Aurora Australis Marine Science Cruise AU1121 - Oceanographic Field Measurements and Analysis

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1 INTRODUCTION

Oceanographic measurements were collected aboard Aurora Australis cruise au1121, voyage "Marine Science" (i.e. voyage 2.1) 2010/2011, from 4th January to 6th February 2011. The cruise commenced with a full north to south occupation of the CLIVAR/WOCE meridional repeat section SR3, followed by work around the Antarctic continental margin in the region of the Adélie Depression and the former Mertz Glacier ice tongue (Figure 1). Bottom imaging camera work was conducted during the Antarctic phase, as part of the CEAMARC biological program. This report discusses the oceanographic data from the cruise.

Oceanographic program objectives were:

1. to measure changes in water mass properties and inventories throughout the full ocean depth between Australia and Antarctica along 140°E (the CLIVAR/WOCE repeat section SR3);

2. to estimate the transport of mass, heat and other properties south of Australia, and to compare the results to previous occupations of the SR3 line and other sections in the Australian sector;

3. to deploy moorings near the Adélie Depression (142-145°E) to monitor changes in the properties and flow of Adélie Land Bottom Water;

4. to detect changes in bottom water formation as a result of the calving of the Mertz glacier tongue, by comparing measurements in the deep basins on the continental shelf to earlier measurements from this area;

5. to measure ocean circulation and water mass properties in the region formerly occupied by the Mertz glacier tongue and in areas further east that are now accessible for the first time;

6. to document changes to benthic communities in areas that might be affected by the calving event, including (a) the area previously covered by the glacier ice tongue as a baseline and to determine whether the water flowing under the glacier tongue carried sufficient primary production from the area east of the polynya to support a high benthic biomass; (b) in the path of the calved ice-berg; (c) in the canyon system that drains Bottom Water from the Adélie Depression.

A total of 149 CTD vertical profile stations were taken on the cruise, most to within 15 metres of the bottom (Table 1). Over 2000 Niskin bottle water samples were collected for the measurement (Table 2) of salinity, dissolved oxygen, nutrients (phosphate, nitrate+nitrite and silicate), ^{18}O, dissolved inorganic carbon (i.e. TCO_2), alkalinity, pH, helium, tritium, and biological parameters, using a 24 bottle rosette sampler. Upper water column current profile data were collected by a ship mounted ADCP. Full depth current profiles collected by an LADCP attached to the CTD package were only obtained for the first 4 stations – after that the instrument flooded and was terminally damaged. Meteorological and water property data were collected by the array of ship's underway sensors. An array of 3 bottom mounted ADCP moorings were deployed near the Adélie Depression, for recovery in the 2012/13 season.

This report describes the processing/calibration of the CTD data, and details the data quality. Underway sea surface temperature and salinity data are compared to near surface CTD data. CTD station positions are shown in Figure 1, while CTD station information is summarised in Table 1. Mooring and Argo float deployments are summarised in Tables 14a and b; a full description of the mooring deployments can be found in the cruise mooring report (Rosenberg, Aurora Australis Cruise AU1121 – Polynya Moorings, unpublished cruise report). Further cruise itinerary/summary details can be found in the voyage leader report (Australian Antarctic Division unpublished report: Rintoul, Voyage VMS, 2010-2011, RSV Aurora Australis, Voyage Leader's report). The hydrochemistry cruise report is in Appendix 1.

2 CTD INSTRUMENTATION

SeaBird SBE9plus CTD serial 704 (station 1 to 12) and serial 703 (station 13 onwards), with dual temperature and conductivity sensors and a single SBE43 dissolved oxygen sensor (serial 0191, on the primary sensor pump line), were used, mounted on a SeaBird 24 bottle rosette frame, together with a SBE32 24 position pylon and up to 24 x 10 litre General Oceanics Niskin bottles. The following additional sensors/instruments were mounted:

* Tritech 500 kHz altimeter serial 126288
* Wetlabs ECO-AFL/FL fluorometer serial 296
* Biospherical Instruments PAR sensor QCP2300, serial 70110
* Wetlabs C-star transmissometer serial 1016DR
* Sontek lowered ADCP (i.e. LADCP) with downward looking transducer only (operational for stations 1 to 4 only, and not discussed further)
* camera system and strobe lighting, for most stations from station 53 to 140
* Aanderaa optode, for stations 1 to 12, and 82
* SBE37 microcat for Seabird pressure sensor tests (Esmee van Wijk), for the following stations: 9, 10, 22-27, 36, 41, 42, 45, 46, 61, 66-71, 73-83
* Tritech 200 kHz altimeter serial 126376 (instrument never worked)

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" version 7.

The CTD deployment method was as follows:

* CTD initially deployed down to ~10 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

For many of the southern casts the package was stopped within 5 m of the bottom for several minutes, for the camera system.

Pre cruise temperature, conductivity and pressure calibrations were performed by the CSIRO Division of Marine and Atmoshperic Research calibration facility (Table 3) (November 2010). Manufacturer supplied calibrations were used for the dissolved oxygen (initial data display only), fluorometer, transmissometer, PAR and altimeter. Final conductivity and dissolved oxygen calibrations derived from in situ Niskin bottle samples are listed later in the report. Final transmissometer data are referenced to an in situ deep water value (see section 5.5 below).

3 PROBLEMS ENCOUNTERED

The breakup of the Mertz glacier ice tongue was a major event that occurred early in 2010, allowing the breakout of old bergs and fast ice previously trapped east of the glacier. As a result the whole Adélie Depression region, in the past relatively clear, was now filled with hazardous ice on the move, ranging from large chunks of old fast ice up to significant bergs. Caution was required navigating the area, and mooring locations had to be changed.

For the first few days of the cruise, much of the ship's equipment and CTD instrumentation suffered major malfunctions. Most of these malfunctions were sequential rather than simultaneous, a small grace. Among the more significant occurrences were:

* flooding of the LADCP transducer, most likely during station 5, and causing terminal damage

* near loss of the CTD package during recovery at station 10 - after attaching the retrieval safety line, the package was driven hard into the block, due to unpredictable winch response caused by air in the winch hydraulics. The package fell into the water (hanging upside down by the safety line), and only prompt action by the crew saved the day, with a makeshift crane-assisted recovery. After the incident the hydraulics were fully bled down to the tanks, and a station was skipped to make up time.

* spooling problems during stations 11 and 12 – at the bottom of the cast at station 11, the wire jumped across one wind, causing problems for the remainder of the upcast. Station 12 was done back to the north in deeper water (at the site that was previously skipped), allowing the spooling to be fixed – during the upcast, shifting the spooler knife over by one groove solved the problem.

* CTD comms crash during station 12, with inability to fire bottles and no data for the upcast. The cause was later traced to flooding of the optode. A shorting sensor in theory should not crash the Seabird CTD system, yet this did in fact occur.

* engine room fuel leak

* thruster problems causing delays at several stations

* bad transmissometer data due to bad cable, for stations 1 to 12

* bad salinometer analyses for stations 1 to 8, due to operator error

* CTD pump delays - after initial deployment, the CTD pump often took several minutes to come on. The problem may have been bubble related, but remains unexplained.

* a consistent difference of ~0.006°C between the 2 temperature sensors, for the entire cruise. This is discussed in section 5.2 of the report.

* kinking of the beam trawl wire during the stern camera frame deployments, due to spinning of the package

* destruction of bottle 12 due to implosion, at station 85

* At station 36 during the stern pump hose deployment (part of the large volume water sampling for R. Cavicchioli piggyback project), the hose and weights went into the prop.

Note that after the CTD comms crash at station 12, the underwater unit was replaced with serial 703, but all the sensors from the original set-up were retained. The optode problem was not traced till after the swap.

4 CTD DATA PROCESSING AND CALIBRATION

Preliminary CTD data processing was done at sea, to confirm correct functioning of instrumentation. Final processing of the data was done in Hobart. The first processing 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 etc)

An additional step was performed here, running the SeaBird "filter" program on the fluorescence data (discussed further in section 5.5 of the report).

Further processing and data calibration were done in a UNIX environment, using a suite of fortran and matlab 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 centered on 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

Full details of the data calibration and processing methods are given in Rosenberg et al. (unpublished report), referred to hereafter as the *CTD methodology*. Additional processing steps are discussed below in the results section. For calibration of the CTD oxygen data, whole profile fits were used for shallower stations, while split profile fits were used for deeper stations.

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.
* All bottom depth values are corrected for local sound speed, where sound speed values are calculated from the CTD data at each station.
* "Bottom of cast" depths are calculated from CTD maximum pressure (converted to depth) and altimeter values at the bottom of the casts.

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

5 CTD AND BOTTLE DATA RESULTS AND DATA QUALITY

Data from the secondary CTD sensor pair (temperature and conductivity) were used for the whole cruise. Suspect CTD 2 dbar averages are listed in Table 9, while suspect nutrient and dissolved oxygen bottle samples are listed in Tables 11 and 12 respectively. Nutrient and dissolved oxygen comparisons to previous cruises are made in section 7.

5.1 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 4 and 5. Station groupings used for the calibration are included in Table 5. International standard seawater batch numbers used for salinometer standardisation were as follows:

batch number	date	stations
P149	05 Oct 2007	53, 55-61, 87-99, 109-115, 141
P150	22 May 2008	22-25, 28-40, 48-50, 62-68, 84-86, 100-102
P151	20 May 2009	1-9, 11, 12, 41-47, 51, 52, 54, 69-83, 103-108, 142, 144, 146-149
P152	05 May 2010	10, 13-21, 26, 27, 116-140, 143, 145

The Guildline Autosal serial 62548 was used for the cruise, although there were many salinometer problems, as detailed in Appendix 1. Operator error led to mostly bad results for stations 1-8 (Table 10b). For these stations, the few samples retained for the conductivity calibration were those with salinity residuals (i.e. CTD - bottle salinity) looking like those for stations 9 to 12; and stations 1 to 12 were included in a single calibration group (Table 4). As a result of the bad salinometer results, CTD salinity accuracy is reduced for stations 1 to 8, and should be considered accurate to only ~0.003 (PSS78).

A pressure dependent salinity residual is evident for many stations, in particular the deeper stations. The magnitude of the pressure dependency is typically ~0.002 (PSS78) over the whole profile, with the trend a negative increase in bottle-CTD residual with depth, as observed on many previous cruises. The pressure dependency on cruise au1121 is more consistent and in some cases larger than on previous cruises e.g. stations 24, 31, 32, 37, 38, 39, 41, 42, 46, 47 and 48, where the magnitude over the whole profile is up to ~0.004 (PSS78) (Figure 4). The dependency is also evident on some shallow stations e.g. stations 88, 95, 133 and 134 (Figure 4). CTD sensors are unlikely to be the cause, as near identical results are observed for both primary and secondary sensors, and using both the pre cruise and post cruise temperature sensor calibrations; and indeed the salinity residuals for some stations show no pressure dependency. Salinity sampling is also unlikely to be the cause, as there is no correlation between the pressure dependency and either Niskin closure or sample drawing. The most likely source of the error is the salinometer.

Close inspection of the vertical profiles of the bottle-CTD salinity difference values reveals a slight biasing for a few stations, mostly of the order 0.001 (PSS78), as follows:

station	bottle-CTD bias (PSS78)	station	bottle-CTD bias (PSS78)
7	+0.001	87-88	-0.002
9	-0.001	89	-0.001
24-27	-0.0005	90	-0.002
29	+0.001	109	-0.001
33	-0.001	133-134	+0.001
35-36	-0.001	137-138	-0.0005
44-46	-0.0005	139	-0.001
56	-0.0005	143-145	-0.0005
62	-0.0005	146-147	+0.0005
74	+0.003	148	+0.001
77-78	-0.0015		

This is most likely due to a combination of factors, including salinometer performance, and station groupings for shallow stations. There is no significant diminishing of overall CTD salinity accuracy from this apparent biasing.

Bad salinity bottle samples (not deleted from the data files) are listed in Table 10a.

5.2 Temperature

For the primary and secondary CTD temperature data (T_p and T_s respectively), a consistent difference of $T_s - T_p \approx -0.006^oC$ was observed throughout the entire cruise (shown for two example stations in Figure 5a). Post cruise CTD calibrations (June 2011) were performed by SeaBird, and for this case $T_s - T_p$ is close to zero (Figure 5a), a good result. Comparing temperature values for each sensor using the pre and post cruise calibrations (Figure 5b), it appears that the pre cruise calibration for T_p is in error. Moreover for the example station 6, with a larger temperature range, the differences vary significantly through the profile, indicating a temperature dependency of the error. Pre cruise calibrations were discussed with the CSIRO calibration facility, and a calibration shift of temperature sensor serial 4246 (i.e. T_p on this cruise) had been noted on this occasion and on a previous occasion. On this occasion the sensor appears to have re-shifted sometime after the pre cruise calibration. Clearly this sensor is unstable, and should not be used in its current state. Note that this calibration error does not affect temperature data for the cruise, as secondary (not primary) temperature data were used. And the close agreement between the pre and post cruise calibrations for T_s, within 0.001°C (Figure 5b), indicates a reasonably stable temperature sensor.

Data spikes in the primary temperature were common at temperatures below 0°C, of no consequence in this case as primary sensor data were not used. Note that this same behaviour for the particular sensor (serial 4246) has been observed on previous cruises, and is independent of the CTD or channel used.

5.3 Pressure

Surface pressure offsets for each cast (Table 6) were obtained from inspection of the data before the package entered the water. Pressure spiking, a problem on some previous cruises, did not occur, other than during station 12 when the CTD comms crashes were occurring.

5.4 Dissolved oxygen

CTD oxygen data were calibrated as per the *CTD methodology*, with profiles deeper than 1400 dbar (i.e. stations 5 to 52, 60 to 62, and 141 to 149; stations 56 and 63 exceptions) calibrated as split profile fits, and profiles shallower than 1400 dbar calibrated as whole profile fits. Calibration results are plotted in Figure 6, and the derived calibration coefficients are listed in Table 7. Overall the calibrated CTD oxygen agrees with the bottle data to well within 1% of full scale (where full scale is ~400 µmol/l above 1500 dbar, and ~260 µmol/l below 1500 dbar).

* For station 12, there were insufficient bottle samples for calibration of the CTD oxygen.

* For stations 56 and 63, whole profile fits were required to improve the calibration results.

* Bottle overlaps between the shallow and deep fits were varied slightly for the following stations: 8, 11, 20, 21, 23, 38, 51, 52 and 61.

* The top section of the oxygen profile was unusable for the following stations, due to missing near surface bottle oxygen data: 115, 117, 121, 129 and 134.

5.5 Fluorescence, PAR, transmittance, altimeter, optode

All fluorescence and PAR data have a manufacturer supplied calibration (Table 3) applied to the data. Transmittance was scaled against in situ deep water measurements, as described below. In the CTD 2dbar averaged data files, both downcast and upcast data are supplied for these sensors; and the data are strictly 2 dbar averages (as distinct from other calculations used previous cruises i.e. au0703, au0803 and au0806).

Fluorescence spikiness was caused by interference from the camera strobes, mounted on the CTD package and operating for most southern stations. The SeaBird “filter” program (with a low pass filter value of 1 sec) was used to smooth the spikes, for stations 53 to 59, 62, 64, and 66 to 140.

The PAR calibration coefficients in Table 3 were calculated from the manufacturer supplied calibration sheet, using the method described in the following SeaBird documents: page 53 of SeaSave Version 7.2 manual; Application Note No. 11 General; and Application Note No. 11 QSP-L. The PAR calibration “offset” value (Table 3) was derived from deep water voltage values in the au1121 data.

Transmittance values were rescaled as percentages, and initially referenced to clean water using the following manufacturer supplied values:

voltage output in clean water = 4.698 V, representing 100% transmittance
voltage output with beam blocked = 0.058 V, representing 0% transmission

giving linear slope and offset values of 21.5517 and -1.2500 respectively, for conversion of volts to percentage. Output voltages were significantly less than expected, never approaching the in air value of 4.809 V as per the manufacturer calibration sheet, and giving deep water (around 2000 to 3000 dbar) transmittance values of ~75.5%. The most likely cause is sensor windows out of alignment, a common problem with these instruments (Tom Trull, pers. comm.) - at the time of writing, sensor testing is required to confirm this. In the final data set, transmittance values were referenced to a deep water value of 3.562 V (i.e. = 100%), obtained from close examination of transmittance voltage profiles, specifically stations 11 and 14 around 3000 dbar. This scaling yields linear slope and offset values of 28.5388 and -1.6553 respectively (Table 3). No calibration drift correction (as per SeaBird Application Note No. 91) has been applied for the dark voltage value, however this error is assumed to be small. Note that with this referencing to deep water values, some valid signal may have been removed from the upper water column. Also note that with this new scaling, transmittance values on occasion exceed 100%, most notably for station 7 downcast (suspicious data), and for station 15 (unexplained).

* For stations 1 to 12, much of the transmittance data were bad or suspect, due to a faulty cable.

* Transmittance data for station 12 is much noisier than for surrounding stations, possibly related to the flooding optode discussed earlier in the report.

For the Tritech 500 kHz altimeter, a false bottom reading was often observed before coming within the nominal altimeter range of 50 m. This “artefact” is most likely due to detection of the echo from the previous altimeter ping, or alternatively a combination of a good echo return from the bottom and a slightly better range in cold water. As a result of this behaviour, the real bottom was missed for stations 4 and 18. For station 4, the elevation off the bottom at the bottom of the cast could be determined from the LADCP data; for station 18, the minimum elevation above the bottom may have been ~95 m, based on an estimate of the difference between artefact and real bottom returns – however this estimate is not reliable enough for a station 18 “alt” entry in Table 1. For stations 1 and 3, no reliable altimeter data were obtained, and elevations at the bottom of the cast were again obtained from the LADCP. Note that similar behaviour for Tritech 500 kHz altimeters has been observed on previous cruises. Also note that no reliable altimeter data were obtained for station 90.

For optode data (stations 1 to 12 and 82), the following linear calibrations (Craig Neill, CSIRO CMAR) have been applied to the raw voltage data:

optode phase = volts x 12 + 10
optode temperature = volts x 9 - 5

* A calibration error may exist for station 82 optode data - a different optode was used for station 82, however the same calibration coeffiecients were applied as for stations 1 to 12.

5.6 Nutrients

Nutrients measured on the cruise were phosphate, total nitrate (i.e. nitrate+nitrite), and silicate, using a Lachat autoanalyser. Suspect nutrient values not deleted from the bottle data files are listed in Table 11. Nitrate+nitrite versus phosphate data are shown in Figure 7. Note that most values are an average of two repeat analyses. Also note that full scale for phosphate, nitrate and silicate are respectively 3.0 µmol/l, 35 µmol/l, and 140 µmol/l.

* Nitrate+nitrite data are improved compared to the previous cruise (au0806), with a tighter grouping of profile plots over the whole cruise (Figure 10).

* In Figure 7, data points to the left of the main trend line are shallow samples from southern stations. This depressed phosphate feature has been observed for Antarctic shelf stations on previous cruises (see section 7 below).

* For many stations, phosphate appears relatively higher than nitrate+nitrite for samples in the upper water thermocline. The most extreme cases are for stations 142 and 144-149 i.e. the points to the right of the main trend line in Figure 7.

* Phosphate data for stations 134 to 138 were mostly unusable.

* Nitrate data for station 16, bottles 7 to 20, were unusable.

Further assessment of nutrient data quality is given in section 7 below, comparing the data to previous cruises.

5.7 Additional CTD data processing/quality notes

* station 15: CTD oxygen data below bottle 3 are suspect, due to suspect oxygen samples for bottles 1 and 102

* station 57: missed bottle 8 during upcast; returned from 350 dbar back down to 550 dbar to fire bottle 8

* station 84: sensor tubes not removed, according to log notes. Comparing downcast and upcast data, there's no obvious sensor lag, as would be expected with tubes still connected – the data therefore appears to be good.

* station 96: the CTD was accidentally raised out of the water before the last bottle stop. The package was lowered back down to 10 dbar, and the last bottles were fired, though uncertain if the pumps were back on.

* station 146: after firing top bottle at 10 dbar, CTD lowered back to 20 dbar and held for ~1 hour while winch relay was fixed

* optode data: good data for stations 1 to 10, and station 82; bad data (i.e. both phase and temperature) for stations 11 and 12, as optode housing flooded

6 UNDERWAY MEASUREMENTS

Underway data were logged to an Oracle database on the ship. Quality control for the cruise was largely automated. 12 kHz bathymetry data were quality controlled on the cruise (Ben Walter, Navy Hydrographic Office).

1 minute instantaneous underway data are contained in the file au1121.ora as column formatted text; and in the files au1121ora.mat as matlab format. Data from the hull mounted underway temperature sensor (T_{dls}) and the underway thermosalinograph salinity (S_{dls}) are compared to CTD temperature and salinity data at 8 dbar (Figure 8). A lot of scatter is evident, particularly for S_{dls}, where the underway salinities are clearly offset for the first few days of the cruise, and then again for the last few stations, and with significant scatter from decimal days ~21 to 29. CTD based corrections to the underway data were derived (Figures 9a and b), however these corrections are approximate only, and have not been applied to the underway data as on previous cruises.

7 INTERCRUISE COMPARISONS

Intercruise comparisons of nutrient and dissolved oxygen data on neutral density (i.e. γ) surfaces are shown in bulk plots, comparing au1121 and au0806 (Figure 10a), au1121 and au0103 (Figure 10b), and au1121 and au9601 (Figure 10c). Figure 10d is a pressure profile comparison of au1121 and au0803. The same comparison data are also shown as variations with latitude on the different γ surfaces (Figures 11 to 14). Taking averages of the data in Figures 11 to 14, and after removing some outliers, the comparisons can be quantified as follows:

phosphate
au1121 < au0806 by 0.06
au1121 > au0103 by 0.08
au1121 > au9601 by 0.08
au1121 < au0803 by 0.04 (Antarctic shelf region only)

nitrate+nitrite
au1121 < au0806 by ~0.5 (referring to bulk plot in Figure 10a)
au1121 < au0103 by 0.7
au1121 < au9601 by 0.1 (i.e. negligible)
au1121 < au0803 by 0.3 (Antarctic shelf region only)

silicate
au1121 < au0806 by 3
au1121 < au0103 by 2 (but often less)
au1121 > au9601 by 3
au1121 < au0803 by 3 (Antarctic shelf region only)

dissolved oxygen bottle data
au1121 > au0806 by 1.9
au1121 < au0103 by 2.1 (possibly closer to 3.0)
au1121 < au9601 by 1.7
au1121 < au0803 by 0.2 (Antarctic shelf region only) (i.e. negligible)

These results are consistent with previous comparisons of au0806 to au0103 and au9601 in the au0806/au0803 data report (Rosenberg and Rintoul, May 2010 unpublished report). Looking more closely at phosphate data, the au0806/au0803 data report suggested Lachat system data processing techniques as the most likely cause of offsets between au0806/au0803 and previous SR3 cruises. However the phosphate difference shown above of au1121 < au0806 by 0.06 (close to 2% of full scale), for two cruises using both the same analysis system and the same data processing techniques, indicates other causes for the intercruise variability. From the above comparisons, the total range of the intercruise variability for all nutrients is of the order 4% of full scale. For dissolved oxygen, the equivalent number is of the order 1 to 2%.

8 FILE FORMATS

Data are supplied as column formatted text files, or as matlab files, with all details fully described in the README file included with the data set. Note that all dissolved oxygen and nutrient data in these file versions are in units of µmol/l.

The data are also available in WOCE "Exchange" format files. In these file versions, dissolved oxygen and nutrient data are in units of µmol/kg. For density calculation in the volumetric to gravimetric units conversion, the following were used:

dissolved oxygen – in situ temperature and CTD salinity at which each Niskin bottle was fired; zero pressure

nutrients – laboratory temperature (22.5^{o}C), and in situ CTD salinity at which each Niskin bottle was fired; zero pressure

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Table 1: **Summary of station information for cruise au1121. All times are UTC; "alt" = minimum altimeter value (m), "maxp" = maximum pressure (dbar). Note: for stations 1, 3 and 4, "alt" value is from LADCP data, not altimeter.**

	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 SR3	04 Jan 2011	163056	44 07.42 S	146 13.97 E	1066	165632	44 07.46 S	146 14.32 E	1098	173811	44 07.49 S	146 14.73 E	1114	12.0	1098
002 SR3	04 Jan 2011	195416	44 00.08 S	146 19.37 E	241	200144	44 00.11 S	146 19.47 E	235	201751	44 00.17 S	146 19.70 E	235	13.4	224
003 SR3	04 Jan 2011	213307	44 03.13 S	146 17.55 E	597	214357	44 03.16 S	146 17.63 E	619	221723	44 03.17 S	146 17.95 E	515	40.0	584
004 SR3	04 Jan 2011	234616	44 07.18 S	146 13.37 E	-	000358	44 07.23 S	146 13.33 E	1033	004153	44 07.18 S	146 13.36 E	1023	88.0	955
005 SR3	05 Jan 2011	024907	44 23.08 S	146 11.78 E	2330	033752	44 23.36 S	146 11.84 E	2327	050623	44 23.64 S	146 11.91 E	2330	10.6	2348
006 SR3	05 Jan 2011	081412	44 43.09 S	146 02.80 E	3206	092322	44 43.45 S	146 02.85 E	3210	110922	44 43.89 S	146 03.11 E	3228	9.9	3251
007 SR3	05 Jan 2011	153146	45 13.25 S	145 50.95 E	2863	162450	45 13.23 S	145 50.93 E	2859	174002	45 13.15 S	145 51.28 E	2839	11.1	2891
008 SR3	05 Jan 2011	212452	45 41.93 S	145 39.69 E	2000	215934	45 41.89 S	145 39.70 E	2003	230147	45 41.86 S	145 39.82 E	1991	10.6	2019
009 SR3	06 Jan 2011	022703	46 10.45 S	145 28.14 E	2725	032201	46 10.41 S	145 28.80 E	2726	045358	46 10.48 S	145 30.02 E	2731	4.2	2763
010 SR3	06 Jan 2011	081037	46 38.86 S	145 15.22 E	3340	091926	46 38.65 S	145 16.01 E	3315	105458	46 38.40 S	145 16.21 E	3309	7.4	3362
011 SR3	07 Jan 2011	085724	47 28.82 S	144 51.39 E	-	104235	47 28.92 S	144 51.32 E	4459	132223	47 28.39 S	144 52.92 E	-	10.1	4534
012 SR3	07 Jan 2011	154328	47 09.05 S	144 54.04 E	-	171112	47 08.68 S	144 54.23 E	4793	174615	47 08.57 S	144 54.37 E	-	9.1	4879
013 SR3	08 Jan 2011	030454	48 10.27 S	144 35.92 E	-	043716	48 10.01 S	144 36.88 E	4338	063320	48 09.41 S	144 38.27 E	-	9.7	4410
014 SR3	08 Jan 2011	105152	48 46.81 S	144 19.68 E	-	121611	48 47.13 S	144 21.56 E	4143	135346	48 47.48 S	144 23.50 E	-	10.5	4209
015 SR3	08 Jan 2011	170323	49 16.51 S	144 06.24 E	-	181534	49 16.79 S	144 06.88 E	4398	194256	49 17.02 S	144 07.58 E	-	7.7	4475
016 SR3	08 Jan 2011	230833	49 36.70 S	143 55.91 E	-	001323	49 36.60 S	143 55.97 E	3693	013459	49 36.60 S	143 56.00 E	-	10.3	3747
017 SR3	09 Jan 2011	033151	49 53.31 S	143 47.89 E	-	044224	49 53.15 S	143 48.26 E	3731	061815	49 52.77 S	143 48.80 E	-	13.1	3784
018 SR3	09 Jan 2011	082144	50 09.60 S	143 40.40 E	-	094805	50 09.40 S	143 40.92 E	3595	113217	50 08.98 S	143 41.53 E	3798	-	3582
019 SR3	09 Jan 2011	133224	50 23.87 S	143 32.00 E	-	143708	50 23.42 S	143 32.26 E	3460	155349	50 23.07 S	143 32.71 E	-	5.4	3514
020 SR3	09 Jan 2011	181006	50 40.60 S	143 25.31 E	-	191047	50 39.57 S	143 25.10 E	3557	202658	50 38.51 S	143 24.80 E	-	10.6	3608
021 SR3	09 Jan 2011	231815	51 00.05 S	143 16.65 E	-	002559	50 58.51 S	143 16.81 E	3870	020027	50 56.38 S	143 17.11 E	-	12.8	3927
022 SR3	10 Jan 2011	075215	51 23.93 S	143 04.42 E	3697	091327	51 22.28 S	143 06.49 E	3772	105632	51 20.20 S	143 08.69 E	3749	15.1	3824
023 SR3	10 Jan 2011	143005	51 48.65 S	142 51.17 E	-	153257	51 48.22 S	142 52.94 E	3694	165018	51 47.66 S	142 54.79 E	-	12.6	3747
024 SR3	10 Jan 2011	201000	52 13.14 S	142 37.67 E	-	210636	52 12.88 S	142 38.86 E	3478	223214	52 12.46 S	142 40.47 E	-	11.9	3526
025 SR3	11 Jan 2011	033246	52 40.19 S	142 23.45 E	-	043301	52 40.00 S	142 23.21 E	3373	060629	52 39.57 S	142 22.38 E	3370	12.0	3418
026 SR3	11 Jan 2011	091526	53 07.87 S	142 08.24 E	-	102254	53 08.05 S	142 08.14 E	3075	114745	53 08.22 S	142 08.54 E	-	9.2	3116
027 SR3	11 Jan 2011	144121	53 34.84 S	141 52.24 E	2460	152405	53 34.94 S	141 53.00 E	2487	162333	53 35.04 S	141 53.89 E	2620	15.2	2509
028 SR3	11 Jan 2011	193806	54 04.18 S	141 35.93 E	2540	202345	54 04.09 S	141 36.16 E	2545	212918	54 03.92 S	141 36.47 E	2547	10.7	2573
029 SR3	12 Jan 2011	013937	54 31.90 S	141 19.86 E	2773	023338	54 31.57 S	141 20.00 E	2805	040352	54 30.83 S	141 20.30 E	2832	8.9	2840
030 SR3	12 Jan 2011	073510	55 01.33 S	141 01.15 E	-	083301	55 01.17 S	141 01.17 E	3330	095912	55 01.12 S	141 00.85 E	-	12.0	3374
031 SR3	12 Jan 2011	125934	55 29.84 S	140 44.27 E	-	140950	55 29.55 S	140 44.57 E	3922	153139	55 29.33 S	140 44.81 E	-	7.2	3988
032 SR3	12 Jan 2011	182833	55 55.61 S	140 24.99 E	-	193731	55 55.26 S	140 25.33 E	3645	205554	55 55.04 S	140 25.52 E	-	13.2	3698
033 SR3	13 Jan 2011	013631	56 25.97 S	140 06.19 E	-	025338	56 25.51 S	140 07.33 E	3864	042724	56 24.96 S	140 08.55 E	-	14.4	3921
034 SR3	13 Jan 2011	075755	56 56.03 S	139 51.45 E	-	092615	56 55.84 S	139 52.09 E	4176	111350	56 55.48 S	139 52.82 E	-	14.4	4242
035 SR3	13 Jan 2011	151106	57 36.07 S	139 50.80 E	-	163336	57 35.90 S	139 50.96 E	4271	180455	57 35.46 S	139 51.28 E	-	11.9	4342
036 SR3	13 Jan 2011	222859	58 21.03 S	139 51.01 E	-	234051	58 21.17 S	139 51.59 E	3996	010411	58 21.13 S	139 51.62 E	-	14.1	4057
037 SR3	14 Jan 2011	072120	59 05.96 S	139 51.37 E	-	083251	59 05.80 S	139 51.47 E	3929	100708	59 05.51 S	139 50.75 E	-	14.1	3989
038 SR3	14 Jan 2011	144012	59 51.07 S	139 51.46 E	-	160132	59 51.06 S	139 51.97 E	4454	174102	59 51.10 S	139 52.22 E	-	13.2	4530

Table 1: (continued)

	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
039 SR3	14 Jan 2011	211651	60 21.07 S	139 51.28 E	-	222849	60 20.88 S	139 50.82 E	4416	000141	60 20.53 S	139 50.03 E	-	9.0	4496
040 SR3	15 Jan 2011	032628	60 51.33 S	139 50.75 E	4380	045034	60 50.82 S	139 49.92 E	4377	063920	60 50.27 S	139 48.80 E	4386	9.8	4456
041 SR3	15 Jan 2011	093856	61 20.91 S	139 51.28 E	4317	110612	61 20.38 S	139 51.05 E	4318	124249	61 19.87 S	139 50.90 E	4321	10.3	4394
042 SR3	15 Jan 2011	154458	61 51.10 S	139 51.32 E	4271	170105	61 51.25 S	139 51.77 E	4264	182707	61 51.34 S	139 52.21 E	4269	9.5	4339
043 SR3	15 Jan 2011	211855	62 21.05 S	139 50.89 E	-	223142	62 20.71 S	139 50.63 E	3924	235640	62 20.30 S	139 50.56 E	-	9.0	3990
044 SR3	16 Jan 2011	030738	62 51.06 S	139 50.72 E	3176	041144	62 50.94 S	139 50.98 E	3181	053141	62 50.89 S	139 51.43 E	3186	14.7	3221
045 SR3	16 Jan 2011	081417	63 20.98 S	139 50.81 E	3780	092207	63 20.73 S	139 49.81 E	3773	105422	63 20.43 S	139 48.00 E	3780	9.6	3835
046 SR3	16 Jan 2011	134658	63 52.10 S	139 51.32 E	3704	144916	63 51.65 S	139 53.12 E	3703	160620	63 51.20 S	139 55.25 E	3711	8.6	3763
047 SR3	16 Jan 2011	181925	64 12.65 S	139 50.66 E	3493	191957	64 12.18 S	139 50.17 E	3499	203801	64 11.75 S	139 49.88 E	3517	9.4	3554
048 SR3	16 Jan 2011	232928	64 33.25 S	139 50.79 E	3048	002350	64 33.01 S	139 50.87 E	3051	014746	64 32.45 S	139 50.69 E	3065	9.9	3093
049 SR3	17 Jan 2011	033428	64 48.64 S	139 50.98 E	2573	042635	64 48.39 S	139 50.99 E	2579	053509	64 48.10 S	139 51.00 E	2604	9.6	2611
050 SR3	17 Jan 2011	072821	65 04.22 S	139 51.17 E	2473	081201	65 03.96 S	139 50.75 E	2453	091912	65 03.67 S	139 50.56 E	2386	7.4	2485
051 SR3	17 Jan 2011	195239	65 24.27 S	139 50.15 E	2334	203627	65 24.15 S	139 50.14 E	2348	213538	65 24.32 S	139 49.66 E	2313	4.4	2381
052 SR3	17 Jan 2011	232246	65 25.90 S	139 51.26 E	1795	000217	65 25.99 S	139 51.47 E	1907	010336	65 26.04 S	139 51.40 E	1787	5.1	1930
053 SR3	18 Jan 2011	025633	65 32.12 S	139 50.32 E	1312	032154	65 32.32 S	139 50.28 E	1302	040831	65 32.59 S	139 50.05 E	1259	3.2	1315
054 SR3	18 Jan 2011	052342	65 34.24 S	139 50.56 E	745	053840	65 34.31 S	139 50.38 E	755	061749	65 34.60 S	139 50.11 E	619	3.2	761
055 SR3	18 Jan 2011	090220	65 42.76 S	139 51.20 E	288	091741	65 42.71 S	139 50.92 E	298	093805	65 42.65 S	139 50.62 E	296	5.4	295
056 slope	18 Jan 2011	133312	65 37.90 S	140 23.11 E	1394	140632	65 37.98 S	140 22.90 E	1472	145026	65 38.05 S	140 22.80 E	1461	2.8	1489
057 slope	18 Jan 2011	154226	65 38.86 S	140 26.20 E	1137	160349	65 39.00 S	140 25.88 E	1165	165228	65 39.16 S	140 25.52 E	1181	3.3	1177
058 slope	18 Jan 2011	175138	65 41.08 S	140 31.65 E	787	181103	65 41.18 S	140 31.13 E	832	183800	65 41.44 S	140 30.47 E	836	4.4	838
059 slope	18 Jan 2011	215849	65 42.10 S	140 34.17 E	421	221023	65 42.21 S	140 33.96 E	417	222939	65 42.37 S	140 33.53 E	414	3.7	418
060 canyon	19 Jan 2011	112402	65 32.16 S	143 08.93 E	2675	121822	65 32.69 S	143 08.53 E	2665	132448	65 33.01 S	143 08.21 E	2652	7.3	2701
061 canyon	19 Jan 2011	145146	65 39.61 S	143 01.97 E	2370	154015	65 39.64 S	143 01.65 E	2353	162951	65 39.53 S	143 00.80 E	2345	4.8	2385
062 canyon	19 Jan 2011	174718	65 43.32 S	142 57.94 E	2083	182429	65 43.51 S	142 57.05 E	2085	191131	65 44.06 S	142 56.13 E	2016	3.4	2113
063 canyon	19 Jan 2011	202846	65 46.57 S	142 56.92 E	1540	210038	65 47.00 S	142 56.60 E	1486	213604	65 47.33 S	142 55.96 E	1355	7.9	1498
064 canyon	19 Jan 2011	224010	65 48.70 S	142 58.70 E	874	230109	65 48.82 S	142 58.39 E	866	232626	65 48.95 S	142 58.12 E	837	3.8	872
065 canyon	20 Jan 2011	002318	65 50.96 S	142 59.51 E	418	003159	65 50.99 S	142 59.43 E	421	004700	65 51.02 S	142 59.25 E	423	8.0	418
066 shelf	20 Jan 2011	125618	65 55.48 S	142 48.91 E	415	130648	65 55.46 S	142 48.88 E	415	132318	65 55.40 S	142 48.73 E	420	2.5	417
067 shelf	20 Jan 2011	144312	65 59.68 S	142 36.63 E	427	145546	65 59.59 S	142 36.32 E	413	151513	65 59.56 S	142 35.83 E	386	3.4	414
068 shelf	20 Jan 2011	164855	66 00.08 S	142 56.44 E	444	170114	66 00.04 S	142 56.14 E	447	172249	66 00.06 S	142 55.69 E	441	3.6	448
069 shelf	20 Jan 2011	185038	65 59.93 S	143 19.26 E	454	190218	65 59.92 S	143 19.07 E	460	192029	65 59.94 S	143 18.94 E	460	3.9	461
070 shelf	20 Jan 2011	204410	65 59.91 S	143 36.92 E	419	205145	65 59.92 S	143 36.79 E	433	211525	65 59.85 S	143 36.44 E	421	2.6	435
071 shelf	20 Jan 2011	223130	66 00.01 S	143 54.03 E	391	224348	66 00.18 S	143 54.02 E	393	230004	66 00.31 S	143 53.98 E	394	4.7	392
072 shelf	21 Jan 2011	131835	66 10.18 S	143 47.58 E	449	133032	66 10.16 S	143 47.20 E	457	135836	66 09.93 S	143 46.09 E	458	2.7	459
073 shelf	21 Jan 2011	145848	66 10.37 S	143 29.24 E	531	150821	66 10.30 S	143 29.06 E	529	152817	66 10.26 S	143 28.70 E	530	4.3	530
074 shelf	21 Jan 2011	161715	66 10.82 S	143 19.71 E	540	163138	66 10.85 S	143 19.22 E	541	164941	66 10.94 S	143 18.92 E	541	4.6	543
075 shelf	22 Jan 2011	001720	66 10.60 S	143 09.22 E	567	002753	66 10.58 S	143 09.04 E	570	004831	66 10.59 S	143 08.93 E	564	4.1	572
076 shelf	22 Jan 2011	023146	66 09.22 S	142 55.81 E	550	024412	66 09.21 S	142 55.66 E	548	030734	66 09.29 S	142 55.68 E	545	3.0	551
077 shelf	22 Jan 2011	042757	66 10.91 S	142 43.63 E	396	044025	66 10.94 S	142 44.12 E	401	045737	66 11.01 S	142 44.99 E	403	3.5	402

Table 1: (continued)

	------------------------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
078 shelf	22 Jan 2011	062014	66 19.15 S	142 39.96 E	378	063046	66 19.18 S	142 40.30 E	379	064841	66 19.18 S	142 41.06 E	392	2.9	380
079 shelf	22 Jan 2011	082902	66 25.47 S	142 58.88 E	612	084823	66 25.44 S	142 59.05 E	617	091200	66 25.27 S	142 59.20 E	617	4.1	620
080 shelf	22 Jan 2011	103851	66 22.72 S	143 16.72 E	709	105633	66 22.79 S	143 16.57 E	710	111735	66 22.94 S	143 16.44 E	711	3.8	714
081 shelf	22 Jan 2011	131941	66 19.69 S	143 42.46 E	545	133243	66 19.70 S	143 42.31 E	551	135000	66 19.85 S	143 42.14 E	551	3.8	553
082 shelf	23 Jan 2011	112523	66 19.83 S	143 58.04 E	508	113623	66 19.72 S	143 57.87 E	508	115552	66 19.56 S	143 57.65 E	500	2.4	511
083 shelf	23 Jan 2011	131741	66 22.89 S	143 49.79 E	592	133334	66 22.93 S	143 49.43 E	600	135117	66 22.99 S	143 49.02 E	587	3.7	603
084 shelf	23 Jan 2011	150241	66 26.94 S	143 37.90 E	707	151955	66 27.01 S	143 37.69 E	710	154045	66 27.16 S	143 37.45 E	709	3.3	715
085 shelf	24 Jan 2011	035811	66 26.26 S	143 38.15 E	695	041303	66 26.31 S	143 37.98 E	702	043754	66 26.45 S	143 37.42 E	703	1.5	709
086 shelf	24 Jan 2011	054357	66 30.81 S	143 27.86 E	749	055923	66 30.87 S	143 27.51 E	753	062123	66 30.91 S	143 27.18 E	756	3.6	759
087 shelf	24 Jan 2011	072324	66 33.46 S	143 20.07 E	798	073943	66 33.28 S	143 20.02 E	797	080337	66 33.11 S	143 19.84 E	800	3.6	803
088 shelf	24 Jan 2011	090535	66 36.89 S	143 09.87 E	804	092250	66 37.10 S	143 09.60 E	799	095138	66 37.39 S	143 09.16 E	776	3.5	805
089 shelf	24 Jan 2011	105648	66 40.32 S	143 01.67 E	633	110943	66 40.24 S	143 01.58 E	639	113342	66 40.33 S	143 01.18 E	592	3.8	642
090 shelf	24 Jan 2011	123735	66 45.12 S	143 03.52 E	720	125024	66 45.22 S	143 03.34 E	683	131251	66 45.44 S	143 03.10 E	644	-	684
091 shelf	24 Jan 2011	142546	66 42.04 S	143 20.48 E	708	144006	66 41.97 S	143 20.30 E	711	150206	66 42.12 S	143 20.35 E	692	3.7	716
092 shelf	24 Jan 2011	162013	66 42.63 S	143 35.46 E	571	163310	66 42.66 S	143 35.30 E	582	164945	66 42.70 S	143 34.73 E	567	2.9	586
093 shelf	24 Jan 2011	183211	66 43.21 S	143 58.94 E	868	185036	66 43.19 S	143 58.60 E	873	191306	66 43.31 S	143 58.16 E	862	5.0	879
094 shelf	24 Jan 2011	202457	66 46.46 S	144 10.93 E	829	204332	66 46.45 S	144 10.93 E	868	210540	66 46.27 S	144 10.78 E	893	3.6	874
095 shelf	24 Jan 2011	230121	66 50.51 S	144 22.73 E	678	231554	66 50.46 S	144 22.63 E	760	233848	66 50.41 S	144 22.41 E	718	3.9	765
096 shelf	25 Jan 2011	014237	66 56.92 S	144 28.70 E	198	014632	66 56.93 S	144 28.63 E	191	015959	66 56.96 S	144 28.25 E	197	2.5	191
097 iceberg scour	25 Jan 2011	025247	66 55.34 S	144 25.66 E	190	030026	66 55.38 S	144 25.48 E	194	031104	66 55.41 S	144 25.27 E	210	3.0	193
098 deep hole	25 Jan 2011	043516	66 56.95 S	144 04.72 E	845	045341	66 56.95 S	144 04.60 E	893	052254	66 56.84 S	144 04.14 E	899	4.7	899
099 iceberg scour	25 Jan 2011	071720	66 46.88 S	143 53.40 E	282	072428	66 46.79 S	143 53.29 E	283	073905	66 46.82 S	143 53.04 E	279	3.8	282
100 shelf	25 Jan 2011	090652	66 41.29 S	143 41.20 E	746	092120	66 41.24 S	143 41.21 E	748	094953	66 41.26 S	143 41.23 E	748	4.2	753
101 shelf	25 Jan 2011	112033	66 36.40 S	143 42.86 E	741	113738	66 36.43 S	143 42.88 E	741	120600	66 36.29 S	143 42.57 E	731	3.6	746
102 shelf	25 Jan 2011	134228	66 32.51 S	143 42.56 E	743	135802	66 32.55 S	143 42.04 E	740	142050	66 32.47 S	143 41.29 E	743	3.2	746
103 shelf	25 Jan 2011	161322	66 31.69 S	143 55.97 E	761	163112	66 31.62 S	143 55.85 E	762	165235	66 31.66 S	143 55.70 E	761	4.4	766
104 shelf	25 Jan 2011	181706	66 25.88 S	144 08.23 E	576	182844	66 25.84 S	144 08.06 E	576	185010	66 25.90 S	144 07.90 E	578	4.1	579
105 shelf	25 Jan 2011	203145	66 21.02 S	144 26.89 E	438	203956	66 21.01 S	144 26.78 E	441	205938	66 20.98 S	144 26.75 E	442	2.8	443
106 shelf	25 Jan 2011	222821	66 12.72 S	144 30.08 E	376	223802	66 12.73 S	144 30.22 E	379	225423	66 12.83 S	144 30.49 E	374	2.8	380
107 shelf	26 Jan 2011	001001	66 05.23 S	144 40.69 E	352	001837	66 05.27 S	144 40.78 E	351	003040	66 05.29 S	144 40.91 E	346	5.1	350
108 shelf	26 Jan 2011	015904	65 57.74 S	144 51.07 E	717	021311	65 57.76 S	144 50.87 E	711	024106	65 57.85 S	144 50.49 E	625	2.7	716
109 shelf	26 Jan 2011	033745	65 58.72 S	144 54.98 E	563	034951	65 58.72 S	144 54.69 E	559	041456	65 58.75 S	144 54.16 E	534	2.2	563
110 shelf	26 Jan 2011	071457	66 19.67 S	144 59.25 E	380	072515	66 19.69 S	144 59.12 E	388	074113	66 19.73 S	144 58.97 E	389	4.0	388
111 shelf	26 Jan 2011	085447	66 26.90 S	144 49.72 E	448	090711	66 26.89 S	144 49.84 E	452	092443	66 26.88 S	144 49.79 E	455	2.8	455
112 shelf	26 Jan 2011	105104	66 30.17 S	144 38.03 E	524	110448	66 30.16 S	144 37.87 E	523	112435	66 30.13 S	144 37.39 E	519	3.8	525
113 shelf	26 Jan 2011	131431	66 30.74 S	145 03.33 E	424	132506	66 30.70 S	145 03.28 E	424	133937	66 30.76 S	145 03.14 E	423	3.9	425
114 shelf	26 Jan 2011	152159	66 40.60 S	145 20.59 E	495	153217	66 40.60 S	145 20.42 E	495	154816	66 40.64 S	145 20.38 E	493	4.0	497
115 shelf	26 Jan 2011	175041	66 39.56 S	145 45.82 E	376	175808	66 39.58 S	145 45.79 E	375	181356	66 39.63 S	145 45.57 E	371	4.5	375
116 shelf	26 Jan 2011	193555	66 39.41 S	146 09.76 E	174	193950	66 39.41 S	146 09.77 E	178	195009	66 39.41 S	146 09.74 E	176	4.0	176

Table 1: (continued)

CTD station	start of CTD date	time	latitude	longitude	depth	bottom of CTD time	latitude	longitude	depth	end of CTD time	latitude	longitude	depth	alt	maxp
117 shelf	26 Jan 2011	203638	66 42.52 S	146 10.21 E	376	204734	66 42.47 S	146 10.13 E	384	210137	66 42.38 S	146 10.27 E	378	4.6	384
118 shelf	26 Jan 2011	230806	66 47.65 S	146 22.84 E	403	231649	66 47.66 S	146 22.88 E	407	233418	66 47.66 S	146 23.06 E	410	4.0	407
119 shelf	27 Jan 2011	013307	66 56.75 S	146 34.16 E	474	014508	66 56.77 S	146 34.04 E	473	020422	66 56.76 S	146 33.91 E	472	3.7	475
120 east of Mertz	27 Jan 2011	033116	67 05.34 S	146 21.19 E	475	034436	67 05.36 S	146 21.08 E	477	035924	67 05.38 S	146 20.85 E	472	3.9	479
121 east of Mertz	27 Jan 2011	054651	67 14.61 S	146 31.18 E	532	060206	67 14.61 S	146 30.96 E	527	062000	67 14.59 S	146 30.67 E	529	3.5	529
122 east of Mertz	27 Jan 2011	074635	67 23.83 S	146 28.63 E	612	075744	67 23.77 S	146 28.40 E	610	082056	67 23.56 S	146 28.16 E	611	3.0	613
123 east of Mertz	27 Jan 2011	100754	67 29.26 S	146 48.68 E	619	102257	67 29.30 S	146 48.37 E	608	104216	67 29.33 S	146 48.02 E	618	2.7	612
124 east of Mertz	27 Jan 2011	121129	67 31.48 S	147 13.05 E	530	122346	67 31.54 S	147 12.76 E	529	124335	67 31.40 S	147 12.37 E	529	2.9	532
125 east of Mertz	27 Jan 2011	141849	67 36.05 S	147 34.61 E	566	143110	67 36.13 S	147 34.33 E	571	144726	67 36.22 S	147 33.95 E	565	3.7	574
126 east of Mertz	27 Jan 2011	161104	67 40.89 S	147 51.16 E	543	162153	67 40.99 S	147 51.16 E	549	164221	67 41.02 S	147 50.99 E	549	3.1	552
127 east of Mertz	27 Jan 2011	200237	67 12.58 S	147 42.94 E	460	201126	67 12.62 S	147 42.96 E	462	202835	67 12.67 S	147 42.86 E	459	3.8	463
128 east of Mertz	27 Jan 2011	213757	67 12.23 S	147 21.98 E	447	214701	67 12.28 S	147 21.92 E	448	220313	67 12.42 S	147 21.72 E	447	4.0	449
129 east of Mertz	27 Jan 2011	231823	67 12.52 S	147 02.47 E	500	232733	67 12.64 S	147 02.29 E	501	234514	67 12.79 S	147 02.02 E	497	3.4	503
130 east of Mertz	28 Jan 2011	005002	67 12.11 S	146 44.39 E	487	010309	67 12.28 S	146 44.26 E	491	012105	67 12.41 S	146 43.61 E	495	2.5	494
131 east of Mertz	28 Jan 2011	040809	66 53.67 S	146 24.07 E	415	041925	66 53.71 S	146 23.93 E	414	043310	66 53.76 S	146 23.72 E	408	3.7	415
132 east of Mertz	28 Jan 2011	060649	66 53.14 S	146 49.27 E	555	061951	66 53.23 S	146 49.16 E	554	063645	66 53.36 S	146 49.01 E	546	3.4	557
133 east of Mertz	28 Jan 2011	082349	66 53.45 S	147 13.09 E	596	083624	66 53.42 S	147 12.85 E	593	085652	66 53.44 S	147 12.60 E	596	3.5	596
134 east of Mertz	28 Jan 2011	102758	66 54.71 S	147 38.23 E	604	104221	66 54.84 S	147 38.09 E	605	105905	66 54.97 S	147 37.97 E	605	3.7	608
135 east of Mertz	28 Jan 2011	132939	66 52.90 S	148 26.77 E	161	133710	66 52.93 S	148 26.69 E	178	134459	66 52.97 S	148 26.60 E	179	3.4	177
136 east of Mertz	28 Jan 2011	171535	66 28.90 S	148 23.14 E	201	171958	66 28.87 S	148 23.15 E	199	173356	66 28.96 S	148 23.17 E	195	3.9	197
137 east of Mertz	29 Jan 2011	062110	66 31.61 S	147 07.04 E	571	063301	66 31.56 S	147 07.03 E	567	065320	66 31.49 S	147 07.03 E	565	3.4	570
138 east of Mertz	29 Jan 2011	100305	66 15.08 S	147 06.40 E	468	101732	66 15.07 S	147 06.19 E	466	103426	66 15.15 S	147 05.95 E	460	3.3	467
139 trough slope	29 Jan 2011	132653	65 56.65 S	147 15.61 E	564	134838	65 56.59 S	147 15.66 E	602	140448	65 56.57 S	147 15.70 E	585	2.9	606
140 spur	29 Jan 2011	162104	65 58.79 S	147 41.06 E	625	163409	65 58.85 S	147 40.88 E	614	165839	65 58.98 S	147 40.66 E	587	4.2	617
141 P11	29 Jan 2011	233438	65 23.90 S	149 59.81 E	2871	002932	65 23.92 S	149 59.67 E	2867	014456	65 23.99 S	149 59.13 E	2880	9.8	2906
142 P11	30 Jan 2011	061140	65 00.11 S	150 00.77 E	3288	071436	64 59.89 S	150 00.77 E	3285	083110	64 59.51 S	150 01.05 E	3293	7.8	3336
143 P11	30 Jan 2011	105318	64 36.07 S	150 00.10 E	3438	120226	64 36.01 S	149 59.49 E	3429	132531	64 35.81 S	149 58.70 E	3426	8.4	3482
144 P11	30 Jan 2011	151455	64 18.04 S	150 00.08 E	3555	162401	64 18.07 S	149 59.48 E	3559	174639	64 18.39 S	149 58.25 E	3554	8.1	3617
145 P11	30 Jan 2011	200856	63 54.18 S	149 59.46 E	3644	212125	63 54.04 S	149 59.41 E	3638	224005	63 54.02 S	149 59.40 E	3643	8.4	3697
146 P11	31 Jan 2011	013531	63 29.95 S	149 59.58 E	-	030714	63 29.69 S	149 59.88 E	3702	054106	63 29.47 S	149 59.81 E	-	13.0	3758
147 S4	31 Jan 2011	080650	63 18.69 S	149 12.46 E	-	092259	63 18.63 S	149 12.09 E	3767	110132	63 18.45 S	149 12.02 E	-	8.2	3830
148 S4	31 Jan 2011	153311	63 10.48 S	147 51.23 E	-	163727	63 10.46 S	147 51.29 E	3881	175715	63 10.62 S	147 51.02 E	-	8.3	3947
149 S4	31 Jan 2011	213455	63 03.24 S	146 28.70 E	-	224706	63 02.99 S	146 28.45 E	3919	000837	63 03.13 S	146 27.97 E	3923	8.5	3986

<u>Table 2:</u> Cruise au1121 summary of samples drawn from Niskin bottles at each station, including "sal"= salinity, "ox"=dissolved oxygen, "nuts"= nutrients (i.e. phosphate, nitrate+nitrite, silicate), "CO2"=dissolved inorganic carbon (i.e. TCO_2), alkalinity and pH, "^{18}O", "hel"=helium, and "trit"=tritium. Note: biological samples not included here.

station	sal	ox	nuts	CO2	^{18}O	hel	trit
1	X	X	X				
2	X	X	X	X			
3	X	X	X				
4	X	X	X	X			
5	X	X	X	X			
6	X	X	X	X			
7	X	X	X	X			
8	X	X	X	X			
9	X	X	X	X			
10	X	X	X	X			
11	X	X	X	X			
12	X	X	X	X			
13	X	X	X	X			
14	X	X	X	X			
15	X	X	X	X			
16	X	X	X	X			
17	X	X	X	X			
18	X	X	X	X			
19	X	X	X	X			
20	X	X	X	X			
21	X	X	X	X			
22	X	X	X	X			
23	X	X	X	X			
24	X	X	X	X			
25	X	X	X	X			
26	X	X	X	X			
27	X	X	X	X			
28	X	X	X	X			
29	X	X	X	X			
30	X	X	X	X			
31	X	X	X	X			
32	X	X	X	X			
33	X	X	X	X			
34	X	X	X	X			
35	X	X	X	X			
36	X	X	X	X			
37	X	X	X	X	X		
38	X	X	X	X	X		
39	X	X	X	X	X		
40	X	X	X	X	X		
41	X	X	X	X	X		
42	X	X	X	X	X		
43	X	X	X	X	X	X	X
44	X	X	X	X	X		
45	X	X	X	X	X		
46	X	X	X	X	X	X	X
47	X	X	X	X	X		
48	X	X	X	X	X		
49	X	X	X	X	X	X	X
50	X	X	X	X	X		
51	X	X	X	X	X		
52	X	X	X	X	X	X	X
53	X	X	X	X	X		
54	X	X	X	X	X	X	X
55	X	X	X	X	X		
56	X	X	X		X		
57	X	X	X	X	X		
58	X	X	X	X	X		
59	X	X	X	X	X		
60	X	X	X	X	X		
61	X	X	X	X			
62	X	X	X	X			
63	X	X	X	X			
64	X	X	X	X			
65	X	X	X	X			
66	X	X	X	X	X		
67	X	X	X	X			
68	X	X	X	X			
69	X	X	X	X			
70	X	X	X	X			
71	X	X	X	X			
72	X	X	X	X	X		
73	X	X	X	X			
74	X	X	X	X	X	X	X

Table 2: (continued)

station	sal	ox	nuts	CO2	^{18}O	hel	trit
75	X	X	X	X	X	X	X
76	X	X	X	X	X		
77	X	X	X	X	X		
78	X	X	X	X	X		
79	X	X	X	X	X		
80	X	X	X	X	X		
81	X	X	X	X	X		
82	X	X	X	X	X		
83	X	X	X	X	X	X	X
84	X	X	X	X	X		
85	X	X	X		X	X	X
86	X	X	X	X	X	X	X
87	X	X	X	X	X		
88	X	X	X	X	X	X	X
89	X	X	X	X	X		
90	X	X	X	X	X		
91	X	X	X	X	X	X	X
92	X	X	X	X	X	X	X
93	X	X	X	X	X	X	X
94	X	X	X	X	X	X	X
95	X	X	X	X	X		
96	X	X	X	X	X		
97	X	X	X		X		
98	X	X	X	X	X		
99	X	X	X				
100	X	X	X	X	X		
101	X	X	X	X	X		
102	X	X	X		X		
103	X	X	X	X	X	X	X
104	X	X	X	X	X		
105	X	X	X	X			
106	X	X	X	X	X		
107	X	X	X	X			
108	X	X	X	X			
109	X	X	X		X		
110	X	X	X	X			
111	X	X	X	X			
112	X	X	X	X			
113	X	X	X	X			
114	X	X	X	X			
115	X	X	X	X			
116	X	X	X	X			
117	X	X	X	X			
118	X	X	X	X	X		
119	X	X	X	X	X	X	X
120	X	X	X	X	X	X	X
121	X	X	X	X	X	X	X
122	X	X	X	X	X	X	X
123	X	X	X	X	X	X	X
124	X	X	X	X	X	X	X
125	X	X	X	X	X	X	X
126	X	X	X	X	X	X	X
127	X	X	X	X	X	X	X
128	X	X	X	X	X	X	X
129	X	X	X	X	X	X	X
130	X	X	X	X	X		
131	X	X	X	X			
132	X	X	X	X	X		
133	X	X	X	X	X		
134	X	X	X	X	X		
135	X	X	X	X	X		
136	X	X	X	X	X		
137	X	X	X	X	X		
138	X	X	X	X			
139	X	X	X		X		
140	X	X	X		X		
141	X	X	X	X	X		X
142	X	X	X	X	X		
143	X	X	X	X	X	X	X
144	X	X	X	X	X		
145	X	X	X	X	X		
146	X	X	X	X	X		
147	X	X	X	X	X		
148	X	X	X	X	X		
149	X	X	X	X	X		

Table 3: CTD calibration coefficients and calibration dates for cruise au1121. 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. Oxygen, fluorometer and PAR values are manufacturer supplied. Transmissometer values are a rescaling to give transmittance as a %, referenced to the in situ deep water value from the cruise, and using the manufacturer supplied dark voltage. For oxygen, the final calibration uses in situ bottle measurements (the manufacturer supplied coefficients are not used). Note: for both CTD's, 704 (stations 1-12) and 703 (station 13 onwards), all sensors are the same, except for pressure.

Primary Temperature, serial 4246, 18/11/2010

G	: 3.9790446e-003
H	: 6.2194789e-004
I	: 1.9285431e-005
J	: 1.8988456e-006
F0	: 1000.000
Slope	: 1.0000000
Offset	: 0.0000

Secondary Temperature, serial 4248, 18/11/2010

G	: 4.3875942e-003
H	: 6.5176022e-004
I	: 2.3917473e-005
J	: 2.0220187e-006
F0	: 1000.000
Slope	: 1.0000000
Offset	: 0.0000

Primary Conductivity, serial 2977, 18/11/2010

G	: -1.0750554e+001
H	: 1.4912939e+000
I	: -1.5012549e-003
J	: 1.8248090e-004
CTcor	: 3.2500e-006
CPcor	: -9.5700000e-008
Slope	: 1.00000000
Offset	: 0.00000

Secondary Conductivity, serial 2808, 18/11/2010

G	: -9.3230527e+000
H	: 1.4382515e+000
I	: -3.5505215e-003
J	: 3.4627087e-004
CTcor	: 3.2500e-006
CPcor	: -9.5700000e-008
Slope	: 1.00000000
Offset	: 0.00000

CTD704 Pressure, serial 89084, 22/11/2010

C1	: -5.337692e+004
C2	: -5.768735e-001
C3	: 1.541700e-002
D1	: 3.853800e-002
D2	: 0.000000e+000
T1	: 2.984003e+001
T2	: -4.090591e-004
T3	: 3.693030e-006
T4	: 3.386020e-009
T5	: 0.000000e+000
Slope	: 0.99986802
Offset	: 0.01912 (dbar)
AD590M	: 1.283280e-002
AD590B	: -9.705660e+000

CTD703 Pressure, serial 88903, 22/11/20

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	: 1.00000230
Offset	: 0.61322 (dbar)
AD590M	: 1.276320e-002
AD590B	: -9.834110e+000

Oxygen, serial 0191, 15/07/2008

Soc	: 4.4920e-001
Boc	: 0.0000
Offset	: -0.4972
Tcor	: 0.0014
Pcor	: 1.350e-004
Tau	: 0.0

Transmissometer, serial 1016DR

A0	: -1.6553
A1	: 28.5388
A2	: 0.0000
A3	: 0.0000

Fluorometer, serial 296, 23/05/2005

Vblank	: 0.12
Scale factor	: 7.000e+000

PAR, serial 70110, QCP2300, 06/12/2006

M	: 1.000
B	: 0.000
Cal. Constant	: 1.6474465e+010
Multiplier	: 1.0
Offset	: -6.104e-002

(note: offset value derived from au1121 data)

Table 4: CTD conductivity calibration coefficients for cruise au1121. 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
001 to 012	-0.69968592E-02	0.99978006E-03	-0.19024896E-08	97	0.001667
013 to 015	-0.13899768E-01	0.99966262E-03	0.19613855E-07	69	0.000732
016 to 022	-0.14680719E-01	0.10000823E-02	-0.41354302E-08	149	0.000914
023 to 038	-0.15034126E-01	0.99994143E-03	0.11679145E-08	350	0.000936
039 to 050	-0.24699503E-02	0.99986817E-03	-0.62993662E-08	252	0.000792
051 to 058	0.31884408E-02	0.99940719E-03	-0.33052595E-09	100	0.000760
059 to 068	-0.39596613E-02	0.99989757E-03	-0.51805071E-08	89	0.000917
069 to 102	0.13979265E-01	0.99913516E-03	-0.17821362E-08	218	0.001503
103 to 115	0.50652238E-02	0.99939108E-03	-0.11903433E-08	65	0.000744
116 to 149	-0.69942879E-02	0.99983975E-03	-0.88701029E-09	294	0.000858

Table 5: 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, for cruise au1121.

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	0.99977815E-03	39	0.99962250E-03	77	0.99899794E-03	115	0.99925419E-03
2	0.99977625E-03	40	0.99961620E-03	78	0.99899615E-03	116	0.99973686E-03
3	0.99977435E-03	41	0.99960990E-03	79	0.99899437E-03	117	0.99973597E-03
4	0.99977245E-03	42	0.99960360E-03	80	0.99899259E-03	118	0.99973509E-03
5	0.99977054E-03	43	0.99959730E-03	81	0.99899081E-03	119	0.99973420E-03
6	0.99976864E-03	44	0.99959100E-03	82	0.99898903E-03	120	0.99973331E-03
7	0.99976674E-03	45	0.99958470E-03	83	0.99898724E-03	121	0.99973242E-03
8	0.99976484E-03	46	0.99957840E-03	84	0.99898546E-03	122	0.99973154E-03
9	0.99976293E-03	47	0.99957210E-03	85	0.99898368E-03	123	0.99973065E-03
10	0.99976103E-03	48	0.99956580E-03	86	0.99898190E-03	124	0.99972976E-03
11	0.99975913E-03	49	0.99955950E-03	87	0.99898011E-03	125	0.99972888E-03
12	0.99975723E-03	50	0.99955320E-03	88	0.99897833E-03	126	0.99972799E-03
13	0.99991760E-03	51	0.99939033E-03	89	0.99897655E-03	127	0.99972710E-03
14	0.99993722E-03	52	0.99939000E-03	90	0.99897477E-03	128	0.99972622E-03
15	0.99995683E-03	53	0.99938967E-03	91	0.99897299E-03	129	0.99972533E-03
16	0.10000162E-02	54	0.99938934E-03	92	0.99897120E-03	130	0.99972444E-03
17	0.10000120E-02	55	0.99938901E-03	93	0.99896942E-03	131	0.99972355E-03
18	0.10000079E-02	56	0.99938868E-03	94	0.99896764E-03	132	0.99972267E-03
19	0.10000038E-02	57	0.99938835E-03	95	0.99896586E-03	133	0.99972178E-03
20	0.99999964E-03	58	0.99938802E-03	96	0.99896408E-03	134	0.99972089E-03
21	0.99999551E-03	59	0.99959192E-03	97	0.99896229E-03	135	0.99972001E-03
22	0.99999137E-03	60	0.99958674E-03	98	0.99896051E-03	136	0.99971912E-03
23	0.99996829E-03	61	0.99958156E-03	99	0.99895873E-03	137	0.99971823E-03
24	0.99996946E-03	62	0.99957637E-03	100	0.99895695E-03	138	0.99971735E-03
25	0.99997062E-03	63	0.99957119E-03	101	0.99895516E-03	139	0.99971646E-03
26	0.99997179E-03	64	0.99956601E-03	102	0.99895338E-03	140	0.99971557E-03
27	0.99997296E-03	65	0.99956083E-03	103	0.99926847E-03	141	0.99971468E-03
28	0.99997413E-03	66	0.99955565E-03	104	0.99926728E-03	142	0.99971380E-03
29	0.99997530E-03	67	0.99955047E-03	105	0.99926609E-03	143	0.99971291E-03
30	0.99997646E-03	68	0.99954529E-03	106	0.99926490E-03	144	0.99971202E-03
31	0.99997763E-03	69	0.99901219E-03	107	0.99926371E-03	145	0.99971114E-03
32	0.99997880E-03	70	0.99901041E-03	108	0.99926252E-03	146	0.99971025E-03
33	0.99997997E-03	71	0.99900863E-03	109	0.99926133E-03	147	0.99970936E-03
34	0.99998114E-03	72	0.99900685E-03	110	0.99926014E-03	148	0.99970848E-03
35	0.99998230E-03	73	0.99900506E-03	111	0.99925895E-03	149	0.99970759E-03
36	0.99998347E-03	74	0.99900328E-03	112	0.99925776E-03		
37	0.99998464E-03	75	0.99900150E-03	113	0.99925657E-03		
38	0.99998581E-03	76	0.99899972E-03	114	0.99925538E-03		

Table 6: Surface pressure offsets (i.e. poff, in dbar) for cruise au1121. For each station, these values are subtracted from the pressure calibration "offset" value in Table 3.

stn	poff	stn	poff	stn	poff	stn	poff	stn	poff	stn	poff
1	0.08	26	1.02	51	0.66	76	0.50	101	0.33	126	0.41
2	-0.01	27	1.04	52	0.57	77	0.43	102	0.29	127	0.48
3	-0.02	28	0.96	53	0.63	78	0.45	103	0.33	128	0.46
4	-0.01	29	0.96	54	0.55	79	0.45	104	0.31	129	0.40
5	-0.01	30	0.97	55	0.64	80	0.47	105	0.27	130	0.45
6	-0.02	31	0.93	56	0.76	81	0.46	106	0.31	131	0.48
7	0.03	32	0.81	57	0.66	82	0.65	107	0.33	132	0.42
8	0.04	33	0.85	58	0.63	83	0.60	108	0.36	133	0.46
9	0.01	34	0.81	59	0.70	84	0.44	109	0.38	134	0.47
10	-0.04	35	0.72	60	0.67	85	0.63	110	0.38	135	0.51
11	0.20	36	0.75	61	0.52	86	0.59	111	0.40	136	0.51
12	-0.17	37	0.68	62	0.63	87	0.49	112	0.36	137	0.54
13	0.82	38	0.68	63	0.63	88	0.45	113	0.35	138	0.43
14	0.78	39	0.68	64	0.61	89	0.50	114	0.39	139	0.42
15	0.84	40	0.67	65	0.65	90	0.43	115	0.38	140	0.36
16	0.93	41	0.66	66	0.77	91	0.39	116	0.44	141	0.50
17	0.78	42	0.67	67	0.74	92	0.38	117	0.52	142	0.48
18	0.84	43	0.62	68	0.58	93	0.39	118	0.40	143	0.42
19	0.87	44	0.68	69	0.66	94	0.37	119	0.45	144	0.40
20	0.96	45	0.65	70	0.66	95	0.40	120	0.43	145	0.42
21	0.97	46	0.69	71	0.62	96	0.39	121	0.42	146	0.46
22	0.94	47	0.61	72	0.58	97	0.53	122	0.42	147	0.50
23	1.03	48	0.63	73	0.60	98	0.37	123	0.44	148	0.64
24	0.94	49	0.58	74	0.52	99	0.34	124	0.48	149	0.55
25	0.98	50	0.52	75	0.50	100	0.31	125	0.43		

Table 7: CTD dissolved oxygen calibration coefficients for cruise au1121: 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*. For deep stations, coefficients are given for both the shallow and deep part of the profile, according to the profile split used for calibration (see section 5.4 in the text); whole profile fit used for stations shallower than 1400 dbar (i.e. stations with only "shallow" set of coefficients in the table), plus stations 56 and 63.

	shallow					deep				
stn	slope	bias	tcor	pcor	dox	slope	bias	tcor	pcor	dox
1	0.558896	-0.250944	-0.006118	0.000059	0.054191					
2	0.687183	-0.427793	-0.008134	0.000030	0.165179					
3	0.500080	-0.189073	-0.000262	0.000100	0.055197					
4	0.502407	-0.254077	0.004281	0.000173	0.061930					
5	0.560059	-0.360325	0.002265	0.000229	0.159681	0.399154	-0.101874	0.010433	0.000129	0.019402
6	0.509255	-0.218529	-0.000126	0.000108	0.120073	0.492380	-0.210055	-0.002622	0.000134	0.023570
7	0.491759	-0.204328	0.002242	0.000119	0.090592	0.497427	-0.207703	-0.006472	0.000129	0.028587
8	0.496673	-0.203555	0.001252	0.000110	0.095912	0.490210	-0.215861	0.003309	0.000137	0.022222
9	0.554969	-0.233122	-0.008341	0.000062	0.082540	0.489944	-0.221705	0.007295	0.000140	0.030867
10	0.571543	-0.182932	-0.016877	0.000001	0.167911	0.766044	-0.477267	-0.056952	0.000115	0.029450
11	0.560602	-0.301714	-0.003917	0.000142	0.167147	0.493942	-0.222368	0.009936	0.000131	0.040246
12	0.505681	-0.210811	0.008442	0.000102	1.147174	-0.182374	0.658213	-0.024460	0.000083	0.812346
13	0.520627	-0.236728	-0.000688	0.000119	0.061320	0.490269	-0.186089	-0.010471	0.000117	0.028115
14	0.499578	-0.201037	-0.000334	0.000108	0.104314	0.557560	-0.339054	0.027874	0.000160	0.056802
15	0.550556	-0.273649	-0.005685	0.000124	0.082111	0.360236	-0.053610	0.020845	0.000127	0.207731
16	0.494794	-0.215231	0.005743	0.000132	0.123127	0.497781	-0.204142	-0.001873	0.000123	0.064623
17	0.506854	-0.187302	-0.003066	0.000081	0.134836	0.498275	-0.213044	0.000560	0.000128	0.043394
18	0.530121	-0.227041	-0.004528	0.000093	0.104330	0.566142	-0.162455	-0.070794	0.000066	0.062610
19	0.509530	-0.210453	-0.001368	0.000104	0.156130	0.747565	-0.435074	-0.061770	0.000093	0.054925
20	0.556588	-0.273162	-0.006014	0.000112	0.134626	0.637282	-0.363094	-0.025784	0.000122	0.026093
21	0.573063	-0.262565	-0.009720	0.000075	0.146860	0.498461	-0.203877	-0.002454	0.000121	0.080931
22	0.501551	-0.236294	0.004670	0.000150	0.159677	0.495440	-0.216080	0.004209	0.000132	0.069672
23	0.502252	-0.213607	0.001381	0.000123	0.115265	0.501658	-0.200894	-0.007229	0.000119	0.044794
24	0.514894	-0.244574	0.003116	0.000140	0.105033	0.548286	-0.247886	-0.018918	0.000114	0.018254
25	0.528393	-0.261109	0.000430	0.000145	0.093037	0.413970	0.017127	-0.053602	0.000059	0.052625

Table 7: **(continued)**

	shallow					deep				
stn	slope	bias	tcor	pcor	dox	slope	bias	tcor	pcor	dox
26	0.510523	-0.233136	0.003385	0.000128	0.063133	0.800083	-0.596938	-0.027412	0.000140	0.026061
27	0.537694	-0.260626	-0.004783	0.000129	0.051105	0.372300	-0.138091	0.067038	0.000187	0.020245
28	0.498219	-0.228196	0.010788	0.000141	0.105525	0.496408	-0.205216	0.000169	0.000127	0.010853
29	0.510107	-0.237168	0.005614	0.000137	0.066016	0.496026	-0.205888	0.001071	0.000127	0.017450
30	0.518133	-0.249038	0.003150	0.000142	0.073208	0.499575	-0.205878	-0.000816	0.000123	0.027482
31	0.524376	-0.251200	0.000281	0.000139	0.048659	0.550568	-0.244596	-0.022095	0.000110	0.023741
32	0.552804	-0.286788	-0.007430	0.000144	0.062698	0.500100	-0.205967	-0.001883	0.000123	0.030941
33	0.529301	-0.255590	-0.001772	0.000136	0.061502	0.501030	-0.205799	-0.002444	0.000122	0.036342
34	0.535855	-0.264713	-0.003815	0.000138	0.096714	0.788026	-0.657555	-0.004363	0.000201	0.039978
35	0.529669	-0.262799	0.001308	0.000140	0.096741	0.481354	-0.146479	-0.020784	0.000102	0.025572
36	0.536690	-0.270941	-0.001693	0.000141	0.065385	0.499018	-0.203849	-0.000882	0.000123	0.028482
37	0.529419	-0.266885	0.004656	0.000145	0.096603	0.499533	-0.203048	-0.002146	0.000122	0.025313
38	0.550235	-0.240024	-0.032896	0.000109	0.067683	0.497608	-0.204283	0.002036	0.000124	0.027108
39	0.534917	-0.279707	0.010530	0.000147	0.038747	0.498806	-0.203261	0.000766	0.000123	0.028570
40	0.537066	-0.271914	0.002562	0.000140	0.071929	0.794956	-0.601813	-0.046562	0.000147	0.035673
41	0.538333	-0.238755	-0.021531	0.000117	0.043387	0.498853	-0.203707	0.001809	0.000123	0.029857
42	0.541818	-0.286539	0.005638	0.000149	0.068378	0.498429	-0.203687	0.001477	0.000124	0.027102
43	0.542033	-0.294788	0.017003	0.000151	0.062312	0.498752	-0.202183	-0.002369	0.000124	0.022864
44	0.544886	-0.287628	0.002431	0.000151	0.064606	0.497299	-0.203580	0.001575	0.000127	0.013416
45	0.537167	-0.279112	0.013367	0.000142	0.097546	0.496615	-0.206835	0.003736	0.000130	0.017668
46	0.530001	-0.241180	-0.017784	0.000129	0.076838	0.496726	-0.203842	0.002129	0.000129	0.014860
47	0.532560	-0.248636	-0.014406	0.000133	0.091404	0.495617	-0.205264	0.011541	0.000132	0.032225
48	0.548686	-0.301189	0.017882	0.000156	0.058258	0.993255	-0.906381	-0.079530	0.000156	0.042879
49	0.555101	-0.304978	0.001104	0.000159	0.126156	0.506438	-0.153675	-0.080592	0.000073	0.022360
50	0.542060	-0.284114	0.017922	0.000149	0.080721	0.434129	-0.031076	-0.096047	0.000056	0.023747
51	0.530259	-0.252587	-0.002786	0.000133	0.044546	0.497243	-0.162009	-0.079492	0.000085	0.045857
52	0.540016	-0.273019	-0.001173	0.000144	0.071785	0.326939	0.117270	-0.095174	0.000052	0.014638
53	0.482710	-0.134281	0.015615	0.000092	0.135913					
54	0.516307	-0.216700	0.001533	0.000125	0.168257					
55	0.687388	-0.620048	-0.020126	0.000444	0.055629					
56	0.513353	-0.216247	-0.005990	0.000120	0.117513					
57	0.541017	-0.273067	-0.001993	0.000144	0.079640					
58	0.532432	-0.255235	-0.000165	0.000151	0.161916					
59	0.585167	-0.379904	-0.004828	0.000260	0.111709					
60	0.556471	-0.301855	-0.010791	0.000151	0.176240	0.071765	0.537753	-0.157678	0.000009	0.037763
61	0.536187	-0.260788	-0.006796	0.000132	0.110372	0.496574	-0.123862	-0.140193	0.000051	0.040430
62	0.530429	-0.248385	-0.004877	0.000128	0.045344	0.321480	0.110458	-0.085748	0.000070	0.007416
63	0.595979	-0.366292	0.003608	0.000161	0.102498					
64	0.565420	-0.325130	-0.007046	0.000179	0.142790					
65	0.554264	-0.303639	-0.003401	0.000210	0.151306					
66	0.534096	-0.252961	0.004540	0.000165	0.108238					
67	0.499712	-0.195441	-0.023286	0.000072	0.061837					
68	0.536924	-0.280082	-0.033003	0.000066	0.134814					
69	0.535727	-0.264177	0.003836	0.000199	0.087294					
70	0.528907	-0.249368	-0.012265	0.000116	0.122706					
71	0.509145	-0.191000	0.000162	0.000050	0.115532					
72	0.533329	-0.243933	0.015795	0.000207	0.107800					
73	0.517122	-0.197400	0.015166	0.000154	0.066082					
74	0.528489	-0.239146	-0.008529	0.000114	0.113056					
75	0.506443	-0.183919	0.005841	0.000129	0.015697					
76	0.412664	0.108829	0.077212	0.000135	0.055426					
77	0.087178	0.982850	0.178036	0.000039	0.045085					
78	0.451097	0.018032	0.071321	0.000172	0.063413					
79	0.154544	0.883279	0.203521	0.000073	0.038799					
80	0.589199	-0.405874	-0.027386	0.000172	0.013626					
81	0.484086	-0.093375	0.034492	0.000125	0.122259					
82	0.535296	-0.258142	0.000477	0.000149	0.061524					
83	0.441974	0.061287	0.078334	0.000115	0.076380					
84	0.512094	-0.188667	0.012605	0.000141	0.106017					
85	0.542590	-0.259735	0.011345	0.000156	0.076150					
86	0.363953	0.241278	0.094905	0.000106	0.116016					
87	0.536997	-0.300191	-0.037031	0.000123	0.103122					
88	0.589123	-0.408584	-0.022977	0.000182	0.034814					
89	0.505988	-0.187006	0.001921	0.000125	0.047934					
90	0.392594	0.129891	0.057818	0.000104	0.030396					
91	0.743664	-0.881974	-0.149793	0.000261	0.046619					
92	0.234316	0.618175	0.162920	0.000132	0.042214					
93	0.512139	-0.199330	0.004461	0.000131	0.057805					
94	0.501156	-0.196176	-0.008079	0.000130	0.060682					
95	0.542279	-0.271748	0.000474	0.000154	0.043947					

Table 7: (continued)

	shallow					deep				
stn	slope	bias	tcor	pcor	dox	slope	bias	tcor	pcor	dox
96	1.166046	-1.005738	0.287760	0.000443	0.063126					
97	0.597653	-0.398107	0.001150	0.000284	0.018032					
98	0.472451	-0.028640	0.057129	0.000114	0.047629					
99	0.502269	-0.149669	0.025238	0.000142	0.019399					
100	0.455345	-0.027002	0.041883	0.000124	0.048830					
101	0.511949	-0.192130	0.007682	0.000130	0.033533					
102	0.510626	-0.218914	-0.016184	0.000117	0.045248					
103	0.548940	-0.293816	-0.007180	0.000150	0.038083					
104	0.523738	-0.247739	-0.011804	0.000143	0.133345					
105	0.529940	-0.244620	-0.004096	0.000131	0.067353					
106	0.522691	-0.242203	-0.012701	0.000121	0.072429					
107	0.554127	-0.316784	-0.013695	0.000187	0.072716					
108	0.573427	-0.336775	0.003028	0.000170	0.045000					
109	0.505433	-0.184615	-0.002914	0.000051	0.097666					
110	0.531427	-0.245843	0.001353	0.000150	0.018319					
111	0.505478	-0.216463	-0.020982	0.000116	0.056750					
112	0.513959	-0.235323	-0.025275	0.000106	0.030646					
113	0.487944	-0.149679	0.002474	0.000102	0.021632					
114	0.530267	-0.226544	0.015225	0.000156	0.036741					
115	0.534535	-0.280780	-0.019084	0.000165	0.028759					
116	0.447991	-0.062439	0.005717	0.000074	0.009880					
117	0.437500	-0.077966	-0.016714	0.000101	0.021573					
118	0.500857	-0.113569	0.051892	0.000160	0.031583					
119	0.399728	0.090237	0.055305	0.000143	0.054368					
120	0.541753	-0.428712	-0.127291	0.000129	0.019369					
121	0.502095	-0.196075	-0.004269	0.000144	0.018133					
122	0.511115	-0.189790	0.012911	0.000144	0.023133					
123	0.509434	-0.187792	0.012288	0.000142	0.017773					
124	0.441632	0.011102	0.057115	0.000151	0.053245					
125	0.484441	-0.167391	-0.012300	0.000124	0.015746					
126	0.533862	-0.248591	0.004107	0.000154	0.032351					
127	0.471535	-0.131368	0.000166	0.000144	0.052008					
128	0.321049	0.083724	-0.080763	0.000020	0.058544					
129	0.406750	-0.014714	-0.019545	0.000079	0.041393					
130	0.535427	-0.251695	0.004364	0.000156	0.046086					
131	0.496500	-0.324856	-0.125740	0.000065	0.023108					
132	0.509763	-0.191956	0.008190	0.000139	0.017776					
133	0.509620	-0.190273	0.011160	0.000147	0.030593					
134	0.402333	0.013423	0.000339	0.000104	0.020403					
135	0.503640	-0.192712	-0.004084	0.000115	0.001791					
136	0.502964	-0.397758	-0.170367	0.000179	0.012853					
137	0.534032	-0.250592	0.006108	0.000157	0.029240					
138	0.517733	-0.193840	0.027244	0.000179	0.016776					
139	0.534074	-0.245509	0.006732	0.000108	0.106264					
140	0.579100	-0.338359	0.008719	0.000165	0.038880					
141	0.537534	-0.266163	-0.007199	0.000137	0.066266	0.496187	-0.205269	0.001083	0.000131	0.012181
142	0.525906	-0.269970	0.011558	0.000156	0.038916	0.703249	-0.494844	-0.031275	0.000141	0.013850
143	0.512304	-0.248344	0.016536	0.000143	0.067188	0.497046	-0.204214	0.000058	0.000126	0.011522
144	0.528094	-0.273002	0.011535	0.000153	0.035540	0.704003	-0.493800	-0.030356	0.000143	0.016193
145	0.549218	-0.271862	-0.014011	0.000129	0.032383	0.499944	-0.202317	-0.004552	0.000122	0.021013
146	0.526504	-0.263148	0.006531	0.000147	0.017672	0.500509	-0.200015	-0.003965	0.000119	0.029094
147	0.533788	-0.268063	0.001386	0.000141	0.029278	0.498999	-0.202514	-0.003457	0.000123	0.021494
148	0.539934	-0.263357	-0.009291	0.000131	0.055597	0.498030	-0.203228	-0.000771	0.000124	0.021209
149	0.533929	-0.269410	0.003191	0.000142	0.035673	0.498100	-0.203910	-0.000978	0.000125	0.022186

<u>Table 8:</u> Missing data points in 2 dbar-averaged files for cruise au1121. "x" indicates missing data for the indicated parameters: T=temperature; S/C=salinity and conductivity; O=oxygen; F=fluorescence downcast; PAR=photosynthetically active radiation downcast; TR=transmittance downcast; F_up=fluorescence upcast; PAR_up=photosynthetically active radiation upcast; TR_up=transmittance upcast.
Note: 2 and 4 dbar values not included here - 2 dbar value missing for most casts, 4 dbar value missing for many casts.

station	pressure (dbar) where data missing	T	S/C	O	F	PAR	TR	F_up	PAR_up	TR_up
1	602-1060									x
1	1062-1098						x			x
2	6			x						
2	6-224						x			x
3	6-584						x			x
4	6-956						x			x
5	6-2348						x			x
6	6-3252						x			x
7	590-1672, 1770-1868									x
7	1674-1768, 1870-2890						x			x
8	6-1894									x
8	1896-2018						x			x
9	1436-1438						x			
10	1686-1688						x			
11	156-160, 714						x			
12	12-14, 64, 4338-4358						x			
12	6-4506, 4558-4562, 4674-4850							x	x	x
12	6-4880			x						
21	6	x	x	x	x	x	x			
33	6-8	x	x	x	x	x	x			
38	66-138			x						
47	3372-3554			x						
64	6-8	x	x	x	x	x	x			
98	798-826						x			
102	418-426						x			
105	422-428						x			
106	236-240						x			
107	6	x	x	x	x	x	x			
107	228-232						x			
108	206-212						x			
115	6-46			x						
117	6-46			x						
121	6-70			x						
124	376-382						x			
127	6	x	x	x	x	x	x			
128	6	x	x	x	x	x	x			
129	6	x	x	x	x	x	x			
129	8-56			x						
133	272-284						x			
134	6-86			x						
138	184-190						x			
139	200-204						x			
140	40-44						x			
143	66-68						x			
146	6-8	x	x	x	x	x	x			

Table 9: Suspect CTD 2 dbar averages (not deleted from the CTD 2 dbar average files) for the indicated parameters, for cruise au1121.

station	suspect 2 dbar value (dbar)	parameters	comment
7	1406-1868	transmittance (downcast)	bad cable
9	110-2338	transmittance (downcast)	bad cable
10	114-1816	transmittance (downcast)	bad cable
12	whole station	transmittance	noisy data
15	4000-4474	oxygen	reduced accuracy due to suspect bottle samples
125	2-38	oxygen	suspect
128	2-30	oxygen	transient error at start

Table 10a: Bad salinity bottle samples (not deleted from bottle data file) for cruise au1121.

station	rosette position	station	rosette position
4	10	65	4
5	21, 20	69	24
23	4	101	24
24	17	106	4
28	24	121	14
30	10, 9, 8	125	11, 8
37	6	127	24
50	16	147	6
54	3	148	1
55	9		

Table 10b: Bad salinometer analyses for station 1 to 8 (not deleted from bottle data file), for cruise au1121.

station	rosette position
1	14, 13, 12, 11, 10, 9, 8, 7, 6, 5, 4, 3, 102, 1
2	7, 6, 5, 4, 3, 102, 1
3	10, 9, 6, 5, 4, 3, 102, 1
4	7, 4, 3, 102
5	24, 22, 13, 12, 11, 6, 5, 4, 3
6	6, 4, 3
7	24, 23, 22, 21, 20, 17, 16, 15, 14, 13, 11, 10, 5
8	24, 23, 22, 21, 20, 19, 18, 17, 16, 15, 14, 13, 12, 11, 10, 9, 8, 7, 6, 5, 4, 3, 102, 1

Table 11: Suspect nutrient sample values (not deleted from bottle data file) for cruise au1121.

PHOSPHATE		NITRATE		SILICATE	
station number	rosette position	station number	rosette position	station number	rosette position
36	1-17				
41	18	41	whole stn		
		54	24		

Table 12: Suspect dissolved oxygen bottle values (not deleted from bottle data file) for cruise au1121.

station	rosette position
13	7
15	102, 1
17	102
18	7, 5, 102
20	7
21	102, 1
22	7

Table 13: Scientific personnel (cruise participants) for cruise au1121.

Karen Barlow	ABC reporter
Kate Berry	carbon
Kim Briggs	electronics
Michael Brooks	ABC cameraman
Miguel de Salas	phytoplankton, camera
Michael Field	electronics
Kevin Harmey	doctor
Laura Herraiz Borreguero	CTD
Nick Herrald	RMT
Will Howard	RMT
Peter Hughes	hydrochemistry
Rob Johnson	phytoplankton
Fraser Kennedy	FRRF
Gerrit Klomp	gear
Matt Longmire	comms, CTD
Harvey Marchant	Parmales
Antonio Mozqueira	RMT
Alicia Navidad	hydrochemistry
Fred Olivier	deputy voyage leader, CTD
Beatriz Pena Molino	CTD
Heidi Pethybridge	hydrochemistry
Penny Purdie	gear
Sue Reynolds	hydrochemistry
Steve Rintoul	CTD, voyage leader
Miquel Rosell-fieschi	CTD
Mark Rosenberg	CTD, moorings
Graham Simpkins	carbon
Jodie Smith	camera
Laura Smith	FRRF
Serguei Sokolov	CTD
Adam Swadling	carbon
Bronte Tilbrook	carbon
Esmee van Wijk	CTD, ARGO floats, XBT
Ben Walter	bathymetry
Dave Watts	programming, CPR
David Wilkins	genetics
Tim Williams	genetics

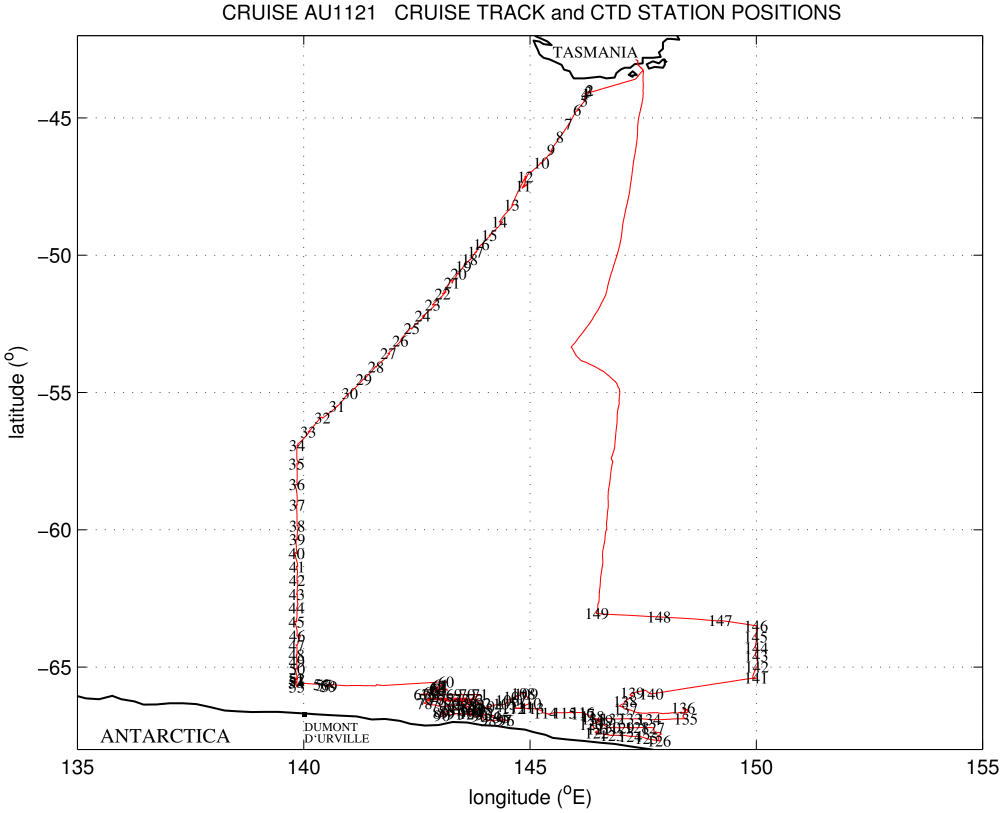
<u>Table 14a:</u> Summary of mooring deployment and TOGS (gyroscope) recovery information on cruise au1121. Sounder depths are corrected for the local sound speed (1445 m/s). "Release time" = final component released (for mooring deployments); = release signal sent to releases, and release confirmed (for TOGS recoveries). All times are UTC.

Mooring	position	depth (m)	release time (UTC)	position (decimal degrees)
Mooring deployments				
POLYNYA1	66° 11.853'S 143° 28.052'E	542	2220, 23/01/2011	66.19755°S 143.46754°E
POLYNYA2	66° 12.235'S 143° 12.334'E	593	2128, 22/01/2011	66.20391°S 143.20557°E
POLYNYA3	66° 08.976'S 143° 00.684'E	548	0508, 23/01/2011	66.14960°S 143.01140°E
TOGS recoveries				
@POLYNYA1			0057, 24/01/2011	
@POLYNYA2			2301, 22/01/2011	
@POLYNYA3			0700, 23/01/2011	

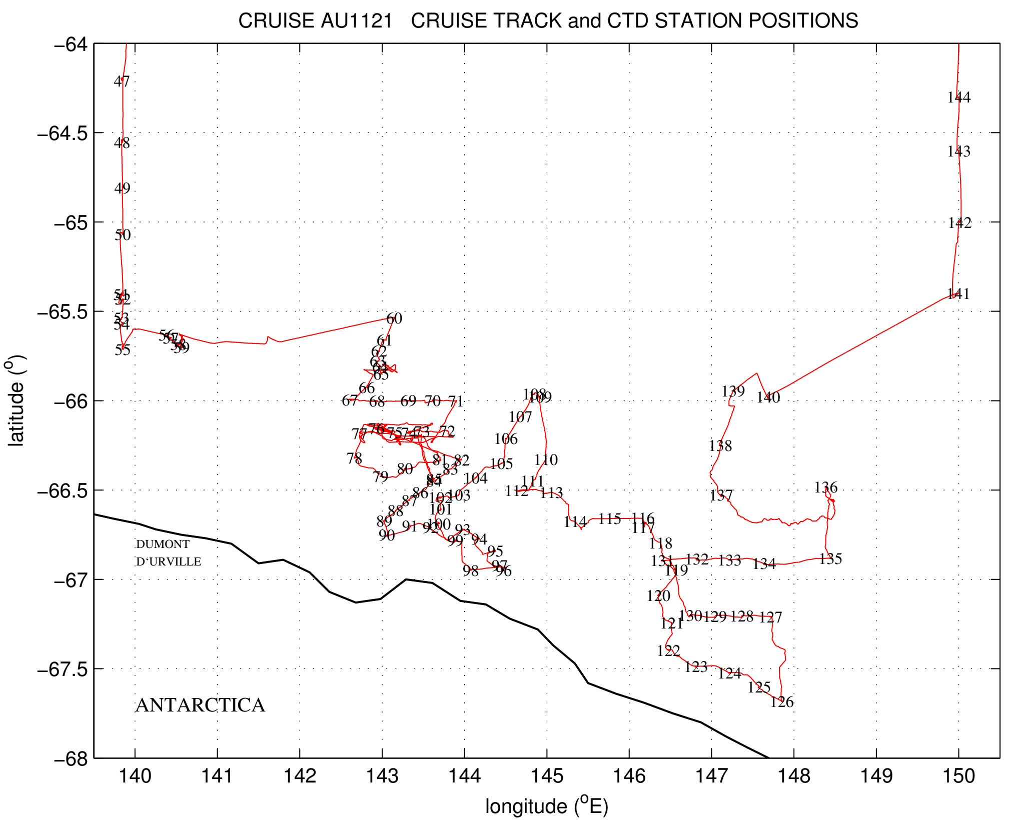
<u>Table 14b:</u> Summary of ARGO float deployments on cruise au1121.

hull ID	position	time	depth (m)
ARGO #5117	46° 39.25'S 145° 13.40'E	1235, 06/01/2011	3450
ARGO #5166	65° 03.68'S 139° 50.54'E	0930, 17/01/2011	2492
ARGO #5168	65° 50.99'S 147° 33.27'E	1516, 29/01/2011	1907

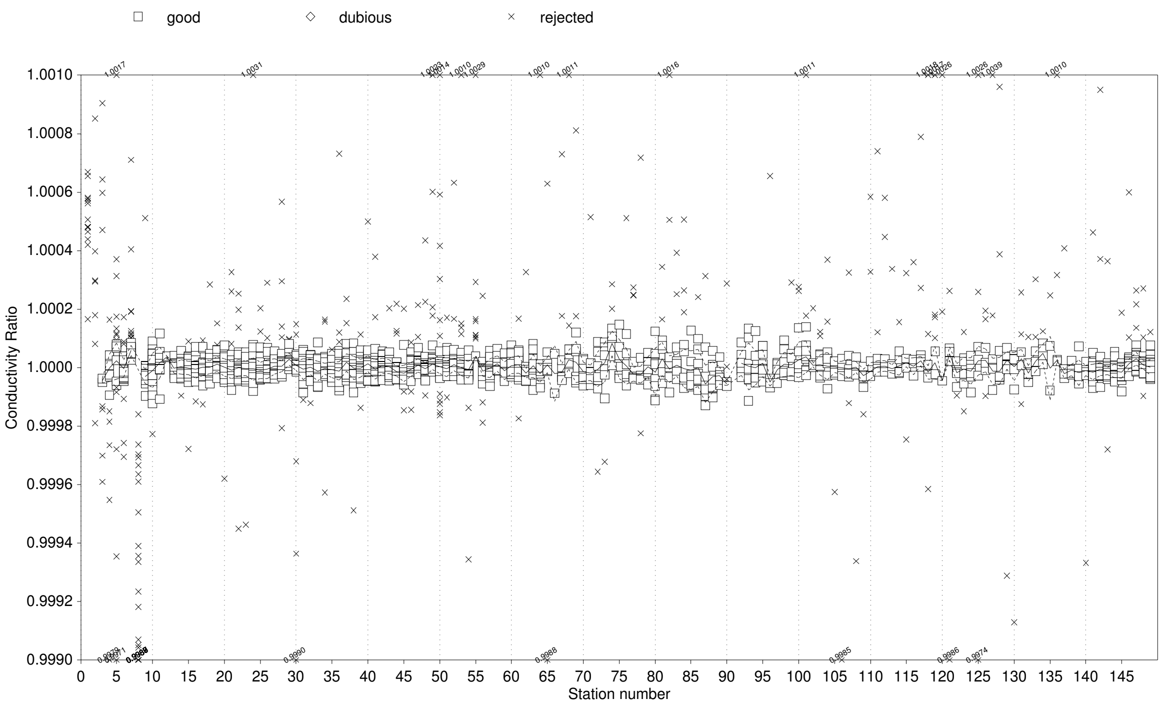
(a)



(b)



<u>Figure 1:</u> CTD station positions and ship's track for cruise au1121, for (a) whole cruise, and (b) southern stations.



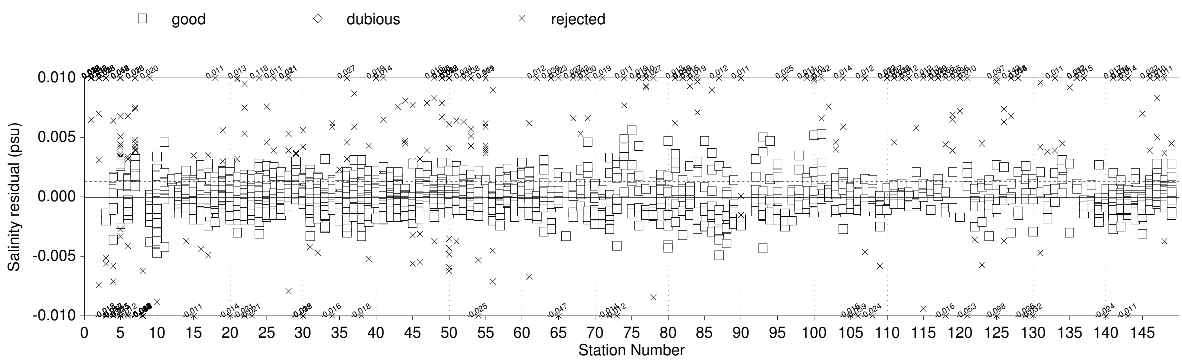
Calibration data for cruise : au1121

Calibration file : a1121.bot

Conductivity s.d. = 0.00003

Number of bottles used = 1683 out of 2008 Mean ratio for all bottles = 1.00000

Figure 2: Conductivity ratio c_{btl}/c_{cal} versus station number for cruise au1121. 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.



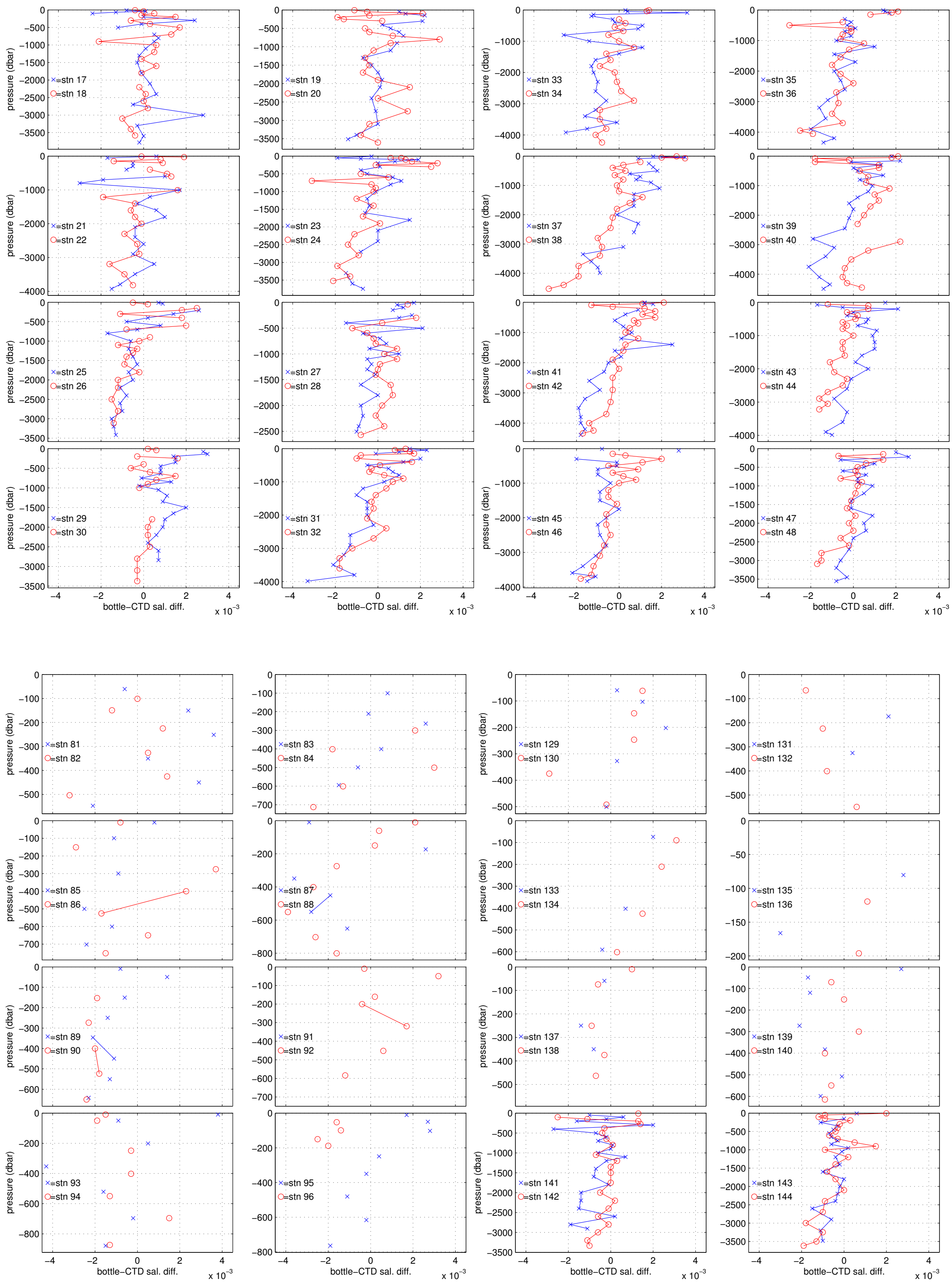
Calibration data for cruise : au1121

Calibration file : a1121.bot

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

Number of bottles used = 1683 out of 2008

Figure 3: Salinity residual (s_{btl} - s_{cal}) versus station number for cruise au1121. 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.



<u>Figure 4:</u> Vertical profiles of salinity residuals (i.e. bottle – CTD salinity) for various stations.

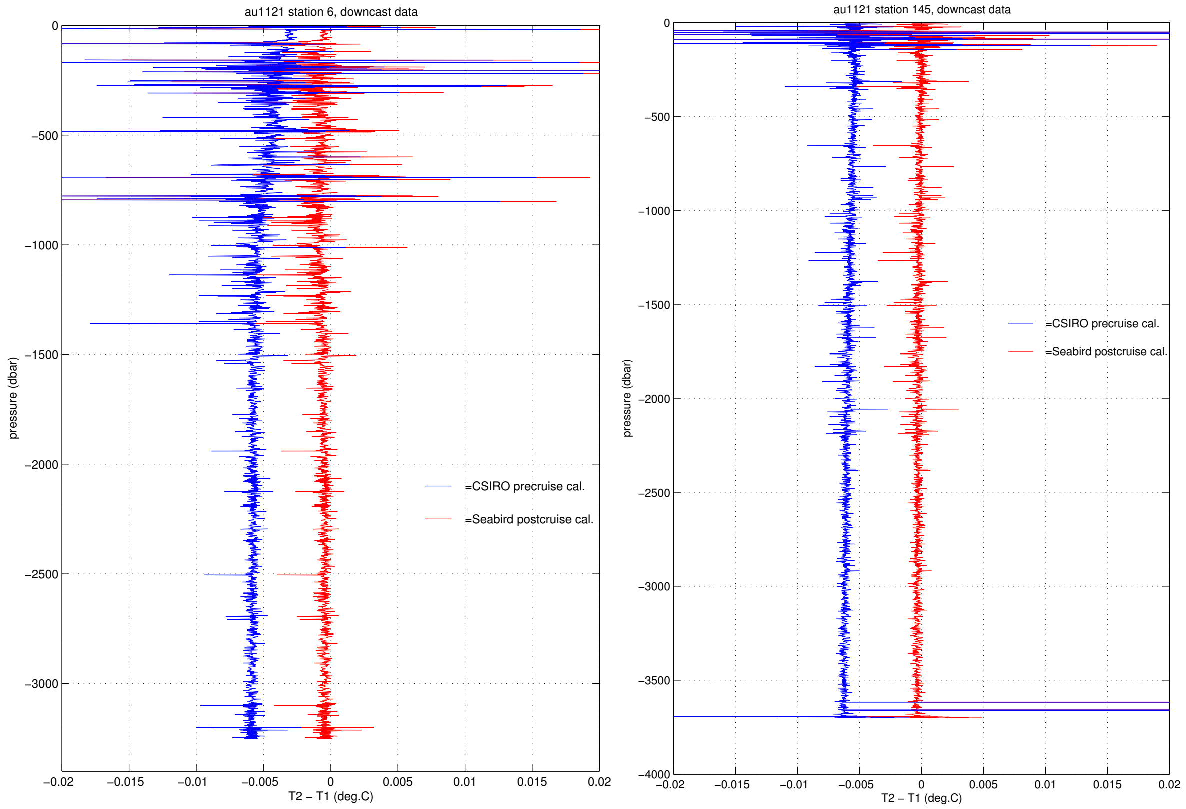


Figure 5a: **Difference between secondary and primary temperature sensors (T_s - T_p), using pre and post cruise temperature calibrations – for 2 example stations.**

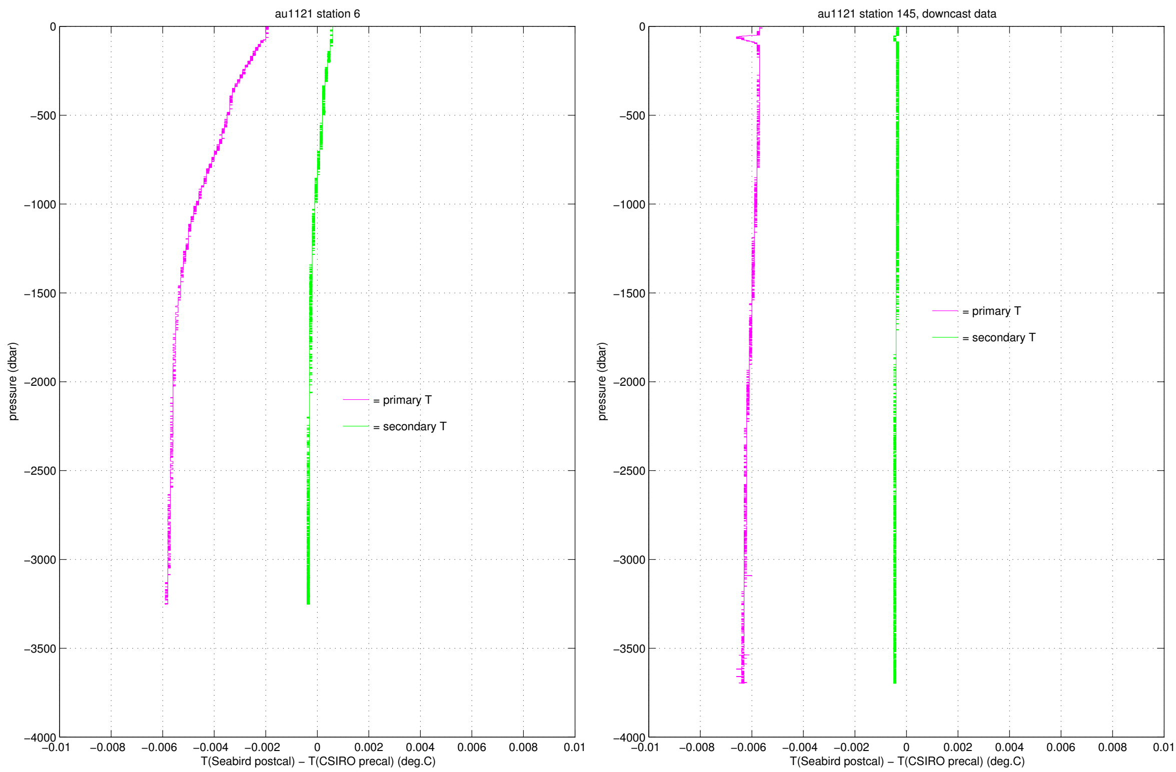


Figure 5b: **Difference between pre and post cruise temperature calibrations, for each temperature sensor – for 2 example stations.**

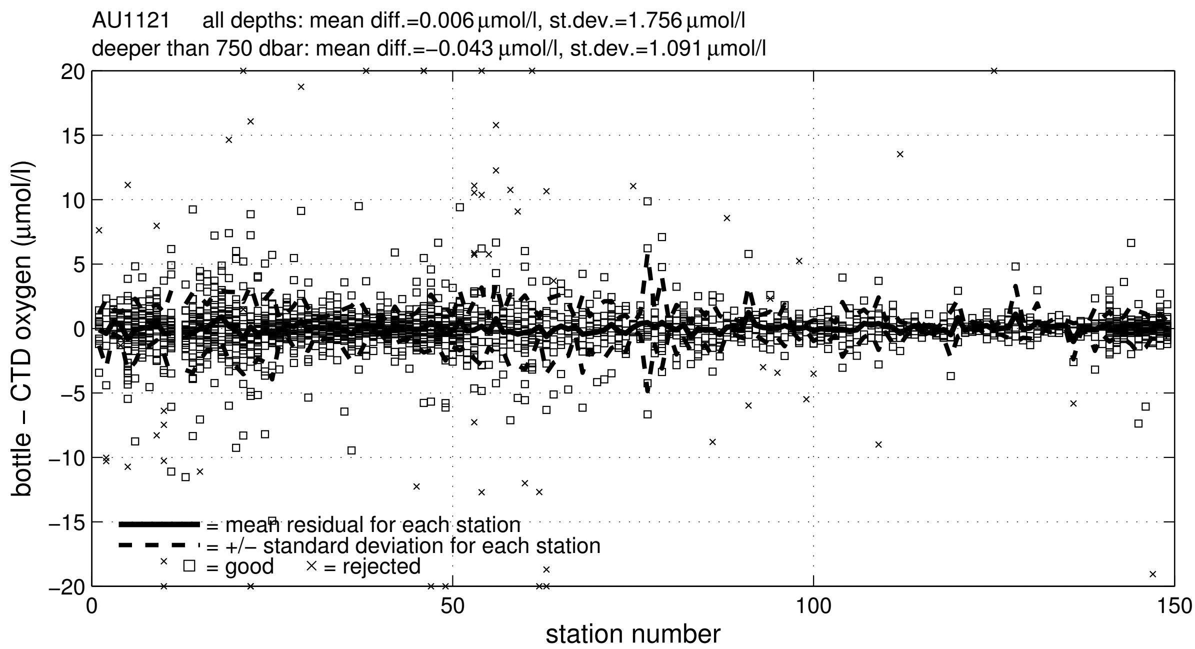


Figure 6: **Dissolved oxygen residual (o_{btl} - o_{cal}) versus station number for cruise au1121. The solid line follows the mean residual for each station; the broken lines are ± the standard deviation of the residuals for each station. o_{cal}=calibrated downcast CTD dissolved oxygen; o_{btl}=Niskin bottle dissolved oxygen value. Note: values outside vertical axes are plotted on axes limits.**

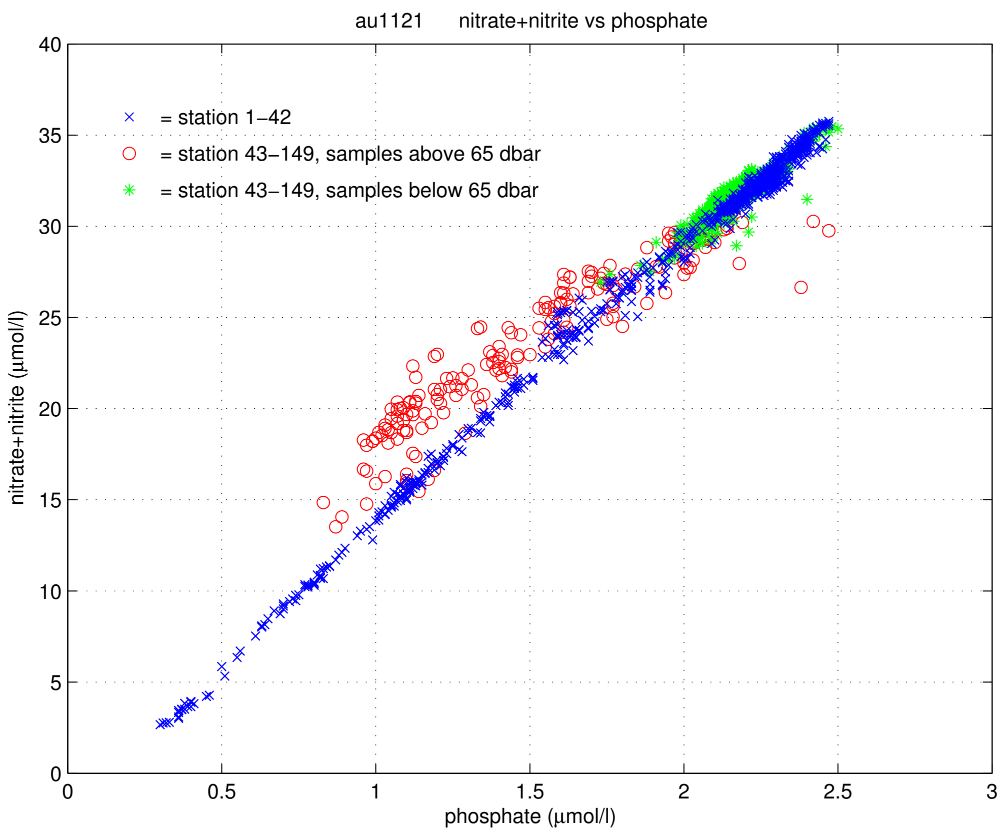
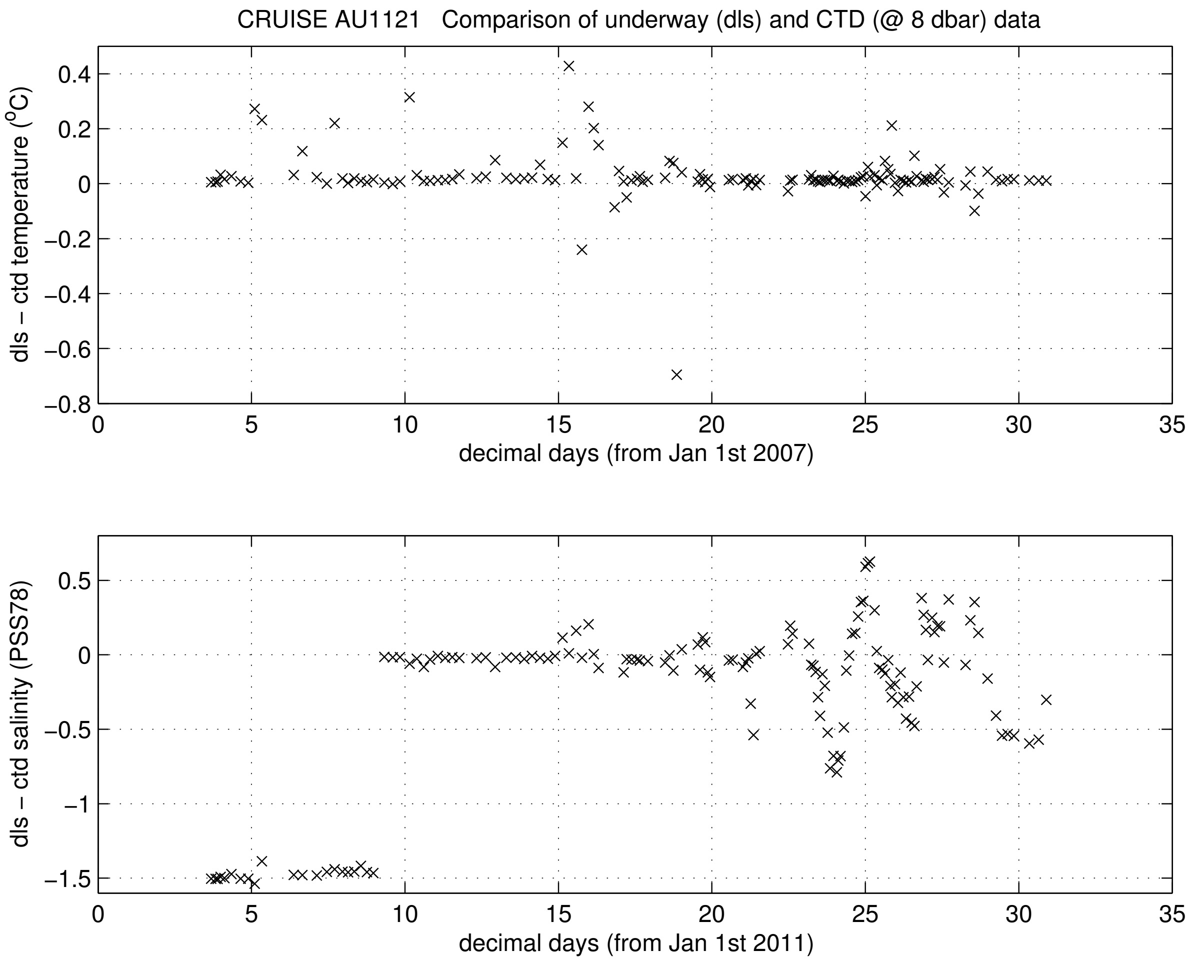
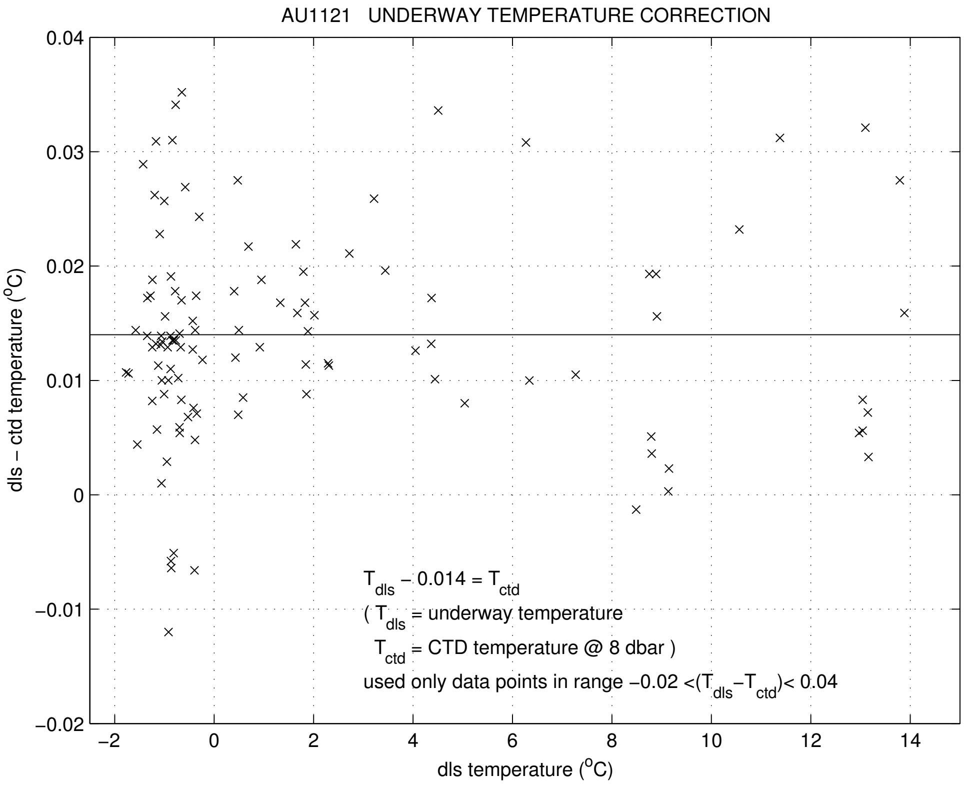


Figure 7: **Nitrate+nitrite versus phosphate data for cruise au1121.**

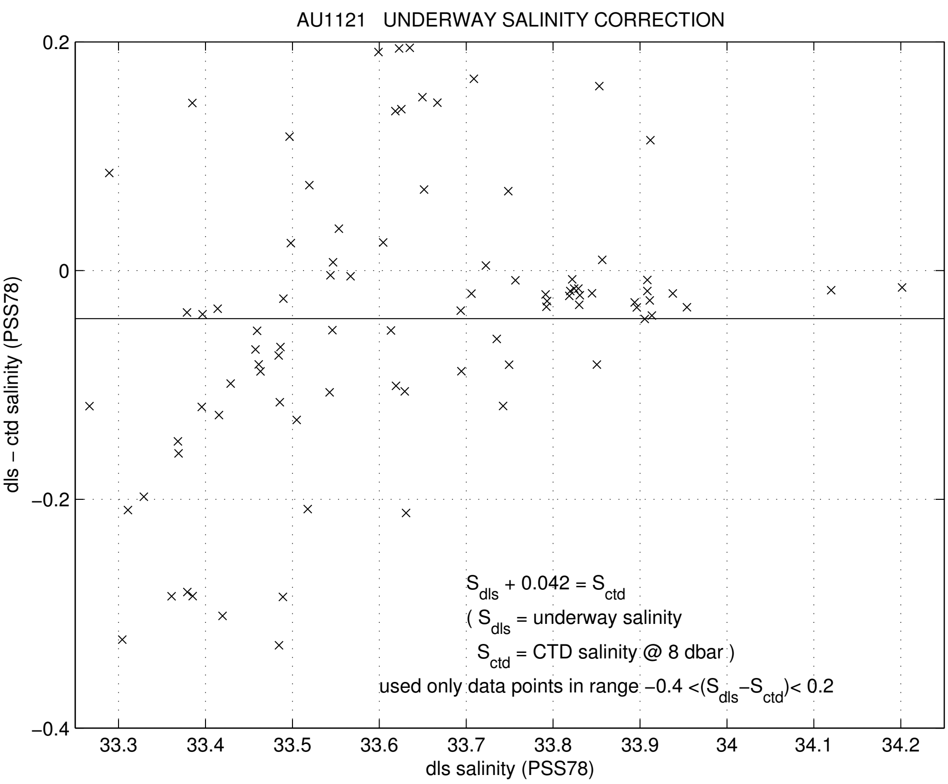


<u>Figure 8:</u> au1121 comparison of underway temperature and salinity data to CTD data, with time. A clear offset in the underway salinity data is evident for the first few days of the cruise, and for the last few stations.

(a)



(b)



<u>Figure 9a and b:</u> au1121 comparison between (a) CTD and underway temperature data (i.e. hull mounted temperature sensor), and (b) CTD and underway salinity data, including bestfit lines. Note: dls refers to underway data. Note that due to the large scatter, particularly for the underway salinity data, these corrections have not been applied to the underway data.

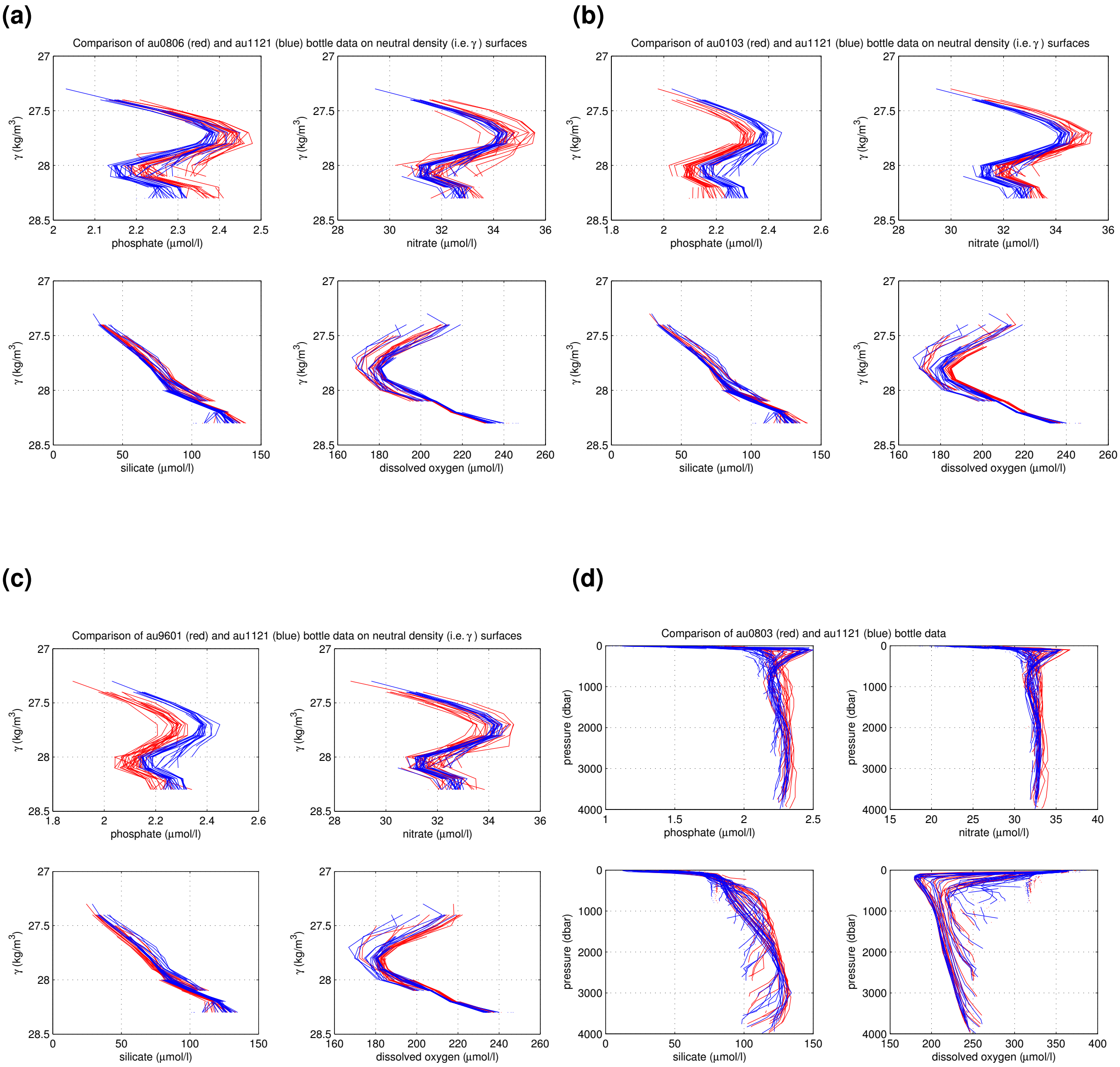


Figure 10: Bulk plots showing intercruise comparisons of nutrient and oxygen data for:
(a) au1121 and au0806, on neutral density (i.e. γ) surfaces,
(b) au1121 and au0103, on neutral density (i.e. γ) surfaces,
(c) au1121 and au9601, on neutral density (i.e. γ) surfaces, and
(d) au1121 and au0803, pressure profiles (Mertz region only).

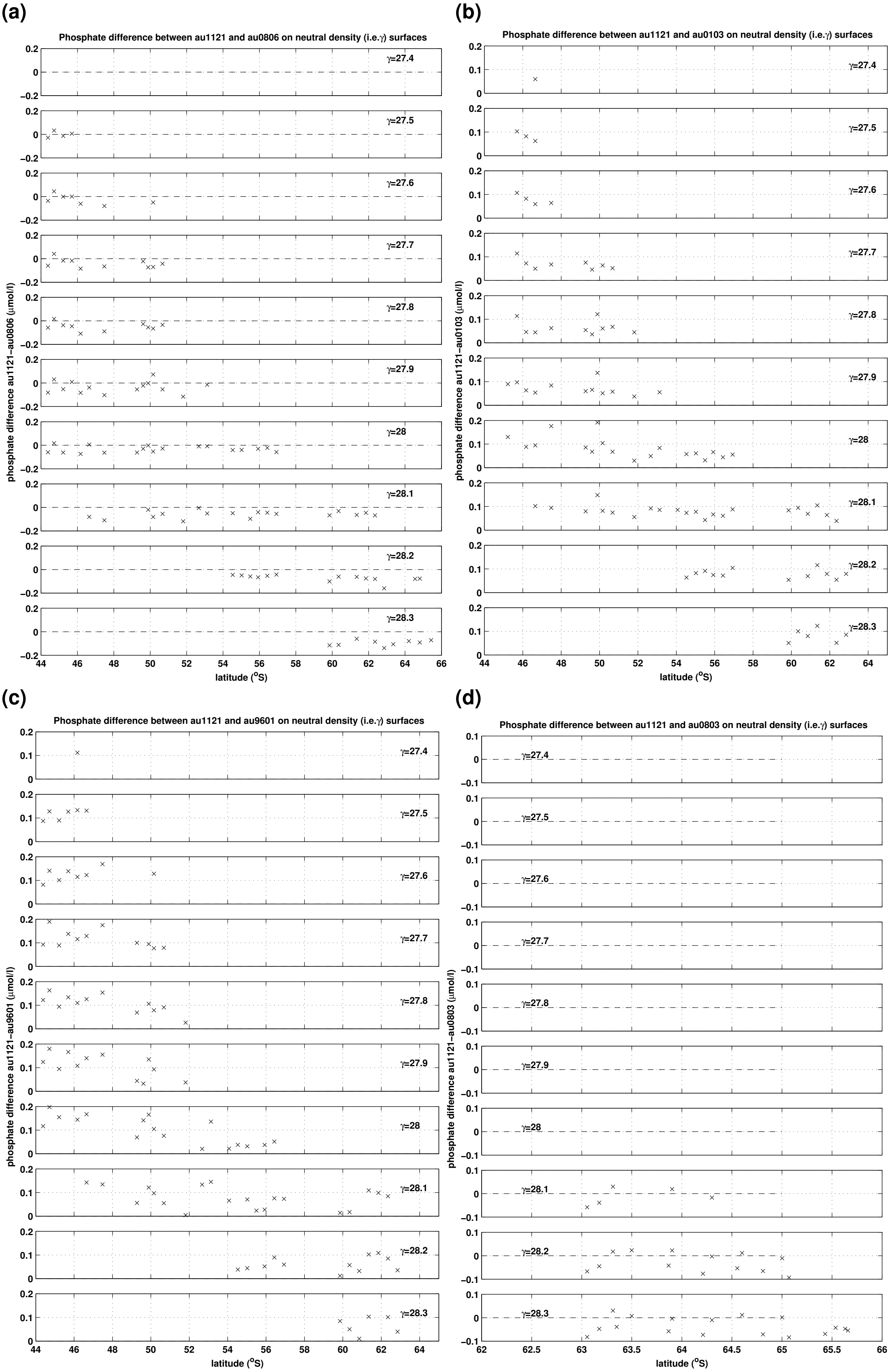
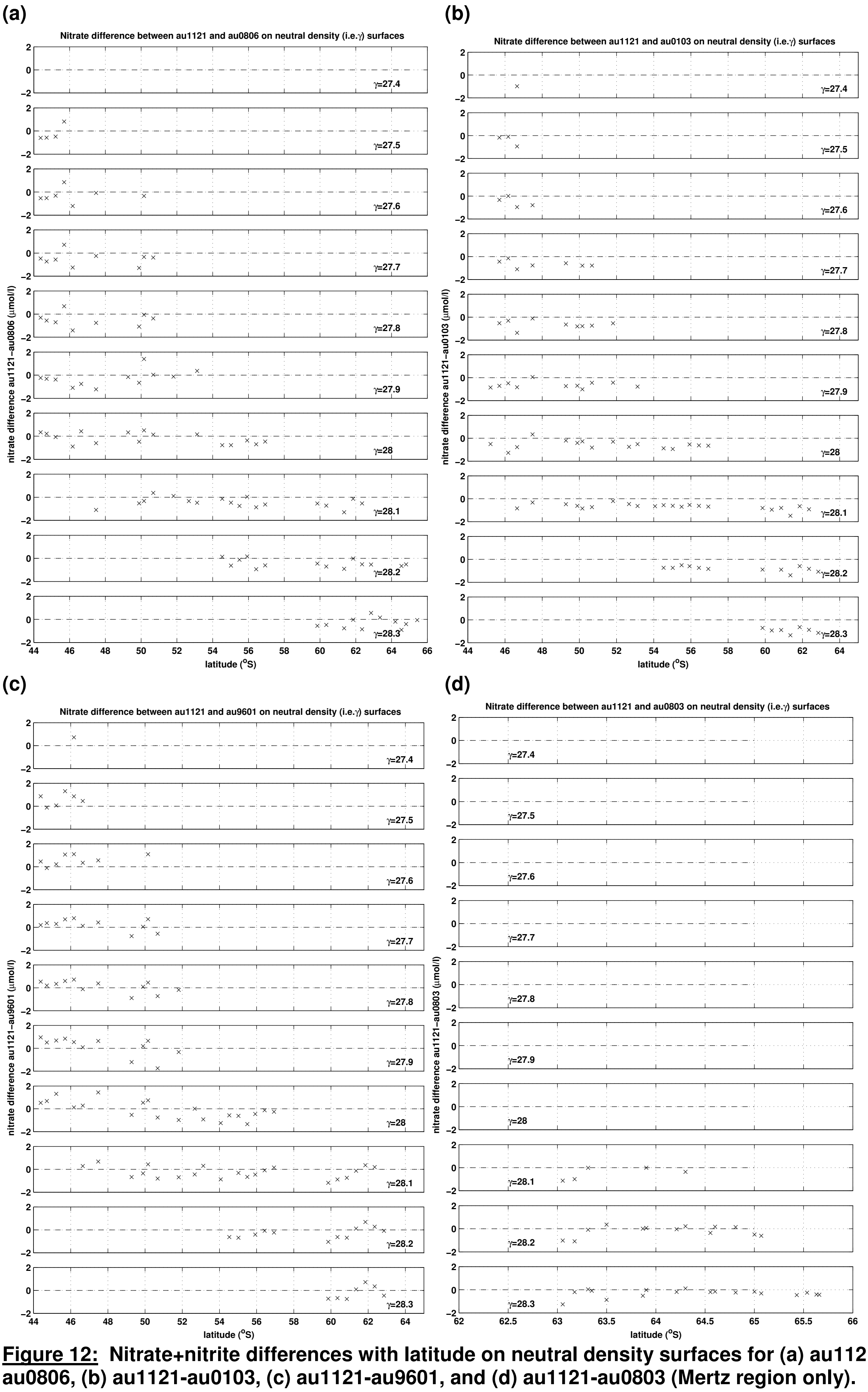


Figure 11: **Phosphate differences with latitude on neutral density surfaces for (a) au1121-au0806, (b) au1121-au0103, (c) au1121-au9601, and (d) au1121-au0803 (Mertz region only).**



<u>Figure 12:</u> Nitrate+nitrite differences with latitude on neutral density surfaces for (a) au1121-au0806, (b) au1121-au0103, (c) au1121-au9601, and (d) au1121-au0803 (Mertz region only).

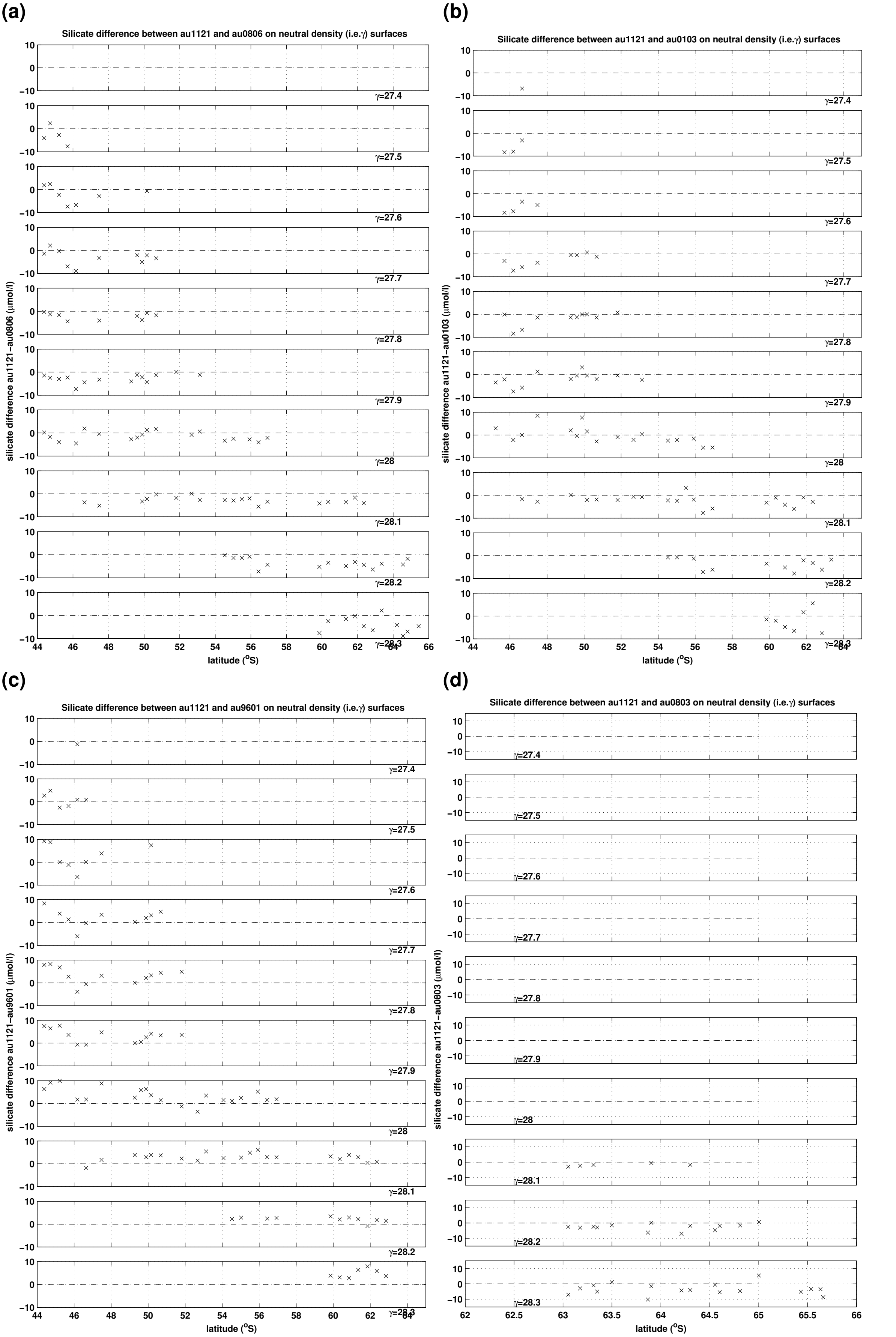


Figure 13: Silicate differences with latitude on neutral density surfaces for (a) au1121-au0806, (b) au1121-au0103, (c) au1121-au9601, and (d) au1121-au0803 (Mertz region only).

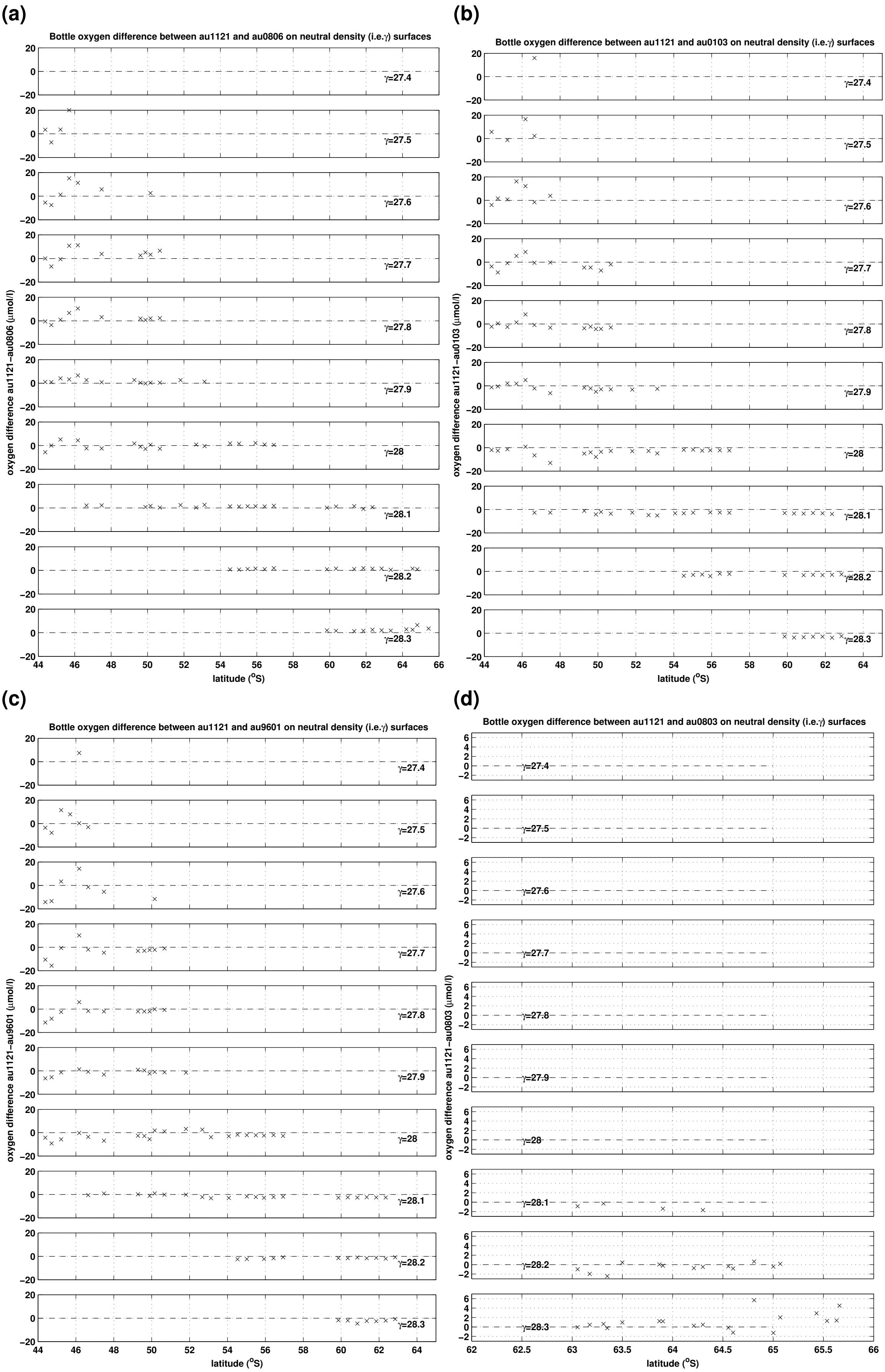


Figure 14: Bottle oxygen differences with latitude on neutral density surfaces for (a) au1121-au0806, (b) au1121-au0103, (c) au1121-au9601, and (d) au1121-au0803 (Mertz region only).

APPENDIX 1 AU1121 Hydrochemistry Cruise Report

ALICIA NAVIDAD, PETER HUGHES, SUE REYNOLDS and HEIDI PETHYBRIDGE, *CSIRO CMAR*

(this appendix summarised from the complete cruise lab report by the above authors)

Analaysts: Alicia Navidad and Peter Hughes (nutrients)
Sue Reynolds (dissolved oxygen)
Heidi Pethybridge (salinity)

A1.1 Nutrients

Set-up details:

carrier used	ASW
diluent for manual standards	LNSW
standard range used (nitrate+nitrite in µm/l)	0-35
standard range used (silicate in µm/l)	0-140
standard range used (phosphate in µm/l)	0-3.0
SRM range used (nitrate+nitrite in µm/l)	10 & 30
SRM range used (silicate in µm/l)	10, 30 & 140
SRM range used (phosphate in µm/l)	1 & 3

The Lachat analyser was used for nutrient analyses on the cruise. Prior to running samples, an initial quality run was carried out to calculate the method detection limits, giving values of 0.010 for nitrate+nitrite, 0.027 for phosphate, and 0.075 for silicate. These reported detection limits are the lmit of detection of the analyte at 99% confidence interval.

A1.1.1 MQ water supply

* Unable to get the RO unit to operate at the start of the voyage. The pump would not remain on as the controlling pressure sensor and the RO inlet solenoid did not work. As a result, the ship's supply was fed through the RO unit's carbon filters and not the membrane, until the pump was fixed. The quality of the MQ diminished with time with increasing amounts of Si present in the MQ used for the MQBLK & MQCOL. The Si values for the QC solution dropped as a result.

* Electronic tech. managed to get the RO unit working by by-passing the pressure sensor and solenoid. Some Si contamination continued, though this was corrected after replacing the cartridges in the MQ unit, The Si values in the QC solution returned to normal.

A1.1.2 General analysis issues on the Lachat

* Valves - not connected properly to motor drives after being serviced back in Hobart. This caused some issues within the voyage when they de-coupled during a run. A temporary fix was made by wrapping tape around all couplings to secure.

* Rough seas and vibrations of the ship - had substantial affects on some of the runs. These are outlined in the more detailed data processing section below.

* Laboratory temperature control - The large temperature gradient between floor and ceiling caused oxalic acid to crystallise out 2 or 3 times when stored on the floor. Temperature gradient probably caused by keeping the lab door open for extended periods to allow fresh air into the lab.

* Si valve - partially leaks, evident when checking valve timing with dye on the other channels - there is some ingress of the dye into the Si sample loop.

* Instrument errors - There were a few runs in which the instrument (software) spontaneously stopped the run. This only had a minor affect on the end samples of a run. For the case of run 24, end samples were stitched to the following run.

* Maintenance time for the instrument - the amount of time available for this on the cruise was minimal. This was possibly the cause of instrument errors. In addition, given the effects on samples stored over time, it would be ideal to ensure that samples are run in real time and that an allowance for maintenance on the instrument is scheduled in every ~4-5 days.

A1.2 Dissolved oxygen

The Automated Photometric Oxygen system built by Scripps Institution of Oceanography was used for all oxygen analysis and worked well throughout the voyage. During the initial set-up, the following items in the Dissolved Oxygen system had to be replaced: micro-tip for 1ml burette/exchange unit; 1ml exchange unit; and 10ml exchange unit. Once all of these items had been replaced with new spares, the system functioned very well throughout the cruise. It was noted early on that there is a nominal size for the stir bar when titrating a sample, as one somewhat smaller stir bar that was being used did not allow proper mixing and was the assumed cause for a few bad titration curves. A few questionable dissolved oxygen data points ensued, but nothing significant.

South of the Polar Front, and especially in the shallower stations far south in the Southern Ocean, the surface DO levels were so high, requiring the 1ml burette to dispense its full volume and then refill. However, often times once it refilled, it discontinued and aborted the titration and the sample was lost. To remedy this, a stronger Sodium Thiosulphate reagent was made up (55g/L) so that less titre volume was needed.

A1.3 Salinity

The Guildline salinometers were operated in the wet lab. In the first week several problems were encountered, with both salinometers and with the peristaltic pump units. Instrument 1 (62548) was used initially, but there was a problem with the efficiency of the peristaltic pumps supplied. There was no replacement tubing for the pumps, so a fourth (back-up) pump, with the correct tubing, was used. After solving the pump efficiency problem there was still difficulty operating instrument 1. The cell did not always fill and multiple bubbles were sticking to the conductivity cell, particularly cell #4. At times the cell would drain itself without a recognisable cause. This meant that large amounts of sample (and standard) material were used in an attempt to achieve a reliable (replicated to ±0.5/100) reading. Often, it was not possible to achieve an accurate reading as water levels decreased beyond a reliable level. Due to the difficulties associated with gaining consistent readings, the second salinometer (instrument 2, 62549) was commissioned.

Instrument 2 was filled and left to equilibrate for 24 hours. Next, when attempting to use the instrument, water would not pump through to the cell, due to a blockage in the inner tubing just before entering the cell. Removing the blockage seemingly fixed the problem, however, the conductivity cells were still unable to fill consistently, and there were issues with water sticking on the cell walls. Instrument 2 was deemed unusable.

Operation reverted back to instrument 1 as it was operating the best of the two. Despite problems with filling of the cell, the instrument was run for several analyses. During stn 9, the pump tubing was replaced and the cell was soaked in decon/ethanol cleaning solution. One of the internal heating lamps was also replaced. When the data up to stn 10 were processed and tested against the CTD data, many errors were found. At this stage, further samples were run by a different operator and comparison to CTD showed very stable results. One on one training was undertaken with more attention to things such as interpretation of sample readings/stability, using a constant pump speed, and a much stricter variance allowance of ± 0.02/1000 between readings. There was also more attention paid to maintaining a constant temperature in the wet lab. From this stage on, results were more stable and reproducible.

In the Antarctic shelf area of the voyage, questionable scatter in the data was noted. The cell was cleaned with decon/ethanol cleaning solution and some of the exterior tubing (including that in the pump) was replaced, then further samples were run by a different operator. These modifications did not change the questionable scatter in the data. As repeated analyses of international standards were constant from one run to another, it was considered that the data scatter was directly associated with the water collected in the shelf area of Antarctica. This was likely due to anomalies in the environmental (biological or physiochemical) conditions in this area. Indeed there were very high levels of diatoms present in the shelf area which caused a notable decrease in carbon dioxide levels and increased levels of dissolved oxygen.

A1.4 Nutrient data processing

Note in the following notes that "run" number refers to Lachat analysis run, and does not correspond to CTD station number.

* Anything unusual when looking at the first set of matlab plots (looking within a run and mostly at the calibration) is noted in Table A1.1.

* Anything unusual when looking at the overall voyage plots in matlab is also noted in Table A1.1.

* By scanning through the data processing notes (from both omnion and matlab stages), notes of anything unusual are listed in Table A1.2.

* Any notes made when comparing duplicates over the entire voyage were also noted in Table A1.2.

* For a small number of stations, for nitrate and phosphate, all data were rejected as both the fresh runs and runs from storage (including frozen) are not trustworthy.

* Runs 96-101 - there was a very obvious error on these runs, for phosphate. The concentrations did not match up, and by investigating the overall voyage parameters (QC's, baseline elements and calibrants for both peak areas and concentration trends) the cause was attributed to contamination in the 1/10th diluted stock solution for the phosphate standards. A correction factor was applied to some of these data (and rejecting others), calculated as follows: the QC from runs 2 to 75 (most stable) was averaged, then compared to the average QC for each of the problem runs (i.e. 96 to 101), resulting in a correction factor for each problem run. These correction factors were then applied to samples from the problem runs.

* Interesting patterns on storage life of the samples were observed on the cruise. Nitrates very obviously did not last long in storage, a not unexpected feature. However there was a significant difference in silicate concentrations after storage, an unexpected result. At the time of writing, this is to be further investigated. As a result, in the data processing, if there was a single dip silicate result vs an older duplicate result, the fresher single dip has been chosen without taking the matching older duplicate from the later run.

A1.5 Laboratory temperature control

Laboratory temperatures, as measured by a thermistor taped to the dissolved oxygen standard bottle (close to the Lachat autoanalyser), are shown in Table A1.3. Most fluctuations occurred when the skylab door to the mezzanine was left open. On 22/01/2011 temperatures dropped significantly when the air conditioner failed.

Table A1.1: Anything outside the normal for all plots within runs and also from run to run generated through matlab.

Station	Plot reference	Analyte	Any Comments on patterns etc
46,69	QC%diff from the mean conc	NOX	For all of these stations despite acceptable calibrations **all QC's** don't fit in like all the other runs within the voyage. Could be just the actual QC sample and so nothing wrong but just to be aware.
48,49,54,59,60,61,65,70,90	QC%diff from the mean conc	NOX	**Same as above but just partial** (ie half the points are within the lines and the other half out). This again could mean just bad QC or it could mean there was a major drift within the run (which would be strange since this would have been picked up and corrected for in the calibration) but be aware.
34-61	QC%diff from the mean conc	Silicate	Pattern shows QC well centred to start with but then all showing **lower** values from these runs.
66-90	QC%diff from the mean conc	Silicate	Pattern shows QC well centred to start with but then all showing **higher** values from these runs.
0-91	QC%diff from the mean conc	Phosphate	Pretty good, oscillates around the lines but pretty close if anything dips low and then centres again.
96-101	QC%diff from the mean conc	Phosphate	Significantly higher QC values, but calibration ok … was this just bad QC?
34-61	LNSW conc	Silicates	Goes significantly downwards and then jumps back up on following run.
all	LNSW conc	phosphates	Shows very clear difference between LNSW batches … but all stable and either above or below the line.
64&80	LNSW conc	Nitrates	Lower than the majority of the voyage for some reason.
54-79	Baseline peak area	nitrates	Much lower than the rest
Overall glance	Cals peak area	nitrates	Quite a bit of changes in the sensitivity. Factors such as the colour reagent and cadmium column affect this a lot.
Overall glance	Cals	phosphates	Appears to have trends affecting peak area and the concs. Most likely the LNSW batches since this also shows obvious changes.
53&54	Baseline elements-conc	Nitrates	When looking at the nuts.xls plot generated by dave's macro, it showed how these two runs had a substantial higher conc for MQBG at the start of each of the runs.

Table A1.2: Anything to be aware of during processing in matlab and duplicates.

Sample	Runs	Nutrient	Comments
Fresh		NOX	It was noticed through going through all the duplicates that quite often the samples repeated fresh in following runs usually did not agree with the original result. It became evident with theses samples that nitrate is very sensitive to storage time.
Frozen		NOX	It is not clear if the samples analysed frozen have the same validity as the ones done when fresh. These also needs investigation. There were some cases where it was clear that the repeat frozen was not in tolerance to the fresh. Fresh was always chosen if possible but need to be aware of frozen samples.
All	24	ALL	This run had an instrument software error (instrument stopped on it's own). The samples were continued and files were 'stitched together' they were repeated as frozens on 101 just in case.
	64,50,62,96,68,93,94 and possibly more	all	Rough weather/greater than normal vibrations-ship thrusters etc.
	85	all	Was labelled in nutrient software for part of run as 114 when it was all 144.
	87&24	all	Tubes mislabelled and backwards from RP17-24
	various	phosphates	An initial data entry mistake of telling software the conc for calibration #4 had a known conc of 2.6 rather than the actual 2.4 caused several unacceptable calibrations during the voyage. As this wasn't known for sure during the voyage for some part some repeats were done because of this. Similarly, when re-processing recently some runs were deemed not ok and repeated but it turned out to be for this reason. So original runs were put back in with correct calibrations, compared to the frozens, but as always fresh always preferred where possible.
all	11	Silicates(indirectly nox&po4)	Valve stopped working. Repeated stn 11 on run 12
	62	phosphate	Calibration not as brilliant as normal but not unacceptable.
	101	all	Typo – 8101 entered for first RP – doesn't exist – meant to be 8202
	79	Po4	Major baseline jump. Samples in this were removed and obvious when repeated they were not ok. Don't believe anything else affected by this. Also the detector was changed. Calibration still looks ok.
	80-83	Po4	Removed out of data set.
	78	Po4	79-83 were deemed not ok. It's not clear if the problem was starting from run 78 as some dup overlaps don't look the best.
	Various	silicates	Surprisingly any repeats of silicates in following runs were quite often not matching. This has instigated the need for investigation as it was thought that silicates were the one nutrient which had the longest storage capability when fresh.
	4&7	all	Instrument error from autosampler, run ended prematurely at the end (nothing affected just no end MQCOL)
	19	Po4	Calibration required cal 4's and 2 to be removed in order for it to be ok. Looks ok but it's possible there was a problem.
	53,48,59,61,69	Nox	Calibration not as good as normal
	62,63,96,97	Po4	Calibration not as good as normal
	62	silicate	Air conditioning not working in lab – freezing – silicate reagent went out of solution and blocked up the lines.

Table A1.3: Laboratory temperatures (^{o}C) from thermistors on oxygen standard bottles.

Date	Min	Max	file	Average	stdev	Average (i.e. for the day)	stdev
5/01/2011	23.8	24.7	101	24.25	0.64		
	23.7	24.7	201	24.2	0.71		
	23.9	24.7	401	24.3	0.57		
	24.3	24.8	501	24.55	0.35		
	23.7	24.4	601	24.05	0.49	24.3	0.2
6/01/2011	24	24.7	701	24.35	0.49		
	23.9	24.8	801	24.35	0.64		
	23.6	24.6	901	24.1	0.71	24.3	0.1
7/01/2011	23.6	24.4	1001	24	0.57	24.0	
8/01/2011	24.2	24.9	1101	24.55	0.49		
	23.7	24.7	1301	24.2	0.71	24.4	0.2
9/01/2011	23.7	24.2	1401	23.95	0.35		
	23.4	24.2	1501	23.8	0.57		
	23.5	24.1	1601	23.8	0.42		
	22.6	23.7	1701	23.15	0.78	23.7	0.4
10/01/2011	22.2	22.9	1801	22.55	0.49		
	21.8	22.4	1901	22.1	0.42		
	22.4	23.3	2001	22.85	0.64		
	22.2	23	2101	22.6	0.57	22.5	0.3
11/01/2011	22	22.7	2201	22.35	0.49		
	21.5	22.1	2301	21.8	0.42		
	21	21.8	2401	21.4	0.57		
	22.7	24	2501	23.35	0.92	22.2	0.8
12/01/2011	23.1	24.2	2601	23.65	0.78		
	21.7	22.4	2701	22.05	0.49		
	21.3	23	2801	22.15	1.20		
	22.2	23.6	2901	22.9	0.99	22.7	0.7
13/01/2011	20	21.9	3001	20.95	1.34		
	20.8	21.5	3101	21.15	0.49		
	21.5	22.1	3201	21.8	0.42		
	21.1	22.7	3301	21.9	1.13	21.5	0.5
14/01/2011	20.5	21.6	3401	21.05	0.78		
	21.2	21.8	3501	21.5	0.42		
	21	22.1	3601	21.55	0.78	21.4	0.3
15/01/2011	22.6	23.1	3701	22.85	0.35		
	22.7	23.2	3801	22.95	0.35	22.9	0.1
16/01/2011	21.5	23.2	3901	22.35	1.20		
	20.8	23	4001	21.9	1.56		
	22.4	23	4101	22.7	0.42		
	21.1	21.9	4201	21.5	0.57		
	20.9	21.6	4301	21.25	0.49		
	21.5	22.1	4401	21.8	0.42	21.9	0.5
17/01/2011	21.8	23.4	4501	22.6	1.13		
	21.3	22.2	4601	21.75	0.64		
	21.5	21.8	4701	21.65	0.21		
	21.2	21.6	4801	21.4	0.28		
	21.3	21.9	4901	21.6	0.42		
	22.5	23.1	5001	22.8	0.42		
	21.1	22	5101	21.55	0.64	21.9	0.6
18/01/2011	21.5	22.3	5201	21.9	0.57		
	21.1	21.7	5301	21.4	0.42		
	20.9	22.6	5401	21.75	1.20		
	21.6	22.7	5501	22.15	0.78	21.8	0.3
19/01/2011	21.4	22	5601	21.7	0.42		
	19.1	22.2	5701	20.65	2.19	21.2	0.7
20/01/2011	20.5	20.8	5901	20.65	0.21		
	20.5	21.2	6001	20.85	0.49		
	20.7	21.2	6101	20.95	0.35		
	21.4	21.2	6201	21.3	0.14		
	22.4	23.2	6301	22.8	0.57		
	21.8	23.4	6401	22.6	1.13		
	21.8	21.9	6501	21.85	0.07	21.6	0.9
21/01/2011	19.3	19.6	6601	19.45	0.21		
	19.2	19.6	6701	19.4	0.28		
	20	22	6801	21	1.41	20.0	0.9
22/01/2011	14.9	15.5	6901	15.2	0.42 (the day oxalic fell out of solution - aircon not working)		
	15.3	15.7	7001	15.5	0.28		
	15.6	15.8	7101	15.7	0.14		
	20.7	21.8	7201	21.25	0.78		
	22.2	22.7	7301	22.45	0.35		
	22.2	23.1	7401	22.65	0.64	18.8	3.7

Table A1.3: (continued)

Date	Min	Max	file	Average	stdev	Average (i.e. for the day)	stdev
23/01/2011	21.4	21.9	7501	21.65	0.35		
	21.3	22	7601	21.65	0.49		
	22	22.9	7701	22.45	0.64		
	22.1	23.6	7801	22.85	1.06		
	23.2	23.5	7901	23.35	0.21		
	23.3	23.7	8001	23.5	0.28		
	23.1	23.4	8101	23.25	0.21	22.7	0.8
24/01/2011	23	23.3	8201	23.15	0.21		
	23.2	24.1	8301	23.65	0.64		
	23.6	24.1	8401	23.85	0.35	23.6	0.4
25/01/2011	23.7	23.8	8501	23.75	0.07		
	23.7	23.8	8601	23.75	0.07		
	23.7	23.8	8701	23.75	0.07		
	24.1	24.3	8801	24.2	0.14		
	24.1	24.2	8901	24.15	0.07		
	24	24.1	9001	24.05	0.07		
	23.2	23.6	9101	23.4	0.28		
	23.1	24.6	9201	23.85	1.06		
	24.1	24.5	9301	24.3	0.28		
	22.5	23.4	9401	22.95	0.64		
	21.3	22.3	9501	21.8	0.71		
	22.4	22.6	9601	22.5	0.14	23.5	0.8
26/01/2011	23.1	23.3	9701	23.2	0.14		
	23	23.3	9801	23.15	0.21		
	22.6	22.8	9901	22.7	0.14		
	22.1	22.6	10001	22.35	0.35		
	21.9	22.4	10101	22.15	0.35		
	21.6	22.3	10201	21.95	0.49		
	21.8	22.5	10301	22.15	0.49		
	21.9	22.2	10401	22.05	0.21		
	21.8	22.6	10501	22.2	0.57		
	21.9	22.3	10601	22.1	0.28		
	21.7	22.6	10701	22.15	0.64	22.4	0.4
27/01/2011	22.1	22.9	10801	22.5	0.57		
	21.9	22.2	10901	22.05	0.21		
	21.4	22.9	11001	22.15	1.06		
	21.7	23.1	11101	22.4	0.99		
	21.8	22.2	11201	22	0.28		
	21.5	21.8	11301	21.65	0.21		
	21.6	22.1	11401	21.85	0.35		
	22.1	22.4	11501	22.25	0.21		
	21.3	21.7	11601	21.5	0.28		
	21.5	22	11701	21.75	0.35		
	21	21.7	11801	21.35	0.49	22.0	0.4
28/01/2011	21.1	22.2	11901	21.65	0.78		
	21.2	21.6	12001	21.4	0.28		
	22.9	23	12101	22.95	0.07		
	22.1	23.2	12201	22.65	0.78		
	21.6	23	12301	22.3	0.99		
	21.9	23.8	12401	22.85	1.34		
	23.1	23.8	12501	23.45	0.49		
	22.2	22.9	12601	22.55	0.49		
	23.3	24.1	12701	23.7	0.57		
	23.7	23.9	12801	23.8	0.14		
	23.2	23.9	12901	23.55	0.49	22.8	0.8
29/01/2011	22.8	23.5	13001	23.15	0.49		
	23.6	23.7	13101	23.65	0.07		
	23.6	23.8	13201	23.7	0.14		
	23.7	23.9	13301	23.8	0.14	23.6	0.3
30/01/2011	22.3	22.5	13401	22.4	0.14		
	22.4	22.6	13501	22.5	0.14		
	21.7	22.2	13601	21.95	0.35		
	21.9	23.1	13701	22.5	0.85		
	21.8	21.9	13801	21.85	0.07		
	22.6	22.9	13901	22.75	0.21		
	23	23.1	14001	23.05	0.07		
	21.2	23.1	14101	22.15	1.34		
	23.7	24.5	14201	24.1	0.57	22.6	0.7

Table A1.3: (continued)

Date	Min	Max	file	Average	stdev		Average stdev (i.e. for the day)	
31/01/2011	20.9	22.9	14301	21.9	1.41			
	21.2	22.8	14401	22	1.13			
	20.9	21.6	14501	21.25	0.49			
	22.1	22.7	14601	22.4	0.42		21.9	0.5
1/02/2011	21.5	22	14701	21.75	0.35			
	21.3	22.1	14801	21.7	0.57			
	21.9	22.7	14901	22.3	0.57		21.9	0.3
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					For the voyage:		22.37	1.44