SAZ-SENSE, Marine Science Cruise AU0703
- Oceanographic Field Measurements and Analysis

MARK ROSENBERG
ACE CRC, Hobart, Australia
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1 INTRODUCTION

Oceanographic measurements were collected aboard Aurora Australis cruise au0703 (voyage 3 2006/2007, 17th January to 20th February 2007) as part of the "SAZ-SENSE" experiment south of Tasmania, between 43^o and 55^o south. A total of 109 CTD vertical profile stations were taken to various depths, focussing chiefly on the upper water column. Over 1300 Niskin bottle water samples were collected for the measurement of salinity, dissolved oxygen, nutrients (phosphate, nitrate+nitrite, silicate, ammonia and nitrite), dissolved inorganic carbon, alkalinity, particulate organic carbon/nitrogen/silicate, dissolved and particulate barium, thorium, dissolved organic carbon, ammonium, pigments, phytoplankton, bacteria, viruses, diatoms, amino acids, and other biological parameters (list incomplete), using a 24 bottle rosette sampler. Near surface current profile data were collected by a ship mounted ADCP. Data from the array of ship's underway sensors are included in the data set.

This report describes the processing/calibration of the CTD and ADCP data, and details the data quality. An offset correction is derived for the underway sea surface temperature and salinity data, by comparison with near surface CTD data. CTD station positions are shown in Figure 1, while CTD station information is summarised in Table 1.

During the cruise, various sites were occupied for multiple measurement activities, and these sites were named and referred to as "stations". Note however that in this report "station" refers to a single CTD cast i.e. CTD station 1 to 109 for the cruise.

2 CTD INSTRUMENTATION

SeaBird SBE9plus CTD serial 704, with dual temperature and conductivity sensors and a single SBE43 dissolved oxygen sensor (serial 0178, on the primary sensor pump line), was used for the entire cruise, mounted on a SeaBird 24 bottle rosette frame, together with a SBE32 24 position pylon and 24 x 10 litre General Oceanics Niskin bottles. The following additional sensors were mounted:

* Tritech 200 kHz and 500 kHz altimeters
* Wetlabs ECO-AFL/FL fluorometer serial 296
* Wetlabs C-star transmissometer serial 899DR
* Biospherical Instruments photosynthetically active radiation (i.e. PAR) sensor
* old Antarctic Division PAR sensor

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 SeaBird data acquisition software "Seasave". The transmissometer was plumbed inline with the main CTD sensors for the first 35 casts, with a closed tube joining the 2 transmissometer windows. The tube and plumbing to the transmissometer were removed after CTD 35.

The CTD deployment method was as follows:

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

* after returning to just below the surface, downcast proper commenced

Cast depths varied according to the sampling requirements at each station, and full depth casts were only taken on 3 occasions.

Pre cruise temperature, conductivity and pressure calibrations were performed by the CSIRO Division of Marine and Atmoshperic Research calibration facility (Table 2) (July to August 2006). Manufacturer supplied calibrations were used for the dissolved oxygen, fluorometer, transmissometer and altimeters. PAR sensors were uncalibrated (raw voltage data only). Final conductivity and dissolved oxygen calibrations derived from in situ Niskin bottle samples are listed later in the report.

For stations 49, 50 and 51, six seal tags (P.I. Judy Horsburgh) were attached to the rosette, to calibrate and check functioning of the tag sensors.

3 CTD DATA PROCESSING AND CALIBRATION

CTD data were processed in Hobart. The first step is application of a suite of the SeaBird "Seasoft" processing programs to the raw data, in order to:
* convert raw data signals to engineering units
* remove the surface pressure offset for each station
* realign the oxygen sensor with respect to time (note that conductivity sensor alignment is done by the deck unit at the time of data logging)
* remove conductivity cell thermal mass effects
* apply a low pass filter to the pressure data
* flag pressure reversals
* search for bad data (e.g. due to sensor fouling)

Further processing and data calibration were done in a UNIX environment, using a suite of fortran programs. Processing steps here include:
* forming upcast burst CTD data for calibration against bottle data, where each upcast burst is the average of 10 seconds of data prior to each Niskin bottle firing
* merging bottle and CTD data, and deriving CTD conductivity calibration coefficients by comparing upcast CTD burst average conductivity data with calculated equivalent bottle sample conductivities
* forming pressure monotonically increasing data, and from there calculating 2 dbar averaged downcast CTD data
* calculating calibrated 2 dbar averaged salinity from the 2 dbar pressure, temperature and conductivity values
* deriving CTD dissolved oxygen calibration coefficients by comparing bottle sample dissolved oxygen values (collected on the upcast) with CTD dissolved oxygen values from the equivalent 2 dbar downcast pressures
* extracting the appropriate fluorescence and transmittance data to assign to each 2 dbar bin

Full details of the data calibration and processing methods are given in Rosenberg et al. (in preparation), referred to hereafter as the *CTD methodology*. Additional processing steps, in particular for the fluorescence and transmittance data, are discussed below in the results section. For calibration of the CTD oxygen data, whole profile fits were used for each station.

Final station header information, including station positions at the start, bottom and end of each CTD cast, were obtained from underway data for the cruise (see section 6 below). Note the following for the station header information:
* All times are UTC.
* "Start of cast" information is at the commencement of the downcast proper, as described above.
* "Bottom of cast" information is at the maximum pressure value.
* "End of cast" information is when the CTD leaves the water at the end of the cast, as indicated by a drop in salinity values.
* 12 kHz depth sounder data were not processed for this cruise. and all bottom depth information are the values recorded at the time of CTD logging i.e. as read from the "Echogram" display, with sound speed 1500 m/s. The Echogram display was often difficult to read through the thruster noise, and bottom depth values are mostly approximate only.

* "Bottom of cast" depths for CTD 38 and 43 are calulated from CTD maximum pressure and altimeter value at the bottom of the casts.

Lastly, data were converted to MATLAB format, and final data quality checking was done within MATLAB.

4 CTD AND BOTTLE DATA RESULTS AND DATA QUALITY

Data from the primary CTD sensor pair (temperature and conductivity) were used for this cruise, with the exception of stations 8 and 30 - for these two stations the primary sensors were fouled, and data from the secondary sensor pair were used.

4.1 Conductivity/salinity

The conductivity calibration and equivalent salinity results for the cruise are plotted in Figures 2 and 3, and the derived conductivity calibration coefficients are listed in Tables 3 and 4. Station groupings used for the calibration are included in Table 3. International standard seawater batch numbers used for salinometer standardisation were as follows:

station 1	P146
station 2 to 30	P147
station 31 to 63	P146
station 64 to 104	P147
station 105 to 109	P146

The salinometer (Guildline Autosal serial 62549) used for stations 1 to 104 appeared stable throughout the cruise. Stations 105 to 109 were analysed back in Hobart immediately following the cruise, using salinometer serial 62550. Overall, CTD salinity for the cruise can be considered accurate to better than 0.0015 (PSS78).

Close inspection of the vertical profiles of the bottle-CTD salinity difference values reveals a slight positive biasing of the order 0.001 (PSS78) for station 1, and a slight negative biasing of the same magnitude for station 47. This is most likely due to salinometer performance and/or bottle samples, and there is no significant diminishing of CTD salinity accuracy.

4.2 Temperature

Primary and secondary CTD temperature data (t_p and t_s respectively) are compared for the cruise in Figure 4. CTD upcast burst data, obtained at each Niskin bottle stop, are used for the comparison. From previous cruises (e.g. Rosenberg, unpublished report, 2006), a very small pressure dependency of t_p-t_s for CTD704 of the order 0.0005^{o}C is evident over the full ocean depth range. For cruise au0703, measurements were only taken down to ~2500 dbar, and a small pressure dependency similar to previous cruises is evident by the deepest measurements (Figure 4). Note that the magnitude of this pressure dependency lies within the assumed temperature accuracy of 0.001^{o}C (i.e. the accredited temperature accuracy of the CSIRO calibration facility). Also note that without some temperature standard for comparison, it cannot be determined whether the 2 temperature sensors have the same or different pressure dependencies.

4.3 Pressure

Surface pressure offsets for each cast (Table 5) were obtained from inspection of the data before the package entered the water. For station 24, logging commenced when the CTD was already in the water, and the surface pressure offset was estimated from surrounding stations.

4.4 Dissolved oxygen

CTD oxygen data for his cruise were calibrated as whole profile fits - with the limited depth range for the CTD deployments, splitting profiles into separate shallow and deep calibrations was not required. The CTD oxygen calibration results are plotted in Figure 5, and the derived calibration coefficients are listed in Table 6. Overall the calibrated CTD oxygen agrees with the bottle data to well within 1% of full scale (where full scale is ~350 µmol/l above 750 dbar, and ~240 µmol/l below 750 dbar).

Reliable calibration of a CTD dissolved oxygen profile is only possible with an adequate profile of bottle oxygen samples. The Niskin bottle sampling scheme for this cruise resulted in many CTD stations with either low numbers of bottle oxygen samples, or none at all. For the former, only that part of the CTD oxygen profile covered by samples was usable; for the latter, CTD oxygen data were not usable. Figure 6 summarizes calibrated CTD oxygen data coverage.

Note that oxygen bottle samples for stations 105 to 109 were analysed back in Hobart, immediately following the cruise.

4.5 Fluorescence, PAR, transmittance

All fluorescence and transmittance data have a calibration, as supplied by the manufacturer (Table 2), applied to the data. PAR sensor data are uncalibrated, and supplied as raw voltages. The data have **not** been verified by linkage to other data sources (e.g. chlorophyll-a concentration data, particulate data, etc).

In the ***CTD 2 dbar averaged data files***, both downcast and upcast data are supplied for fluorescence, PAR and transmittance. In these files, fluorescence and transmittance data are not in fact averages: fluorescence data are the **minimum** value within each 2 dbar bin, providing a profile "envelope" which minimizes the spikiness of the data; transmittance data are the **maximum** value within each 2 dbar bin, again minimizing the spikiness of the data. An additional parameter describing the spikiness of the transmittance data is supplied, calculated as follows. Pressure monotonic data (increasing for downcast, decreasing for upcast) are first formed from the full 24 Hz data, omitting equal pressure points as well as pressure reversals. For each transmittance reading tr_{mon} in the montonic data, transmittance "spike size" trsize is given by the deviation from the transmittance maximum envelope, i.e.

$$trsize = tr_{interp} - tr_{mon}$$

where

$$tr_{interp} = trmax_{bin1} + [(p_{mon} - p_{bin1}) / (p_{bin2} - p_{bin1}) \times (trmax_{bin2} - trmax_{bin1})]$$

p_{mon} = the pressure value corresponding with tr_{mon}
p_{bin1} = the nearest 2 dbar pressure bin less than p_{mon}
p_{bin2} = the nearest 2 dbar pressure bin greater than p_{mon}
$trmax_{bin1}$ = the 2 dbar maximum transmittance value for pressure bin p_{bin1}
$trmax_{bin2}$ = the 2 dbar maximum transmittance value for pressure bin p_{bin2}

(i.e. tr_{interp} is the transmittance value from the 2 dbar transmittance maximum envelope, linearly interpolated to p_{mon}). For a small number of cases in steep vertical gradients, tr_{interp} is a small negative value. This is due to the pressure mismatch between the even pressure bin to which tr_{max} is assigned, and the actual pressure value at which tr_{max} occurs. For these cases, the tr_{interp} value is changed to zero. Lastly, the transmittance "spikiness" trspike for each 2 dbar bin is the standard deviation of trsize values in each bin, i.e.

$$trspike = \{ [\sum_{i=1}^{n} (trsize_i - trsize_{mean})^2] / (n - 1) \}^{1/2}$$

where

n = number of trsize values in the 2 dbar bin
$trsize_{mean}$ = mean of the trsize values in the 2 dbar bin

In the ***bottle data files***, fluorescence and transmittance (and PAR) values are the averages of 10 second bursts of CTD data, and thus include all the data spikes within each 10 second averaging period. For comparison with Niskin bottle data, these 10 second averages best represent (short of referring to the full 24 Hz data) what the Niskin bottle samples as the package moves up and down with the swell prior to bottle closure. Note that these fluorescence and transmittance data are different to the data in the CTD 2 dbar averaged files (described above).

The plumbing arrangement used for the transmissometer during the first 35 stations (mentioned above in section 2) caused bad downcast transmittance data for several stations. These bad data, listed in Table 7, were removed from the data files.

4.6 Nutrients

Nutrients measured on the cruise were phosphate, total nitrate (i.e. nitrate+nitrite), silicate, ammonia, and nitrite (only up to station 86). Appendix 1 (by Neale Johnston) gives some details on analysis methods. Suspect nutrient values not deleted from the bottle data files are listed in Table 8. Nitrate+nitrite versus phosphate data are shown in Figure 7. A group of depressed phosphate values are evident in the figure, around nitrate+nitrite ≈ 5 µmol/l. These values are from the tops of various profiles up to station 32, and appear to be real features.

Only limited data were available from other cruises for comparison with the au0703 nutrient data, and only very rough comparisons were possible. In general, low level readings from the Lachat autoanalyser, including low level near surface phosphate and nitrate+nitrite data, and all ammonia and nitrite data, should be used with caution. The accuracy for these low level values is unknown.

4.7 Additional CTD data processing/quality notes

* Station 3 - the primary CTD sensors were fouled for part of the downcast profile, and these data were deleted from the 2 dbar averaged file.

* Station 7 - the salinity value flagged as -1 in the bottle data file was due to a CTD data spike in the primary sensor pair.

* Station 26 - after deployment of the CTD, there was no stop to wait for the pumps to come on. Most of the downcast for this very shallow cast was therefore unusable.

* Stations 27, 32, 34, 57 - after waiting for the pumps to come on, the package was not returned to a shallower position to commence the downcast (due to swell). The downcast profile for these stations commences between 20 and 40 dbar.

* Station 61 - top 2 Niskins tripped on the fly, due to heavy rolling of ship.

* Station 86 - the pressure sensor was fouled just prior to firing of bottle 24. Data used for CTD burst averages were shifted forward by 100 scans (i.e. 4.17 seconds).

* Stations 1 and 94 - logging ended before the CTD left the water. The last few bins of upcast fluorescence, PAR and transmittance data are therefore missing.

* Station 96 - the CTD sensor tubes and fluorometer sensor cap were not removed prior to deployment. The only usable profiles for this station are transmittance and PAR.

* For version of WOCE "Exchange" format bottle data file with µmol/kg units for nutrient data (available on request) - a laboratory temperature of 19^{o}C was used for conversion of units from µmol/l to µmol/kg.

4.8 Additional CTD sensor notes

* The ocean bottom was rarely approached on this cruise, however on both occasion where the bottom was in altimeter range, the 500 kHz altimeter (50 m range) gave reliable readings, while the 200 kHz altimeter (100 m range) did not work.

* The secondary temperature sensor malfunctioned on several occasion during the first 9 stations (possibly due to a bad connector), in turn causing bad secondary conductivity data. When this occured, secondary conductivity data took a while to recover.

* Data from the old Antarctic Division PAR sensor were unusable - not a worry, as good data were obtained from the Biospherical Instruments PAR sensor.

5 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 and calibration coefficients for the cruise are summarised in Table 9. Current vectors for the cruise are plotted in Figures 8a and b; the apparent vertical current shear error for different ship speed classes is plotted in Figure 9.

In general, ADCP data are contaminated by ship's motion when the ship accelerates i.e. changes direction or speed. Noise and turbulence often diminish ADCP data quality when the ship travels at speeds greater than ~13 knots, or during rough sea states. Thus the best quality ADCP data is when the ship is steaming in a straight line at a suitable constant speed, and during milder sea conditions. The most reliable data are collected when the ship is "on station" (on station data is defined here as data where ship speed $\leq$ 0.35 m/s).

An erroneous vertical ADCP current shear occurs when the ship is underway. This shear has a magnitude for this cruise of up to ~0.13 m/s over the ADCP current profile (Figure 9), although more often ~0.05-0.08 m/s. A likely cause for this error is acoustic ringing against a small air/water interface inside the transducer seachest. From Figure 9, when the ship is underway the effect is most significant over bins 1 to 10, and data from these bins should be treated with caution. Also from the figure, when the ship is travelling at $\leq$ 1 m/s the effect is no longer significant.

6 UNDERWAY MEASUREMENTS

Underway data were logged to an Oracle database on the ship. Quality control for this cruise was largely automated.

1 minute averaged underway data are contained in the files *sazsense.txt* (column formatted text file) and *sazsenseora.mat* (matlab format). Note that the latitude and longitude data in these files are 1 minute instantaneous values (i.e. not averaged).

Bathymetry data for the cruise were not processed, and depths are all null values in the underway data files.

Underway salinity data from the Antarctic Division thermosalinograph (in the oceanographic lab) display a response lag which becomes significant when crossing frontal regions where the horizontal gradients are high (Bronte Tilbrook, CSIRO, personal communication); these salinity data should not be used. Alternative underway salinity data were obtained from a separate CSIRO thermosalinograph in lab 1 (P.I. Bronte Tilbrook, CSIRO), and these data are considered reliable. Underway temperature data from the Antarctic Division hull mounted temperature sensor near the sea water inlet are good. A correction for the hull mounted temperature sensor and the lab 1 salinity was derived by comparing the underway data to CTD temperature and salinity data at 8 dbar (Figures 10a and b). The following corrections were then applied to the underway data:

$$T = T_{dls} - 0.022$$
$$S = S_{dls} + 0.077$$

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

REFERENCES

Rosenberg, M., unpublished. *Aurora Australis ADCP data status.* Antarctic Cooperative Research Centre, unpublished report, November 1999. 51 pp.

Rosenberg, M., unpublished. *BROKE West Survey, Marine Science Cruise AU0603 - Oceanographic Field Measurements and Analysis.* ACE Cooperative Research Centre, unpublished report, July 2006. 24 pp.

Rosenberg, M., Fukamachi, Y., Rintoul, S., Church, J., Curran, C., Helmond, I., Miller, K., McLaughlan, D., Berry, K., Johnston, N. and Richman, J., in preparation. *Kerguelen Deep Western Boundary Current Experiment and CLIVAR I9 transect, marine science cruises AU0304 and AU0403 - oceanographic field measurements and analysis.* ACE CRC Research Report.

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Table 1: **Summary of station information for cruise au0703. All times UTC; "TEST" = test cast, "transit" = transit station; "process" = process station; "alt" = minimum altimeter value (m), "maxp" = maximum pressure (dbar).**

	------------------------start of CTD-------------------------------					----------------bottom of CTD----------------				------------------end of CTD------------------					
CTD station	date	time	latitude	longitude	depth	time	latitude	longitude	depth	time	latitude	longitude	depth	alt	maxp
001 TEST	19 Jan 2007	120309	43 50.48 S	144 44.11 E	3176	123908	43 50.39 S	144 43.80 E	-	132700	43 50.21 S	144 43.51 E	-	-	1503
002 transit	19 Jan 2007	155939	43 50.15 S	144 41.57 E	3185	163543	43 50.07 S	144 41.27 E	-	171713	43 49.96 S	144 40.93 E	-	-	1001
003 transit	20 Jan 2007	004550	45 00.01 S	142 58.87 E	4900	014537	44 59.85 S	142 59.05 E	-	025526	44 59.59 S	142 59.20 E	-	-	2502
004 transit	20 Jan 2007	110647	44 55.13 S	143 01.70 E	4900	112511	44 55.04 S	143 01.69 E	-	120755	44 54.80 S	143 01.42 E	-	-	1004
005 transit	20 Jan 2007	135503	44 53.33 S	143 03.19 E	4300	141311	44 53.26 S	143 03.15 E	-	145619	44 53.06 S	143 02.99 E	-	-	801
006 transit	21 Jan 2007	002451	45 59.84 S	141 17.79 E	4700	004210	45 59.75 S	141 17.78 E	-	011449	45 59.46 S	141 17.82 E	-	-	1001
007 process1	21 Jan 2007	100833	46 23.46 S	140 39.25 E	4283	105304	46 23.46 S	140 39.35 E	-	115939	46 23.29 S	140 39.41 E	-	-	2504
008 process1	21 Jan 2007	153549	46 18.94 S	140 39.68 E	4500	154038	46 18.95 S	140 39.70 E	-	155753	46 18.97 S	140 39.80 E	-	-	102
009 process1	21 Jan 2007	173724	46 19.07 S	140 39.02 E	4500	175450	46 19.14 S	140 39.04 E	-	182249	46 19.24 S	140 39.14 E	-	-	1001
010 process1	22 Jan 2007	012838	46 19.25 S	140 36.06 E	4400	013910	46 19.34 S	140 36.06 E	-	021243	46 19.53 S	140 36.09 E	-	-	405
011 process1	22 Jan 2007	103533	46 19.30 S	140 36.67 E	4300	105547	46 19.33 S	140 36.67 E	-	113846	46 19.46 S	140 36.53 E	-	-	1002
012 process1	22 Jan 2007	190330	46 22.98 S	140 28.79 E	4800	190930	46 23.01 S	140 28.81 E	-	193141	46 23.14 S	140 28.77 E	-	-	203
013 process1	22 Jan 2007	231116	46 24.64 S	140 25.23 E	4300	231621	46 24.66 S	140 25.21 E	-	232959	46 24.73 S	140 25.17 E	-	-	153
014 process1	23 Jan 2007	015953	46 25.90 S	140 31.23 E	4200	024304	46 26.07 S	140 31.04 E	-	035518	46 26.17 S	140 30.58 E	-	-	2509
015 process1	23 Jan 2007	120040	46 26.61 S	140 30.05 E	4305	121754	46 26.62 S	140 30.00 E	-	130217	46 26.73 S	140 29.76 E	-	-	804
016 process1	23 Jan 2007	154102	46 27.70 S	140 24.66 E	4300	154511	46 27.69 S	140 24.65 E	-	155816	46 27.67 S	140 24.69 E	-	-	101
017 process1	23 Jan 2007	170738	46 27.37 S	140 23.90 E	4050	172930	46 27.37 S	140 23.86 E	-	175854	46 27.35 S	140 23.84 E	-	-	1004
018 process1	23 Jan 2007	210924	46 27.39 S	140 21.20 E	4450	211706	46 27.38 S	140 21.16 E	-	215645	46 27.46 S	140 21.09 E	-	-	202
019 process1	23 Jan 2007	234225	46 29.75 S	140 18.39 E	4700	000110	46 29.79 S	140 18.27 E	-	003718	46 29.89 S	140 17.98 E	-	-	804
020 process1	24 Jan 2007	212618	46 33.29 S	140 38.53 E	4500	213154	46 33.27 S	140 38.54 E	-	221404	46 33.17 S	140 38.76 E	-	-	203
021 process1	25 Jan 2007	000513	46 33.23 S	140 37.73 E	4600	001119	46 33.22 S	140 37.75 E	-	003341	46 33.19 S	140 37.78 E	-	-	201
022 process1	25 Jan 2007	031002	46 33.10 S	140 37.83 E	4100	031240	46 33.08 S	140 37.80 E	-	032444	46 33.08 S	140 37.72 E	-	-	100
023 process1	25 Jan 2007	060232	46 32.89 S	140 39.79 E	4300	060544	46 32.89 S	140 39.77 E	-	063317	46 32.87 S	140 39.41 E	-	-	201
024 process1	25 Jan 2007	092346	46 33.74 S	140 38.10 E	4700	092954	46 33.74 S	140 38.02 E	-	093335	46 33.77 S	140 38.02 E	-	-	37
025 process1	25 Jan 2007	120839	46 34.12 S	140 37.13 E	4600	121258	46 34.13 S	140 37.13 E	-	123825	46 34.15 S	140 37.13 E	-	-	204
026 process1	25 Jan 2007	150248	46 34.05 S	140 39.50 E	4800	150400	46 34.05 S	140 39.50 E	-	151615	46 34.05 S	140 39.56 E	-	-	39
027 process1	25 Jan 2007	180424	46 34.72 S	140 37.56 E	4800	181049	46 34.73 S	140 37.51 E	-	181559	46 34.74 S	140 37.46 E	-	-	37
028 process1	25 Jan 2007	210559	46 35.11 S	140 36.94 E	4800	211032	46 35.11 S	140 36.91 E	-	213615	46 35.02 S	140 36.82 E	-	-	202
029 process1	25 Jan 2007	231020	46 34.64 S	140 38.92 E	4600	231113	46 34.64 S	140 38.93 E	-	231943	46 34.62 S	140 38.99 E	-	-	40
030 process1	25 Jan 2007	235637	46 34.78 S	140 38.48 E	4650	001939	46 34.76 S	140 38.49 E	-	005840	46 34.60 S	140 38.47 E	-	-	1000
031 process1	26 Jan 2007	114447	46 28.55 S	140 20.24 E	4400	123419	46 28.47 S	140 20.09 E	-	134307	46 28.28 S	140 19.28 E	-	-	2504
032 process1	26 Jan 2007	153728	46 29.60 S	140 17.90 E	4500	154034	46 29.61 S	140 17.90 E	-	155030	46 29.63 S	140 17.83 E	-	-	51
033 process1	28 Jan 2007	140934	46 42.64 S	140 12.02 E	4600	142727	46 42.62 S	140 11.86 E	-	151139	46 42.55 S	140 11.40 E	-	-	805
034 process1	28 Jan 2007	162405	46 39.15 S	140 17.12 E	4600	165211	46 39.18 S	140 16.88 E	-	173434	46 39.25 S	140 16.52 E	-	-	1004
035 transit	29 Jan 2007	100750	49 00.01 S	142 59.92 E	3940	101534	48 59.97 S	142 59.92 E	-	104408	48 59.74 S	142 59.80 E	-	-	402
036 transit	29 Jan 2007	123838	48 59.44 S	143 00.26 E	3940	132347	48 59.21 S	143 00.30 E	-	142735	48 58.99 S	143 00.34 E	-	-	2505
037 process2	31 Jan 2007	164644	53 59.86 S	145 55.19 E	2800	165349	53 59.83 S	145 55.19 E	-	170903	53 59.74 S	145 55.20 E	-	-	205
038 process2	01 Feb 2007	014142	54 00.14 S	145 52.91 E	2700	023722	54 00.28 S	145 52.98 E	2779	035256	54 00.26 S	145 52.80 E	-	40.0	2782
039 process2	01 Feb 2007	052503	54 00.24 S	145 52.11 E	2850	052926	54 00.26 S	145 52.13 E	-	054857	54 00.33 S	145 52.27 E	-	-	201

Table 1: (cntd)						------------------------start of CTD-------------------------------			-----------------bottom of CTD-----------------				-------------------end of CTD-------------------				
CTD station	date	time	latitude	longitude	depth	time	latitude	longitude	depth	time	latitude	longitude	depth	alt	maxp
040 process2	01 Feb 2007	071636	54 00.87 S	145 52.06 E	2700	073515	54 00.87 S	145 52.04 E	-	082231	54 00.91 S	145 52.00 E	-	-	1001
041 process2	01 Feb 2007	101218	54 00.86 S	145 51.23 E	2600	101613	54 00.85 S	145 51.25 E	-	103348	54 00.82 S	145 51.19 E	-	-	201
042 process2	01 Feb 2007	161111	54 03.13 S	146 09.91 E	2500	162947	54 03.17 S	146 10.06 E	-	170553	54 03.23 S	146 10.40 E	-	-	1004
043 process2	02 Feb 2007	000203	54 01.04 S	146 07.65 E	2400	004709	54 01.21 S	146 07.65 E	2456	015303	54 01.36 S	146 07.38 E	-	28.7	2464
044 process2	02 Feb 2007	032840	54 00.88 S	146 07.98 E	2500	034603	54 00.88 S	146 08.09 E	-	042841	54 00.80 S	146 08.33 E	-	-	1001
045 process2	02 Feb 2007	103012	54 02.66 S	146 14.60 E	1500	103411	54 02.67 S	146 14.62 E	-	104218	54 02.64 S	146 14.69 E	-	-	201
046 process2	02 Feb 2007	144557	54 07.66 S	146 19.15 E	2500	145553	54 07.64 S	146 19.19 E	-	151126	54 07.64 S	146 19.21 E	-	-	200
047 process2	02 Feb 2007	161328	54 07.56 S	146 19.40 E	2500	163808	54 07.54 S	146 19.52 E	-	171015	54 07.43 S	146 19.73 E	-	-	1004
048 process2	02 Feb 2007	214122	54 08.46 S	146 17.86 E	2250	214620	54 08.48 S	146 17.90 E	-	221059	54 08.50 S	146 18.12 E	-	-	202
049 process2	03 Feb 2007	041536	54 09.10 S	146 18.38 E	2200	043124	54 09.08 S	146 18.47 E	-	050807	54 09.04 S	146 18.68 E	-	-	803
050 process2	03 Feb 2007	062059	54 08.93 S	146 18.88 E	2300	062359	54 08.93 S	146 18.92 E	-	063547	54 08.95 S	146 19.02 E	-	-	153
051 process2	03 Feb 2007	075031	54 08.26 S	146 18.41 E	2222	080639	54 08.27 S	146 18.51 E	-	085445	54 08.24 S	146 18.92 E	-	-	1002
052 process2	03 Feb 2007	151227	54 07.96 S	146 27.80 E	3500	151632	54 07.97 S	146 27.83 E	-	154119	54 08.06 S	146 28.15 E	-	-	203
053 process2	03 Feb 2007	211847	54 09.65 S	146 32.99 E	3350	212336	54 09.67 S	146 33.05 E	-	214900	54 09.73 S	146 33.20 E	-	-	202
054 process2	04 Feb 2007	031404	54 10.80 S	146 30.52 E	3500	032120	54 10.80 S	146 30.51 E	-	034545	54 10.85 S	146 30.37 E	-	-	200
055 process2	04 Feb 2007	050424	54 11.15 S	146 28.45 E	3500	052440	54 11.27 S	146 28.60 E	-	060433	54 11.44 S	146 28.75 E	-	-	1007
056 process2	04 Feb 2007	091355	54 11.15 S	146 30.57 E	3400	091925	54 11.15 S	146 30.58 E	-	094338	54 11.18 S	146 30.80 E	-	-	202
057 process2	04 Feb 2007	155024	54 15.76 S	146 43.90 E	3600	160040	54 15.82 S	146 44.04 E	-	162852	54 15.92 S	146 44.35 E	-	-	202
058 process2	05 Feb 2007	180327	54 27.53 S	147 07.94 E	3400	183419	54 27.59 S	147 08.46 E	-	190759	54 27.64 S	147 08.81 E	-	-	1000
059 process2	06 Feb 2007	051304	54 26.89 S	147 06.25 E	3500	052720	54 26.96 S	147 06.37 E	-	061008	54 27.01 S	147 06.85 E	-	-	827
060 transit	06 Feb 2007	151616	53 00.40 S	146 50.01 E	4100	152759	53 00.72 S	146 50.27 E	-	155212	53 01.37 S	146 50.75 E	-	-	402
061 transit	06 Feb 2007	224410	52 00.59 S	147 42.68 E	4000	233246	52 00.56 S	147 42.89 E	-	003646	52 00.47 S	147 43.05 E	-	-	2503
062 transit	07 Feb 2007	095509	50 59.12 S	148 34.16 E	4251	104212	50 58.43 S	148 34.57 E	-	114641	50 57.78 S	148 35.07 E	-	-	2506
063 transit	07 Feb 2007	131448	50 56.28 S	148 34.74 E	4200	132518	50 56.14 S	148 34.87 E	-	135219	50 55.83 S	148 35.34 E	-	-	403
064 transit	07 Feb 2007	201106	50 52.48 S	148 39.04 E	4200	203350	50 52.27 S	148 39.38 E	-	211505	50 51.98 S	148 40.04 E	-	-	1005
065 transit	08 Feb 2007	023250	50 00.18 S	149 26.48 E	3910	024106	50 00.13 S	149 26.53 E	-	030739	49 59.98 S	149 26.50 E	-	-	402
066 transit	08 Feb 2007	080543	49 59.30 S	149 25.36 E	3900	082454	49 59.24 S	149 25.57 E	-	091141	49 59.14 S	149 26.00 E	-	-	1003
067 transit	08 Feb 2007	111740	49 59.87 S	149 25.20 E	3900	120142	49 59.71 S	149 25.55 E	-	130122	49 59.49 S	149 26.10 E	-	-	2502
068 transit	08 Feb 2007	210653	48 59.93 S	150 20.06 E	1500	213108	48 59.89 S	150 20.21 E	-	220426	48 59.84 S	150 20.39 E	-	-	1004
069 transit	09 Feb 2007	042322	48 00.41 S	151 13.10 E	4000	051054	48 00.60 S	151 13.16 E	-	061318	48 00.89 S	151 13.14 E	-	-	2506
070 transit	09 Feb 2007	102837	48 01.63 S	151 13.00 E	4171	103633	48 01.66 S	151 13.00 E	-	110100	48 01.79 S	151 13.22 E	-	-	402
071 transit	09 Feb 2007	133227	48 03.50 S	151 11.72 E	4300	135125	48 03.67 S	151 11.90 E	-	143419	48 04.09 S	151 12.29 E	-	-	1001
072 transit	09 Feb 2007	232837	46 59.84 S	152 04.43 E	4800	234903	46 59.87 S	152 04.55 E	-	001908	47 00.00 S	152 04.70 E	-	-	1001
073 transit	10 Feb 2007	061218	45 59.65 S	152 54.55 E	4500	062824	45 59.63 S	152 54.60 E	-	070409	45 59.55 S	152 54.56 E	-	-	1000
074 transit	10 Feb 2007	094206	45 31.31 S	153 06.26 E	4700	100027	45 31.28 S	153 06.38 E	-	103930	45 31.13 S	153 07.00 E	-	-	1002
075 transit	10 Feb 2007	133500	45 59.89 S	153 11.81 E	4700	135626	45 59.79 S	153 11.89 E	-	143724	45 59.66 S	153 12.17 E	-	-	1001
076 process3	10 Feb 2007	184616	45 29.95 S	153 11.99 E	4600	185910	45 29.95 S	153 12.11 E	-	190754	45 29.92 S	153 12.23 E	-	-	401
077 process3	11 Feb 2007	011109	45 32.91 S	153 10.74 E	4500	011853	45 32.88 S	153 10.70 E	-	014248	45 32.93 S	153 10.57 E	-	-	401
078 process3	11 Feb 2007	044026	45 32.90 S	153 10.58 E	4600	045956	45 32.90 S	153 10.61 E	-	053924	45 33.08 S	153 10.71 E	-	-	1002
079 process3	11 Feb 2007	110422	45 33.47 S	153 10.58 E	4600	114532	45 33.31 S	153 10.66 E	-	124738	45 32.94 S	153 10.96 E	-	-	2502
080 process3	11 Feb 2007	151036	45 30.77 S	153 13.45 E	4700	151838	45 30.73 S	153 13.46 E	-	153002	45 30.67 S	153 13.48 E	-	-	201

Table 1: **(cntd)**

	------------------------start of CTD------------------------------					-----------------bottom of CTD-----------------				-------------------end of CTD-------------------					
CTD station	date	time	latitude	longitude	depth	time	latitude	longitude	depth	time	latitude	longitude	depth	alt	maxp
081 process3	11 Feb 2007	161116	45 30.87 S	153 13.66 E	4600	163326	45 30.79 S	153 13.67 E	-	170144	45 30.71 S	153 13.72 E	-	-	1001
082 process3	11 Feb 2007	190832	45 31.01 S	153 14.20 E	4600	191254	45 30.98 S	153 14.21 E	-	192747	45 30.90 S	153 14.24 E	-	-	200
083 process3	12 Feb 2007	021341	45 26.41 S	153 17.37 E	4500	022101	45 26.39 S	153 17.35 E	-	024711	45 26.42 S	153 17.10 E	-	-	403
084 process3	12 Feb 2007	073226	45 27.14 S	153 16.96 E	4600	074823	45 27.16 S	153 17.09 E	-	082306	45 27.10 S	153 17.51 E	-	-	801
085 process3	12 Feb 2007	164151	45 27.13 S	153 20.51 E	3700	170123	45 27.16 S	153 20.63 E	-	173803	45 27.28 S	153 20.86 E	-	-	1002
086 process3	12 Feb 2007	200730	45 27.86 S	153 21.01 E	4600	202334	45 27.83 S	153 21.16 E	-	210129	45 27.66 S	153 21.61 E	-	-	902
087 transit	13 Feb 2007	020503	44 45.22 S	153 00.28 E	4800	021250	44 45.21 S	153 00.38 E	-	023931	44 45.21 S	153 00.74 E	-	-	413
088 transit	13 Feb 2007	054338	45 06.40 S	153 13.57 E	4750	054954	45 06.38 S	153 13.63 E	-	061458	45 06.37 S	153 14.12 E	-	-	402
089 process3	13 Feb 2007	113237	45 26.09 S	153 27.28 E	4500	113422	45 26.09 S	153 27.27 E	-	114339	45 26.10 S	153 27.29 E	-	-	101
090 process3	13 Feb 2007	150512	45 26.22 S	153 28.27 E	4700	151230	45 26.31 S	153 28.34 E	-	152502	45 26.32 S	153 28.48 E	-	-	207
091 transit	13 Feb 2007	211536	44 56.41 S	152 23.93 E	4700	212306	44 56.41 S	152 23.98 E	-	215058	44 56.33 S	152 24.26 E	-	-	401
092 transit	14 Feb 2007	015641	44 56.72 S	152 27.95 E	4600	020414	44 56.75 S	152 28.06 E	-	023218	44 56.74 S	152 28.45 E	-	-	401
093 transit	14 Feb 2007	035053	44 56.07 S	152 29.59 E	4600	040703	44 56.07 S	152 29.79 E	-	044853	44 55.87 S	152 30.36 E	-	-	1003
094 transit	14 Feb 2007	072416	45 13.50 S	152 45.46 E	4600	073115	45 13.50 S	152 45.49 E	-	080900	45 13.53 S	152 45.72 E	-	-	400
095 transit	14 Feb 2007	102151	45 16.41 S	153 00.79 E	4500	102802	45 16.43 S	153 00.83 E	-	105139	45 16.55 S	153 01.16 E	-	-	408
096 process3	14 Feb 2007	171014	45 30.14 S	153 37.09 E	4500	173419	45 30.19 S	153 37.19 E	-	180330	45 30.32 S	153 37.49 E	-	-	1004
097 process3	14 Feb 2007	220940	45 30.47 S	153 36.47 E	4500	225648	45 30.42 S	153 36.68 E	-	001546	45 30.37 S	153 36.97 E	-	-	2505
098 process3	15 Feb 2007	073453	45 30.70 S	153 38.78 E	4500	074228	45 30.76 S	153 38.87 E	-	080534	45 30.81 S	153 39.10 E	-	-	403
099 process3	15 Feb 2007	130845	45 31.40 S	153 36.14 E	4400	131656	45 31.42 S	153 36.14 E	-	134452	45 31.53 S	153 36.32 E	-	-	438
100 process3	15 Feb 2007	150607	45 32.11 S	153 36.89 E	4600	151050	45 32.14 S	153 36.91 E	-	152320	45 32.17 S	153 36.85 E	-	-	202
101 process3	15 Feb 2007	190610	45 32.05 S	153 41.98 E	4430	191317	45 32.04 S	153 42.00 E	-	195025	45 32.10 S	153 42.17 E	-	-	411
102 process3	16 Feb 2007	010459	45 32.17 S	153 39.77 E	4500	011159	45 32.15 S	153 39.79 E	-	013528	45 32.20 S	153 39.88 E	-	-	403
103 process3	16 Feb 2007	070450	45 33.33 S	153 40.15 E	4400	071131	45 33.34 S	153 40.15 E	-	073729	45 33.19 S	153 40.34 E	-	-	403
104 process3	16 Feb 2007	093308	45 35.42 S	153 40.72 E	4400	094929	45 35.45 S	153 40.79 E	-	102401	45 35.69 S	153 40.99 E	-	-	901
105 transit	18 Feb 2007	033238	44 14.39 S	150 11.81 E	2600	041022	44 14.45 S	150 11.74 E	-	051251	44 14.43 S	150 11.80 E	-	-	2512
106 transit	18 Feb 2007	070422	44 14.06 S	150 12.53 E	2600	071347	44 14.11 S	150 12.61 E	-	073813	44 14.23 S	150 12.85 E	-	-	403
107 transit	19 Feb 2007	035501	43 39.42 S	148 35.83 E	3700	040248	43 39.52 S	148 35.81 E	-	042729	43 39.82 S	148 35.53 E	-	-	405
108 transit	19 Feb 2007	055122	43 41.24 S	148 34.87 E	3700	060935	43 41.42 S	148 34.84 E	-	064703	43 41.88 S	148 34.60 E	-	-	1019
109 transit	19 Feb 2007	090511	43 43.21 S	148 33.23 E	3700	094317	43 43.27 S	148 33.02 E	-	104347	43 43.27 S	148 32.72 E	-	-	2506

Table 2: CTD serial 704 calibration coefficients and calibration dates for cruise au0703. Note that platinum temperature calibrations are for the ITS-90 scale. Pressure slope/offset, temperature and conductivity values are from the CSIRO Division of Marine and Atmospheric Research calibration facility. Remaining values are manufacturer supplied.

Primary Temperature, serial 4248, 24/07/2006

G	: 4.3872750e-003
H	: 6.5089714e-004
I	: 2.3231241e-005
J	: 1.8524638e-006
F0	: 1000.000
Slope	: 1.00000000
Offset	: 0.0000

Secondary Temperature, serial 4246, 24/07/2006

G	: 3.9791760e-003
H	: 6.2178475e-004
I	: 1.8665869e-005
J	: 1.5651022e-006
F0	: 1000.000
Slope	: 1.00000000
Offset	: 0.0000

Primary Conductivity, serial 2977, 24/07/2006

G	: -1.0730631e+001
H	: 1.4850393e+000
I	: 5.1899715e-005
J	: 7.3324498e-005
CTcor	: 3.2500e-006
CPcor	: -9.57000000e-008
Slope	: 1.00000000
Offset	: 0.00000

Secondary Conductivity, serial 2808, 24/07/2006

G	: -9.2832718e+000
H	: 1.4248306e+000
I	: -7.1457502e-005
J	: 9.4841234e-005
CTcor	: 3.2500e-006
CPcor	: -9.57000000e-008
Slope	: 1.00000000
Offset	: 0.00000

Pressure, serial 89084, 09/08/2006

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	: 1.000061
Offset	: 0.9607
AD590M	: 1.276320e-002
AD590B	: -9.834110e+000

Oxygen, serial 0178, 04/11/2006

Soc	: 5.6550e-001
Boc	: 0.0000
Offset	: -0.5039
Tcor	: 0.0020
Pcor	: 1.350e-004
Tau	: 0.0

Fluorometer, serial 296, 23/05/2005

Vblank	: 0.12
Scale factor	: 7.000e+000

Transmissometer, serial 899DR, 08/11/2005

A0	: -0.0130705
A1	: 0.214270

Table 3: 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. Note: these are for the primary sensor pair; for CTD 8 and 30, data from the secondary sensor pair were used, and the coefficients in the table do not apply.

stn grouping	F_1	F_2	F_3	n	σ
001 to 036	0.85922478E-03	0.99990161E-03	0.48370422E-09	310	0.000742
037 to 060	-0.72274696E-02	0.10001739E-02	-0.58525107E-10	221	0.000747
061 to 080	-0.50080844E-03	0.10000613E-02	-0.16215688E-08	213	0.000499
081 to 098	0.23089863E-02	0.10000102E-02	-0.16264460E-08	129	0.001243
099 to 104	0.29369010E-02	0.10000110E-02	-0.16673300E-08	54	0.000812
105 to 109	0.64693695E-02	0.99867054E-03	0.10596057E-07	67	0.001205

Table 4: **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. Note: for CTD 8 and 30, the slope term is from the secondary sensor pair.**

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	0.99988747E-03	29	0.99990198E-03	57	0.10001614E-02	85	0.99987198E-03
2	0.99988799E-03	30	0.99966276E-03	58	0.10001614E-02	86	0.99987035E-03
3	0.99988851E-03	31	0.99990302E-03	59	0.10001613E-02	87	0.99986872E-03
4	0.99988903E-03	32	0.99990354E-03	60	0.10001613E-02	88	0.99986710E-03
5	0.99988954E-03	33	0.99990406E-03	61	0.99995909E-03	89	0.99986547E-03
6	0.99989006E-03	34	0.99990457E-03	62	0.99995752E-03	90	0.99986384E-03
7	0.99989058E-03	35	0.99990509E-03	63	0.99995596E-03	91	0.99986222E-03
8	0.99964935E-03	36	0.99990561E-03	64	0.99995439E-03	92	0.99986059E-03
9	0.99989162E-03	37	0.10001622E-02	65	0.99995282E-03	93	0.99985896E-03
10	0.99989214E-03	38	0.10001621E-02	66	0.99995125E-03	94	0.99985734E-03
11	0.99989265E-03	39	0.10001621E-02	67	0.99994969E-03	95	0.99985571E-03
12	0.99989317E-03	40	0.10001620E-02	68	0.99994812E-03	96	0.99985409E-03
13	0.99989369E-03	41	0.10001620E-02	69	0.99994655E-03	97	0.99985246E-03
14	0.99989421E-03	42	0.10001620E-02	70	0.99994498E-03	98	0.99985083E-03
15	0.99989473E-03	43	0.10001619E-02	71	0.99994342E-03	99	0.99985483E-03
16	0.99989525E-03	44	0.10001619E-02	72	0.99994185E-03	100	0.99985415E-03
17	0.99989576E-03	45	0.10001619E-02	73	0.99994028E-03	101	0.99985348E-03
18	0.99989628E-03	46	0.10001618E-02	74	0.99993872E-03	102	0.99985280E-03
19	0.99989680E-03	47	0.10001618E-02	75	0.99993715E-03	103	0.99985213E-03
20	0.99989732E-03	48	0.10001617E-02	76	0.99993558E-03	104	0.99985145E-03
21	0.99989784E-03	49	0.10001617E-02	77	0.99993401E-03	105	0.99978313E-03
22	0.99989836E-03	50	0.10001617E-02	78	0.99993245E-03	106	0.99979372E-03
23	0.99989887E-03	51	0.10001616E-02	79	0.99993088E-03	107	0.99980432E-03
24	0.99989939E-03	52	0.10001616E-02	80	0.99992931E-03	108	0.99981491E-03
25	0.99989991E-03	53	0.10001616E-02	81	0.99987848E-03	109	0.99982551E-03
26	0.99990043E-03	54	0.10001615E-02	82	0.99987686E-03		
27	0.99990095E-03	55	0.10001615E-02	83	0.99987523E-03		
28	0.99990146E-03	56	0.10001614E-02	84	0.99987360E-03		

Table 5: **Surface pressure offsets (i.e. poff, in dbar). For each station, these values are subtracted from the pressure calibration "offset" value from Table 2.**

stn	poff	stn	poff	stn	poff	stn	poff	stn	poff	stn	poff
1	0.95	20	0.65	39	0.56	58	0.54	77	1.04	96	0.90
2	0.63	21	0.60	40	0.65	59	0.54	78	0.93	97	0.76
3	0.58	22	0.62	41	0.61	60	0.57	79	0.88	98	0.90
4	0.58	23	0.63	42	0.71	61	0.59	80	0.86	99	0.95
5	0.47	24	0.60	43	0.63	62	0.69	81	0.91	100	0.79
6	0.60	25	0.64	44	0.44	63	0.50	82	0.81	101	0.81
7	0.61	26	0.56	45	0.55	64	0.54	83	0.96	102	0.84
8	0.67	27	0.58	46	0.64	65	0.70	84	0.90	103	0.82
9	0.68	28	0.51	47	0.67	66	0.77	85	0.89	104	0.76
10	0.65	29	0.58	48	0.67	67	0.76	86	0.86	105	0.77
11	0.66	30	0.59	49	0.69	68	0.84	87	0.85	106	0.53
12	0.70	31	0.61	50	0.62	69	0.84	88	0.81	107	0.76
13	0.57	32	0.61	51	0.62	70	0.78	89	0.83	108	0.79
14	0.53	33	0.64	52	0.72	71	0.79	90	0.82	109	0.82
15	0.69	34	0.64	53	0.72	72	0.84	91	0.83		
16	0.65	35	0.52	54	0.74	73	0.84	92	0.87		
17	0.61	36	0.44	55	0.71	74	0.79	93	0.73		
18	0.68	37	0.80	56	0.60	75	0.90	94	0.85		
19	0.65	38	0.75	57	0.50	76	0.86	95	0.77		

<u>Table 6:</u> CTD dissolved oxygen calibration coefficients for cruise au0703: slope, bias, tcor (= temperature correction term), and pcor (= pressure correction term). dox is equal to 2.8σ , for σ as defined in the *CTD Methodology*.

stn	slope	bias	tcor	pcor	dox
1	0.533531	-0.234971	0.009847	0.000092	0.154112
2	0.611262	-0.311012	0.004876	0.000014	0.127303
3	0.502297	-0.212684	0.015264	0.000110	0.139094
4	0.395942	-0.035662	0.019290	0.000171	0.114435
5	0.596545	-0.307282	0.005942	0.000036	0.054670
6	0.555232	-0.283225	0.010671	0.000118	0.056833
7	0.579410	-0.288913	0.005531	0.000097	0.188718
8	-	-	-	-	-
9	0.587934	-0.303937	0.007112	0.000074	0.064326
10	0.690378	-0.529686	0.005110	0.000117	0.053671
11	0.534769	-0.235585	0.009539	0.000073	0.033839
12	0.691684	-0.520362	0.004331	0.000080	0.054544
13	-	-	-	-	-
14	0.547492	-0.281555	0.010657	0.000122	0.162841
15	0.588812	-0.328808	0.006819	0.000090	0.091898
16	0.701029	-0.498117	0.000601	0.000083	0.010933
17	0.568921	-0.268367	0.007028	0.000059	0.14775
18	0.492247	-0.124135	0.008470	0.000001	0.081500
19	0.495984	-0.165574	0.011230	0.000058	0.074953
20	0.988604	-1.125186	0.000452	0.000260	0.041084
21	1.215239	-1.407491	-0.013898	0.000062	0.062999
22	-	-	-	-	-
23	1.295518	-1.806445	0.000563	0.000659	0.043709
24	-	-	-	-	-
25	0.698083	-0.632700	0.012437	0.000324	0.061084
26	-	-	-	-	-
27	-	-	-	-	-
28	0.654240	-0.469326	0.007422	0.000141	0.022733
29	-	-	-	-	-
30	0.587822	-0.305774	0.005662	0.000074	0.082830
31	0.538941	-0.241171	0.008864	0.000088	0.141150
32	-	-	-	-	-
33	0.562691	-0.297560	0.007904	0.000117	0.086732
34	0.607250	-0.302570	0.000088	0.000070	0.042354
35	0.692725	-0.519195	0.000733	0.000132	0.035247
36	0.518914	-0.236705	0.011278	0.000122	0.136185
37	0.807060	-0.842258	0.008534	0.000828	0.071252
38	0.583468	-0.312685	0.004795	0.000135	0.194078
39	0.797739	-0.791190	0.002442	0.000471	0.109049
40	0.619110	-0.358274	-0.002383	0.000167	0.108540
41	-	-	-	-	-
42	0.586868	-0.331813	0.013843	0.000170	0.096752
43	0.595966	-0.309549	-0.000778	0.000133	0.102832
44	0.612990	-0.347827	-0.001774	0.000185	0.069648
45	-	-	-	-	-
46	0.593856	-0.310385	0.000236	0.000164	0.014029
47	0.607868	-0.325680	-0.000323	0.000158	0.188107
48	0.645221	-0.380577	-0.005803	0.000021	0.169319
49	0.593216	-0.305578	0.001279	0.000164	0.184688
50	-	-	-	-	-
51	0.604264	-0.320789	0.001301	0.000171	0.124682
52	0.602443	-0.310360	-0.001458	0.000136	0.150009
53	0.628083	-0.362105	-0.002224	0.000117	0.104327
54	0.601326	-0.303347	-0.001045	0.000176	0.052867
55	0.595682	-0.306872	-0.000034	0.000173	0.090291
56	0.622789	-0.361141	-0.001078	0.000227	0.089424
57	0.691422	-0.511385	-0.001597	0.000315	0.071593
58	0.592063	-0.298154	-0.001178	0.000145	0.133685
59	0.627398	-0.379162	-0.000005	0.000257	0.156463
60	0.537285	-0.167263	-0.001381	0.000017	0.075782
61	0.592836	-0.296082	-0.000997	0.000136	0.140805
62	0.573489	-0.267981	0.000511	0.000132	0.083040
63	0.626745	-0.374503	-0.000809	0.000150	0.055658
64	0.592590	-0.296243	-0.000576	0.000127	0.155797
65	0.594490	-0.311868	0.000272	0.000143	0.062669
66	0.599416	-0.312167	-0.001156	0.000146	0.100290
67	0.591138	-0.285446	-0.001907	0.000129	0.108693
68	0.596314	-0.300893	-0.001275	0.000135	0.043119
69	0.559357	-0.261020	0.002699	0.000141	0.076307
70	0.594423	-0.311088	0.000173	0.000136	0.029816
71	0.571187	-0.261287	0.000059	0.000136	0.048912
72	0.367522	0.040611	0.013573	0.000158	0.062976
73	0.575099	-0.318771	0.004194	0.000198	0.086627
74	0.271133	0.206562	0.019226	0.000151	0.135262
75	0.589002	-0.307428	0.001061	0.000151	0.111337
76	-	-	-	-	-
77	0.692697	-0.506032	-0.001887	0.000175	0.114969
78	0.533933	-0.242146	0.006294	0.000150	0.070821
79	0.587948	-0.296134	-0.000795	0.000144	0.104721
80	0.258611	-0.058892	0.051674	0.000626	0.065325
81	0.584883	-0.295841	0.000534	0.000138	0.079591
82	0.417304	-0.063277	0.013823	0.000194	0.060979
83	0.592021	-0.325191	0.001634	0.000147	0.044411
84	0.564700	-0.260775	0.001534	0.000124	0.029286
85	0.520790	-0.199548	0.004848	0.000123	0.056928
86	0.506763	-0.205110	0.008329	0.000156	0.097307
87	0.742160	-0.500716	-0.008640	0.000047	0.078392
88	0.595524	-0.321156	0.000602	0.000148	0.102217
89	-	-	-	-	-
90	1.368823	-1.598109	-0.030197	0.001827	0.170616
91	0.598403	-0.293218	-0.001425	0.000088	0.099030
92	0.429604	-0.133461	0.014468	0.000274	0.189154
93	0.483383	-0.127786	0.004608	0.000082	0.161821
94	0.687870	-0.523619	0.000190	0.000258	0.053776
95	0.433505	-0.140748	0.014328	0.000300	0.091396
96	-	-	-	-	-
97	0.513180	-0.227475	0.009967	0.000154	0.088182
98	0.392681	-0.014353	0.013457	0.000158	0.048359
99	0.492491	-0.129344	0.003370	0.000110	0.047894
100	0.419727	-0.439933	0.048293	0.003545	0.030213
101	0.569750	-0.268069	0.000375	0.000135	0.110373
102	0.304088	0.167373	0.014166	0.000145	0.153787
103	0.486027	-0.133387	0.004384	0.000142	0.147501
104	0.524186	-0.189284	0.003669	0.000093	0.111832
105	0.507897	-0.234044	0.009710	0.000164	0.118992
106	0.422287	-0.133685	0.016062	0.000255	0.149169
107	0.695041	-0.495762	-0.001376	0.000137	0.105955
108	0.527626	-0.252050	0.007658	0.000160	0.066279
109	0.549920	-0.269794	0.004601	0.000149	0.158256

Table 7: Bad transmissometer downcast data deleted from the 2 dbar averaged files.

station number	bad transmissometer data (dbar)	station number	bad transmissometer data (dbar)
3	2 - 50	25	2 - 94
7	2 - 398	26	2 - 38
16	whole station	27	2 - 22
17	2 - 14	31	2 - 104
19	2 - 6	32	2 - 48
20	2 - 148	33	2 - 158
22	whole station	35	2 - 210

Table 8: Suspect nutrient sample values (not deleted from bottle data file) for cruise au0703.

PHOSPHATE station number	PHOSPHATE rosette position	NITRATE station number	NITRATE rosette position	SILICATE station number	SILICATE rosette position
19	7	19	7	19	7
38	12	38	13	38	12
39	8				
42	3	42	3	42	3
		46	19		
50	1,24	50	1,24		
51	whole stn				
		52	23		
62	23				

AMMONIA

station number	rosette position
20	18
24	22
96	2
103	9
105	12,16

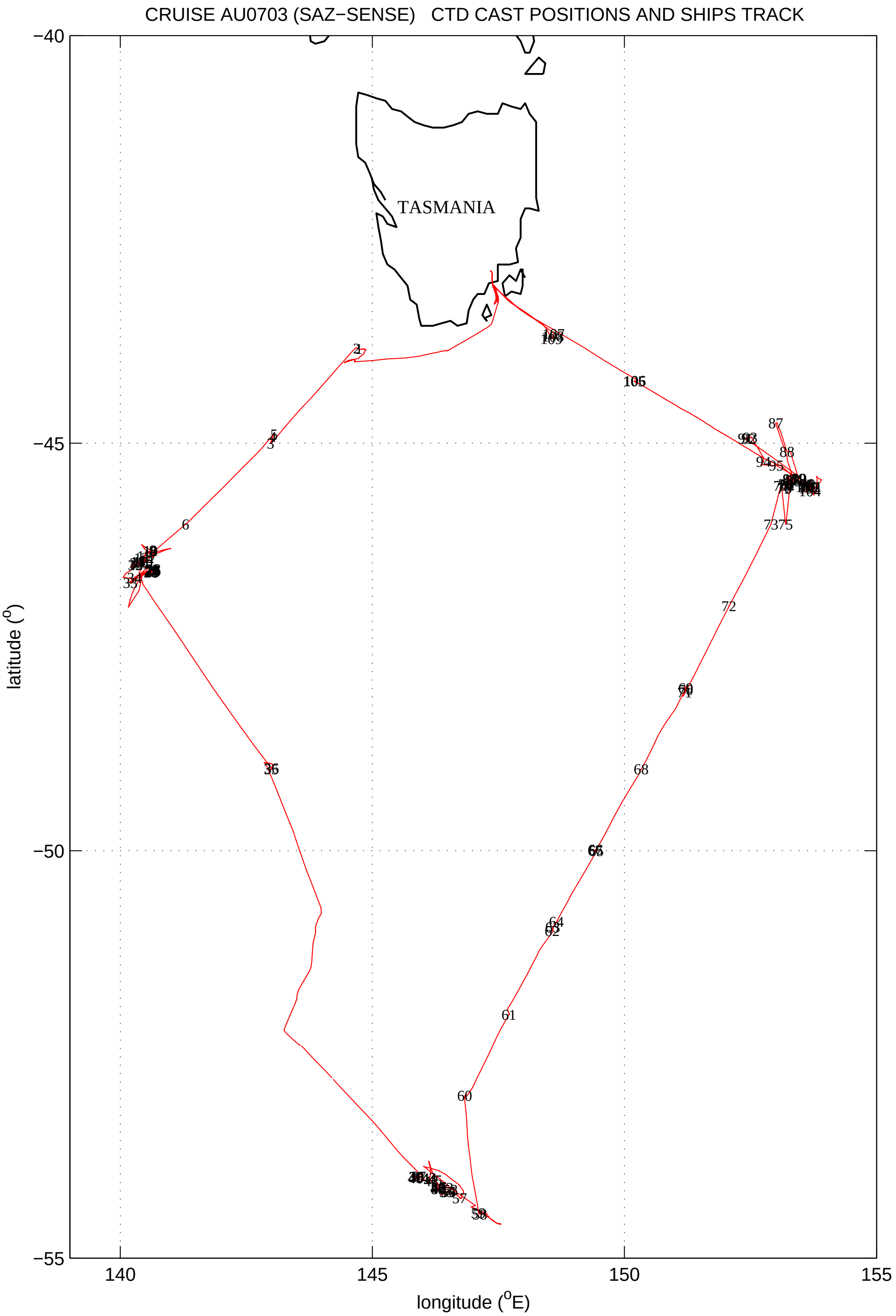
Table 9: ADCP logging and calibration parameters for cruise au0703.

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

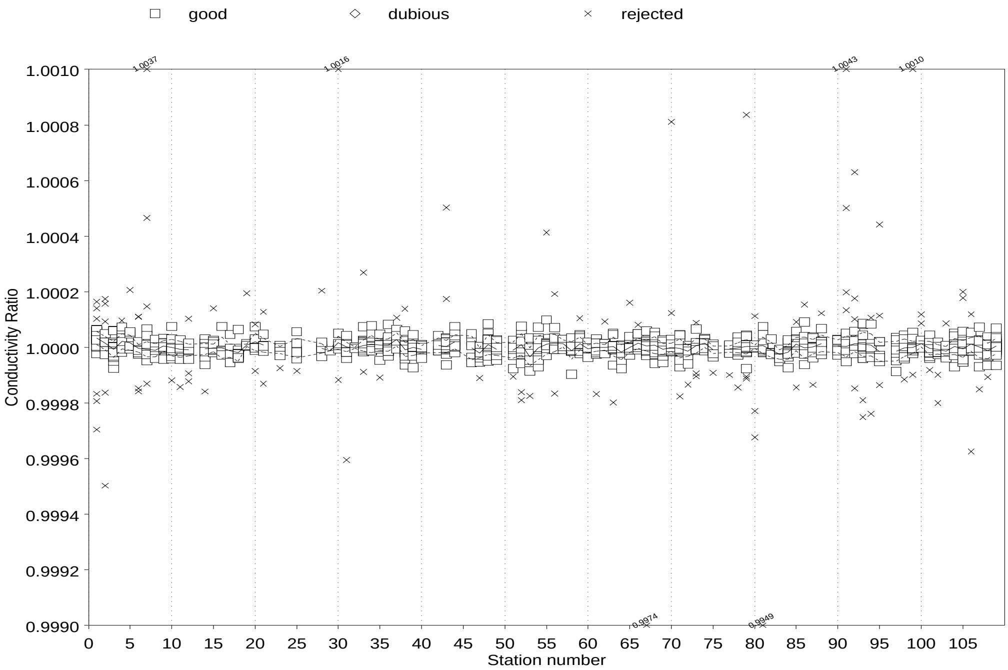
reference layer averaging:	bins 8 to 20
XROT:	822
ensemble averaging duration:	3 min. (for logged data) 30 min. (for final processed data)

calibration

α ($\pm$ standard deviation)	$1+\beta$ ($\pm$ standard deviation)	no. of calibration sites
2.507 ± 0.375	1.0388 ± 0.010	62



<u>Figure 1:</u> CTD cast positions and ship's track for cruise au0703.



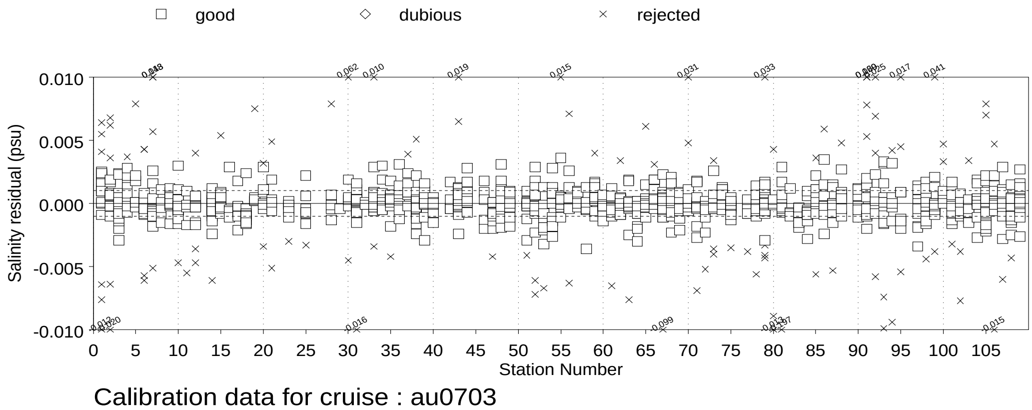
Calibration data for cruise : au0703

Calibration file : a0703.bot

Conductivity s.d. = 0.00002

Number of bottles used = 1056 out of 1170 Mean ratio for all bottles = 1.00000

<u>Figure 2:</u> Conductivity ratio c_{btl}/c_{cal} versus station number for cruise au0703. The solid line follows the mean of the residuals for each station; the broken lines are ± the standard deviation of the residuals for each station. 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.



Calibration data for cruise : au0703

Calibration file : a0703.bot

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

Number of bottles used = 1056 out of 1170

<u>Figure 3:</u> Salinity residual (s_{btl} - s_{cal}) versus station number for cruise au0703. The solid line is the mean of all the residuals; the broken lines are ± the standard deviation of all the residuals. s_{cal} = calibrated CTD salinity; s_{btl} = Niskin bottle salinity value.

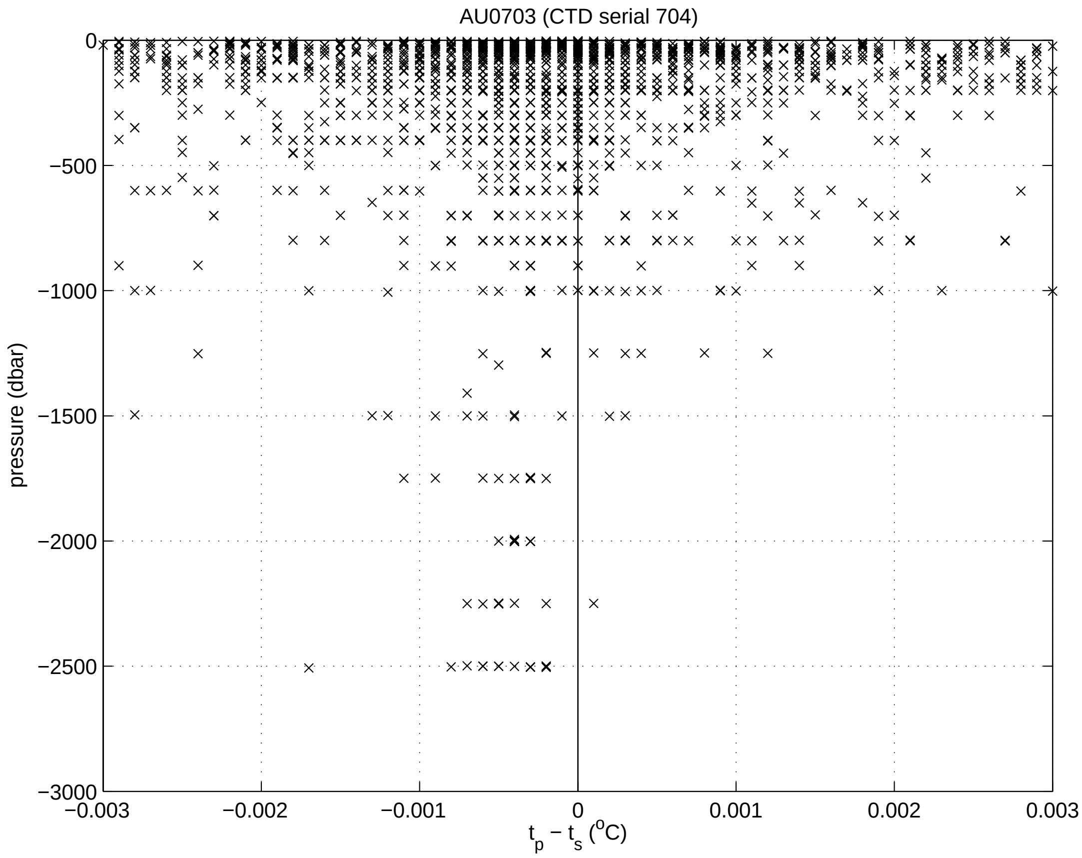


Figure 4: **Difference between primary and secondary temperature sensor (t_p - t_s) for CTD upcast burst data from Niskin bottle stops, for cruise au0703.**

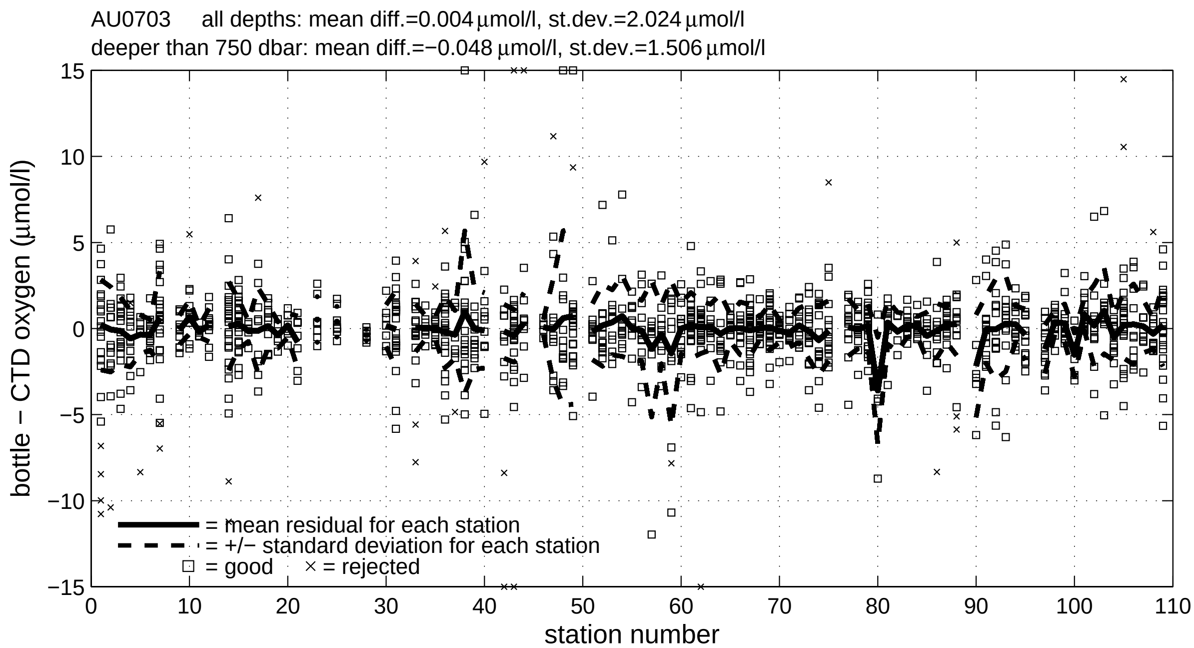
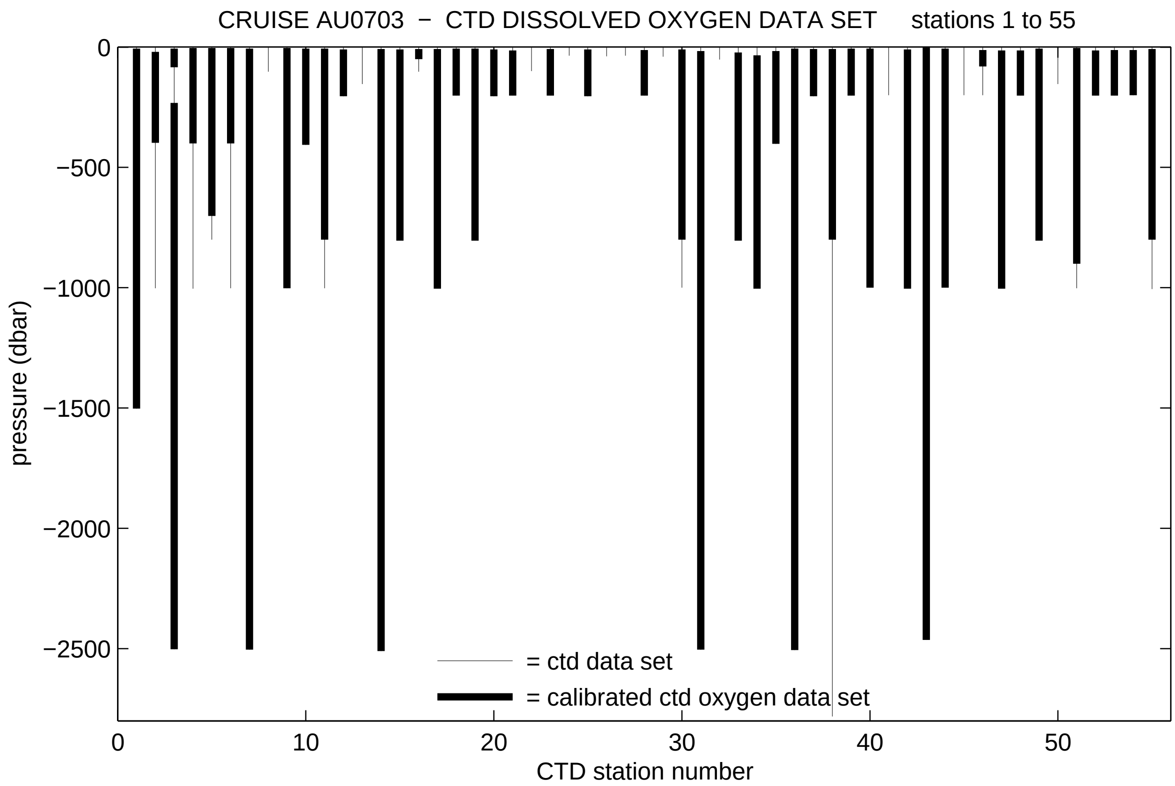
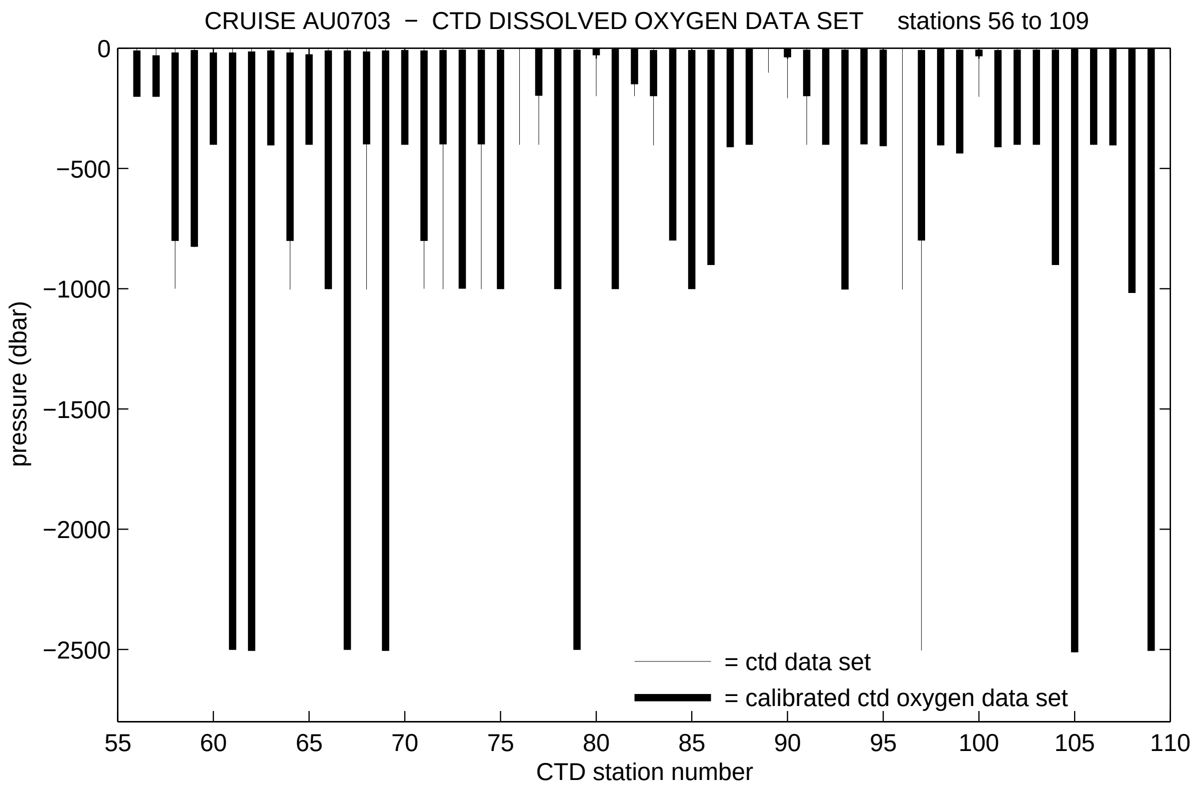
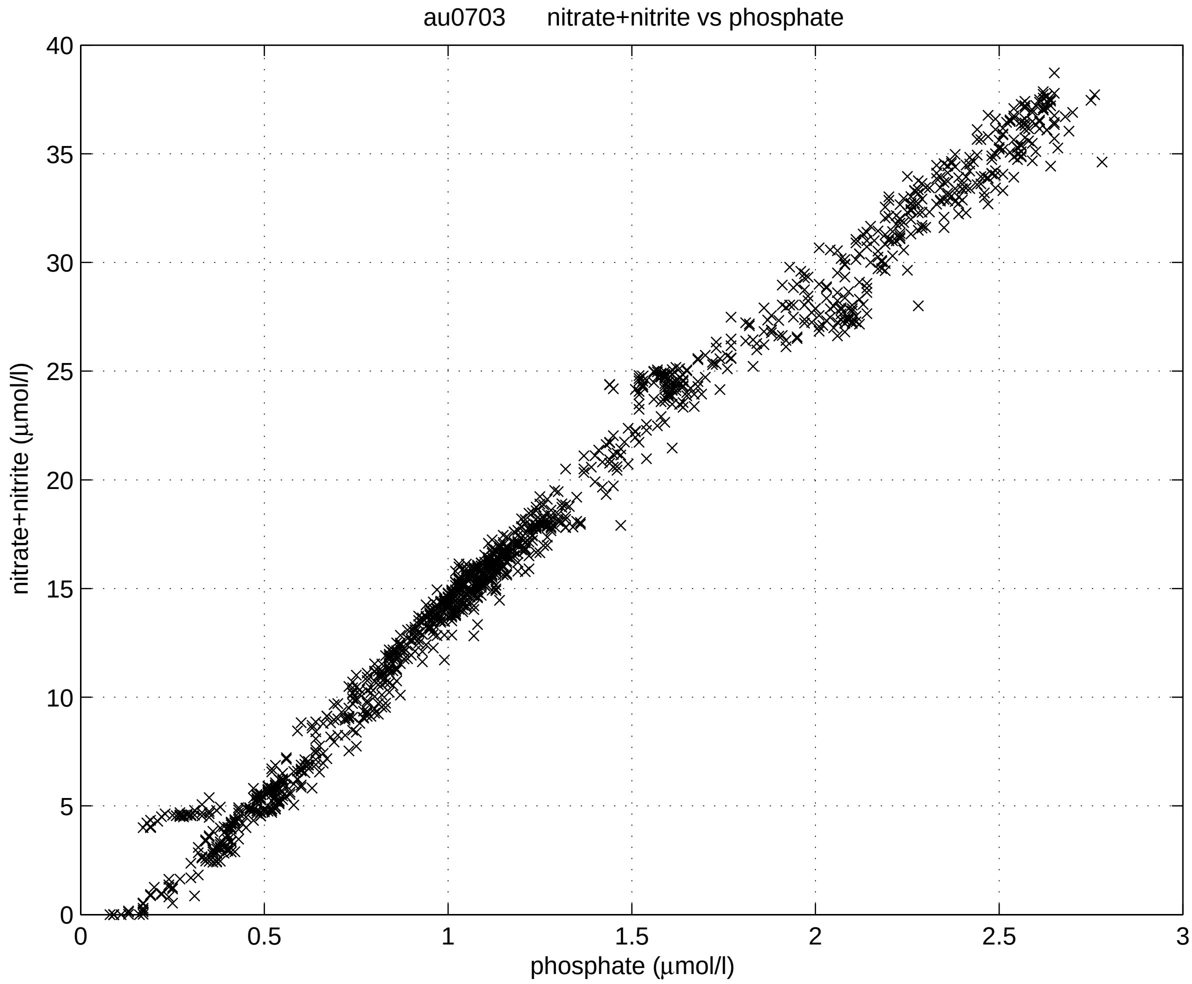


Figure 5: **Dissolved oxygen residual (o_{btl} - o_{cal}) versus station number for cruise au0703. The solid line follows the mean residual for each station; the broken lines are ± the standard deviation of the residuals for each station. o_{cal}=calibrated downcast CTD dissolved oxygen; o_{btl}=Niskin bottle dissolved oxygen value. Note: values outside vertical axes are plotted on axes limits.**



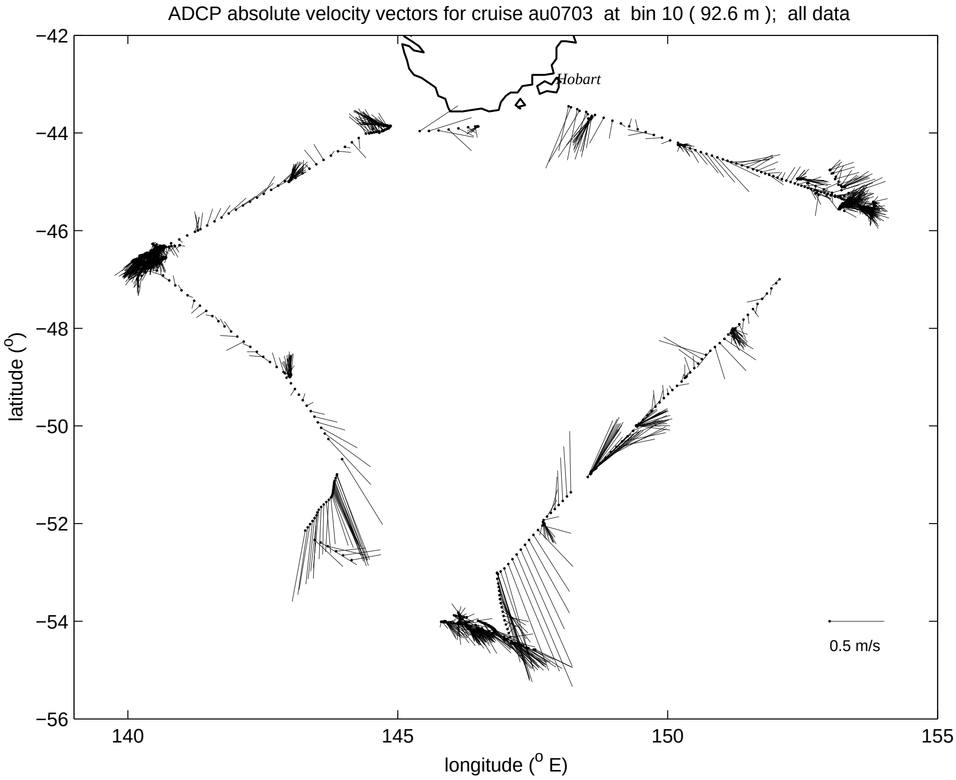


<u>Figure 6:</u> CTD dissolved oxygen data coverage for cruise au0703.

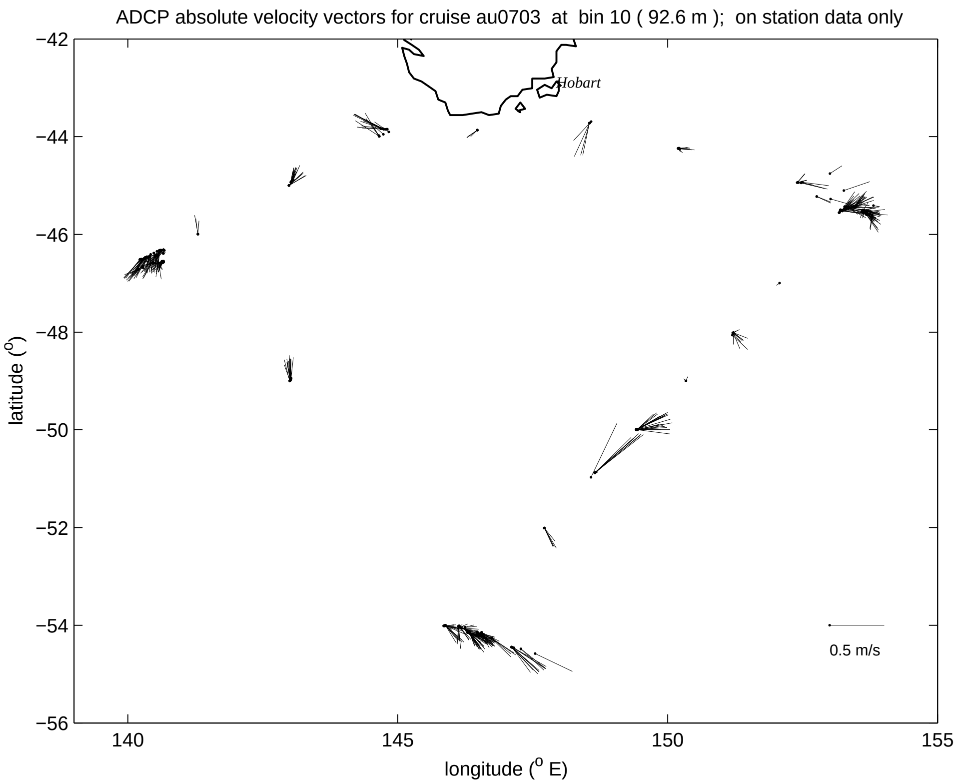


<u>Figure 7:</u> **Nitrate+nitrite versus phosphate data for cruise au0703.**

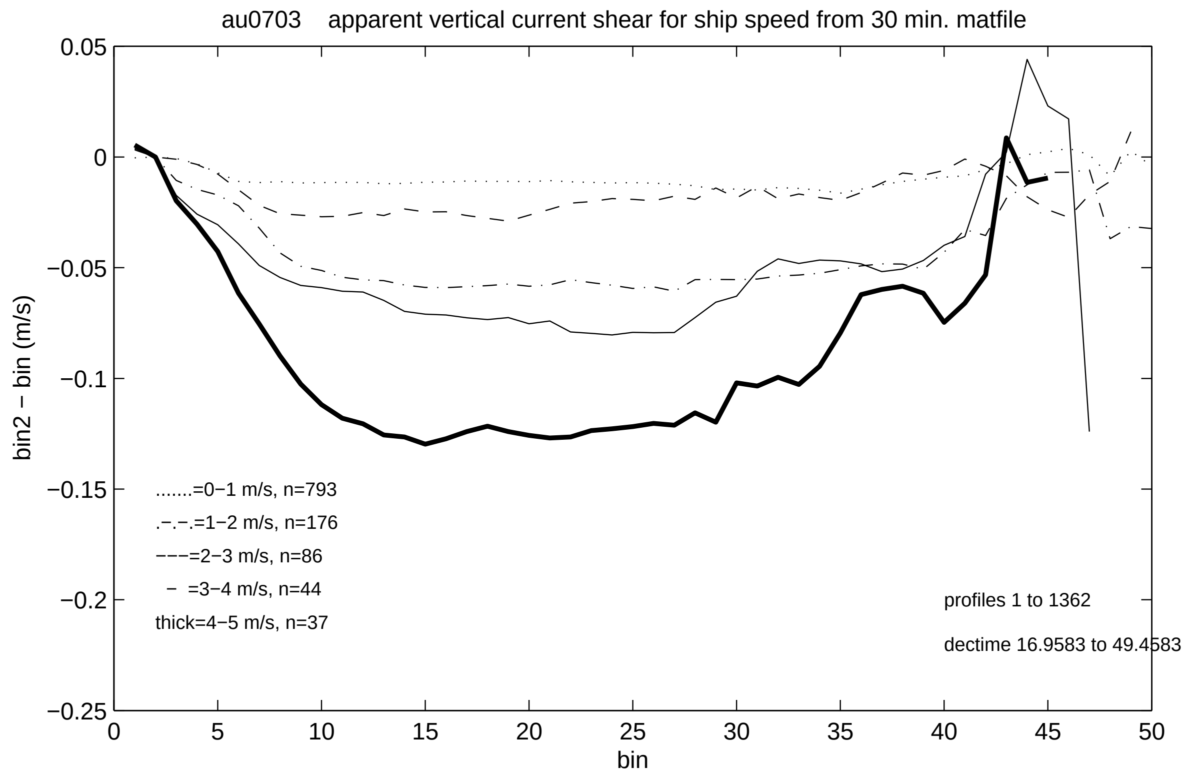
(a)

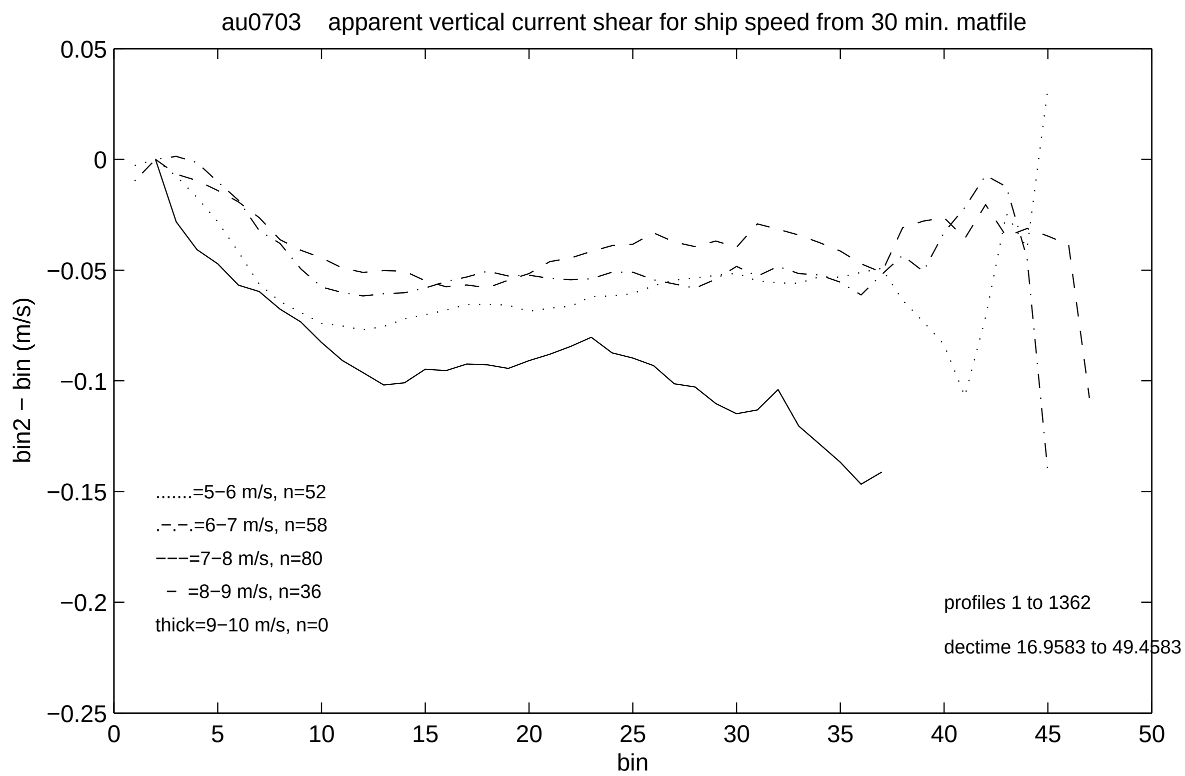


(b)



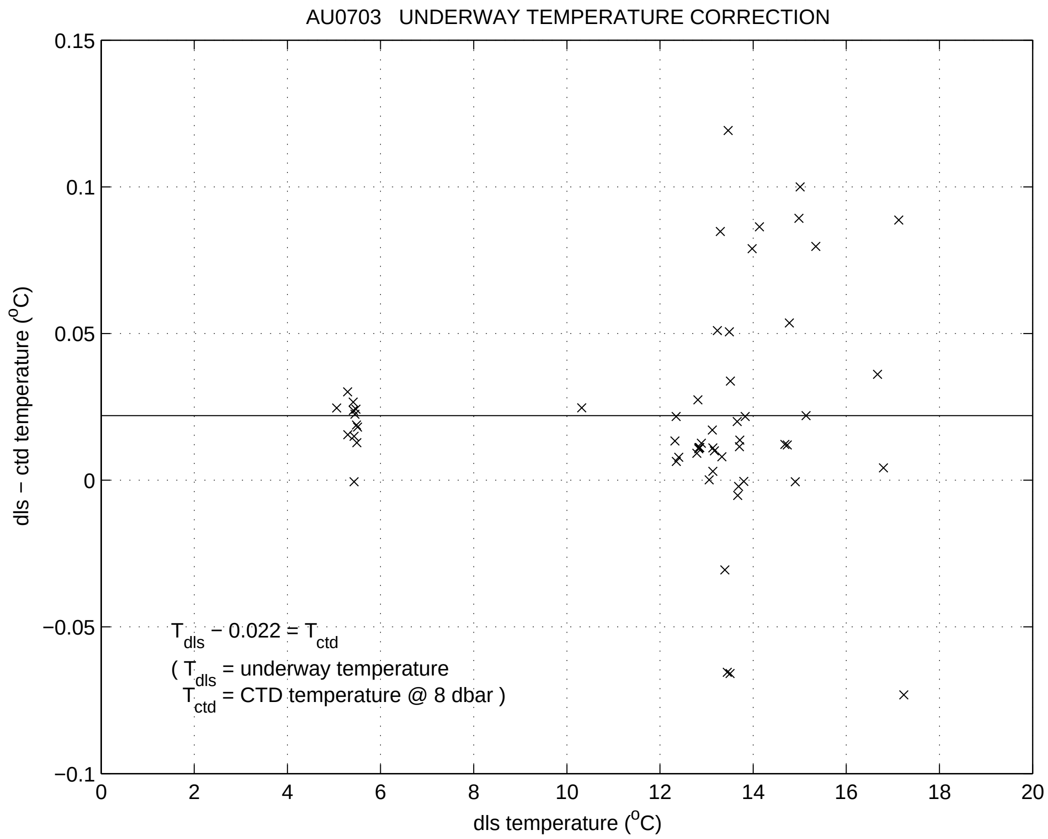
<u>Figure 8a and b:</u> au0703 hull mounted ADCP 30 minute ensemble data, for (a) whole cruise, and (b) "on station" data only.





<u>Figure 9:</u> au0703 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)

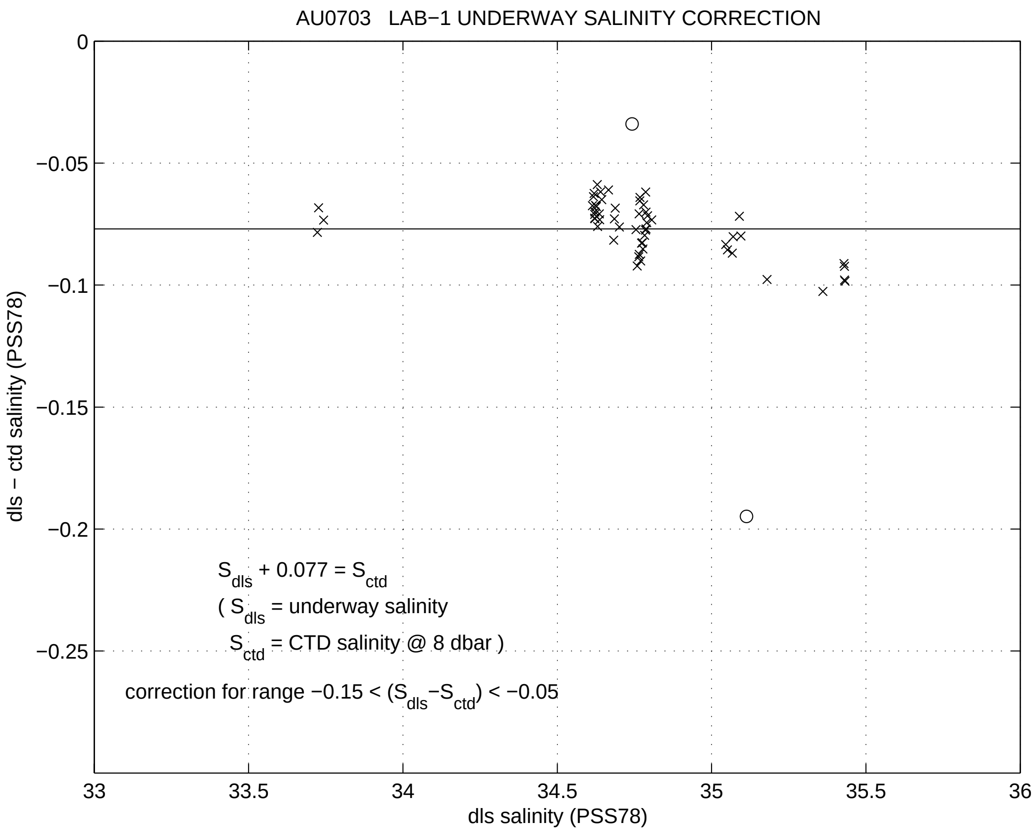


Figure 10a and b: au0703 comparison between (a) CTD and underway temperature data (i.e. hull mounted temperature sensor), and (b) CTD and underway salinity data (i.e. Tilbrook's lab 1 SeaBird), including bestfit lines. Note: dls refers to underway data.

APPENDIX 1 NOTES ON NUTRIENT ANALYSES

Neale Johnston (*CSIRO Marine and Atmospheric Research, Floreat, Western Australia)*

Nutrient samples were run on a Lachat Quickchem series 8000 FIA. Samples were analysed for silicate, phosphate, nitrate+nitrate, nitrite and ammonia.

The following methods were used:

* silicate - Quickchem Method 31-114-27-1-D (i.e. in Lachat manual)

* orthophosphate - Quickchem Method 31-115-01-1-G

* nitrate+nitrite - Quickchem Method 31-107-04-1-A

* ammonia - used an automated method based on the manual method in Watson et al. (2005); a Shimadzu RF - 10Axl fluorescence detector was used in the ammonia analysis.

* nitrite used the same method as nitrate+nitrite, but with the cadmium reduction column removed.

For all analysis, calibration and reference standards were made using nutrient depleted seawater (reference standards from Ocean Scientific International were diluted with nutrient depleted seawater). Calibration standards were run at the start and end of each run. Reference standards were run every 15 samples. The carrier for silicate, phosphate and nitrate+nitrite was artificial seawater (3.6% sodium chloride). This carrier was taken to contain no silicate, nitrate+nitrite or phosphate, and was checked by observing the baseline voltage reading for each channel each time it was prepared. The carrier for ammonia was a 2ml/l sulphuric acid solution. The carrier solution was subject to contamination from atmospheric-born contamination. This was checked each run by checking the baseline and by running a known ammonia depleted sample against the carrier.

Baseline voltages changed slightly each time reagents were changed so where possible reagents and carrier were not changed at the same time.

Nutrient depleted seawater was depleted for nitrate+nitrite, phosphate and ammonia, but did often have low silicate values. This was corrected for each run.

REFERENCES

Roslyn J. Watson, Edward C. V. Butler, Lesley A. Clementson and Kate M. Berry, 2005. Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater. *Journal of Environmental Monitoring*, Vol. 7, pp 37-42.