity data at this stage are from the initial salinity calculations in the Sea-Bird software. These salinity values are not used for calibration purposes.

Intermediate bottle data files *calib1.dat:01* and *calib2.dat:01* (i.e. version 1 intermediate file, for respectively primary and secondary sensor data) are formed by merging the hydrochemistry data (salinity, dissolved oxygen and nutrients) with the upcast CTD burst data in *calib1.dat* and *calib2.dat.* Prior to calibration of the CTD conductivity and dissolved oxygen data, the Niskin bottle data undergo preliminary quality control. Salinity data which are obviously bad are given the quality flag -1 (i.e. bottle not used in the calibration of CTD conductivity) in the intermediate bottle data files. Reasons for rejecting salinity bottle data at this stage include bad samples due to leaking of incorrectly tripped Niskin bottles, mixed up samples due to a misfiring rosette pylon, samples drawn out of sequence from Niskin bottles, significant salinometer problems, etc.

Dissolved oxygen bottle data pass through an initial quality control similar to salinity bottle data, except that bad dissolved oxygen bottle values are removed from the bottle data files. Questionable values (not removed) are noted (e.g. Table 1.17 in the main text). Nutrient data are quality controlled at a later stage, following calibration of all the CTD data. For cruises using the Lachat nutrient analyser (i.e. AU0403 onwards), nutrient data are merged into the bottle data file at a later stage, after calibration of the conductivity.

A1.2.8 CALIBRATION OF CTD CONDUCTIVITY

For the CTD conductivity data, calibrations are carried out by comparing the upcast CTD burst data with the Niskin bottle data, then applying the resulting calibrations to the downcast CTD data. The conductivity calibration follows the method of Millard and Yang (1993). For groups of consecutive stations, a conductivity slope and bias term are found to fit the CTD conductivity from the upcast burst data to the Niskin bottle data; a linear station-dependent slope correction (Millard and Yang, 1993) is applied within each station group to account for calibration drift. The SeaBird 911 manual claims a slope term only is required, however data from these and other cruises indicate improved calibration results when a bias term is also used. The relative stability of the Sea-Bird conductivity cells between stations, compared with sensors on the older type CTD's used on previous cruises, means that observed calibration drift or variability can often be attributed to salinometer analyses.

Data from the entire water column are used in the conductivity calibration. Also note that no correction is made for the vertical separation of the Niskin bottles and the CTD sensors (of the order 1 m); and the International Standard Seawater (ISS) is assumed to be correct i.e. no corrections are made for any variations in ISS batch numbers.

A1.2.8.1 Determination of CTD conductivity calibration coefficients

The following definitions apply for the conductivity calibration:

c_{ctd} = uncalibrated CTD conductivity from the upcast burst data
c_{cal} = calibrated CTD conductivity from the upcast burst data
c_{btl} = 'in situ' Niskin bottle conductivity, found by using CTD pressure and temperature from the burst data in the conversion of Niskin bottle salinity to conductivity
F_1 = conductivity bias term
F_2 = conductivity slope term
F_3 = station-dependent conductivity slope correction
N = station number

CTD conductivities are calibrated by the equation

$$c_{cal} = (1000\ c_{ctd}) \ .\ (F_2 + F_3\ .\ N) + F_1 \qquad \text{(eqn A1.2.2)}$$

Niskin bottle salinity data are first converted to 'in situ' conductivities c_{btl}. The ratio c_{btl}/c_{cal} for all bottle samples is then plotted against station number, along with the mean and standard deviation of the ratio for each station (Figure 1.7 in the main text is the version of this plot for the final calibrated data). Groups of consecutive stations are selected to follow approximately linear trends in the drift of the station-mean c_{btl}/c_{cal} (Table 1.12 in the main text). For each of these groups, the three calibration coefficients F_1, F_2 and F_3 are found by a least squares fit: F_1, F_2 and F_3 in eqn A1.2.2 are all varied to minimize the variance σ^2 of the conductivity residual (c_{btl}-c_{cal}), where σ^2 is defined by

$$\sigma^2 = \sum (c_{btl} - c_{cal})^2 / (n - 1) \qquad \text{(eqn A1.2.3)}$$

for n equal to the total number of bottle samples in the station grouping.

Note that samples with a previously assigned quality code of -1 (sections A1.2.7) are excluded from the above calculations. In addition, samples for which

$$|\ (c_{btl} - c_{cal})\ | > 2.8\ \sigma \qquad \text{(eqn A1.2.4)}$$

are also flagged with the quality code -1, and excluded from the final calculation of the conductivity calibration coefficients F_1, F_2 and F_3. Samples rejected at this stage often include those collected in steep vertical temperature and salinity gradients, and not already rejected.

This process is often iterative, as more bad salinity bottle samples are found, station groupings adjusted, and upcast CTD burst conductivity data are flagged. During the iteration, different intermediate bottle data files are named *calib1.dat:nn* and *calib2.dat:nn* (for primary and secondary sensors respectively), where *nn* is the file version number. Additionally, during this stage of the processing a decision is made which of the CTD temperature/conductivity sensor pair data to use i.e. primary or secondary sensor data. In general, primary and secondary sensor data are not mixed (i.e. primary T is not mixed with secondary C, and primary C is not mixed with secondary T), as notionally the primary and secondary sensors are not measuring the same parcel of water pumped past the sensors.

A1.2.8.2 Application of CTD conductivity calibration coefficients

The set of coefficients F_1, F_2 and F_3 found for each station (Tables 1.12 and 1.13 in the main text) are first used to calibrate the upcast CTD conductivity burst data in the intermediate bottle data file. The conductivity calibration is applied to the mean value for each burst only (as opposed to each raw data scan in the burst). Upcast CTD salinity burst values are recalculated from the calibrated CTD burst mean values of conductivity, temperature and pressure.

Next, the conductivity calibration is applied to the 24 Hz conductivity data in the cnv CTD files, to produce the cnn CTD files.

A1.2.8.3 Processing flow

The intermediate bottle file data, containing upcast CTD burst data means and Niskin bottle data, are used to determine the conductivity calibration coefficients F_1, F_2 and F_3. Station groupings are determined from the bias drift of the conductivity cell/salinometer comparison with time (section A1.2.8.1). For each station group, the following occurs:

1. 3 iterations are made of the least squares fitting procedure (section A1.2.8.1) to calculate F_1, F_2 and F_3, each iteration beginning with the latest value for the coefficients;

2. bottles are rejected according to the criterion of eqn A1.2.4;

3. steps 1 and 2 are repeated until no further bottle rejection occurs.

For each station group, there is a single value for each of the 3 coefficients F_1, F_2 and F_3 (Table 1.12 in the main text); following the station-dependent correction, an individual corrected slope term (F_2 + F_3.N) (as in eqn A1.2.2) applies to each station (Table 1.13 in the main text). When final values of the coefficients have been obtained, the conductivity calibration is applied to both the upcast CTD burst data and the 24 Hz CTD data in the cnv files (section A1.2.8.2). Finally, plots are made of both the ratio c_{btl}/c_{cal} and the residual (s_{btl} - s_{cal}) versus station number (Figures 1.7 and 1.8 in the main text), where s_{btl} is the Niskin bottle salinity and s_{cal} is the calibrated CTD salinity from the upcast burst data (section A1.2.8.2).

Following calibration of the CTD conductivity, the mean of the salinity residuals (s_{btl} - s_{cal}) for the entire data set is equal to 0 (for a good data set). The standard deviation about 0 of the salinity residual (section A1.2.13) provides an indicator for the quality of the data set. With good CTD and salinometer performance, this standard deviation should be significantly less than 0.002 (PSS78).

A1.2.9 CREATION OF 2 DBAR-AVERAGED FILES

Downcast data from each 24 Hz cnn CTD file (i.e. with calibrated conductivity) are written to a pressure monotonically increasing file, omitting scans previously flagged as a pressure reversal (section A1.2.5.5), and omitting scans previously flagged as bad (section A1.2.5.7). The pressure monotonic data are then sorted into 2 dbar pressure bins, with each bin centered on the even integral pressure value, starting at 2 dbar, as follows. A data scan is placed into the ith 2 dbar pressure bin if

$$pmid_i - 1 \; < \; p \; \leq \; pmid_i + 1 \qquad \text{(eqn A1.2.5)}$$

where $pmid_i$ is the ith 2 dbar pressure bin centre, and p is the pressure value for the data scan. Data scans previously flagged as bad (section A1.2.5.7),

After sorting, the temperature, conductivity, oxygen voltage and additional sensor values (i.e. fluorescence, P.A.R., transmittance) in each 2 dbar bin are averaged and written to the 2 dbar-averaged file. There is no pressure centering of these parameters i.e. for the ith 2 dbar pressure bin, the parameters are assigned to the even integral pressure value at the centre of the bin. Note that if the number of points in a bin is less than 8, no averages are calculated for that bin. Also note that data from only one of the temperature/conductivity sensor pairs are used, as per section A1.2.8.1 above.

The salinity s_{av} for each 2 dbar bin is calculated from T_{av}, c_{av} and pmid, where T_{av} and c_{av} are respectively the temperature and conductivity averages for the bin. Note that T_{av} is first converted from the ITS-90 scale to the IPTS-68 scale using eqn A1.2.1.

A1.2.10 CALIBRATION OF CTD DISSOLVED OXYGEN

CTD dissolved oxygen data are calibrated using the downcast raw CTD oxygen voltages. Downcast 2 dbar-averaged CTD data are matched with the Niskin bottle dissolved oxygen samples on equivalent pressures. The calibration is based on the method of Owens and Millard (1985).

In general, single whole profile fits for deeper stations leave a significant residual between bottle and calibrated CTD values near the bottom. So separate calibration fits are down for the shallow and deep parts of the CTD profiles, using the following scheme (and where maxp = maximum pressure of the cast):

(i) *for casts where maxp ≥ 4000 dbar*
* profile split at 2000 dbar
* shallow fit done for top down to 1 bottle below 2000 dbar
* deep fit done for 1 bottle above 2000 dbar down to bottom
* in final calculation of 2 dbar CTD oxygen values, shallow and deep fits linearly "blended" over the pressure window 1800 to 2200 dbar i.e. ±200 dbar around the split point

(ii) *for casts where 1800 ≤ maxp < 4000 dbar*
* profile split at 1500 dbar
* shallow fit done for top down to 1 bottle below 1500 dbar
* deep fit done for 1 bottle above 1500 dbar down to bottom
* in final calculation of 2 dbar CTD oxygen values, shallow and deep fits linearly "blended" over the pressure interval 1350 to 1650 dbar i.e. ±150 dbar around the split point

(iii) *for casts where 1400 ≤ maxp < 1800 dbar*
* profile split at 1000 dbar
* shallow fit done for top down to 1 bottle below 1000 dbar
* deep fit done for 1 bottle above 1000 dbar down to bottom
* in final calculation of 2 dbar CTD oxygen values, shallow and deep fits linearly "blended" over the pressure interval 900 to 1100 dbar i.e. ±100 dbar around the split point

(iv) *for casts where maxp < 1400 dbar*
* single whole profile fit

Note that a minimum of 4 bottles is required to run the fitting routine.

All calibration calculations are performed on dissolved oxygen (i.e. Niskin bottle and CTD dissolved oxygen values, and oxygen saturation values) in units of ml/l; all values are reported in units of μmol/l. The conversion factor used is (μmol/l) = 44.6595 x (ml/l).

The following definitions apply for the dissolved oxygen calibration:

o_{cal} = calibrated CTD dissolved oxygen
o_v = raw CTD oxygen voltage
T = CTD temperature
s = CTD salinity
p = CTD pressure
slope = oxygen signal slope
bias = oxygen signal bias
tcor = temperature correction term
pcor = pressure correction term
o_{btl} = Niskin bottle dissolved oxygen value

All the above CTD parameters are 2 dbar-averaged data. CTD dissolved oxygen is calibrated using a simplification (i.e. time constant and weighting factor set equal to 0) of the sensor model of Owens and Millard (1985), as follows:

$$o_{cal} = [\text{ slope } . (o_v + \text{bias})] . \text{oxsat}(T,s) . \exp(\text{tcor} . T + \text{pcor} . p) \qquad \text{(eqn A1.2.6)}$$

where the oxygen saturation value oxsat is calculated at T and s using the formula of Weiss (1970):

$$\text{oxsat}(T,s) = \exp\{ A_1 + A_2.(100/T_K) + A_3.\ln(T_K/100) + A_4.(T_K/100) + s.[B_1 + B_2.(T_K/100) + B_3.(T_K/100)^2] \} \qquad \text{(eqn A1.2.7)}$$

for T_K equal to the CTD temperature in degrees Kelvin (= T + 273.16), and the additional coefficients having the values (Weiss, 1970):

A_1 = -173.4292	B_1 = -0.033096
A_2 = 249.6339	B_2 = 0.014259
A_3 = 143.3483	B_3 = -0.0017
A_4 = -21.8492	

Note that the CTD temperature T in equations A1.2.6 and A1.2.7 is first converted from the ITS-90 scale to the IPTS-68 scale using the approximation of Saunders (1990) (i.e. eqn A1.2.1).

CTD dissolved oxygen is calibrated for individual stations. For each individual station the 4 calibration coefficients (slope, bias, tcor and pcor) in eqn A1.2.6 are found by varying all 4 coefficients in order to minimize the variance σ^2 of the dissolved oxygen residual $o_{btl} - o_{cal}$, where σ^2 is defined by

$$\sigma^2 = \sum (o_{btl} - o_{cal})^2 / (n-1) \qquad \text{(eqn A1.2.8)}$$

for n equal to the total number of bottle samples at the station (or in the station grouping). A non-linear least squares fitting routine, utilising the subroutines MRQMIN, MRQCOF, COVSRT and GAUSSJ in Press et al. (1986), is applied to find the 4 coefficients. In application of the routine, convergence is judged to have occurred when

$$\sum (o_{btl} - o_{cal})^2 / (0.6)^2 < 0.96\, n \qquad \text{(eqn A1.2.9)}$$

or else after a maximum of 5 iterations. Note that when calculating σ^2 for each Niskin bottle sample, the pressure from the upcast CTD burst data (i.e. the pressure assigned to the bottle sample) is used in eqn A1.2.6, while all other parameters are from the downcast data (at the nearest equivalent 2 dbar pressure value). Downcast CTD pressure is used in eqn A1.2.6 when the resulting calibration is being applied to finalise the entire 2 dbar dissolved oxygen data. Also note that there is no automatic rejection of dissolved oxygen bottle data analogous to eqn A1.2.4 in the conductivity calibration.

Prior to calibration, bad oxygen bottle data are excluded. When matching upcast bottle data with equivalent downcast CTD data, mismatches can occur due to temporal differences between the downcast and upcast profiles, particularly in sharp local features and gradients in the upper water column. Calibrations for individual stations are significantly improved by exclusion of these worst cases from calibration fits. The fit for a station (or group of stations) is usually not considered satisfactory until $2.8\sigma < 0.3$ (for σ defined as in eqn A1.2.8).

The oxygen residuals ($o_{btl} - o_{cal}$) are plotted against station number (Figure 1.10 in the main text). The mean of the residuals for an entire cruise should be very close to 0. In general, a standard deviation of the residuals < 1% of full scale (see section 1.5.1.4 in the main text) is a good result.

CTD 2 dbar-averaged dissolved oxygen values are calculated for a station using the values for slope, bias, tcor and pcor found for the station, and applying the scheme described above for melding calibrations from the shallow and deep part of the profile. When calculating oxygen for each 2 dbar bin using eqns A1.2.6 and A1.2.7, the 2 dbar bin values for temperature, salinity and pressure are used.

A1.2.11 QUALITY CONTROL OF 2 DBAR-AVERAGED DATA

Plots of the 2 dbar-averaged CTD data are inspected to identify additional bad or suspicious data. Suspect data are most commonly due to sensor hardware malfunction, fouling of the conductivity cell, insufficient or no oxygen bottle samples (for oxygen data), and transient effects near the surface (much less prevalent than for the Neil Brown type CTD's used on previous cruises). Obvious bad values are removed from the data, and questionable values are noted (Table 1.15 in the main text).

A1.2.12 QUALITY CONTROL OF NUTRIENT DATA

Nutrient data are checked using plots of individual station profiles, overlaying profiles from groups of consecutive stations, looking at bulk plots (nitrate+nitrite versus phosphate), and where possible comparing values with any available historical data. Nutrient data which are obviously bad are removed from the bottle data file. Questionable values are noted (Table 1.16 in the main text). On occasion, autoanalyser errors may necessitate the flagging of an entire station as questionable.

A1.2.13 RESIDUALS FOR CTD CALIBRATION COMPARISONS TO BOTTLE DATA

Final residuals for (s_{btl} - s_{cal}) and (o_{btl} - o_{cal}) (where s_{btl} and o_{btl} are respectively Niskin bottle salinity and oxygen values, and s_{cal} and o_{cal} are respectively final calibrated CTD salinity and oxygen values), are plotted for a cruise, and standard deviations of the residuals calculated from

$$x_{std} = \left\{ \left[\sum_{i=1}^{n} (x_i - x_{mean})^2 \right] / (n - 1) \right\}^{1/2} \qquad \text{(eqn A1.2.10)}$$

where x_{std} is the standard deviation of x (for x equal to the salinity or dissolved oxygen residual). For salinity, the summation in eqn A1.2.10 does not include points rejected for the CTD conductivity calibration. Similarly for dissolved oxygen, the summation does not include points rejected for the CTD dissolved oxygen calibration. Thus n is equal to the total number of data points x_i not rejected for the relevant calibration, with mean value x_{mean} of the all the x_i values (i.e. mean for all the stations in the plot).

These calculated standard deviation values are important indicators for the quality of the CTD data set.

APPENDIX 1.3 DATA FILE TYPES AND FORMATS

A1.3.1 CTD DATA

* CTD serial 703 was used for all of cruise AU0304, and for stations 1 to 41 of cruise AU0403. CTD serial 704 was used for stations 42 to 115 of cruise AU0403.

* CTD data are in text files named *.all, containing 2-dbar averaged data. An example of file naming convention:

a03043020.all a = Aurora Australis
03 = year
04 = cruise number
3 = CTD instrument number (3 for serial 703, 4 for serial 704)
020 = CTD station number

* The files consist of a 15 line header with station information (all times are UTC), followed by the data in column format, as follows:

column 1 - pressure (dbar)
column 2 - temperature (degrees C, ITS-90 scale)
column 3 - conductivity (mS/cm)
column 4 - salinity (PSS78)
column 5 - dissolved oxygen (µmol/l)
column 6 - fluorescence (volts)
column 7 - no. of data points used in the 2 dbar bin

* All files start at 2 dbar, and there is a line for each 2 dbar value. Any missing 2 dbar data are filled by the null value -9.

* All CTD data are downcast data.

* Any missing header information is filled by blanks.

A1.3.2 NISKIN BOTTLE DATA

* Bottle data are contained in the text files a0304.bot and a0403.bot (for cruises AU0304 and AU0403 respectively), with the following columns:

column 1 - station number
column 2 - ctd pressure (dbar)
column 3 - ctd temperature (deg. C, ITS-90 scale)
column 4 - digital reversing thermometer temperature (no thermometer data for these cruises)
column 5 - ctd conductivity (mS/cm)
column 6 - ctd salinity (PSS78)
column 7 - bottle salinity (PSS78)
column 8 - phosphate (µmol/l)
column 9 - nitrate (µmol/l) (i.e. total nitrate+nitrite)
column 10 - silicate (µmol/l)
column 11 - bottle dissolved oxygen (µmol/l)
column 12 - bottle flag (1=good,0=suspicious,-1=bad, relevant to bottle or CTD salinity values for CTD conductivity calibration)
column 13 - Niskin bottle number

* Columns 2, 3, 5 and 6 are all the averages of upcast CTD burst data (i.e. averages of the 10 seconds of CTD data centered around each bottle firing).

* Any missing data are filled by the null value -9.

A1.3.3 STATION INFORMATION

A summary of the station information is contained in the text files a0304.sta and a0403.sta (for cruises AU0304 and AU0403 respectively). This station information is also included in the matlab files a0304.mat and a0403.mat. The station information files contain position, time, bottom depth, maximum pressure and minimm altimeter value for CTD stations. Position, time (UTC) and bottom depth are specified at the start, bottom and end of the cast. Decimal time is also included for the start, bottom and end of the cast, defined as below in the matlab files.

A1.3.4 MATLAB FORMAT

* CTD 2 dbar data are contained in the matlab files a0304.mat and a0403.mat (both including header information), and bottle data are contained in the matlab files a0304bot.mat and a0403bot.mat.

* In the matlab files, column number for each array corresponds with CTD station number.

* In the matlab files, NaN is a null value.

* In the bottle file, the rows 1 to 24 are the shallowest to deepest Niskins respectively.

* For the files a0304.mat and a0403.mat, the array names have the following meaning:
(all times are UTC)
"start" refers to start of cast
"bottom" refers to bottom of cast
"end" refers to end of cast
"decimal time" is decimal days: for AU0304, this is measured from 2400 on 31st Dec. 2002 (so, for example, midday on 2nd January 2001 = decimal time 1.5); for AU0403, it's measured from 2400 on 31st Dec. 2003.
"lat" is latitude (decimal degrees, where -ve = south)
"lon" is longitude (decimal degrees, where +ve = east)
"time" is hhmmss time
botd = ocean depth (m)
maxp = maximum pressure of the CTD cast (dbar)
lastbin = deepest 2 dbar pressure bin (for AU0403 only)
altimeter = minimum reliable altimeter reading of the CTD cast (m)
press_alt = pressure value (dbar) at the minimum altimeter reading
ctdunit = instrument serial number
station = station number
date = ddmmyyyy date at the start of the cast
"ctd" is the upcast CTD burst data, for the parameters:
  cond=conductivity
  fluoro=fluorescence
  npts=number of data points used in the 2 dbar bin
  ox=dissolved oxygen (μmol/l)
  press=pressure (dbar)
  sal=salinity (PSS78)
  temp=temperature (deg.C T90)

* For the files a0304bot.mat and a0403bot.mat, the array names have the following meaning:
"ctd" refers to upcast CTD burst data, for the parameters:
  cond=conductivity (mS/cm)
  press=pressure (dbar) (also called hyd_press)
  sal=salinity 9PSS78)
  temp=temperature (deg.C T90)
"hyd" refers to bottle data, for the parameters:
  ox=dissolved oxygen (μmol/l)
  sal=salinity (PSS78)

flag = the bottle flagged described under the bottle data section
niskin = Niskin bottle number
nitrate,phosphate,silicate = µmol/l
station = station number
therm = digital reversing thermometer temperature (no data for these cruises)

A1.3.5 WOCE DATA FORMAT

The data are also available as WOCE format files, following the standard WOCE format as described in Joyce and Corry (1994).

A1.3.5.1 CTD 2 dbar-averaged data files

* Data are contained in the files *.ctd
* CTD 2 dbar-averaged file format for AU0304 is as per Table 4.7 of Joyce and Corry (1994). Data for AU0403 are in "WHP-exchange" format (see WHPO website at http://whpo.ucsd.edu for description of the format). In both cases, measurements are centered on even pressure bins, with the first value at 2 dbar.
* The quality flags for CTD data are defined in Table A1.3.1.

A1.3.5.2 Bottle data files

* Data for the two cruises are contained in the files a0304.sea and a0403.sea.
* a0304.sea format is as per Table 4.5 of Joyce and Corry (1994); a0403.sea is in WHP-Exchange format. Quality flags are defined in Tables A1.3.2 and A1.3.3.
* The total value of nitrate+nitrite only is listed.
* For AU0304, silicate is reported to the first decimal place only; for AU0403, silicate and nitrate+nitrite are reported to the first 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.
* SAMPNO is equal to the rosette position of the Niskin bottle.
* Salinity samples rejected for conductivity calibration, as per eqn A1.2.4 in Appendix 1.2, are not flagged in the .sea file.

A1.3.5.3 Conversion of units for dissolved oxygen and nutrients

A1.3.5.3.1 Dissolved oxygen

Niskin bottle data

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

$$C_k = 1000\, C_l / \rho(\theta,s,0) \qquad \text{(eqn A1.3.1)}$$

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

$$\theta = \theta(T,s,p) \qquad \text{(eqn A1.3.2)}$$

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 A1.3.1 and A1.3.2 are CTD 2 dbar-averaged data.

A1.3.5.3.2 Nutrients

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

$$C_k = 1000\ C_l / \rho(T_l,s,0) \qquad \text{(eqn A1.3.3)}$$

where 1000 is a conversion factor, and $\rho(T_l,s,0)$ is the water density in the hydrochemistry laboratory at the laboratory temperature $T_l = 20.0^oC$, and at zero pressure. Upcast CTD burst data averages are used for s.

<u>Table A1.3.1:</u> Definition of quality flags for CTD data (after Table 4.10 in Joyce and Corry, 1994). These flags apply both to CTD data in the 2 dbar-averaged *.ctd files, and to upcast CTD burst data in the *.sea files.

flag	definition
2	acceptable measurement
3	questionable measurement
4	bad measurement
5	measurement not reported
6	interpolated over >2 dbar interval
7	despiked
9	parameter not sampled

<u>Table A1.3.2:</u> Definition of quality flags for Niskin bottles (i.e. parameter BTLNBR in *.sea files) (after Table 4.8 in Joyce and Corry, 1994).

flag	definition
2	no problems noted
3	bottle leaking
4	bottle did not trip correctly
5	not reported
9	samples not drawn from this bottle

<u>Table A1.3.3:</u> Definition of quality flags for water samples in *.sea files (after Table 4.9 in Joyce and Corry, 1994).

flag	definition
2	acceptable measurement
3	questionable measurement
4	bad measurement
5	measurement not reported
9	parameter not sampled

A1.3.5.4 Station information file

* Data for the two cruises are contained in the files a0304.sum and a0403.sum, with the file format as per section 3.3 of Joyce and Corry (1994).
* Depth and altimeter readings are as described previously in the report.
* Wire out (i.e. meter wheel readings of the CTD winch) were unavailable.

A1.3.6 ADCP DATA

ADCP data are available as 30 ensemble averages, contained in the following files:

au030401.cny and au040301.cny- text format, all data
au0304_slow35.cny and au0403_slow35.cny - text format, "on station" data i.e. data for which ship speed ≤ 0.35 m/s
a0304dop.mat and a0403dop.mat - matlab format, all data
a0304dop_slow35.mat and a0403dop_slow35.mat - matlab format, "on station" data i.e. data for which ship speed ≤ 0.35 m/s

Full file format description is given in the text files README_au0304_adcp and README_au0403_adcp, included with the data.

A1.3.7 UNDERWAY DATA

See section 1.3.3 in the main text of this report. Full file format descriptions are given in the text files README_au0304_underway and README_au0403_underway, included with the data.

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