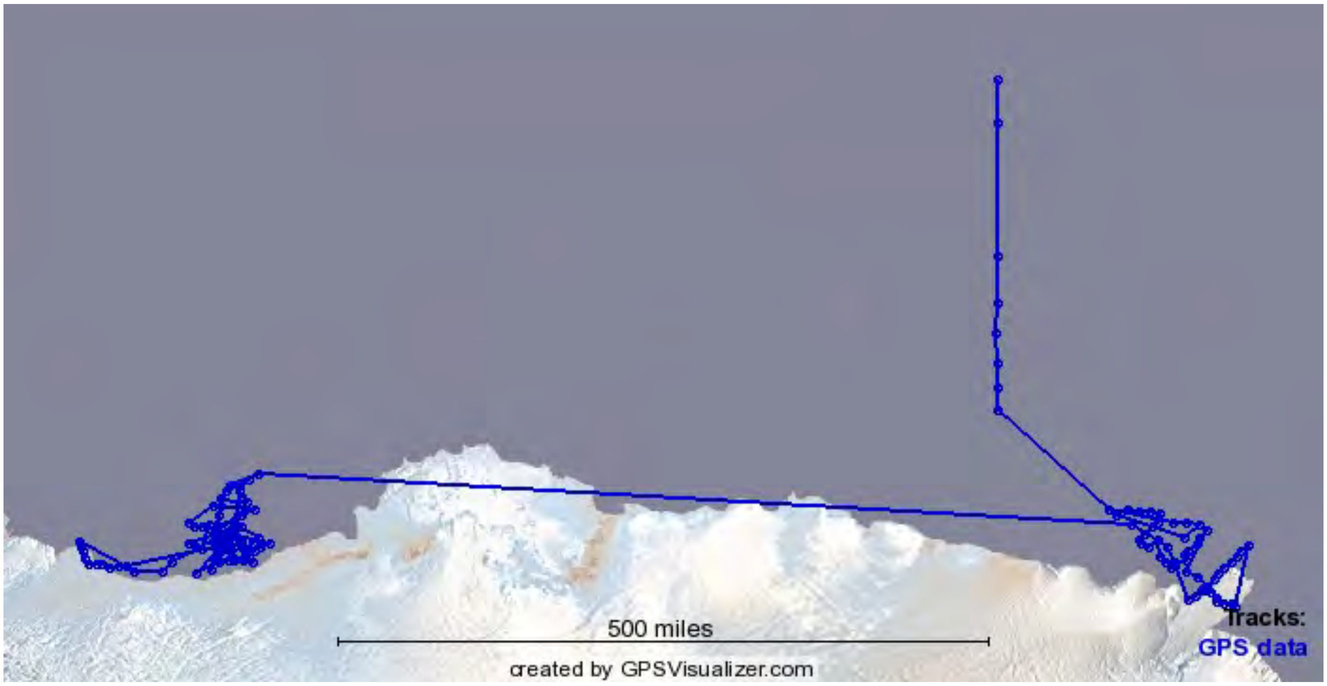
CRUISE REPORT: AU1402

(Updated NOV 2020)



Highlights

Cruise Summary Information

Section Designation	**AU1402**
Expedition designation (ExpoCodes)	**09AR20141205**
Chief Scientists	**Steve Rintoul / CSIRO**
Dates	2014 DEC 05 – 2015 JAN 25
Ship	RSV Aurora Australis
Ports of call	Hobart, Australia – Casey, Australia
Geographic Boundaries	61° 21' 13.68" S 116° 20' 47" E 146° 15' 2.52" E 67° 16' 20"
Stations	141 CTD stations
Floats and drifters deployed	10 'Argo equivalent' floats deployed
Moorings deployed or recovered	9 moorings recovered

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ANTARCTIC CLIMATE & ECOSYSTEMS
COOPERATIVE RESEARCH CENTRE

Aurora Australis Marine Science Cruise AU1402, Totten and Mertz CTDs and Moorings - Oceanographic Field Measurements and Analysis

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Aurora Australis Marine Science Cruise AU1402, Totten and Mertz CTDs and Moorings - Oceanographic Field Measurements and Analysis

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ABSTRACT

Oceanographic measurements were collected aboard Aurora Australis cruise au1402, voyage 2 2014/2015, from 5th December 2014 to 25th January 2015. The cruise commenced with a Casey resupply, followed by work around the Dalton Polynya/Moscow University Iceshelf/Totten Glacier system, and then around the Mertz Glacier region. A total of 141 CTD vertical profile stations were taken on the cruise, most to within 11 metres of the bottom (Table 1.1). Over 1000 Niskin bottle water samples were collected for the measurement of salinity, dissolved oxygen, nutrients (phosphate, nitrate+nitrite and silicate), dissolved inorganic carbon (i.e. TCO_2), alkalinity, helium, ^{18}O, and biological parameters, using a 24 bottle rosette sampler. Full depth current profiles were collected by an LADCP attached to the CTD package, and bottom video footage was collected by a camera system (also mounted to the CTD package) for most casts. Upper water column current profile data were collected by a ship mounted ADCP. An underway CTD system (P.I. Alex Orsi, Texas A&M University) was used to collected measurements from the aft of the ship along several small transects around the Dalton Polynya. Meteorological and water property data were collected by the array of ship's underway sensors. 10 'Argo equivalent' floats were also deployed in both the Totten and Mertz regions (Table 1.12), for an ice float pilot study.

Six oceanographic moorings were recovered from around the Dalton Polynya, three Australian and three US (for the US moorings: P.I.'s Alex Orsi, Texas A&M University, Amy Leventer, Colgate University, and Eugene Domack, University of South Florida). Three temporary acoustic sound source moorings were also deployed then recovered in the same area, in support of an autonomous glider deployment (P.I. Craig Lee, University of Washington). Three oceanographic moorings were recovered from the Mertz region, two Australian and one French (P.I. Marie-Noëlle Houssais, Université Pierre et Marie Curie, for the French mooring).

Part 1 of this report describes the processing/calibration of the CTD data, and gives data quality details. Underway sea surface temperature and salinity data are compared to near surface CTD data. CTD station positions are shown in Figures 1.1a to d, while CTD station information is summarised in Table 1.1. Mooring station information and data from the Australian moorings are discussed in Part 2 of the report. Data from the LADCP, ADCP, underway CTD, glider and US and French moorings are not discussed further.

CRUISE NARRATIVE (with a strong mooring bias)

The marine science component of cruise au1402 was a late starter, with funding only approved the month prior to sailing. A recovery attempt on the Totten moorings was a commitment to the US (as three of the Totten mooring array belonged to the US), and was therefore scheduled into the cruise from commencement of planning, independent of marine science funding. Had funding not been approved there would have been no visit to the Mertz region.

The six "Totten" moorings (more properly described as the Dalton Polynya moorings), were all deployed from the Nathaniel B Palmer on cruise nbp1402 in February-March 2014. Three were Australian moorings, three were US. The older Mertz mooring array, 3 Australian moorings (deployed on cruise au1121 in January 2011) and one French (deployed from l'Astrolabe in January 2012), were originally scheduled for recovery from RV Tangaroa cruise tan1302 in early 2013. They could not however be accessed, due to pack ice beyond the capabilities of Tangaroa. A brief visit was made to the Mertz region at the start of nbp1402 in February 2014 for geoscience work, however the old Mertz mooring array remained inaccessible – satellite images clearly showed the array covered by fast ice and icebergs.

The ship departed Hobart on December 5th 2014, and at the time of sailing ice conditions looked bad for access to the Totten moorings. And although conditions looked more promising around the Mertz array, with significant break-up of the fast ice and clearing of the pack, there was only low expectation of success for the Mertz mooring recoveries as the release batteries were already four years old (three years for the French mooring). So there was every expectation of returning to Hobart empty handed mooring-wise, and with only limited CTD's.

After a nine day visit to Casey for resupply and refuelling, the ship headed for the Dalton Polynya. Access through the band of pack ice north of the polynya was easier than expected (and easier than the heavy ice encountered on the way out of Casey), and took less than a day. Mooring ops commenced on Christmas Day with deployment of three sound source moorings from north to south, intended as navigation references for autonomous glider deployments. These moorings were all deployed anchor first (in open water), to ensure accurate location. CTD work also commenced, with a test cast to 200 m to test the winch, followed by start of the CTD program in the polynya. At this time three of the six Totten moorings were ice free, with the remaining three under heavy ice. The three ice free moorings were recovered in rapid succession, Totten3, then Totten2, and lastly the US sediment trap mooring. Totten3 and Totten2 recoveries were smooth and simple, however the single CART release on the sediment trap mooring did not communicate. Time was spent attempting release communication from all sides of the target, then three miles W, N and S of the target, with no success. So a blind release was attempted back at the original target, and thankfully the mooring surfaced a few minutes later, complete with three happy sediment samples.

For the remaining three Totten moorings (US moorings M2 and M3, and Australian mooring Totten1), the plan was to watch the satellite images for the remaining time in the Totten region, and access each mooring opportunistically, ice willing. M2 was first approached on the 26th December, entering the ice three miles from the location, but ice conditions were too heavy for a closer approach. The M3 mooring location supplied by the US was first accessed on 27th December, but after three hours unsuccessfully trying to communicate with the releases the operation was called off for the day. A couple of days later the underway data from the nbp1402 deployment cruise was unearthed and closely scrutinized, revealing an error in the supplied M3 location. The correct location was confirmed as 2.8 miles to the ENE. This site was accessed on 30th December, in moderate to heavy ice cover, and after successful communication with the releases the ship spent time clearing a 200-300 m diameter hole around the site. Buoys surfaced in the slush and broken rubble, and the whole lot was recovered from the bow.

Mooring ops were suspended for a few days while the ship made a bold dash for the Totten Glacier, darting along narrow leads at the front of the Moscow University Iceshelf and squeezing around bergs, pausing for a night en route at a significant polynya. The glacier front was reached on New Year's Day, in stunning weather.

Based on weather forecasts, a strict return time to a specific location to the east was set, to ensure a safe exit back to the Dalton Polynya. So limited time only was available for CTD's near the Totten and on the return east, and unfortunately a few valuable hours were lost at the front of the Totten due to CTD winch spooling problems.

After returning to the Dalton Polynya, CTD operations continued around the polynya. US mooring M2 was accessed on 3rd January, with loose pack ice covering the site. After two hours spent clearing a hole a thick fog came over from the SE, forcing a temporary shutdown of the clearing operation. Two hours later the fog lifted, however the mobility of the pack meant the ship had to start from scratch clearing the site. A particularly large and brutish floe featured heavily in all these clearing ops, lingering menacingly around the spot. After a further hour of floe demolition (not including the brute) the mooring was released, and recovery was from the trawl deck.

The latest ice image showed new large open leads running SE to NW through the pack, and on 3rd January one of these was followed most of the way to the Totten1 location. The last mile or two to the site was through heavy ice. Five hours were spent trying to clear a hole, but with the heavy ice cover there was nowhere for the rubble to clear away, and wriggling the ship around during the clearing operation was very difficult, particularly at the start. At last a rubble filled area was created, somewhat more promising than the surrounding heavy ice, but still marginal for surfacing of a mooring. Nevertheless this was the last opportunity for a recovery, so the mooring was released. Nothing appeared through the rubble, but luckily communication with the releases was still possible with the mooring at the surface. Nearly two hours was spent nudging floes around, until at last the bottom frame popped out from under a floe. After gently backing up to the floats, and with some delicate grappling from the stern, the mooring was recovered from the trawl deck.

(pic by Steve Rintoul)

Totten1 mooring recovery

The three sound source moorings were recovered a few days later from south to north, shortly before leaving the Dalton Polynya. The only hitch was at the northern mooring, where the ice at first was too thick for access. Twelve hours later conditions had improved, and after some floe clearing operations the mooring was recovered. Exit north from the polynya was easy, taking less than five hours, and the transit east to the Mertz region commenced.

On the morning of approach to the Australian Mertz moorings (Polynya West, Polynya Centre and Polynya East), the ship stopped for some krill fishing. Two hours later it was up stumps to divert for a rendezvous with a New Zealand navy frigate, tailing an illegal fishing boat. Visitors from the navy ship were welcomed aboard (and included the ice pilot Captn Andrew Leachman, formerly of Tangaroa). Transit to the Mertz moorings then continued, and on the way in the ship passed by the large berg covering Polynya West. This berg, a fragment off the Ninnis Glacier, had been in the vicinity four years earlier during the deployment of Polynya West, pivoting around its grounding point from day to day. A few months after deployment the berg had moved over the mooring, covering it for the next 3.5 years. When the ship passed by on 11th January it was estimated that Polynya West lay several miles under the berg, so the ship continued on to the remaining Mertz moorings.

At Polynya Centre, the location was under a floe field clinging to the SE corner of the same berg that covered Polynya West, and within a few hundred metres of the berg. Communication with both releases was loud and clear (surprisingly with the alkaline battery release as well as with the lithium battery unit). Release was attempted, but after two hours waiting the mooring remained fixed to the anchor. The ship then moved to Polynya East. No communication was received from the releases, and nothing surfaced after going for a blind release. And that was the end of a bad day for the Polynya mooring array.

The ship next headed SE towards the Mertz depression, doing three CTD’s on the way, and the French “Albion” mooring was approached. The area over the site had been ice free for a long time before the ship arrived, but during the transit from Totten a large berg (formerly of the Ninnis Glacier) released and was on the move from the east, in turn releasing a mass of old pack ice. When the ship arrived there was open pack covering the site, but conditions were marginal given that the Albion mooring consisted of a single instrumented frame only, no strings (or floats) attached. Communication with the releases was delayed until a hole was cleared, on the assumption that at best there might only be limited battery power remaining. Surprisingly, release communication was loud and clear, however the mooring was pinpointed to a location ~200 m from the target. So hole clearing operations started again, over the more accurate location. After release of the mooring, and with the package rising at ~100 m per minute, the ship made a final desperate pass over the location to clear some more floes, and the package appeared two ship lengths directly astern, next to a floe. Recovery of the package was fast and simple. Stowing of the package in the upper halfheight container took considerably longer…

CTD operations continued around the Mertz region, and with spirits raised by successful recovery of the French mooring a plan was hatched to "lasso" the two accessible Australian moorings, Polynya Centre and East. The engineers fabricated three grapples from steel angle and cross section lengths. Meanwhile the old wire from the towing winch (used up to now as the stoppering winch, and for towing the CPR) was peeled off onto the netdrum over the 50 m starter wire, adding up to 890 m of additional wire (10 mm and 12 mm). Three bulldog clips were used to make a termination. After the proposed operation received the thumbs up from Kingston head office, final preparations were made for an attempt on Polynya Centre. The grapples were attached along ~20 m of chain (salvaged from the recovered float groups), with the chain shackled to the end of the wire now on the netdrum. A "dump" weight, consisting of a length of old anchor chain weighing ~100 kg, was attached to the end of the grapple chain. A "clump" weight, consisting of a lesser amount of old anchor chain, was held ready for attachment, as described below. With the ship holding station at the start of a planned lasso circle, the dump weight, chain/grapples and first 600 m of netdrum wire were lowered to the bottom via the CSIRO grey mooring block on the gantry. The ship then commenced its slow circle manoeuvre, with the idea being to lay wire on the bottom encircling the mooring. After all old wire was paid out from the netdrum, the trawl wire from the starboard trawl winch was passed through the fairlead and forward again to join to the netdrum wire, with a 15 m shot of terminated mooring wire (from one of the recovered sound source moorings) separating the two. The clump weight was attached to the join between the netdrum wire and the 15 m shot (on later attempts a short wire strop was fed off the wire join to the clump, allowing much easier connection and disconnection). The join and clump weight were then deployed from the gantry, then hauled in on the trawl winch till the join was in reach of the starboard stern gallows. With the load on the trawl wire, the 50 m netdrum starter wire was then disconnected. The 15 m wire shot between the netdrum wire and trawl wire, with a nominal breaking strain of 3 tons, was intended as a "weak link" in case of snagging, noting that any break would be below the trawl wire. 550 m of trawl wire was then paid out, keeping the trawl wire clear of the bottom. On the first attempt the ship came up just short of a lap (~350 m diameter) around the mooring before all wire was paid out. After making a further lap the ship moved off at a tangent from the circle, hauling in from a stand-off point ~500 m away. No luck on the first attempt. The whole exercise was repeated, this time with the ship in lips and therefore allowing a tighter circle to be laid. With all trawl wire back on board and while hauling on the netdrum wire, the mooring appeared behind the ship, obviously

(pic by Rose Croasdale)

Grapples fabricated by the ship's engineers, for improvised lassoing operations

freed of the anchor. By the conclusion of the operation Polynya Centre was on deck and complete, albeit rather slimey and furry with four year's growth. The first grapple in the line ("Golden Retriever") was snagged on the nylon strop above the ADCP, but the netdrum wire itself must have initially bumped the bottom frame assembly, at some stage freeing it from the anchor. One of the shackles near the bottom of the mooring was close to sawn in half, the effect of several hundred metres of wire being dragged over it. And the three corners of the bottom frame showed significant corrosion, obviously the corrosive binding point to the anchor. Total time for the two lasso operations at Polynya Centre was less than four hours.

The rest of the day was spent at the Polynya East location, with two lasso deployments coming up empty handed; and after the second attempt the grapples were badly bent. The intention was to continue grappling the next morning, but come the day a small diversion was made, the plan being to listen for the mooring from 4 miles NE, N and NW of the target. A sniff was in the air that perhaps an iceberg had been at work. At the N listening post, a release range unexpectedly flashed on the deck unit, with a range of 3700 m. The next couple of hours were then spent tracking down the mooring, and it was eventually pinpointed 4.4 miles NNW of the original deployment location. It was still on the bottom, at a nervy distance of <100 m from a large and gnarly berg, but miraculously not under the berg. Later reviewing of satellite images showed that this berg had indeed passed over the original mooring location and moved to the current location between the 9^{th} and 16^{th} January, the very week we were in the Mertz region. The mooring had only just been dragged, then "thoughtfully" deposited by the berg in a depth of 500 m, a matter of metres before the berg itself grounded. All this after the mooring had been in the water for four years. The biggest upside to this recent iceberg tow was the likelihood that the corrosive bond between the bottom frame and anchor had been shaken free. Very timely. Communication with the releases was loud and clear (both the alkaline and lithium battery units), and the mooring released from the anchor on the first attempt. Given such close proximity to the iceberg, the FRC (fast rescue craft) had been deployed prior to mooring release, ready to move in for a quick snatch and grab. After release the FRC closed in rapidly, fired the hand held grapple launcher, then hooked up and towed the mooring closer to the ship. A throwing line from the stern was used to pass the netdrum wire to the FRC, for connection to the rope already attached to the mooring pick-up line. After retrieval of the FRC, mooring recovery proceeded fast and trouble free. Polynya East on board, with three missing floats from the top float group, large skid marks on the bottom frame, dents in the hardhats mounted on the bottom frame, and much mud. But crucially, all instruments were intact.

(pic by Erik van Ooijen)

(pic by Steve Rintoul)

FRC approaching Polynya East floats; and the bottom frame after recovery.

Buoyed by the unexpected recoveries of both Polynya Centre and East, the ship turned for Polynya West. Approaching the location involved detouring north around a large berg. As the massive ex-Ninnis chunk was approached, it became apparent that the berg had just wriggled its hips in a significant way, enough such that the mooring location was now out from under the berg (as judged from the latest satellite image)…but only just. Moving along the berg front, there was no communication from the releases, but on rounding a promontory the release comms sprang to life, loud and clear. And in front of the ship lay a narrow “inlet”. Of the 60 miles or so of berg “coastline”, here was an inlet, less than 200 m across, and with towering ice cliffs on either side… and with the mooring parked in the inlet, under a small puddle amongst the floes… but with the puddle hard up

(pic by Steve Rintoul)

View from the ship into the narrow inlet in the iceberg at Polynya West.

against one of the cliffs. The ship manoeuvred to another puddle, but dared not approach closer. The minimum horizontal range to the mooring, as recorded by the release deck unit, was 1151 m. If release had been attempted, and even if the mooring had broken free of the corrosive binding to the anchor, there’s no way it could have been retrieved, either by the ship or the FRC. The words were written large: “You can look, but don’t touch”. The releases were disabled and the ship moved on. Farewell Polynya West. The oceanography concluded with a line of 8 CTD’s along the south end of the SR3 transect, before the transit north to Hobart.

Summary of cruise itinerary:

Expedition Designation	AU1402, voyage 2 2014/2015
Projects	Totten and Mertz Glacier projects
Chief Scientist	Steve Rintoul (CSIRO)
Ship	RSV Aurora Australis
Ports of Call	Hobart Casey
Cruise Dates	Dec 5th 2014 – Jan 25th 2015

PART 1 CTD DATA

1.1 INTRODUCTION

A total of 141 CTD’s were completed on the cruise (Table 1.1), 82 in the Dalton Polynya/Moscow University Iceshelf/Totten Glacier region, and the remaining 59 in the Mertz region (Figures 1.1a to d).

1.2 CTD INSTRUMENTATION

SeaBird SBE9plus CTD serial 704, with dual temperature and conductivity sensors and a single SBE43 dissolved oxygen sensor (serial 0178, on the primary sensor pump line), was used, mounted on a SeaBird 24 bottle rosette frame, together with a SBE32 24 position pylon and up to 22 x 10 litre General Oceanics Niskin bottles. The following additional sensors/instruments were mounted:

* Wetlabs ECO-AFL/FL fluorometer serial 756
* Biospherical Instruments PAR sensor QCP2300HP, serial 70110
* Wetlabs C-star transmissometer serial 1421DR
* Teledyne RDI lowered ADCP (i.e. LADCP) workhorse monitor – 300 kHz upward looking head; 150 kHz downward looking head; battery housing
* Tritech 200 kHz altimeter serial 126287
* Tritech 500 kHz altimeter serial 126288
* camera system and strobe lighting

CTD data were transmitted up a 8 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 unknown). Note that this was the first cruise with the new and thicker 8 mm seacable, replacing the old 6 mm cable used previously.

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 most casts the package was stopped on the upcast at ~50 m above the bottom, for collection of bottom track data by the LADCP. When the camera system was fitted the package was stopped for several minutes within 5 m of the bottom.

Pre cruise temperature, conductivity and pressure calibrations were performed by SeaBird (Table 1.2) (June 2014). The SeaBird calibration for the SBE43 oxygen sensor was used for initial data display only. Manufacturer supplied calibrations were used for the 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 a clean water value.

1.3 PROBLEMS ENCOUNTERED

The main CTD related problem was the salinometer performance. Of the two instruments brought on the cruise, one was unusable from the start, while the other was troublesome.

Wire spooling on the CTD winch was a problem at times, due to incorrect gearing, and on two occasions a few hours were lost while gear sprockets were changed.

The ship was stuck in heavy pack ice for a day on the way out of Casey.

There was trouble downloading data from the LADCP for the first 8 stations. The problem turned out to be a windows issue on the PC. After changing to a spare laptop there was no further problem.

Other ship related problems (effecting CTD's) are included in section 1.5.7 below.

1.4 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)

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). 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 (stations 1-133), while split profile fits were used for deeper stations (stations 134-141).

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 1.6 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.

1.5 CTD AND BOTTLE DATA RESULTS AND DATA QUALITY

Data from the primary CTD sensor pair (temperature and conductivity) were used for the whole cruise. Suspect CTD 2 dbar averages are listed in Table 1.8, while suspect nutrient samples are listed in Table 1.10. Nutrient and dissolved oxygen comparisons to previous cruises are made in section 1.7. Appendix 1.1 contains the hydrochemistry lab report for salinity (at time of writing, dissolved oxygen report not yet done).

1.5.1 Conductivity/salinity

The conductivity calibration and equivalent salinity results for the cruise are plotted in Figures 1.2 and 1.3, and the derived conductivity calibration coefficients are listed in Tables 1.3 and 1.4. Station groupings used for the calibration are included in Table 1.3. International standard seawater batch number P157 (15th May 2014) was used for salinometer standardisations. Lab temperature for salinity analyses ranged between 19.4 and 21.1°C over the course of the cruise.

Guildline Autosal serial 62021 was used for the whole cruise, with analyses taking place in the skylab. Salinometer performance was troublesome. Salinity analyses were only done when the instrument appeared reasonably stable, but even during these times there was much bubble trouble within the instrument (see Appendix 1.1 for more details). Salinometer bubbles have been a similar problem on previous Antarctic shelf cruises (e.g. cruise au1121, Rosenberg and Rintoul, unpublished-1), and are assumed due to high biological activity in the samples collected from Antarctic shelf waters.

From station 86 onwards, duplicate salinity samples were taken from many of the Niskins for analysis back at home. These analyses proved to be unreliable, with mean values ~0.0025 (PSS78) higher than the at sea analyses, and with significantly more scatter in the salinity residuals (i.e. bottle-CTD differences); and for stations 134-141, inconsistent with previous cruise data from the south end of SR3. Sufficient reliable results were obtained from the at sea analyses, so these were used for the conductivity calibration. No obvious calibration drift was evident, so large stations groupings were used for the calibration (Table 1.3), dampening the effect of any problematic stations, and overall CTD salinity accuracy for the cruise is within 0.002 (PSS78).

Pressure dependent salinity residuals are evident for most cruises (Rosenberg and Rintoul, unpublished-1). These residuals can only be assessed for deep stations, specifically stations 134-141 for this cruise. Where they occurred they were of the order 0.001 (PSS78) over the whole vertical profile. Note that where the pressure dependency occurred, the magnitude over the whole profile was often larger for the secondary sensor data (not shown here).

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)
10	+0.001
13	-0.001
31, 32	-0.0015
35, 40	-0.001
55-58	+0.002
62-70, 78, 85, 101-104	-0.001
109-111	+0.001
122, 127	-0.001

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

* for station 54, 2 to 18 dbar – data suspect as sensors possibly frozen

Bad salinity bottle samples (not deleted from the data files) are listed in Table 1.9.

1.5.2 Temperature

Temperature differences between the primary and secondary CTD temperature sensors (T_p and T_s respectively), from data at Niskin bottle stops, are shown in Figure 1.4. Temperature ranges for this Antarctic cruise are relatively small, and the difference $T_s - T_p$ is well within the manufacturer quoted sensor accuracy of 0.001°C.

* for station 54, 2 to 18 dbar – data suspect as sensors possibly frozen

1.5.3 Pressure

Surface pressure offsets for each cast (Table 1.5) were obtained from inspection of the data before the package entered the water. Pressure spiking, a problem on some previous cruises, did not occur.

1.5.4 Dissolved oxygen

CTD oxygen data were calibrated as per the *CTD methodology*, with profiles deeper than 1400 dbar (i.e. stations 134-141) calibrated as split profile fits, and profiles shallower than 1400 dbar (i.e. stations 2-133) calibrated as whole profile fits. For most stations a duplicate sample was drawn from one of the Niskins, as a quality check on the analyses. For station 1, no bottle samples were collected, therefore CTD oxygen data were not calibrated:

Calibration results are plotted in Figure 1.5, and the derived calibration coefficients are listed in Table 1.6. Overall the calibrated CTD oxygen agrees with the bottle data to within 1% of full scale (where full scale is ~400 µmol/l above 1500 dbar, and ~260 µmol/l below 1500 dbar) i.e. from the standard deviation values in Figure 1.5. Note that for most of the cruise, in Antarctic shelf waters, there was significant variability between down and upcast data, and as a result more than the usual number of samples were rejected (Figure 1.5) during the calibration procedure i.e. when comparing downcast CTD data with bottle samples collected on the upcast, as per the *CTD methodology*. Nevertheless sufficient samples remained for reliable calibration of the CTD data.

* for station 54, 2 to 18 dbar – data suspect as sensors possibly frozen

* for station 94, 4 to 20 dbar - oxygen values high by ~6 µmol/l due to problem calibrating the profile

1.5.5 Fluorescence, PAR, transmittance, altimeter

All fluorescence, PAR and transmittance data have a manufacturer supplied calibration (Table 1.2) applied to the data, with transmittance values referenced to clean water. 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 in previous cruises i.e. au0703, au0803 and au0806).

For fluorescence and transmittance, the 2 dbar averaged upcast data (in the CTD 2 dbar files) do not always match the upcast 10 second burst average data (in the bottle data file). This is due to the difference between 2 dbar and 10 second averaging on data with frequent significant vertical structure.

The PAR calibration coefficients in Table 1.2 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 usual altimeter "artefacts", as seen on previous cruises (described in Rosenberg and Rintoul, unpublished-1), were observed on both the 200 and 500 kHz Tritech sensors, with false bottom readings often observed before coming within nominal altimeter range.

* Fluorescence data for station 30 are all bad and have been removed from the files – the sensor cap was accidentally left on.

* Near bottom transmittance spikes, possibly indicating bottom contact, are evident for stations 18, 28, 62 and 72.

* Deeper fluorescence data are slightly negative in value, due to the calibration coefficients supplied.

* Maximum transmittance values are slightly less than the expected 100%, due to a small calibration error (possibly by referencing to clean water).

1.5.6 Nutrients

No nutrient analyser was available for the cruise, so nutrients were frozen and taken home for analysis. Analyses were done by Christine Rees at CSIRO and on the RV Investigator, between March and June 2015. Note that a full set of nutrient samples were collected for all stations, however samples were run for only a selection of stations, due to shortage of funding. Nutrients measured were phosphate, total nitrate (i.e. nitrate+nitrite), and silicate, using a SEAL Autoanalyzer 3 HR (AA3) (a continuous segmented flower analyser).

Nitrate+nitrite versus phosphate data are shown in Figure 1.6. The differing trend for the Mertz data appears to be a real feature, and is also evident in data from the previous cruise au1203 (Rosenberg and Rintoul, unpublished-2). Further assessment of nutrient data quality is given in section 1.7 below, comparing the data to previous cruises.

For most samples, a repeat analysis was done on the same analyser run. In some cases (e.g. stations 134-141) repeat runs were required. The following repeat analysis values were used (either from the same run, or from the repeat run):

* station 20 phosphate – repeat 2 for bottle 19
* station 82 silicate – repeat 3 for bottle 17
* station 92 phosphate – repeat 2 for bottle 1
* station 113 phosphate and nitrate – repeat 2 for bottle 21
* station 134-136 phosphate and nitrate – repeat 3 for all bottles
* station 137 phosphate and nitrate – repeat 2 for all bottles
* station 138-140 phosphate and nitrate – repeat 3 for all bottles
* station 141 phosphate – repeat 4 for bottles 15 and 18, repeat 3 for all other bottles
* station 141 nitrate – repeat 3 for all bottles

To summarize the data quality, nitrate and silicate are considered reasonable. For phosphate, the overall spread is wider than for previous cruises (Figures 1.6, 1.9a and 1.9b), and data are offset by up to ~5% from previous cruises (Figure 1.9a). This is attributed partly to freezing of the samples for storage prior to analysis, and evidenced by the wide variation in phosphate concentrations obtained from different repeat runs. All phosphate data for this cruise should be considered suspect.

1.5.7 Additional CTD data processing/quality notes

* station 38 – bottle 24 deployed closed, so it imploded.

* station 40 – small oxygen noise on downcast from 200 dbar onwards (connectors cleaned after cast)

* station 42 – bottles 13 to 24 tripped on the fly, due to approaching large floe

* stations 47, 55, 56 all near misses (or maybe bottom hits)

* stations 74 to 77 – scatter of salinity residuals possibly due to incorrectly cocked Niskin top caps

* station 91 - some oxygen noise (connectors cleaned after cast)

* station 100 – possible bottom contact

* station 106 – delayed start while pump for CTD door repaired

* station 113 – on first attempt, cast aborted due to ice: didn't keep the data; on real station 113, after firing bottle 21 at 7 m, CTD returned down to 20 m and last 3 bottles fired

* station 137 – discontinuity in profiling due to ship losing heading. Specifically: initial downcast down to 2750 dbar, stayed there 35 min. while ship remanoeuvred; lips not working, so retrieval commenced as ship could not maintain heading - CTD hauled back up to 2100 dbar; downcast then resumed (ship now ~2 nautical miles from original deployment location) driving the ship manually (not in lips), with the ship drifting at ~1 knot, and a large wire angle

* station 138 – done with wind and swell on the portside; drifted over 4 nautical miles during the cast; large loads and wire angles, and CTD door dipping towards the water; upcast mostly at half speed

* For Antarctic shelf data (station 1 to 133), when lowering or raising of the CTD slowed down in regions of significant vertical structure, high variability is at times evident in the profile data. Examples of this are sensor spikes near the bottom of stations 50, 55 and 72. This variability is also evident as sensor drift during bottle stops. In all these cases, similar profile features can be seen in both the primary and secondary data, however primary/secondary sensor data mismatch is more than usual. Possible reasons are highly variable ocean structure (most likely) and sensor time constants (possible contributor). These data are not flagged as suspect, but are perhaps at the limit of what the CTD can accurately measure in a highly variable environment. Other examples are stations 3, 7 and 80, as the CTD slows on bottom approach.

* Many stations occurred around highly variable bottom topography, and in a few cases (e.g. stations 3 and 114) there's a mismatch between bottom depth from the 12 kHz sounder and bottom depth as measured by the CTD (i.e. pressure at bottom of cast + altimeter reading). Clearly the CTD does not always lie in the measurement cone of the sounder; and bottom picking of sounder data (during quality control) can be difficult in highly variable topography.

1.6 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 (all depths from the water surface, and calculated using sound speed 1445 m/s).

1 minute instantaneous underway data are contained in the file au1402.ora as column formatted text; and in the file au1402ora.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 (Figures 1.7 and 1.8). In both cases a simple offset correction appears best (Figures 1.8a and b), with the S_{dls}-S_{CTD} difference for the cruise approximately equal to -0.038 (PSS78), and the T_{dls}-T_{CTD} difference for the cruise approximately equal to +0.018 (^{o}C). Note that these comparisons have not been applied to the underway data.

1.7 INTERCRUISE COMPARISONS

Intercruise comparisons of nitrate vs phosphate, silicate and dissolved oxygen bottle data compare data from cruise au1402 with previous cruises. At the south end of SR3, comparisons are made to Aurora Australis cruises au9407, au9404, au0103, au0803, au0806 and au1121, ranging over the years 1994 to 2011 (Figures 1.9a, 1.10a and 1.11a). For shelf data in the Mertz region, comparisons are made to Aurora Australis cruises au0803, au1121 and au1203 (Figures 1.9b, 1.10b and 1.11b).

For nitrate vs phosphate, at the south end of SR3 the au1402 phosphates are lower than the other cruises (except for au0103) by ~0.1 µmol/l, as well as being more widely scattered (Figure 1.9a). From the bulk plot of shelf stations in the Mertz region (Figure 1.9b), au1402 phosphates agree well with other cruises at higher concentrations (i.e. deeper samples), though the scatter is wider. For lower concentrations (i.e. shallower samples), the trends followed by au1402 and 1203 are in agreement, but they diverge from the au1121 and au0803 data. This is not investigated further here. Au0103 data, seen as an apparent outlier in Figure 1.9a, have been discussed in previous data reports (with au0103 phosphates in general agreement with the 1996 cruise au9601). For phosphates in general. intercruise variability is most likely due to variation in autoanalyser performance (specific reasons unknown), and due to the freezing of samples for au1402. Phosphate results have previously shown significant intercruise offsets (Rosenberg and Rintoul, unpublished-1).

For silicate, at the south end of SR3 the au1402 data lie mostly at the lower end of the intercruise scatter (Figure 1.10a). From the bulk plot of shelf stations in the Mertz region (Figure 1.10b), there appears to be an overall drop in silicates below 100 m as follows:
au1402 < au1203 and au1121 by ~3 µmol/l
au1402 < au0803 by ~6 µmol/l

For dissolved oxygen, at the south end of SR3 the au1402 data lie mostly within the intercruise scatter. From the bulk plot of shelf stations in the Mertz region (Figure 1.11b), cruises au1402 and au1121 overlay, but are both less than au1203 and au0803 by ~4 µmol/l.

For the above trends seen in the shelf stations for the silicate and dissolved oxygen data (Figures 1.10b and 1.11b), it would be useful to compare coinciding stations, rather than just the bulk regional plots. This is not undertaken here.

1.8 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, and in situ CTD salinity at which each Niskin bottle was fired; zero pressure. Note that laboratory temperature for all the nutrient runs, run over several weeks, ranged from 19.2 to 24.1^{o}C; a mean value of 22.0^{o}C (over all the runs) was used.

Table 1.1: **Summary of station information for cruise au1402. All times are UTC; "alt" = minimum altimeter value (m), "maxp" = maximum pressure (dbar). Note: "Totten" refers to Dalton Polynya/Moscow University Iceshelf/Totten Glacier region.**

	start of CTD					bottom of CTD				end of CTD					
CTD station	date	time	latitude	longitude	depth	time	latitude	longitude	depth	time	latitude	longitude	depth	alt	maxp
001 test	25 Dec 2014	082143	66 25.09 S	120 18.90 E	499	083149	66 25.07 S	120 18.89 E	498	084142	66 25.04 S	120 19.00 E	498	-	215
002 Totten	25 Dec 2014	113158	66 22.03 S	120 31.67 E	503	114408	66 22.04 S	120 31.67 E	501	123313	66 22.11 S	120 31.63 E	506	9.5	497
003 Totten	25 Dec 2014	155206	66 44.88 S	119 56.39 E	419	160655	66 44.86 S	119 56.44 E	505	163626	66 44.96 S	119 56.39 E	410	10.6	500
004 Totten	26 Dec 2014	084332	66 07.60 S	120 27.72 E	571	085659	66 07.60 S	120 27.75 E	570	094018	66 07.54 S	120 28.12 E	571	4.8	571
005 Totten	26 Dec 2014	113850	66 02.83 S	119 59.08 E	507	115429	66 02.89 S	119 59.10 E	504	123123	66 03.03 S	119 59.14 E	506	8.7	501
006 Totten	26 Dec 2014	141549	66 08.92 S	119 57.89 E	501	142828	66 08.92 S	119 57.94 E	502	150446	66 08.85 S	119 57.56 E	490	8.8	498
007 Totten	26 Dec 2014	162327	66 15.02 S	119 55.94 E	522	163344	66 15.04 S	119 56.01 E	523	170449	66 15.11 S	119 56.23 E	522	10.5	518
008 Totten	26 Dec 2014	183800	66 20.89 S	119 53.03 E	658	184942	66 20.92 S	119 53.15 E	657	192422	66 20.99 S	119 53.25 E	658	9.9	654
009 Totten	26 Dec 2014	232512	66 27.27 S	119 48.23 E	706	233740	66 27.22 S	119 48.10 E	699	002113	66 27.19 S	119 47.56 E	689	4.5	703
010 Totten	27 Dec 2014	015646	66 33.04 S	119 48.50 E	715	021126	66 33.07 S	119 48.50 E	754	024432	66 33.08 S	119 48.83 E	692	8.4	754
011 Totten	27 Dec 2014	040155	66 38.96 S	119 54.10 E	442	041243	66 39.04 S	119 54.20 E	456	044146	66 39.05 S	119 54.37 E	451	10.2	451
012 Totten	27 Dec 2014	132220	66 53.88 S	119 23.02 E	985	134148	66 53.88 S	119 23.02 E	1003	142738	66 53.88 S	119 23.02 E	987	9.4	1006
013 Totten	27 Dec 2014	174718	66 46.31 S	119 56.76 E	266	175400	66 46.33 S	119 56.76 E	269	181746	66 46.35 S	119 56.90 E	278	9.1	262
014 Totten	27 Dec 2014	191746	66 45.46 S	120 09.78 E	274	192342	66 45.47 S	120 09.83 E	279	194720	66 45.49 S	120 09.86 E	277	6.3	276
015 Totten	27 Dec 2014	210129	66 44.71 S	120 20.03 E	233	210527	66 44.70 S	120 19.99 E	230	212928	66 44.70 S	120 20.06 E	230	5.8	227
016 Totten	27 Dec 2014	223557	66 44.13 S	120 33.05 E	360	224347	66 44.16 S	120 33.10 E	360	230716	66 44.21 S	120 33.34 E	354	4.3	359
017 Totten	28 Dec 2014	002817	66 43.06 S	120 42.33 E	200	003542	66 43.07 S	120 42.41 E	201	005226	66 43.09 S	120 42.47 E	198	4.8	198
018 Totten	28 Dec 2014	021055	66 38.99 S	120 51.79 E	229	021514	66 39.00 S	120 51.73 E	237	023914	66 38.98 S	120 51.59 E	229	2.0	238
019 Totten	28 Dec 2014	040315	66 36.05 S	121 01.33 E	241	040841	66 36.08 S	121 01.34 E	239	043137	66 36.16 S	121 01.32 E	237	5.5	236
020 Totten	28 Dec 2014	055115	66 33.56 S	121 13.60 E	230	055524	66 33.56 S	121 13.66 E	229	061742	66 33.59 S	121 13.70 E	229	5.0	227
021 Totten	28 Dec 2014	115818	66 25.51 S	119 53.46 E	736	121440	66 25.47 S	119 53.30 E	745	125253	66 25.47 S	119 53.37 E	743	7.5	746
022 Totten	28 Dec 2014	141210	66 29.16 S	119 57.22 E	718	142513	66 29.17 S	119 57.14 E	718	150831	66 29.12 S	119 57.08 E	723	5.1	722
023 Totten	28 Dec 2014	163116	66 32.21 S	120 01.49 E	580	164321	66 32.25 S	120 01.49 E	606	171304	66 32.38 S	120 01.46 E	573	9.9	603
024 Totten	28 Dec 2014	183937	66 34.57 S	120 06.75 E	499	184907	66 34.60 S	120 06.70 E	506	191813	66 34.56 S	120 06.44 E	441	8.4	503
025 Totten	28 Dec 2014	235027	66 38.90 S	120 12.44 E	372	000046	66 38.93 S	120 12.34 E	382	002356	66 38.96 S	120 12.17 E	372	8.6	378
026 Totten	29 Dec 2014	014837	66 43.45 S	120 18.21 E	310	015600	66 43.47 S	120 18.20 E	318	022009	66 43.39 S	120 18.52 E	318	6.8	315
027 Totten	29 Dec 2014	032501	66 36.07 S	120 19.07 E	316	033122	66 36.08 S	120 19.11 E	321	035706	66 36.10 S	120 19.13 E	312	7.1	317
028 Totten	29 Dec 2014	053155	66 32.17 S	120 18.01 E	466	054228	66 32.16 S	120 18.13 E	475	061029	66 32.19 S	120 18.22 E	465	8.1	472
029 Totten	29 Dec 2014	071005	66 28.75 S	120 19.00 E	601	072325	66 28.73 S	120 19.02 E	600	075453	66 28.76 S	120 19.07 E	601	5.8	601
030 Totten	29 Dec 2014	091531	66 24.02 S	120 18.83 E	465	092614	66 24.06 S	120 18.91 E	466	095201	66 24.19 S	120 19.00 E	465	9.1	462
031 Totten	30 Dec 2014	023152	66 46.10 S	118 43.57 E	391	024126	66 46.09 S	118 43.55 E	409	030535	66 46.13 S	118 43.52 E	404	5.5	407
032 Totten	30 Dec 2014	043933	66 52.63 S	118 28.94 E	481	044833	66 52.63 S	118 28.94 E	505	051956	66 52.64 S	118 28.94 E	480	8.4	502
033 Totten	30 Dec 2014	162739	66 52.88 S	117 45.22 E	690	164732	66 52.87 S	117 45.22 E	802	173949	66 52.90 S	117 45.16 E	641	7.2	804
034 Totten	31 Dec 2014	235747	66 32.34 S	116 20.78 E	657	001159	66 32.40 S	116 20.65 E	718	004024	66 32.40 S	116 20.74 E	627	8.0	718
035 Totten	01 Jan 2015	060254	66 36.61 S	116 25.25 E	890	061948	66 36.56 S	116 25.28 E	915	070341	66 36.75 S	116 25.36 E	912	8.1	918
036 Totten	01 Jan 2015	084119	66 39.02 S	116 26.93 E	1098	090120	66 39.07 S	116 27.07 E	1096	095108	66 39.11 S	116 27.29 E	1007	7.8	1102
037 Totten	01 Jan 2015	120529	66 43.17 S	116 32.08 E	584	121511	66 43.15 S	116 32.09 E	591	124614	66 43.23 S	116 32.03 E	585	9.0	588
038 Totten	01 Jan 2015	141018	66 47.84 S	116 37.46 E	510	142109	66 47.83 S	116 37.46 E	509	145435	66 47.80 S	116 37.55 E	508	9.0	506

Table 1.1: (continued)

CTD station	date	start of CTD time	latitude	longitude	depth	bottom of CTD time	latitude	longitude	depth	end of CTD time	latitude	longitude	depth	alt	maxp
039 Totten	01 Jan 2015	163039	66 47.90 S	116 47.22 E	428	164121	66 47.90 S	116 47.25 E	426	170817	66 47.88 S	116 47.24 E	427	10.0	421
040 Totten	01 Jan 2015	180822	66 47.72 S	116 56.97 E	704	182324	66 47.66 S	116 57.07 E	766	185420	66 47.60 S	116 56.92 E	742	9.2	766
041 Totten	01 Jan 2015	221504	66 49.67 S	117 09.44 E	663	222907	66 49.67 S	117 09.44 E	662	225948	66 49.67 S	117 09.44 E	660	4.7	665
042 Totten	02 Jan 2015	001333	66 49.15 S	117 21.74 E	440	002234	66 49.15 S	117 21.74 E	440	004224	66 49.15 S	117 21.74 E	440	7.9	437
043 Totten	02 Jan 2015	014321	66 48.83 S	117 34.10 E	402	015252	66 48.82 S	117 34.01 E	428	021758	66 48.82 S	117 34.00 E	403	8.2	424
044 Totten	02 Jan 2015	114855	66 35.96 S	119 51.29 E	523	115842	66 35.98 S	119 51.19 E	528	122941	66 36.00 S	119 51.14 E	517	7.0	526
045 Totten	02 Jan 2015	135010	66 27.10 S	119 54.26 E	664	140406	66 27.11 S	119 54.29 E	672	143341	66 27.13 S	119 54.27 E	664	6.1	673
046 Totten	03 Jan 2015	085002	66 33.69 S	119 10.78 E	686	090610	66 33.70 S	119 10.94 E	693	094315	66 33.70 S	119 11.20 E	679	9.9	691
047 Totten	03 Jan 2015	105627	66 35.63 S	119 22.25 E	567	110811	66 35.63 S	119 22.17 E	590	113915	66 35.57 S	119 22.13 E	572	7.6	589
048 Totten	03 Jan 2015	124552	66 37.99 S	119 31.56 E	477	125724	66 37.99 S	119 31.60 E	482	132430	66 37.98 S	119 31.52 E	476	5.9	482
049 Totten	03 Jan 2015	172918	66 21.52 S	119 41.50 E	633	174153	66 21.54 S	119 41.45 E	633	180705	66 21.55 S	119 41.41 E	633	6.1	634
050 Totten	03 Jan 2015	191828	66 22.41 S	119 30.14 E	661	193216	66 22.39 S	119 30.17 E	660	200314	66 22.39 S	119 30.07 E	661	5.5	662
051 Totten	03 Jan 2015	210727	66 22.03 S	119 18.92 E	851	212336	66 21.98 S	119 19.10 E	854	215858	66 21.88 S	119 18.94 E	855	5.7	859
052 Totten	03 Jan 2015	225813	66 19.78 S	119 08.90 E	843	231617	66 19.85 S	119 08.89 E	842	235352	66 19.97 S	119 08.81 E	842	5.7	846
053 Totten	04 Jan 2015	074027	66 08.71 S	119 48.38 E	515	075241	66 08.73 S	119 48.35 E	512	082702	66 08.79 S	119 48.46 E	514	5.6	512
054 Totten	04 Jan 2015	113853	66 10.48 S	120 51.99 E	288	114654	66 10.53 S	120 51.98 E	288	121130	66 10.67 S	120 52.18 E	286	4.6	287
055 Totten	04 Jan 2015	134209	66 14.73 S	120 29.87 E	474	135240	66 14.72 S	120 29.87 E	473	142036	66 14.74 S	120 29.84 E	474	5.6	473
056 Totten	04 Jan 2015	152457	66 18.23 S	120 18.56 E	440	153648	66 18.22 S	120 18.54 E	442	160136	66 18.22 S	120 18.50 E	442	6.1	441
057 Totten	04 Jan 2015	170425	66 21.06 S	120 09.10 E	521	171529	66 21.07 S	120 09.13 E	522	174319	66 21.11 S	120 09.13 E	521	4.1	524
058 Totten	04 Jan 2015	185915	66 24.14 S	119 59.62 E	714	191426	66 24.16 S	119 59.60 E	715	194429	66 24.20 S	119 59.47 E	718	7.1	717
059 Totten	04 Jan 2015	204631	66 28.00 S	120 05.41 E	737	210003	66 28.02 S	120 05.41 E	750	213301	66 28.11 S	120 05.51 E	707	8.9	750
060 Totten	04 Jan 2015	224111	66 28.07 S	120 12.41 E	633	225502	66 28.09 S	120 12.59 E	635	232455	66 28.16 S	120 12.83 E	642	8.4	634
061 Totten	05 Jan 2015	002619	66 28.92 S	120 16.98 E	620	003813	66 28.94 S	120 17.08 E	624	010822	66 28.91 S	120 16.96 E	624	9.8	622
062 Totten	05 Jan 2015	021739	66 30.08 S	120 23.88 E	581	023026	66 30.08 S	120 23.81 E	595	030116	66 30.11 S	120 23.80 E	575	7.9	594
063 Totten	05 Jan 2015	040416	66 31.80 S	120 30.47 E	503	041434	66 31.81 S	120 30.47 E	502	045410	66 31.94 S	120 30.56 E	498	10.0	497
064 Totten	05 Jan 2015	055126	66 33.97 S	120 31.77 E	454	060153	66 33.96 S	120 31.79 E	460	063054	66 33.98 S	120 31.81 E	457	10.3	454
065 Totten	05 Jan 2015	072934	66 36.96 S	120 35.24 E	361	073747	66 36.97 S	120 35.27 E	371	080253	66 36.98 S	120 35.28 E	354	9.1	366
066 Totten	05 Jan 2015	090229	66 40.04 S	120 38.96 E	306	091120	66 40.04 S	120 39.14 E	355	093850	66 40.23 S	120 39.18 E	344	8.4	350
067 Totten	05 Jan 2015	111054	66 46.06 S	120 48.75 E	190	111710	66 46.06 S	120 48.75 E	192	113335	66 46.06 S	120 48.75 E	190	6.0	188
068 Totten	05 Jan 2015	125017	66 45.07 S	120 35.17 E	516	130041	66 45.08 S	120 35.26 E	517	132713	66 45.01 S	120 35.18 E	511	18.7	504
069 Totten	05 Jan 2015	144619	66 37.78 S	120 42.52 E	242	145301	66 37.78 S	120 42.53 E	250	151500	66 37.76 S	120 42.55 E	241	10.5	242
070 Totten	05 Jan 2015	162025	66 34.09 S	120 49.51 E	385	163107	66 34.06 S	120 49.46 E	382	165344	66 34.02 S	120 49.37 E	380	6.8	379
071 Totten	05 Jan 2015	181502	66 29.85 S	120 56.95 E	292	182504	66 29.85 S	120 56.97 E	293	184608	66 29.85 S	120 56.98 E	292	6.2	289
072 Totten	07 Jan 2015	074344	66 20.97 S	120 19.05 E	446	075418	66 20.95 S	120 18.99 E	447	082834	66 20.95 S	120 18.79 E	454	6.3	446
073 Totten	07 Jan 2015	113925	66 51.57 S	119 44.93 E	407	114919	66 51.52 S	119 45.05 E	477	122027	66 51.51 S	119 45.63 E	361	4.9	478
074 Totten	07 Jan 2015	135000	66 43.68 S	119 48.62 E	710	140442	66 43.67 S	119 48.67 E	745	143847	66 43.67 S	119 48.67 E	699	20.0	734
075 Totten	08 Jan 2015	013353	66 05.98 S	120 38.72 E	516	014533	66 05.93 S	120 38.65 E	516	021242	66 05.79 S	120 38.77 E	514	4.3	517
076 Totten	08 Jan 2015	031315	66 02.30 S	120 30.76 E	518	032524	66 02.36 S	120 30.77 E	521	035529	66 02.36 S	120 30.56 E	517	5.8	521

Table 1.1: (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
077 Totten	08 Jan 2015	045106	65 58.16 S	120 28.42 E	485	050150	65 58.16 S	120 28.37 E	483	053005	65 58.19 S	120 28.22 E	485	5.8	482
078 Totten	08 Jan 2015	064955	65 50.82 S	120 42.16 E	438	065950	65 50.87 S	120 42.07 E	439	072831	65 50.81 S	120 42.55 E	437	5.3	438
079 Totten	08 Jan 2015	084706	65 54.55 S	120 27.56 E	449	085601	65 54.56 S	120 27.55 E	449	092607	65 54.59 S	120 27.53 E	448	4.8	449
080 Totten	08 Jan 2015	143803	65 58.78 S	120 08.73 E	488	144719	65 58.81 S	120 08.76 E	488	152017	65 58.84 S	120 08.88 E	488	9.3	483
081 Totten	08 Jan 2015	164930	65 54.70 S	120 14.68 E	462	170049	65 54.68 S	120 14.74 E	462	171807	65 54.67 S	120 14.78 E	462	9.9	457
082 Totten	08 Jan 2015	201110	65 46.93 S	120 56.82 E	357	202031	65 46.92 S	120 56.89 E	359	204229	65 46.90 S	120 56.95 E	356	10.0	352
083 Mertz	11 Jan 2015	142434	66 20.59 S	143 17.74 E	684	144248	66 20.55 S	143 17.52 E	685	151356	66 20.54 S	143 17.08 E	699	6.4	687
084 Mertz	11 Jan 2015	183653	66 35.90 S	144 12.77 E	812	185223	66 35.94 S	144 12.87 E	812	192542	66 35.97 S	144 12.87 E	812	4.8	817
085 Mertz	11 Jan 2015	214021	66 45.71 S	144 22.40 E	893	215808	66 45.62 S	144 22.10 E	891	224008	66 45.38 S	144 21.44 E	893	10.3	891
086 Mertz	12 Jan 2015	065941	67 11.90 S	144 42.98 E	311	070827	67 11.96 S	144 42.97 E	334	073547	67 12.01 S	144 42.93 E	338	5.1	332
087 Mertz	12 Jan 2015	084819	67 09.08 S	144 54.11 E	584	090021	67 09.08 S	144 54.17 E	614	093226	67 08.96 S	144 53.95 E	574	4.1	617
088 Mertz	12 Jan 2015	104645	67 05.24 S	145 02.77 E	1112	110711	67 05.24 S	145 02.99 E	1099	114654	67 05.31 S	145 03.25 E	1100	7.9	1105
089 Mertz	12 Jan 2015	140946	66 58.09 S	145 23.74 E	817	142514	66 58.07 S	145 23.84 E	813	150301	66 58.16 S	145 24.17 E	793	4.3	818
090 Mertz	12 Jan 2015	162837	66 54.50 S	145 31.12 E	638	164113	66 54.48 S	145 31.05 E	642	171326	66 54.46 S	145 31.27 E	630	10.1	639
091 Mertz	12 Jan 2015	185619	66 49.86 S	145 38.48 E	518	190751	66 49.82 S	145 38.71 E	517	193517	66 49.59 S	145 38.86 E	507	6.3	517
092 Mertz	12 Jan 2015	210458	66 46.48 S	145 49.33 E	435	211450	66 46.44 S	145 49.40 E	434	214128	66 46.30 S	145 49.66 E	433	5.9	433
093 Mertz	12 Jan 2015	224217	66 42.72 S	145 58.00 E	345	224926	66 42.68 S	145 57.93 E	345	231125	66 42.58 S	145 58.23 E	345	8.6	340
094 Mertz	13 Jan 2015	000836	66 38.70 S	146 05.05 E	273	001541	66 38.69 S	146 05.20 E	271	003631	66 38.75 S	146 05.53 E	269	5.2	269
095 Mertz	13 Jan 2015	015717	66 34.61 S	146 15.04 E	228	020430	66 34.57 S	146 15.04 E	227	022418	66 34.49 S	146 15.02 E	230	5.5	224
096 Mertz	13 Jan 2015	111602	67 16.33 S	145 56.88 E	671	112938	67 16.33 S	145 56.87 E	672	120925	67 16.33 S	145 56.81 E	671	5.8	674
097 Mertz	13 Jan 2015	133557	67 14.35 S	145 49.76 E	761	135107	67 14.35 S	145 49.69 E	758	142444	67 14.31 S	145 49.53 E	758	5.8	761
098 Mertz	13 Jan 2015	153416	67 13.61 S	145 39.90 E	856	155108	67 13.64 S	145 39.94 E	857	162707	67 13.68 S	145 39.65 E	858	5.8	861
099 Mertz	13 Jan 2015	174206	67 12.94 S	145 28.68 E	1156	181936	67 12.90 S	145 28.81 E	1153	190949	67 12.90 S	145 28.74 E	1156	9.3	1159
100 Mertz	13 Jan 2015	203853	67 09.66 S	145 27.05 E	1129	205813	67 09.68 S	145 27.02 E	1127	214151	67 09.58 S	145 26.99 E	1129	0.2	1141
101 Mertz	13 Jan 2015	225339	67 07.08 S	145 18.20 E	1261	231913	67 07.16 S	145 18.14 E	1268	000546	67 07.25 S	145 18.28 E	1270	7.8	1277
102 Mertz	14 Jan 2015	011808	67 05.36 S	145 10.83 E	1300	014229	67 05.35 S	145 10.85 E	1305	023545	67 05.37 S	145 10.82 E	1301	6.0	1317
103 Mertz	14 Jan 2015	033939	67 03.26 S	145 10.64 E	1303	040313	67 03.22 S	145 10.36 E	1300	045309	67 03.08 S	145 09.64 E	1251	5.7	1311
104 Mertz	14 Jan 2015	073106	67 02.33 S	145 14.15 E	1141	075221	67 02.23 S	145 13.88 E	1144	084613	67 01.94 S	145 13.16 E	1149	5.0	1153
105 Mertz	14 Jan 2015	112719	66 56.62 S	144 57.58 E	1023	114516	66 56.48 S	144 57.25 E	1021	123602	66 56.44 S	144 56.88 E	1024	6.3	1027
106 Mertz	14 Jan 2015	142437	66 52.32 S	144 40.33 E	1019	144248	66 52.27 S	144 40.06 E	1018	152243	66 52.19 S	144 39.44 E	1021	9.2	1022
107 Mertz	14 Jan 2015	191755	66 25.17 S	145 12.32 E	389	192907	66 25.18 S	145 12.30 E	389	195516	66 25.18 S	145 12.28 E	389	5.5	388
108 Mertz	14 Jan 2015	210437	66 29.27 S	145 02.12 E	414	211219	66 29.33 S	145 02.02 E	415	213826	66 29.54 S	145 01.66 E	420	9.5	410
109 Mertz	14 Jan 2015	225232	66 33.83 S	144 58.26 E	452	230305	66 33.87 S	144 58.18 E	456	233021	66 33.87 S	144 57.34 E	461	6.8	454
110 Mertz	15 Jan 2015	004925	66 38.30 S	144 44.47 E	629	010202	66 38.27 S	144 44.32 E	629	013625	66 38.25 S	144 44.39 E	624	7.2	629
111 Mertz	15 Jan 2015	023851	66 41.67 S	144 37.81 E	824	025544	66 41.63 S	144 37.87 E	823	033452	66 41.70 S	144 37.84 E	824	5.4	828
112 Mertz	15 Jan 2015	044420	66 44.69 S	144 41.05 E	832	045934	66 44.67 S	144 40.99 E	831	053536	66 44.71 S	144 40.93 E	833	9.1	832
113 Mertz	15 Jan 2015	080010	66 48.38 S	144 24.20 E	966	081737	66 48.28 S	144 23.56 E	965	090307	66 48.00 S	144 21.86 E	934	9.6	967
114 Mertz	15 Jan 2015	100756	66 49.68 S	144 17.95 E	557	101930	66 49.66 S	144 17.99 E	611	104918	66 49.69 S	144 17.90 E	561	54.7	563

Table 1.1: (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
115 Mertz	15 Jan 2015	115919	66 46.17 S	144 10.44 E	915	121711	66 46.19 S	144 10.18 E	922	125528	66 45.95 S	144 08.79 E	903	9.0	924
116 Mertz	15 Jan 2015	141030	66 43.12 S	143 59.29 E	876	142949	66 43.07 S	143 58.74 E	875	150706	66 43.20 S	143 57.88 E	859	5.0	880
117 Mertz	15 Jan 2015	165233	66 31.58 S	143 56.58 E	759	170837	66 31.57 S	143 56.56 E	758	174343	66 31.60 S	143 56.51 E	761	5.7	761
118 Mertz	15 Jan 2015	190128	66 36.38 S	143 42.94 E	743	191649	66 36.40 S	143 42.74 E	742	195009	66 36.59 S	143 42.34 E	740	9.0	741
119 Mertz	15 Jan 2015	210537	66 34.15 S	143 32.29 E	724	211907	66 34.13 S	143 32.32 E	724	215628	66 33.86 S	143 32.51 E	731	5.1	727
120 Mertz	15 Jan 2015	225211	66 30.82 S	143 28.13 E	753	230816	66 30.75 S	143 28.02 E	750	234202	66 30.42 S	143 27.53 E	747	6.1	752
121 Mertz	16 Jan 2015	003853	66 27.44 S	143 37.78 E	713	005256	66 27.49 S	143 37.54 E	714	012858	66 27.43 S	143 37.35 E	711	8.8	713
122 Mertz	16 Jan 2015	030929	66 22.40 S	143 49.90 E	584	032136	66 22.36 S	143 49.94 E	583	035625	66 22.23 S	143 50.11 E	582	5.2	584
123 Mertz	16 Jan 2015	044604	66 19.64 S	143 58.72 E	500	045545	66 19.67 S	143 58.64 E	502	052438	66 19.67 S	143 58.43 E	499	5.0	502
124 Mertz	16 Jan 2015	062309	66 12.89 S	144 01.80 E	431	063053	66 12.91 S	144 01.78 E	430	070417	66 12.86 S	144 01.51 E	429	5.3	430
125 Mertz	16 Jan 2015	080032	66 12.00 S	143 46.75 E	472	081014	66 12.00 S	143 46.76 E	473	083951	66 12.05 S	143 46.79 E	471	5.4	472
126 Mertz	16 Jan 2015	093609	66 11.99 S	143 29.08 E	548	094731	66 11.99 S	143 28.97 E	544	101929	66 12.06 S	143 29.09 E	550	5.1	545
127 Mertz	16 Jan 2015	113229	66 11.49 S	143 10.12 E	580	114137	66 11.45 S	143 10.20 E	576	121916	66 11.47 S	143 10.41 E	583	8.6	574
128 Mertz	16 Jan 2015	132130	66 14.67 S	142 53.35 E	551	133112	66 14.66 S	142 53.40 E	550	140427	66 14.63 S	142 53.50 E	551	4.5	552
129 Mertz	17 Jan 2015	120806	66 30.30 S	144 37.84 E	524	121920	66 30.31 S	144 37.79 E	524	125047	66 30.37 S	144 37.72 E	523	5.7	524
130 Mertz	17 Jan 2015	152749	66 20.49 S	144 59.93 E	386	153607	66 20.47 S	145 00.05 E	392	160800	66 20.39 S	145 00.44 E	387	4.6	391
131 Mertz	17 Jan 2015	171849	66 20.02 S	144 39.55 E	415	173014	66 20.03 S	144 39.58 E	416	175702	66 20.09 S	144 39.61 E	417	4.3	416
132 Mertz	17 Jan 2015	190835	66 20.06 S	144 20.19 E	448	191720	66 20.06 S	144 20.14 E	449	194205	66 20.05 S	144 20.02 E	449	8.9	445
133 Mertz	18 Jan 2015	082141	66 11.02 S	142 41.72 E	385	082958	66 10.96 S	142 41.79 E	385	085610	66 10.81 S	142 41.89 E	389	3.9	385
134 SR3	18 Jan 2015	183536	65 04.22 S	139 51.14 E	2479	192306	65 04.22 S	139 51.07 E	2526	205217	65 04.34 S	139 50.81 E	2523	9.4	2557
135 SR3	18 Jan 2015	224335	64 48.85 S	139 51.06 E	2562	232737	64 48.68 S	139 50.90 E	2564	005415	64 48.68 S	139 50.87 E	2573	10.7	2595
136 SR3	19 Jan 2015	023525	64 33.01 S	139 50.99 E	3054	033047	64 32.99 S	139 50.98 E	3050	051645	64 32.90 S	139 50.49 E	3061	9.3	3093
137 SR3	19 Jan 2015	092518	64 12.47 S	139 49.19 E	3508	112407	64 13.48 S	139 45.33 E	3488	132615	64 15.20 S	139 43.39 E	3453	19.6	3532
138 SR3	19 Jan 2015	163721	63 51.97 S	139 51.70 E	3702	174331	63 53.34 S	139 52.15 E	3697	195740	63 56.84 S	139 53.64 E	3671	17.4	3748
139 SR3	20 Jan 2015	015422	63 20.60 S	139 51.60 E	3777	025153	63 20.26 S	139 53.35 E	3774	051622	63 19.55 S	139 56.65 E	3779	13.9	3831
140 SR3	20 Jan 2015	145127	61 50.65 S	139 50.98 E	4276	162733	61 50.50 S	139 51.88 E	4269	183418	61 50.47 S	139 52.37 E	4270	11.2	4343
141 SR3	20 Jan 2015	214318	61 21.23 S	139 50.85 E	4322	225509	61 21.13 S	139 51.41 E	4317	010643	61 20.90 S	139 52.25 E	4323	12.6	4390

<u>Table 1.2:</u> CTD calibration coefficients and calibration dates for cruise au1402. Note that platinum temperature calibrations are for the ITS-90 scale. Pressure slope/offset, temperature, conductivity and oxygen values are from SeaBird calibrations. Fluorometer and PAR values are manufacturer supplied. Transmissometer values are a rescaling of the manufacturer supplied coefficients to give transmittance as a %, referenced to clean water. For oxygen, the final calibration uses in situ bottle measurements (the manufacturer supplied coefficients are not used).

Primary Temperature, serial 4245, 07/06/2014

G	: 4.38198237e-003
H	: 6.45481759e-004
I	: 2.24519727e-005
J	: 1.83996741e-006
F0	: 1000.000
Slope	: 1.0000000
Offset	: 0.0000

Secondary Temperature, serial 4248, 07/06/2014

G	: 4.38735848e-003
H	: 6.51103222e-004
I	: 2.33781003e-005
J	: 1.88769287e-006
F0	: 1000.000
Slope	: 1.0000000
Offset	: 0.0000

Primary Conductivity, serial 2788, 06/06/2014

G	: -9.73094939e+000
H	: 1.42807667e+000
I	: -3.67341669e-004
J	: 1.17592553e-004
CTcor	: 3.2500e-006
CPcor	: -9.5700000e-008
Slope	: 1.00000000
Offset	: 0.00000

Secondary Conductivity, serial 2821, 06/06/2014

G	: -1.05911956e+001
H	: 1.43436156e+000
I	: 1.11236640e-003
J	: 4.45971069e-006
CTcor	: 3.2500e-006
CPcor	: -9.5700000e-008
Slope	: 1.00000000
Offset	: 0.00000

CTD704 Pressure, serial 89084, 23/06/2014
(for slope, offset only)

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	: 0.9999800
Offset	: -0.06560 (dbar)
AD590M	: 1.283280e-002
AD590B	: -9.705660e+000

Oxygen, serial 0178, 07/06/2014
(for display at time of logging only)

Soc	: 4.79600e-001
Voffset	: -4.95700e-001
A	: -4.28060e-003
B	: 2.14800e-004
C	: -2.94030e-006
E	: 3.60000e-002
Tau20	: 1.25000e+000
D1	: 1.92634e-004
D2	: -4.64803e-002
H1	: -3.30000e-002
H2	: 5.00000e+003
H3	: 1.45000e+003

Transmissometer, serial 1421DR, 18/06/2014
(referenced to clean water)

M	: 21.4557
B	: -0.1502

Path length: 0.25 (m)

Fluorometer, serial 756, 08/05/2014
(analog range 2)

Dark output	: 0.0460
Scale factor	: 1.000e+001

PAR, serial 70110, QCP2300HP, 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 using earlier cruise au1121 dark voltage data)

Table 1.3: CTD conductivity calibration coefficients for cruise au1402. 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 015	0.21722740E-01	0.99933637E-03	-0.13493203E-08	135	0.001227
016 to 100	0.31030850E-01	0.99900002E-03	0.10740518E-09	515	0.001383
101 to 133	0.12091707E-03	0.10001558E-02	-0.41827402E-09	152	0.001136
134 to 141	0.49804622E-02	0.99998371E-03	-0.10160768E-08	100	0.000700

Table 1.4: Station-dependent-corrected conductivity slope term (F_2 + F_3 . N), for station number N, and F_2 and F_3 the conductivity slope and station-dependent correction calibration terms respectively, for cruise au1402.

station number	(F_2 + F_3 . N)	station number	(F_2 + F_3 . N)	station number	(F_2 + F_3 . N)
1	0.99933503E-03	48	0.99900517E-03	95	0.99901022E-03
2	0.99933368E-03	49	0.99900528E-03	96	0.99901033E-03
3	0.99933233E-03	50	0.99900539E-03	97	0.99901043E-03
4	0.99933098E-03	51	0.99900549E-03	98	0.99901054E-03
5	0.99932963E-03	52	0.99900560E-03	99	0.99901065E-03
6	0.99932828E-03	53	0.99900571E-03	100	0.99901076E-03
7	0.99932693E-03	54	0.99900582E-03	101	0.10001136E-02
8	0.99932558E-03	55	0.99900592E-03	102	0.10001131E-02
9	0.99932423E-03	56	0.99900603E-03	103	0.10001127E-02
10	0.99932288E-03	57	0.99900614E-03	104	0.10001123E-02
11	0.99932153E-03	58	0.99900625E-03	105	0.10001119E-02
12	0.99932018E-03	59	0.99900635E-03	106	0.10001115E-02
13	0.99931883E-03	60	0.99900646E-03	107	0.10001111E-02
14	0.99931748E-03	61	0.99900657E-03	108	0.10001106E-02
15	0.99931613E-03	62	0.99900668E-03	109	0.10001102E-02
16	0.99900174E-03	63	0.99900678E-03	110	0.10001098E-02
17	0.99900184E-03	64	0.99900689E-03	111	0.10001094E-02
18	0.99900195E-03	65	0.99900700E-03	112	0.10001090E-02
19	0.99900206E-03	66	0.99900711E-03	113	0.10001085E-02
20	0.99900216E-03	67	0.99900721E-03	114	0.10001081E-02
21	0.99900227E-03	68	0.99900732E-03	115	0.10001077E-02
22	0.99900238E-03	69	0.99900743E-03	116	0.10001073E-02
23	0.99900249E-03	70	0.99900754E-03	117	0.10001069E-02
24	0.99900259E-03	71	0.99900764E-03	118	0.10001065E-02
25	0.99900270E-03	72	0.99900775E-03	119	0.10001060E-02
26	0.99900281E-03	73	0.99900786E-03	120	0.10001056E-02
27	0.99900292E-03	74	0.99900796E-03	121	0.10001052E-02
28	0.99900302E-03	75	0.99900807E-03	122	0.10001048E-02
29	0.99900313E-03	76	0.99900818E-03	123	0.10001044E-02
30	0.99900324E-03	77	0.99900829E-03	124	0.10001039E-02
31	0.99900335E-03	78	0.99900839E-03	125	0.10001035E-02
32	0.99900345E-03	79	0.99900850E-03	126	0.10001031E-02
33	0.99900356E-03	80	0.99900861E-03	127	0.10001027E-02
34	0.99900367E-03	81	0.99900872E-03	128	0.10001023E-02
35	0.99900378E-03	82	0.99900882E-03	129	0.10001019E-02
36	0.99900388E-03	83	0.99900893E-03	130	0.10001014E-02
37	0.99900399E-03	84	0.99900904E-03	131	0.10001010E-02
38	0.99900410E-03	85	0.99900915E-03	132	0.10001006E-02
39	0.99900421E-03	86	0.99900925E-03	133	0.10001002E-02
40	0.99900431E-03	87	0.99900936E-03	134	0.99984755E-03
41	0.99900442E-03	88	0.99900947E-03	135	0.99984654E-03
42	0.99900453E-03	89	0.99900958E-03	136	0.99984552E-03
43	0.99900464E-03	90	0.99900968E-03	137	0.99984451E-03
44	0.99900474E-03	91	0.99900979E-03	138	0.99984349E-03
45	0.99900485E-03	92	0.99900990E-03	139	0.99984247E-03
46	0.99900496E-03	93	0.99901001E-03	140	0.99984146E-03
47	0.99900506E-03	94	0.99901011E-03	141	0.99984044E-03

Table 1.5: Surface pressure offsets (i.e. poff in dbar) for cruise au1402. For each station, these values are subtracted from the pressure calibration "offset" value in Table 1.2.

stn	poff	stn	poff	stn	poff	stn	poff	stn	poff	stn	poff
1	-0.25	26	-0.29	51	-0.21	76	-0.17	101	-0.23	126	-0.19
2	-0.35	27	-0.32	52	-0.22	77	-0.29	102	-0.28	127	-0.19
3	-0.35	28	-0.36	53	-0.25	78	-0.39	103	-0.28	128	-0.22
4	-0.30	29	-0.25	54	-0.30	79	-0.38	104	-0.13	129	-0.08
5	-0.38	30	-0.35	55	-0.24	80	-0.35	105	-0.30	130	-0.17
6	-0.42	31	-0.23	56	-0.25	81	-0.29	106	-0.27	131	-0.15
7	-0.40	32	-0.26	57	-0.23	82	-0.40	107	-0.25	132	-0.22
8	-0.46	33	-0.20	58	-0.27	83	-0.18	108	-0.19	133	-0.15
9	-0.44	34	-0.25	59	-0.23	84	-0.28	109	-0.27	134	-0.17
10	-0.44	35	-0.38	60	-0.27	85	-0.29	110	-0.25	135	-0.28
11	-0.48	36	-0.47	61	-0.21	86	-0.23	111	-0.25	136	-0.39
12	-0.28	37	-0.50	62	-0.32	87	-0.14	112	-0.26	137	-0.46
13	-0.42	38	-0.39	63	-0.25	88	-0.37	113	-0.16	138	-0.49
14	-0.34	39	-0.34	64	-0.25	89	-0.35	114	-0.22	139	-0.35
15	-0.39	40	-0.33	65	-0.28	90	-0.27	115	-0.21	140	-0.11
16	-0.43	41	-0.30	66	-0.25	91	-0.30	116	-0.21	141	-0.10
17	-0.42	42	-0.28	67	-0.27	92	-0.30	117	-0.28		
18	-0.37	43	-0.27	68	-0.23	93	-0.26	118	-0.23		
19	-0.42	44	-0.11	69	-0.31	94	-0.18	119	-0.22		
20	-0.41	45	-0.11	70	-0.25	95	-0.25	120	-0.21		
21	-0.35	46	-0.14	71	-0.27	96	-0.12	121	-0.24		
22	-0.36	47	-0.17	72	-0.21	97	-0.19	122	-0.23		
23	-0.35	48	-0.26	73	-0.35	98	-0.29	123	-0.16		
24	-0.38	49	-0.24	74	-0.38	99	-0.20	124	-0.22		
25	-0.33	50	-0.16	75	-0.32	100	-0.31	125	-0.17		

Table 1.6: CTD dissolved oxygen calibration coefficients for cruise au1402: 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 1.5.4 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).

	shallow					deep				
stn	slope	bias	tcor	pcor	dox	slope	bias	tcor	pcor	dox
1	-	-	-	-	-					
2	0.481665	-0.228203	-0.002665	0.000137	0.072219					
3	0.394725	-0.012042	-0.000809	0.000060	0.051394					
4	0.478520	-0.230500	-0.006989	0.000157	0.089345					
5	0.508339	-0.279500	0.003281	0.000157	0.051189					
6	0.440770	-0.130193	-0.005475	0.000106	0.059352					
7	0.483577	-0.226843	-0.000889	0.000144	0.064154					
8	0.483214	-0.228492	-0.003121	0.000132	0.121441					
9	0.449077	-0.164580	-0.014075	0.000119	0.155384					
10	0.506331	-0.288282	-0.003444	0.000181	0.077713					
11	0.687322	-0.721216	0.003065	0.000392	0.034580					
12	0.466425	-0.216190	-0.017298	0.000152	0.041130					
13	0.434330	-0.083656	0.022492	0.000158	0.112071					
14	0.483313	-0.230670	-0.001205	0.000158	0.013270					
15	0.257875	0.402117	0.073374	0.000077	0.055771					
16	0.400046	-0.006409	0.014218	0.000092	0.046352					
17	0.494927	-0.227992	0.020649	0.000217	0.038141					
18	0.509514	-0.277071	0.010113	0.000231	0.021869					
19	0.210261	0.524082	0.082438	0.000053	0.014664					
20	0.436681	-0.076344	0.030923	0.000167	0.050182					
21	0.458776	-0.185164	-0.011657	0.000141	0.073067					
22	0.504675	-0.283612	-0.003561	0.000175	0.047323					
23	0.508833	-0.281274	0.005105	0.000160	0.086992					
24	0.506642	-0.287392	-0.001139	0.000186	0.027961					
25	0.485465	-0.231101	0.004183	0.000159	0.056367					
26	0.390802	0.020207	0.020388	0.000091	0.030120					

Table 1.6: (continued)

	shallow					deep				
stn	slope	bias	tcor	pcor	dox	slope	bias	tcor	pcor	dox
27	0.400826	0.002107	0.022944	0.000078	0.029591					
28	0.485882	-0.230558	-0.000702	0.000137	0.017181					
29	0.507209	-0.288343	-0.003695	0.000184	0.049158					
30	0.418188	-0.067575	-0.007180	0.000054	0.032060					
31	0.298937	0.199015	0.000848	0.000060	0.024399					
32	0.398390	0.251841	0.150811	0.000060	0.048078					
33	0.501466	-0.280062	-0.008690	0.000155	0.029624					
34	0.483935	-0.234329	-0.004037	0.000146	0.053685					
35	0.507615	-0.283807	-0.003008	0.000163	0.053588					
36	0.287303	0.117095	-0.054522	0.000115	0.081357					
37	0.443583	-0.180470	-0.026909	0.000147	0.018709					
38	0.299150	0.197456	0.004558	0.000071	0.021924					
39	0.392731	-0.013864	0.005652	0.000119	0.022748					
40	0.298193	0.194496	0.004599	0.000090	0.027317					
41	0.374495	-0.036353	-0.035797	0.000126	0.053291					
42	0.395487	-0.012517	0.008861	0.000114	0.022513					
43	0.365511	0.086195	0.029793	0.000105	0.015453					
44	0.511658	-0.290971	0.003252	0.000171	0.083455					
45	0.504615	-0.272416	0.003206	0.000157	0.098977					
46	0.513388	-0.296555	0.001132	0.000166	0.096836					
47	0.486277	-0.229109	0.001116	0.000130	0.038286					
48	0.412470	-0.078429	-0.012578	0.000101	0.045576					
49	0.509786	-0.242044	0.020992	0.000050	0.055103					
50	0.403167	-0.069317	-0.022922	0.000081	0.082097					
51	0.471803	-0.196757	-0.003440	0.000105	0.088431					
52	0.367768	-0.017895	-0.039891	0.000106	0.069265					
53	0.458652	-0.170821	-0.005275	0.000097	0.078408					
54	0.398949	-0.012640	0.013333	0.000109	0.010798					
55	0.443388	-0.121892	0.002418	0.000030	0.106514					
56	0.458094	-0.174078	-0.000140	0.000134	0.120735					
57	0.481741	-0.229187	-0.003864	0.000149	0.084003					
58	0.414464	-0.100008	-0.022269	0.000118	0.050978					
59	0.483779	-0.230229	-0.003060	0.000139	0.104289					
60	0.486603	-0.229331	0.001849	0.000128	0.105384					
61	0.484311	-0.230207	-0.002935	0.000138	0.056882					
62	0.483618	-0.231708	-0.003453	0.000138	0.065737					
63	0.506567	-0.288431	-0.004117	0.000172	0.079465					
64	0.482800	-0.227719	-0.002983	0.000140	0.019839					
65	0.461980	-0.179382	-0.001179	0.000131	0.050887					
66	0.485417	-0.228761	0.000795	0.000149	0.013849					
67	0.461629	-0.176907	-0.000805	0.000138	0.040547					
68	0.311362	0.217599	0.036240	0.000076	0.022410					
69	0.484010	-0.230088	0.000628	0.000168	0.017197					
70	0.459573	-0.169964	-0.001367	0.000109	0.033581					
71	0.420789	-0.058824	0.012027	0.000096	0.020146					
72	0.479940	-0.219824	0.004820	0.000134	0.081669					
73	0.438494	-0.116093	0.003476	0.000109	0.051699					
74	0.481199	-0.225699	-0.002084	0.000140	0.040312					
75	0.480027	-0.227341	-0.002305	0.000146	0.044001					
76	0.477612	-0.213910	-0.001996	0.000116	0.092419					
77	0.481805	-0.223892	-0.001177	0.000133	0.074282					
78	0.510470	-0.280368	0.002765	0.000155	0.137783					
79	0.517402	-0.312786	0.006250	0.000217	0.118564					
80	0.309319	0.121755	-0.041062	0.000019	0.085372					
81	0.400886	-0.070607	-0.018513	0.000106	0.097380					
82	0.487040	-0.228085	0.004301	0.000141	0.086016					
83	0.351021	0.136083	0.052534	0.000120	0.051257					
84	0.440332	-0.096855	0.020746	0.000125	0.075955					
85	0.456075	-0.168437	0.000573	0.000140	0.024284					
86	0.480683	-0.197863	0.022691	0.000192	0.034216					
87	0.457278	-0.119157	0.033666	0.000153	0.036290					
88	0.495867	-0.287895	-0.021714	0.000155	0.078802					
89	0.468846	-0.225357	-0.017407	0.000154	0.040644					
90	0.277679	0.458581	0.143468	0.000098	0.099758					
91	0.523947	-0.378146	-0.047087	0.000159	0.056678					
92	0.508695	-0.285738	-0.003927	0.000158	0.055163					
93	0.511229	-0.296449	-0.004247	0.000174	0.038891					
94	0.517396	-0.261064	0.042920	0.000230	0.045928					
95	0.291663	0.377050	0.135290	0.000017	0.061283					
96	0.488354	-0.138394	0.064242	0.000147	0.057239					

Table 1.6: (continued)

	shallow					deep				
stn	slope	bias	tcor	pcor	dox	slope	bias	tcor	pcor	dox
97	0.451371	0.043932	0.119410	0.000121	0.068991					
98	0.474483	-0.184181	0.015398	0.000144	0.026127					
99	0.431948	-0.030107	0.052894	0.000120	0.068865					
100	0.480480	-0.262144	-0.031157	0.000146	0.094467					
101	0.487576	-0.220992	0.010741	0.000148	0.082024					
102	0.500823	-0.280127	-0.009520	0.000156	0.097963					
103	0.473880	-0.301315	-0.070405	0.000153	0.097269					
104	0.511890	-0.344939	-0.039134	0.000166	0.102704					
105	0.527595	-0.330519	-0.003760	0.000165	0.134356					
106	0.498153	-0.299737	-0.032079	0.000148	0.067583					
107	0.500843	-0.274032	-0.002871	0.000186	0.114890					
108	0.470553	-0.206787	-0.036453	0.000008	0.055614					
109	0.481514	-0.220973	0.004400	0.000170	0.030921					
110	0.498249	-0.267939	-0.004543	0.000166	0.043066					
111	0.498843	-0.295018	-0.025714	0.000152	0.058991					
112	0.485238	-0.230922	-0.001080	0.000146	0.045491					
113	0.485008	-0.212016	0.011707	0.000145	0.046588					
114	0.495081	-0.243392	0.005708	0.000154	0.024551					
115	0.455671	-0.110954	0.036520	0.000137	0.077747					
116	0.459555	-0.142671	0.017821	0.000131	0.039506					
117	0.484256	-0.226260	-0.001293	0.000141	0.040356					
118	0.487820	-0.224931	0.006924	0.000149	0.031054					
119	0.497394	-0.233565	0.020923	0.000168	0.068544					
120	0.544561	-0.473692	-0.088687	0.000162	0.108920					
121	0.483006	-0.220985	0.005262	0.000153	0.083264					
122	0.404014	-0.002306	0.033709	0.000129	0.068087					
123	0.481459	-0.224654	-0.000072	0.000153	0.047364					
124	0.542300	-0.394036	-0.030292	0.000154	0.037636					
125	0.505939	-0.290812	-0.004459	0.000185	0.043383					
126	0.401702	-0.001541	0.033958	0.000143	0.056968					
127	0.509968	-0.280188	0.004168	0.000164	0.070153					
128	0.469980	-0.189727	0.005321	0.000141	0.087042					
129	0.482608	-0.228250	0.002084	0.000156	0.037489					
130	0.511751	-0.304039	0.014393	0.000270	0.084273					
131	0.483655	-0.229850	0.008387	0.000195	0.108565					
132	0.463427	-0.169919	0.022482	0.000199	0.049204					
133	0.406446	0.040173	0.062061	0.000124	0.059455					
134	0.486776	-0.242623	-0.000067	0.000145	0.059864	0.403547	-0.100057	-0.006174	0.000126	0.022436
135	0.488284	-0.237165	-0.002346	0.000135	0.090254	0.387158	-0.002031	-0.100134	0.000060	0.018209
136	0.488502	-0.243678	-0.002425	0.000145	0.063883	0.399220	-0.102535	0.010901	0.000130	0.015287
137	0.484837	-0.240271	0.001796	0.000146	0.065352	0.402164	-0.102956	0.007157	0.000125	0.047315
138	0.484247	-0.235496	0.001529	0.000140	0.025244	0.397057	-0.104517	0.018817	0.000131	0.040459
139	0.486625	-0.245819	0.000561	0.000151	0.044160	0.400170	-0.104010	0.007756	0.000126	0.026879
140	0.482980	-0.240902	0.005023	0.000145	0.043211	0.600974	-0.395584	-0.023927	0.000145	0.026499
141	0.481767	-0.239587	0.004016	0.000148	0.039481	0.396730	-0.076393	-0.009048	0.000108	0.016238

Table 1.7: **Missing data points in 2 dbar-averaged files for cruise au1402. "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 dbar value (i.e. the first bin) not included here as it's missing for most casts.

station	pressure (dbar) where data missing	T	S/C	O	F	PAR	TR	F_up	PAR_up	TR_up
1	4-22	x	x	x	x	x	x			
1	4.216			x						
23	604	x	x	x	x	x	x			
30	4-462				x			x		
39	422	x	x	x	x	x	x	x	x	x
63	4	x	x	x	x	x	x			
65	4	x	x	x	x	x	x			
92	434	x	x	x	x	x	x	x	x	x
137	4	x	x	x	x	x	x			
138	4	x	x	x	x	x	x			
139	4	x	x	x	x	x	x			
140	4	x	x	x	x	x	x			
141	4	x	x	x	x	x	x			

Table 1.8: **Suspect CTD 2 dbar averages (not deleted from the CTD 2 dbar average files) for the indicated parameters, for cruise au1402.**

station	suspect 2 dbar value (dbar)	parameters	comment
54	2-18	temp, cond, sal, ox	sensors probably frozen
94	4-20	ox	possibly high by ~6 umol/l

Table 1.9: **Obvious bad salinity bottle samples (not deleted from bottle data file) for cruise au1402 (note: there may be other less obvious ones).**

station	rosette position
30	21
76	19
24	1,3,5,7,9,11,15,21
49	13

Table 1.10: **Suspect nutrient sample values (not deleted from bottle data file) for cruise au1402. For phosphate, the suspect values in the table below are all low by ~2 to 3.5% of full scale, where full scale for phosphate = 3.0 μmol/l. (Note: overall, phosphate data are suspect for the whole cruise, as discussed in the report.)**

PHOSPHATE		NITRATE		SILICATE	
station number	rosette position	station number	rosette position	station number	rosette position
18	5	-		-	
37	9, 17				
54	5				
62	15				
79	1, 24				
90	5				
141	2				

Table 1.11: Scientific personnel (cruise participants) for cruise au1402, post Casey resupply.

Ben Jokinen	glider, CTD, RAFOS sound sources
Alex Nauels	CTD
Alejandro Orsi	CTD, moorings
Beatriz Pena-Molino	CTD
Steve Rintoul	CTD
Mark Rosenberg	moorings, CTD
Kate Snow	CTD
Esmee van Wijk	CTD, Argo equivalent floats
Kelly Brown	hydrochemistry (oxygen)
Craig Neill	hydrochemistry (salinity)
Kate Berry	carbon
Erik van Ooijen	carbon
Abe Passmore	carbon
Felix Ho	phytoplankton
Yann Robiou du Pont	phytoplankton
Seanan Wild	phytoplankton
Andrew Cawthorn	gear officer
Tony Foy	voyage leader
Grant Jasiunas	doctor
Peter (Elwood) Mantel	electronics
Jukka Pirhonen	comms
Lloyd Symons	programmer, deputy voyage leader
Paul Brown	Australian Maritime College observer

Table 1.12: Summary of 'Argo equivalent' float deployments (for an ice float pilot study) on cruise au1402 (depths are from underway data file: depth from surface, sound speed 1445 m/s)

WMO ID	position		time	depth (m)
Totten				
7900396	66° 22.2' S	120° 31.2' E	1257, 25/12/2014	502
7900397	66° 07.8' S	120° 28.2' E	0955, 26/12/2014	570
7900398	66° 25.2' S	119° 54.0' E	1303, 28/12/2014	740
7900602	66° 36.6' S	116° 25.2' E	0735, 01/01/2015	892
7900603	66° 36.0' S	120° 00.0' E	1636, 07/01/2015	465
Mertz				
7900604	67° 02.4' S	145° 02.4' E	1018, 14/01/2015	758
7900605	66° 56.4' S	144° 56.4' E	1249, 14/01/2015	1035
7900606	66° 52.2' S	144° 37.8' E	1608, 14/01/2015	1033
7900607	66° 47.4' S	144° 21.6' E	0919, 15/01/2015	968
7900608	66° 30.0' S	145° 03.0' E	1407, 17/01/2015	416

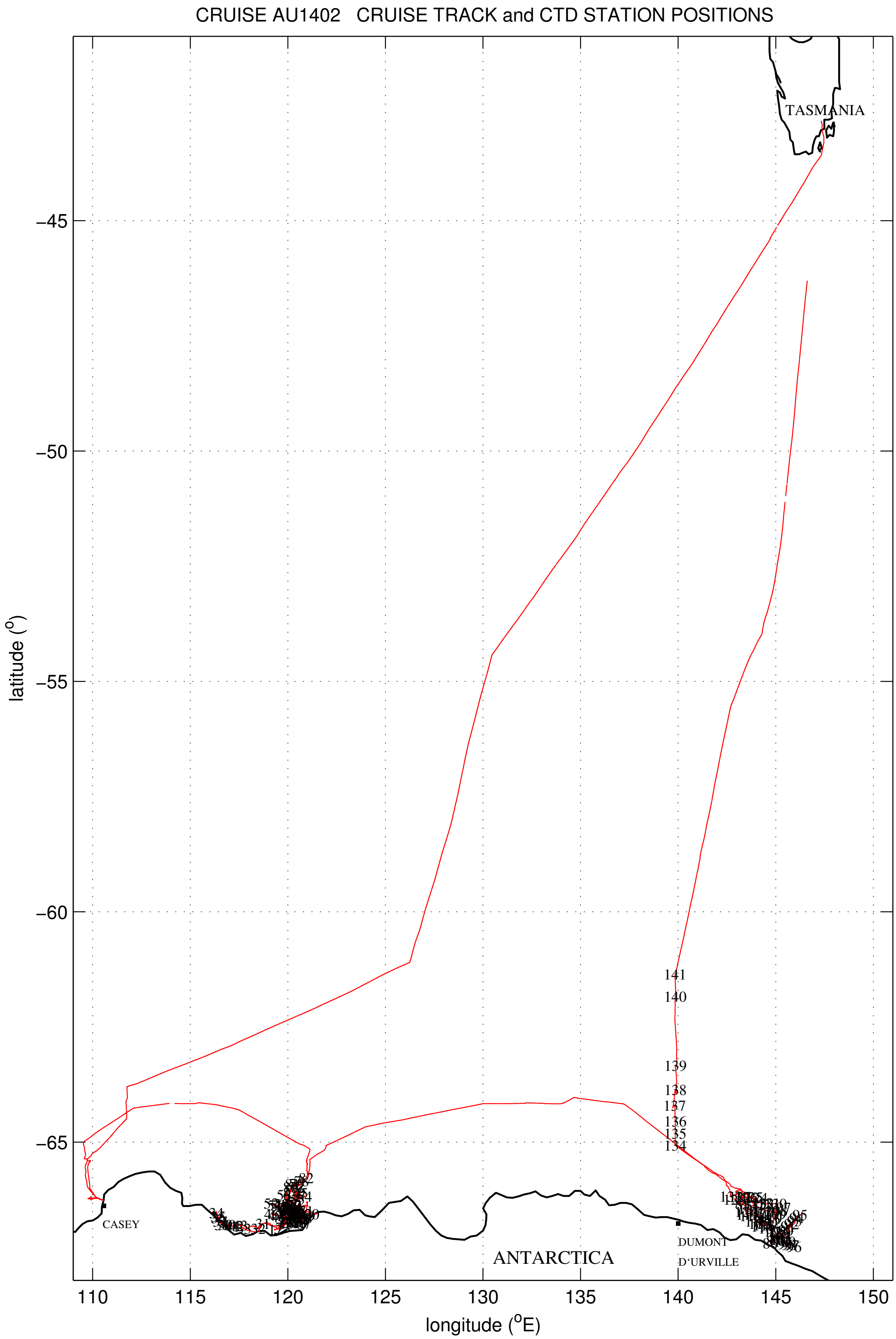


Figure 1.1a: **CTD station positions and ship's track for cruise au1402.**

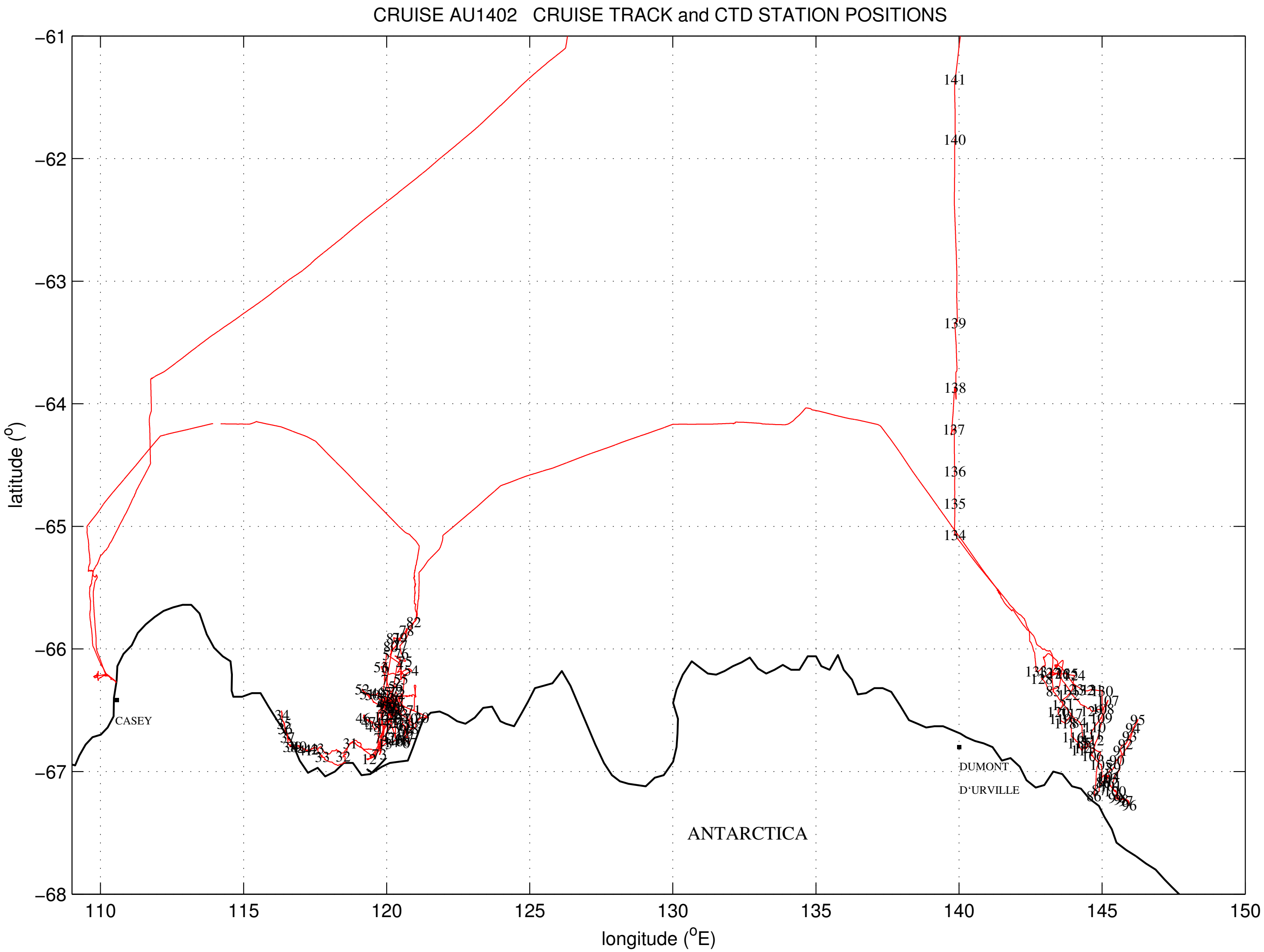
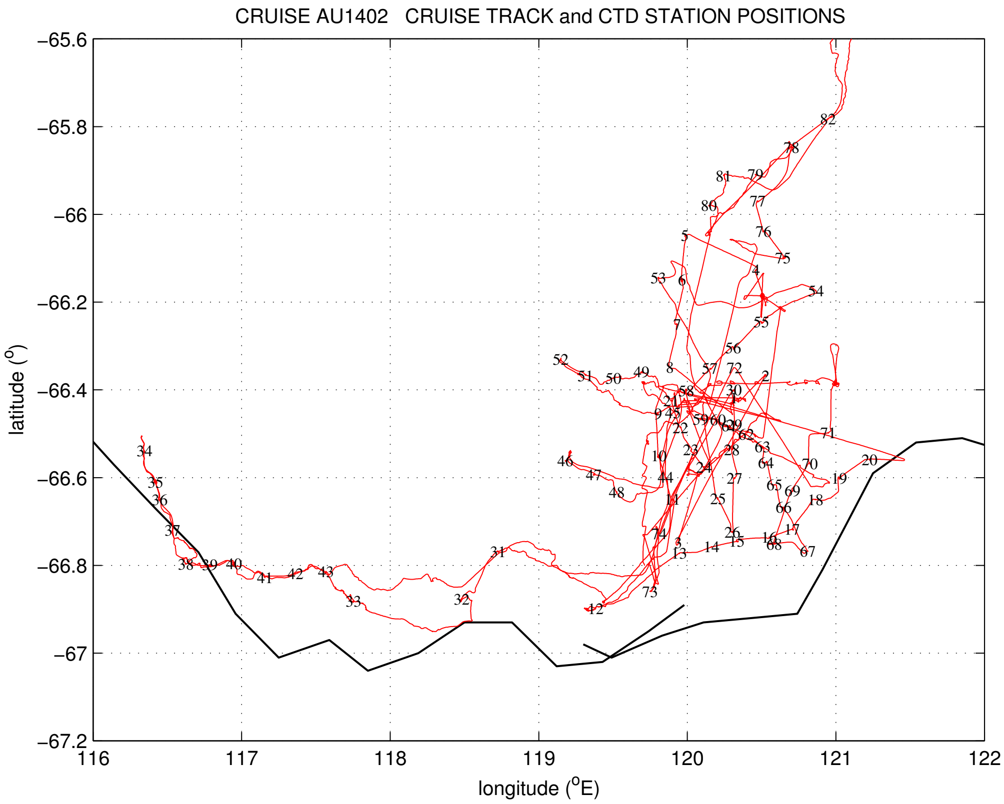
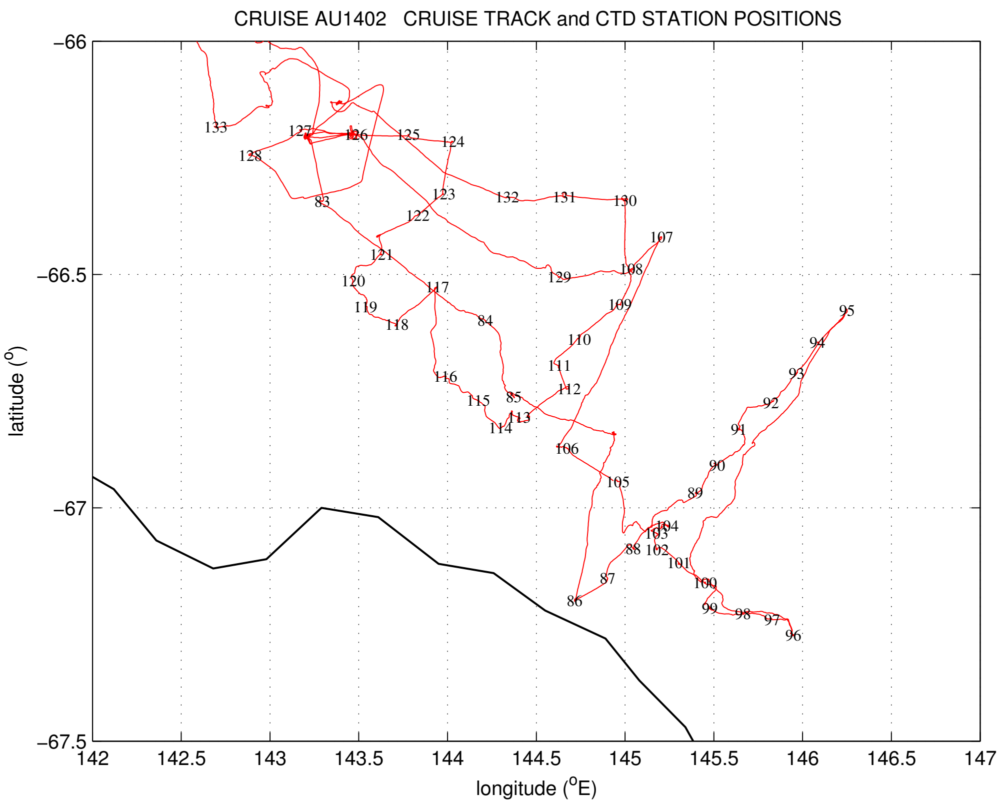


Figure 1.1b: **CTD station positions and ship's track for cruise au1402 – all southern work.**

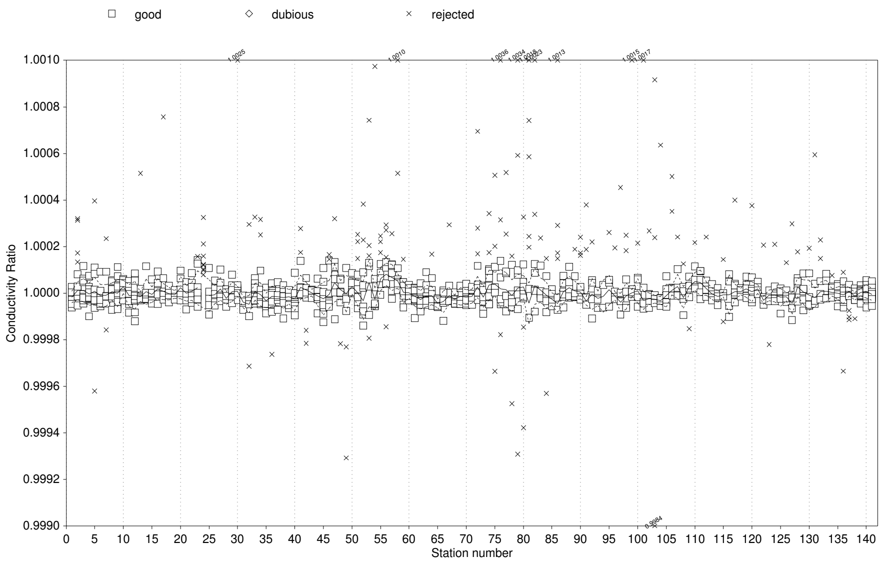
(c)



(d)



<u>Figure 1.1c and d:</u> CTD station positions and ship's track for cruise au1402, for (c) Totten Glacier region, and (d) Mertz Glacier region.



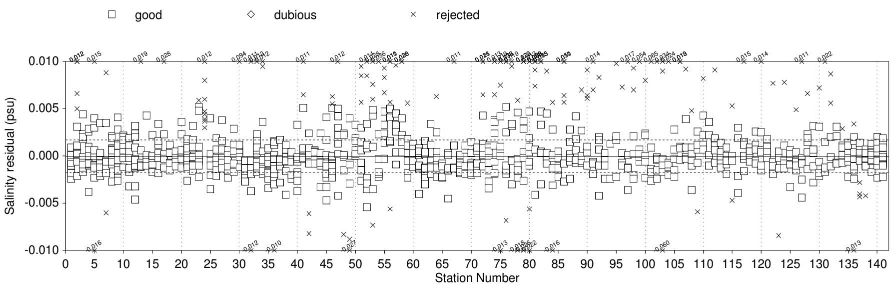
Calibration data for cruise : au1402

Calibration file : a1402.bot

Conductivity s.d. = 0.00004

Number of bottles used = 902 out of 1044 Mean ratio for all bottles = 1.00000

Figure 1.2: Conductivity ratio c_{btl}/c_{cal} versus station number for cruise au1402. 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 : au1402

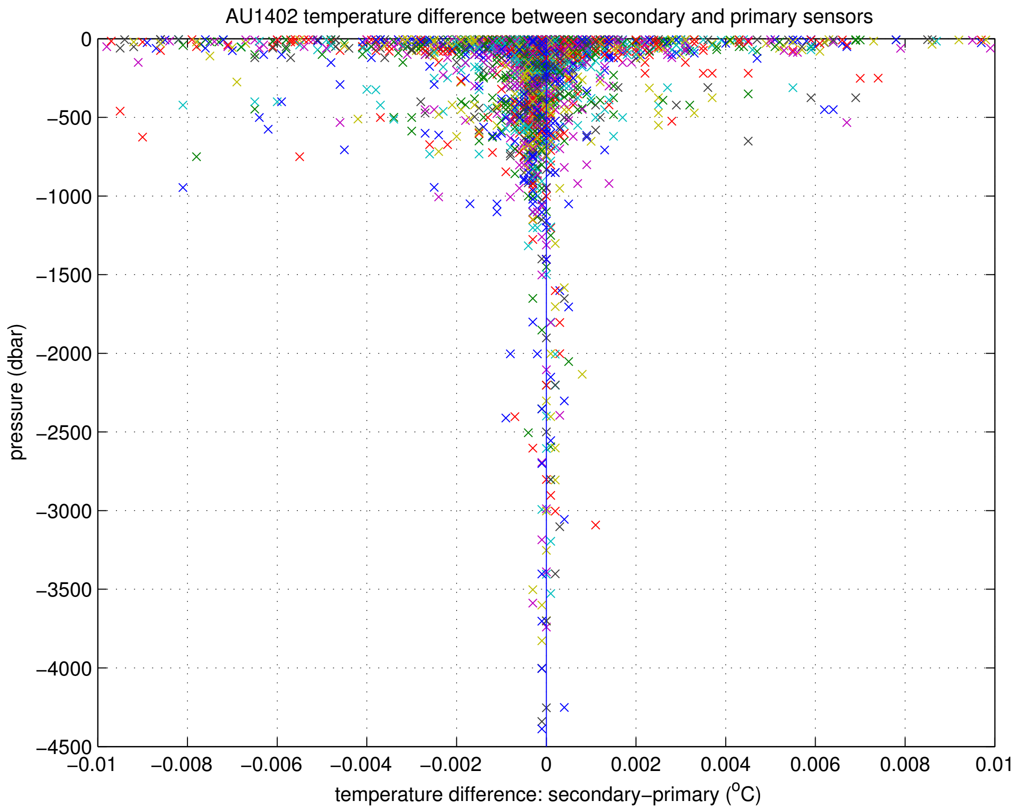
Calibration file : a1402.bot

Mean offset salinity = 0.0000psu (s.d. = 0.0017 psu)

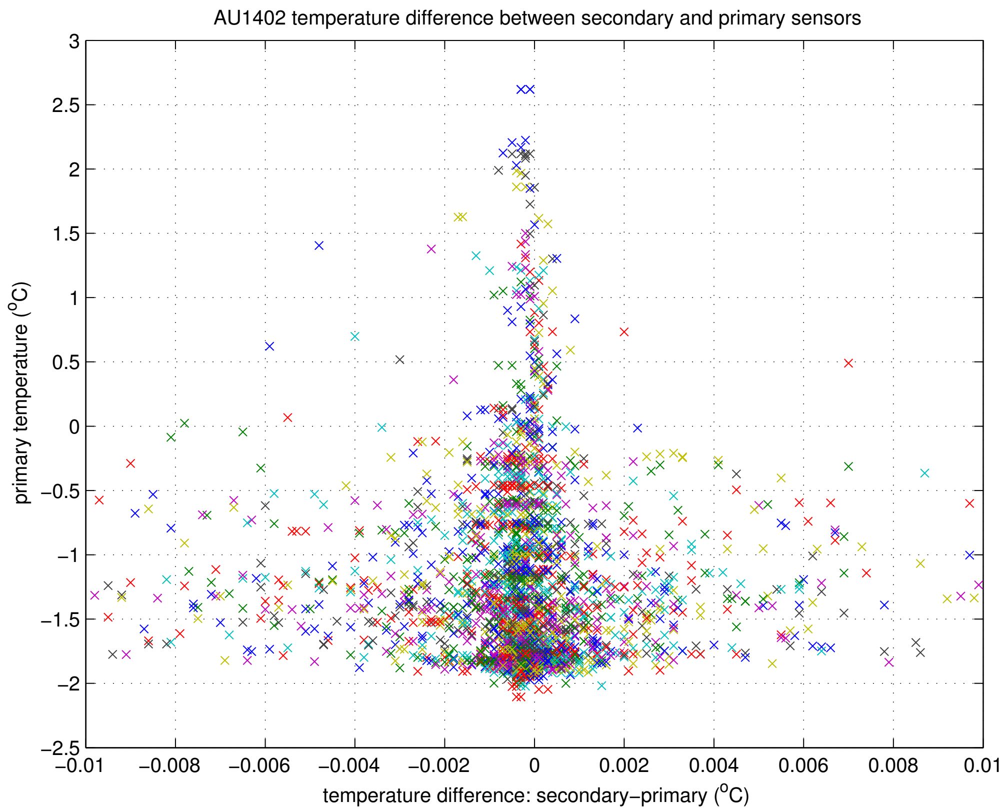
Number of bottles used = 902 out of 1044

Figure 1.3: Salinity residual (s_{btl} - s_{cal}) versus station number for cruise au1402. 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.

(a)



(b)



<u>Figure 1.4:</u> Difference between secondary and primary temperature sensors with (a) pressure, and (b) temperature. Data are from the upcast CTD data bursts at Niskin bottle stops.

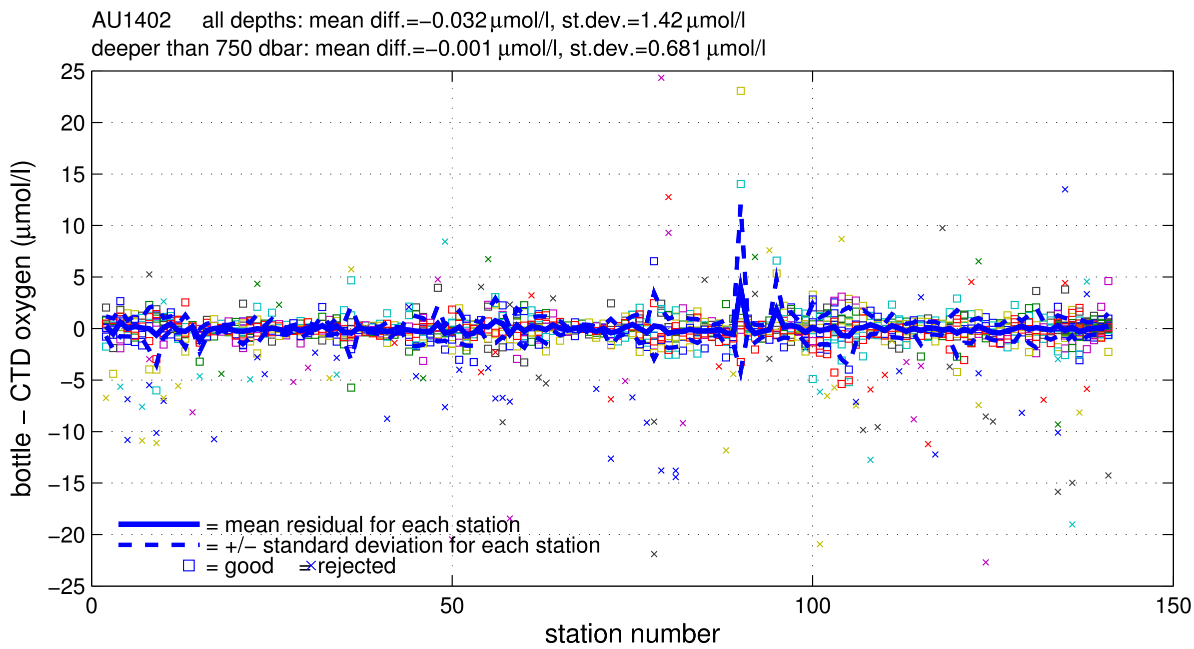


Figure 1.5: Dissolved oxygen residual (o_{btl} - o_{cal}) versus station number for cruise au1402. The solid line follows the mean residual for each station; the broken lines are ± the standard deviation of the residuals for each station. o_{cal}=calibrated downcast CTD dissolved oxygen; o_{btl}=Niskin bottle dissolved oxygen value.

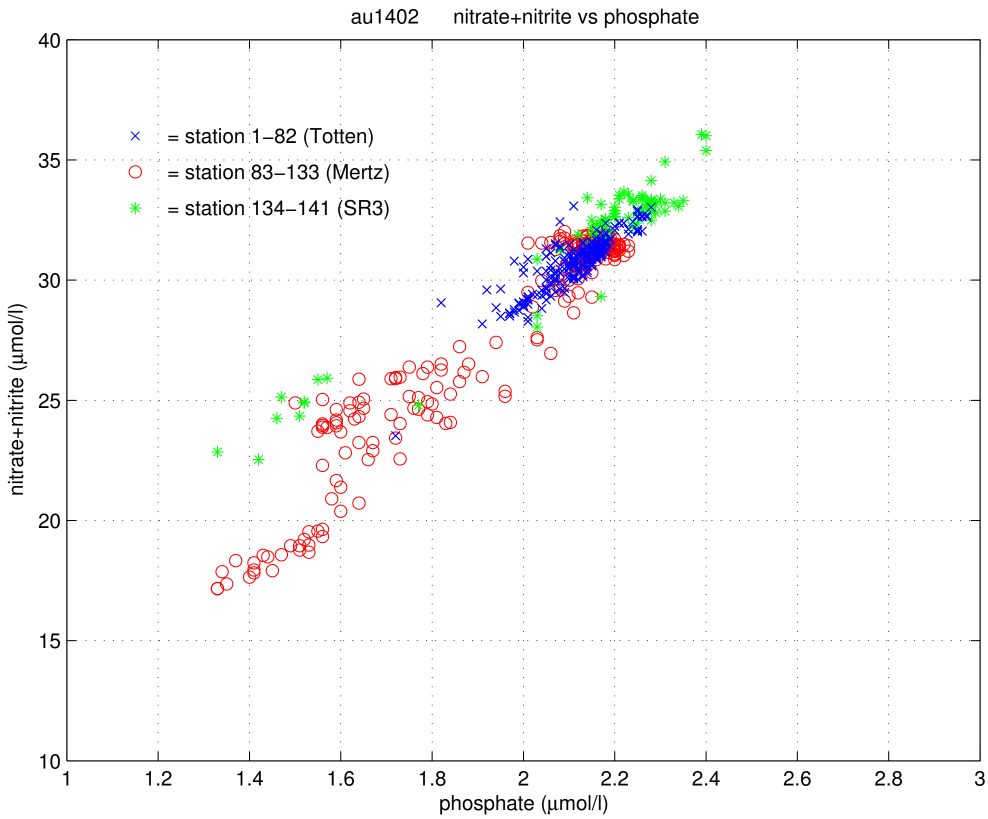


Figure 1.6: Nitrate+nitrite versus phosphate data for cruise au1402.

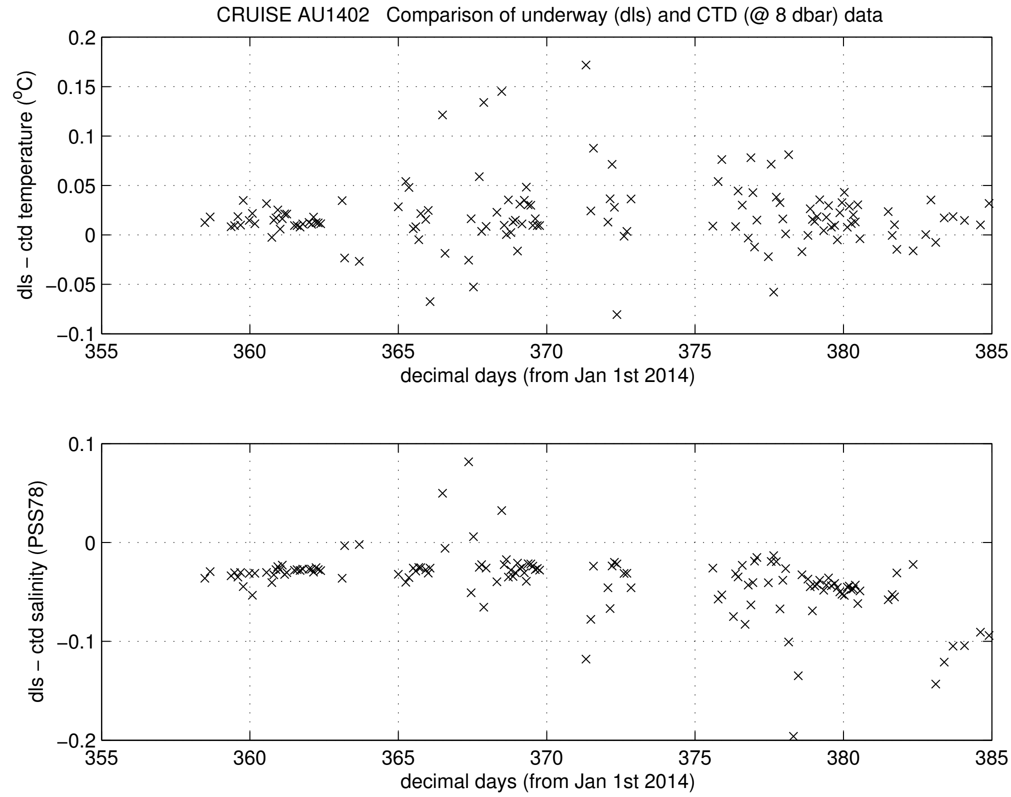


Figure 1.7: au1402 comparison of underway temperature and salinity data to CTD data, with time.

(a) **(b)**

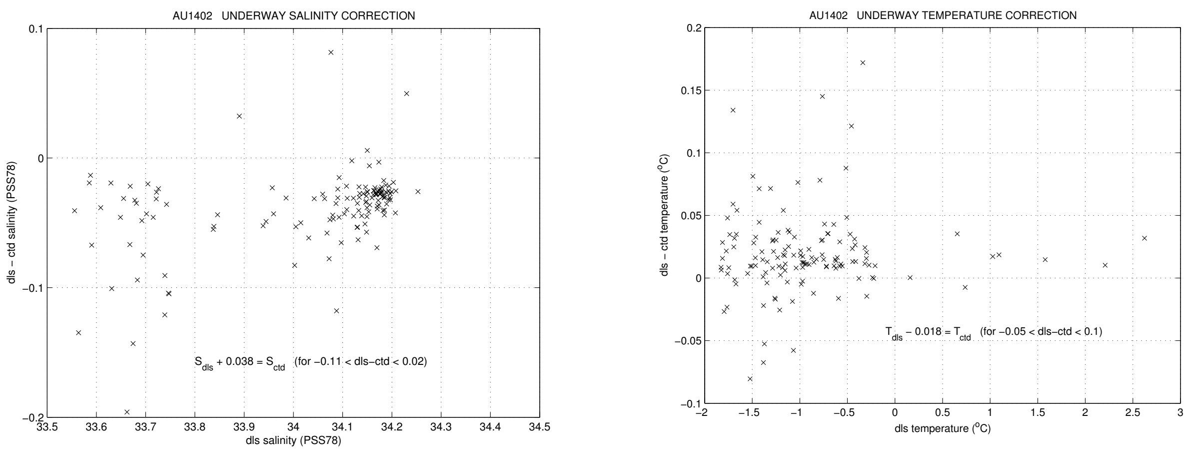
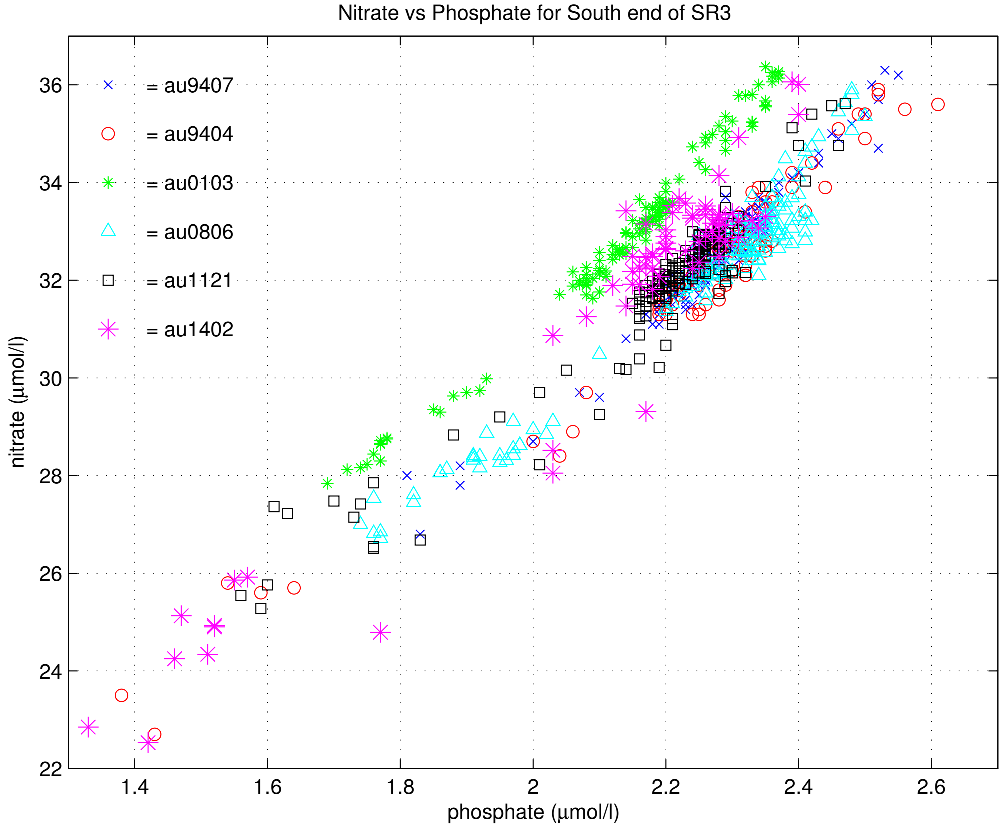
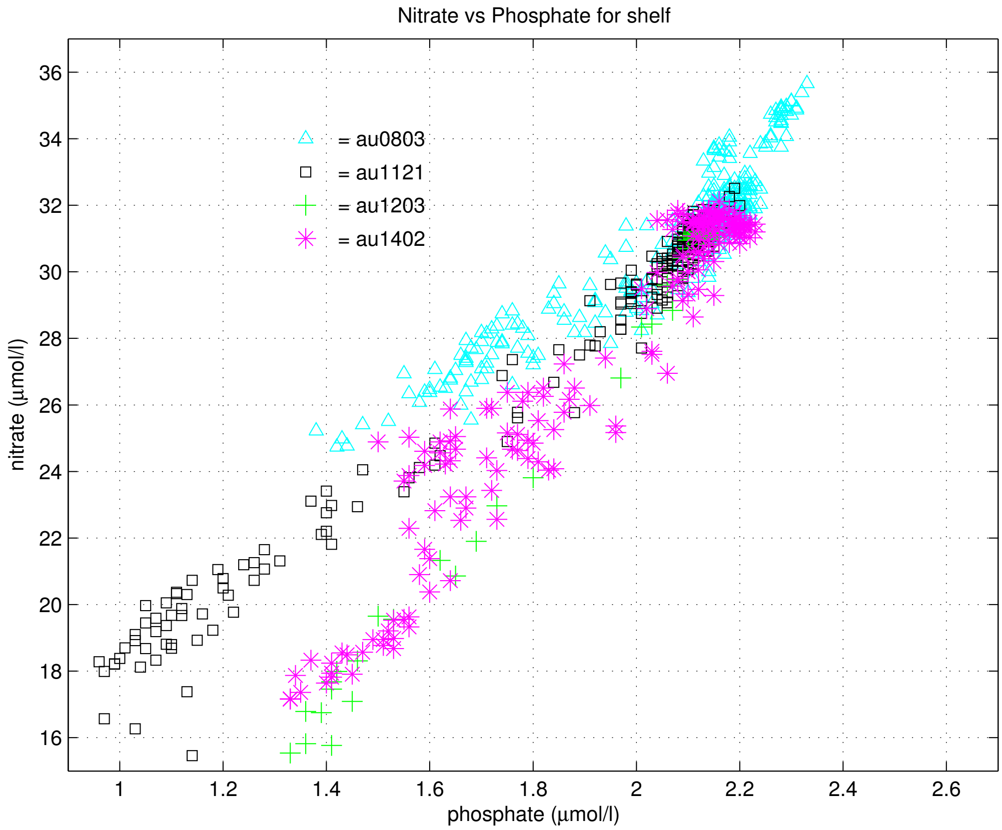


Figure 1.8a and b: au1402 comparison between (a) CTD and underway salinity data and (b) CTD and underway temperature data (i.e. hull mounted temperature sensor). Note: dls refers to underway data. Note that these corrections have not been applied to the underway data.

(a)

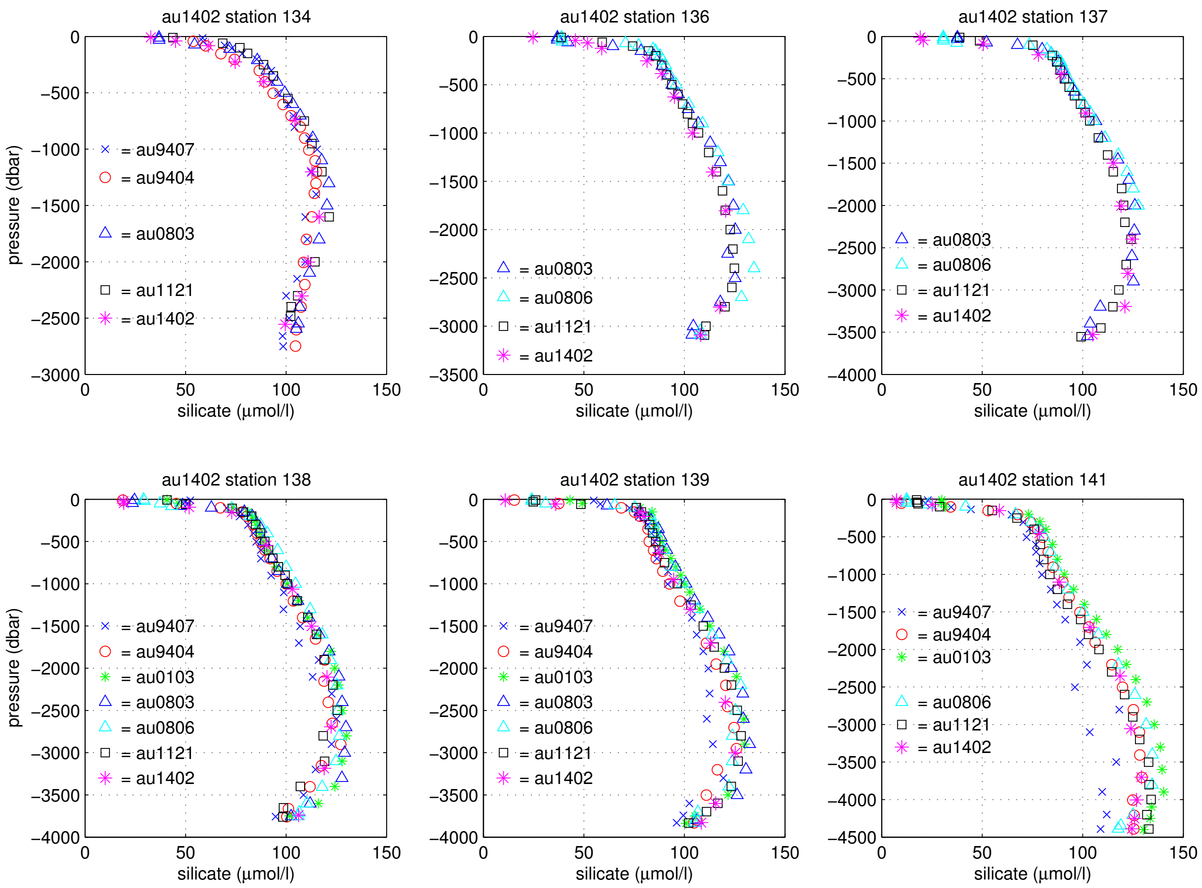


(b)

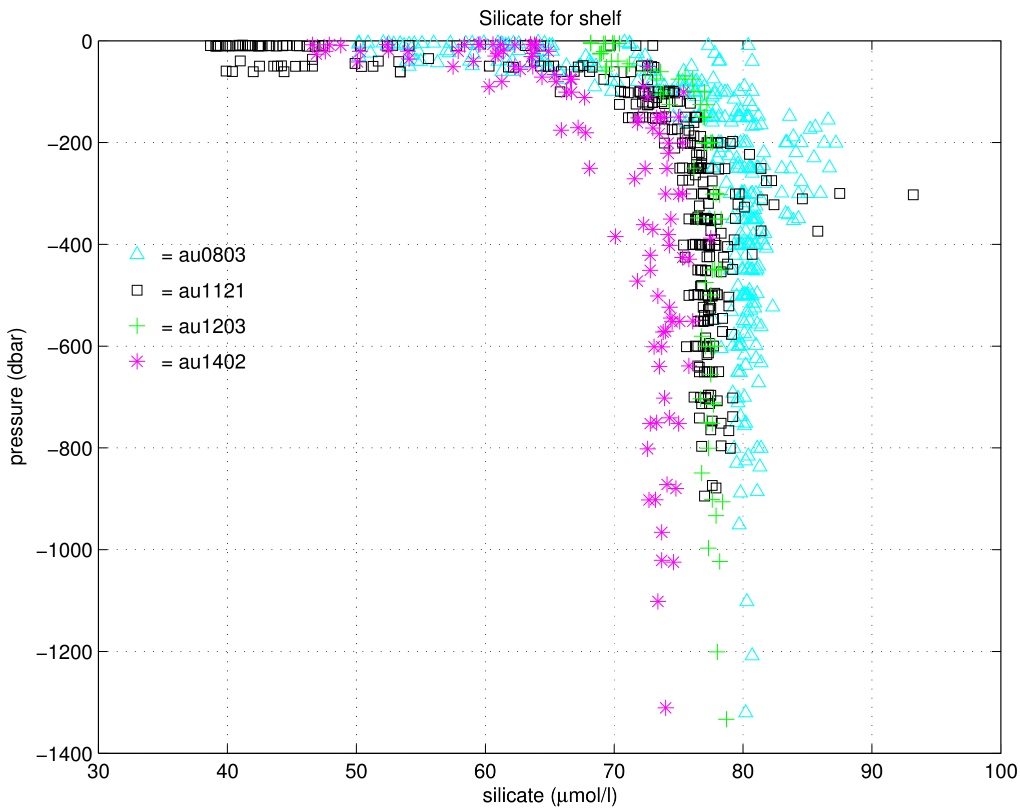


<u>Figure 1.9a and b:</u> Bulk plots showing intercruise comparisons of nitrate vs phosphate data for (a) south end of SR3, and (b) shelf stations in the Mertz region.

(a)

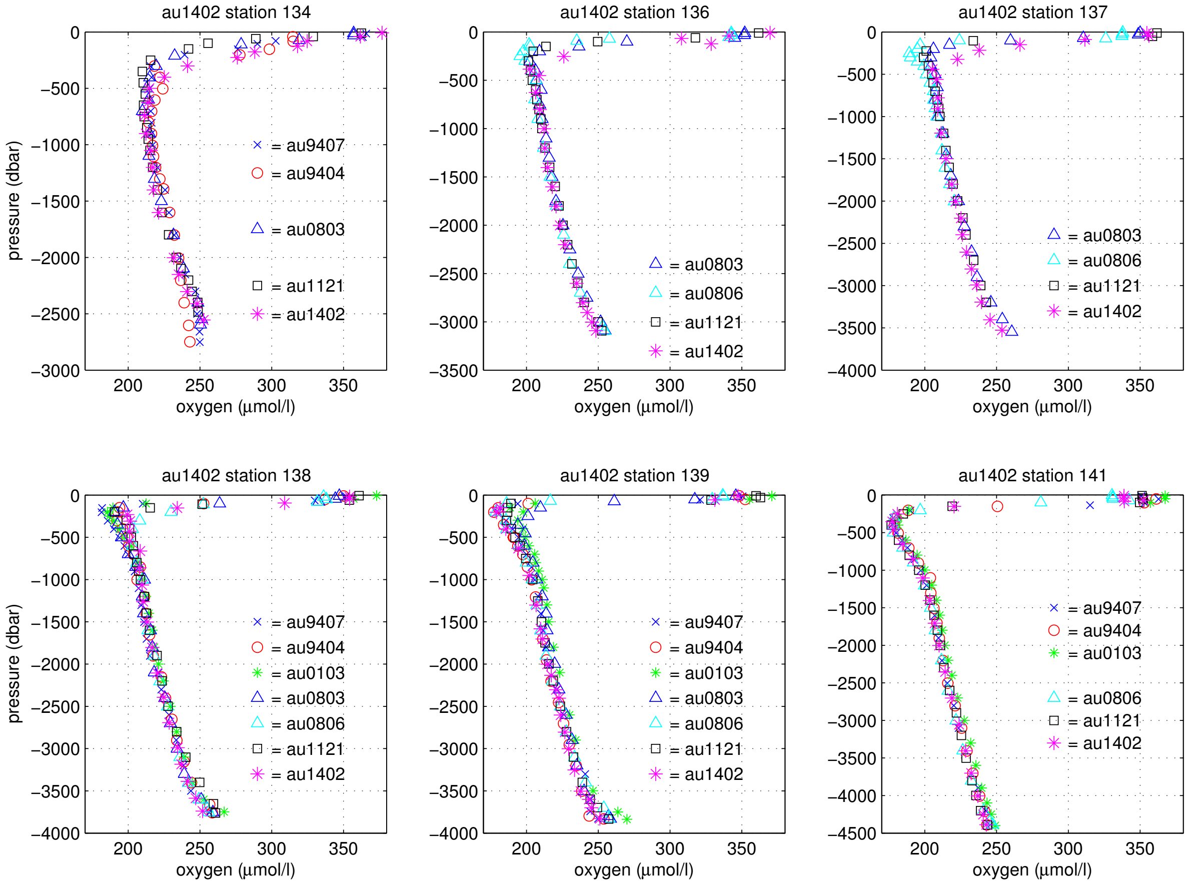


(b)



<u>Figure 1.10a and b:</u> Intercruise comparisons of silicate data for (a) south end of SR3, and (b) shelf stations in the Mertz region.

(a)



(b)

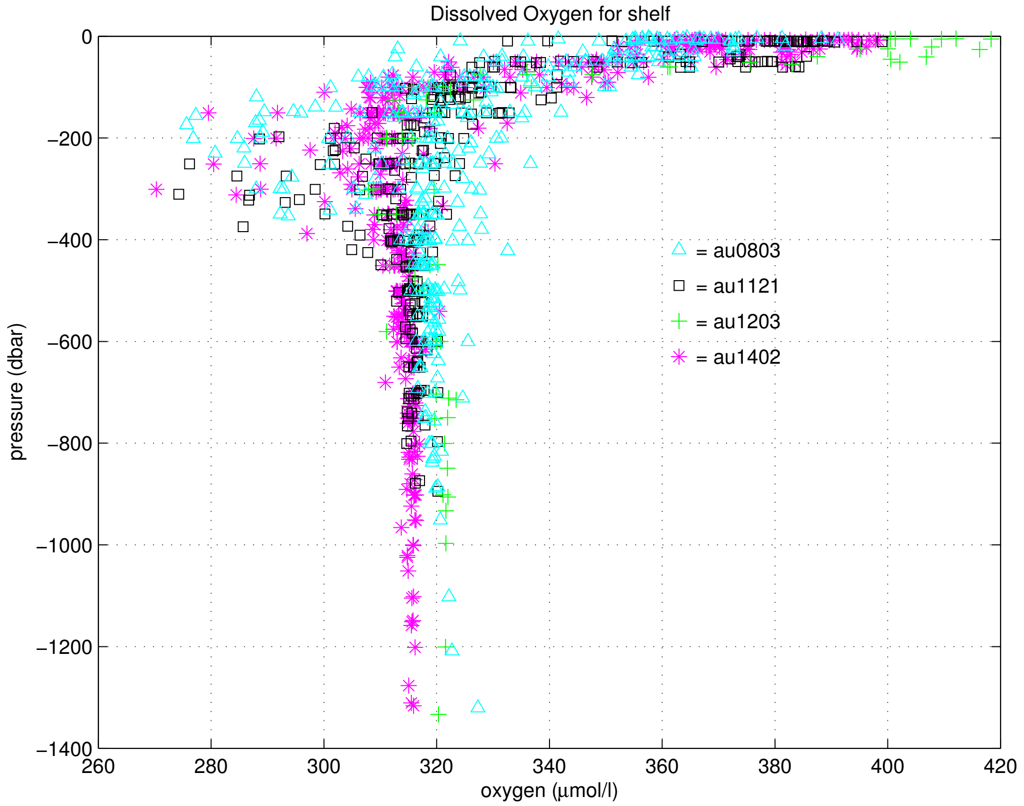


Figure 1.11a and b: Intercruise comparisons of dissolved oxygen bottle data for (a) south end of SR3, and (b) shelf stations in the Mertz region.

APPENDIX 1.1 SALINITY LABORATORY ANALYSES

Cruise report by CRAIG NEILL, *CSIRO CMAR*

A1.1.1 SALINOMETERS

The two salinometers that we had on the voyage were Guildline Autosals, serial numbers 62021 and 62565. 62021 was in the sky lab and 62565 was in the carbon lab.

62565 was too unstable to use. In the early part of the cruise the instability was extreme, with the standby number drifting up and down by more than 50 counts over the span of half an hour or so. Later in the voyage it settled down to where the standby would remain within a window of about 5 counts, but it would still drift up and down within that window on a time scale of just a few minutes (faster than room temperature could change). I measured the bath temperature on two occasions and both times found it to be accurate and stable. At one point I tried running samples on it and found that when reading the counts the number was drifting rapidly up and down by 10 – 15 counts. This salinometer was fully checked out by Val before the cruise, including running standards and samples it. It is therefore assumed that it sustained some kind of damage during transport or loading, as it would never had gotten past her in the state it was in on the voyage.

The 62021 salinometer, located in the sky lab, was the only one that was used to run samples. The stability was good in terms of the standby number, which almost never changed by more than one count during a shift. The stability of the standards however, was not up to the manufacturer's spec of "better than 0.001 PSU in 24 hours". In several cases I saw drift of greater than 0.002 PSU in the course of a shift. For this reason I ran as many standards as I could (without running out). The larger problem with this salinometer was with bubbles sticking to the electrode coils. I spent many hours each day rinsing the cell with alcohol to knock bubbles loose and cleaning it with Triton X and alcohol, which would often make a slight improvement for a short time. At one point in the Mertz Glacier region it got so bad that I was unable to run samples at all. At this point I resorted to removing the cell, taking it apart and cleaning it manually. This usually led to an immediate but often short lived (like one day) improvement. I had bubble troubles in all regions but the Mertz was the worst, followed by the Totten. The SR3 stations were less trouble but still required flushing the cell with cleaning solutions a few times each day. Another minor problem that I noticed with this salinometer is that the thermoelectric bath chiller appears to be somewhat degraded and could use replacing. The manual states that the salinometer should be able to run with the batch temperature between 4 degrees below and 2 degrees above room temperature but this unit did not have enough cooling capacity to maintain a stable bath temperature at all above room temperature.

A1.1.2 SAMPLE BOTTLES

During the transit south I looked over the sample bottles and found that some had a ring of solid deposits at the water line that would not easily dissolve. Also many of the bottles had a cloudy appearance in the upper part of the bottle (the portion that would normally have air not water inside).

I washed all of the bottles with hot water and refilled them with sea water. This helped a bit with the rings of deposits but did not change the cloudy appearance. At Casey station I obtained some HCl and then acid washed all of the bottles by soaking overnight with 10% HCl solution followed by fresh water rinses and refilled again with sea water. This cleaned up all of the rings of deposits and may have helped with the cloudy appearance. In the end Kate and I concluded that the cloudy appearance is probably some kind of etching on the glass itself.

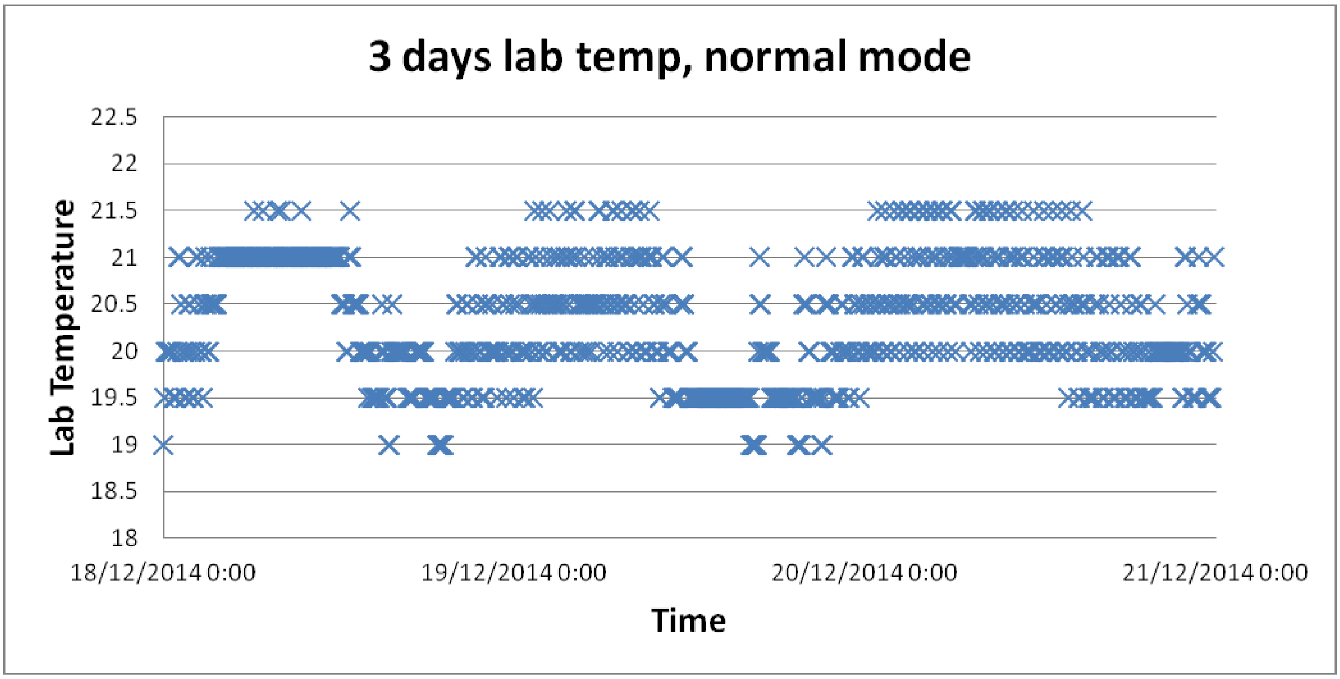
In the process of washing the bottles I noticed that some of the caps have a lot of salt build up under the Teflon liner. I also found that some did not seal well (bottles did not hold the pressure that builds up when the cold sample expands). Both of these problems occurred on caps that did not have any "squish" when tightening them – the liners have been compressed to the point that the Bakelite cap makes hard contact with the glass bottle before any compression of the liner is felt. Many of the worst caps were on the E crate. I took the worst of the caps from all of the other crates and swapped them onto E crate bottles and the spare crate bottles, relabeling the caps as required. **At the end of the voyage, all of the E crate caps and all of the spare caps are caps that I consider unusable.**

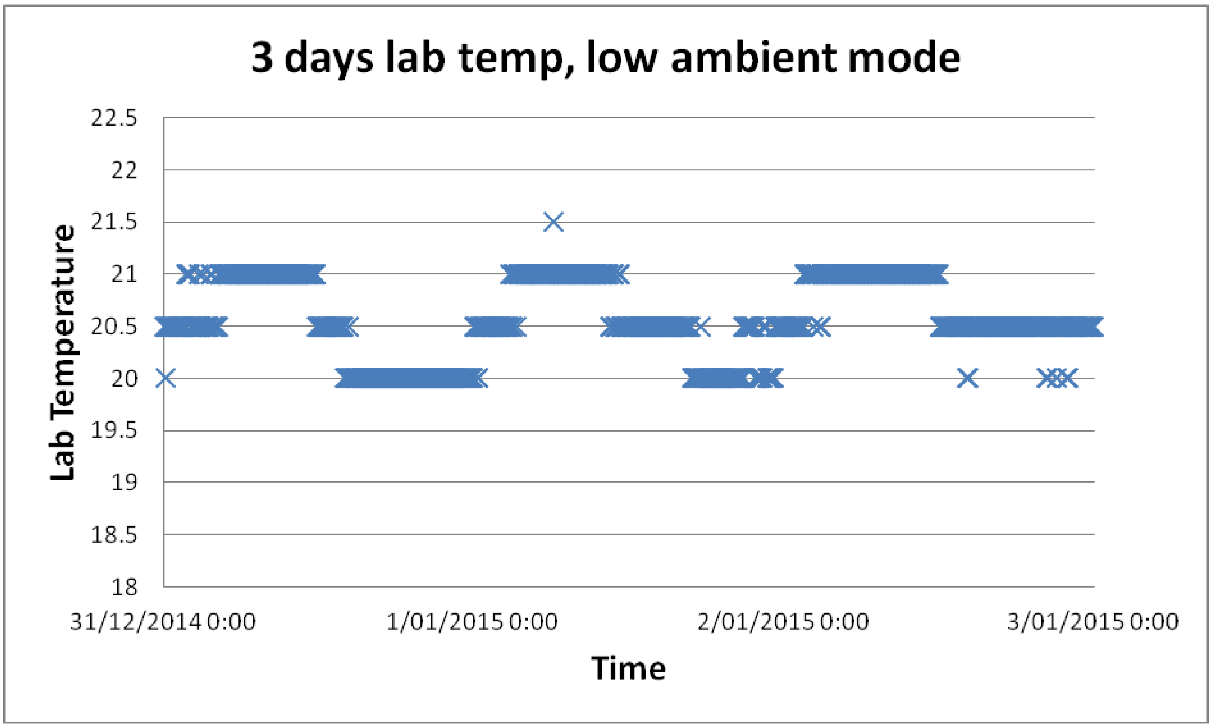
A1.1.3 LAB TEMPERATURE CONTROL

Lab temperature was monitored visually with a handheld digital thermometer and logged automatically every 5 minutes with a temperature logger. The complete temperature record is contained in the file

The sky lab has an independent climate control system that must be switched on manually with a rotary switch on the starboard bulkhead. The engineers provided documentation for the system which enabled me to work out how it works. There are indicator lamps that show when the system is on, when it is in "low ambient" mode, and when an extra bank of heaters is enabled. The heaters follow the low ambient mode. Low ambient mode is set by the controller when the "outside" air temperature goes below a certain set point, which was set to 5 degrees at the start of the cruise. It was apparent that the measured temperature is about 5 degrees above the actual outside air temperature (the sensor is probably in a return air duct). With this setting the system would regularly go in and out of low ambient mode even at Antarctic latitudes (Casey station). I noted that the temperature control was much better in low ambient mode than normal mode.

Just before we started CTD work I got the chief engineer (Evan) to change the set point for low ambient mode from 5 degrees to 10. This made the system stay in low ambient mode for the duration of the cruise (until about 50 degrees south on the way home) and gave much better temperature control in the lab, as illustrated by the plots below. During a typical day in low ambient mode the lab temperature would remain within a 1 degree window (maximum minus minimum), while in normal mode it was more like 3 degrees.





A1.1.4 CTD SAMPLES

Samples were drawn by the CTD team. During my shift (14:00 – 02:00) they were stored in the carbon lab to minimize traffic in and out of the sky lab while I was running the salinometer. All bottles were sampled up until partway into the Mertz Glacier work, when extensive bubble trouble slowed the analysis to the point that we had to cut back sampling to about 2/3 of the bottles. I will leave the assessment of the results mainly to Mark Rosenberg. In general I can say that the SR3 results were the best, followed by parts of the Totten region. In some parts of the Totten region and much of the Mertz I had great difficulty with bubbles and some of the data was not acceptable. I worked with Mark daily to assess the previous day's data and tried to find ways to improve the quality.

A1.1.5 UNDERWAY SAMPLES

During the transit south I took a minimum of one set of triplicate samples per day from the underway system for the purpose of calibrating the thermosalinograph (TSF). On many days I took a great deal more samples so that I could practice up in running the salinometer and gain confidence in the results before starting the CTD work. The samples were drawn from a branch on the manifold that supplies the pCO2 system and the CSIRO SBE-45 TSG. I noted the sampling time (the time at which the bottle finished filling with water) down to the nearest 10 seconds to match the samples as closely as possible to the TSG readings.

A1.1.6 DATA PROCESSING

For calculating salinity from conductivity I used the macro spreadsheet SaltSheet.xlsm, provided by Val Latham in Hydrochemistry. I typed the bottle numbers, rosette position, conductivity ratios, comments and daily metadata into this sheet and exported the contents to CSV files once or twice each day. In the last few rows I often put the results from standards run during the day, to be used later in calculating offsets.

The sample data were cut and pasted from these files into the file **2014-15_AA_V2_CTD_salts** (both Excel and CSV types were maintained), which contains all samples from the cruise IN ORDER OF

ANALYSIS. The results from standards were used to calculate offsets and corrected salinity values for most samples. In most cases the offsets are a linear interpolation between standards.

These files were then sorted by station and rosette position and saved as **2014-15_AA_V2_CTD_salts_sorted**, which was given to Mark Rosenberg for use in calibrating the CTD.

A1.1.7 DAILY NOTES

For the first week or so I made detailed electronic notes about each irregular sample. Later I developed a system of abbreviations for common problems and cell cleaning activities.

ETOH = clean cell with ethanol. The standard cycle is 3 flushes milliQ, fill cell with ethanol, soak a few minutes, flush 5x with milliQ, flush 3x with old standard, back to sample.

ISOH = isopropyl alcohol. Sometimes used alone as above for ETOH. Often used as the chaser after Triton X cleaning.

Triton X = A non-ionic surfactant. At the beginning of the cruise I was using a solution prepared by Kate that was 10% Triton X, 80% ethanol and 10% milliQ. I soon found that I more dilute solution with a much greater proportion of water seemed to work better. Something like 2-5% triton X, 80% milliQ and balance ethanol.

MF = mega flush. This means a very extensive milliQ flush following cleaning the cell with alcohol. At one point near the middle of the cruise I became concerned that I may not have been flushing enough milliQ through to get all of the alcohol off of the cell walls, because a few times I noticed that the readings following an alcohol cleaning would increase steadily by a very small amount. The MF means that I would run almost an entire 500 ml bottle of milliQ through, stopping a few times to let it soak for a few minutes. I would then run old standard until the readings on subsequent flushes were identical before switching to the next sample. Later in the cruise I would leave out the step with the old standard but flush with sample many times and take readings until I got 3 in row unchanged.

DIW = flush cell with milliQ. Normally I would switch to ethanol if the bubble does not come loose within 3 flushes, unless otherwise noted.

RR = rerun (ran sample again after

TRB = Top Right Bubble. This is a tiny bubble at the very top of the right-most coil. It is difficult to see until you get used to seeing the coil with and without it. Absence of TRB is more distinct than TRB. Based on dozens of instances where I got readings on the same sample with and without it, I have concluded that it does not affect the readings like other bubbles do. It is very difficult to flush out and can return immediately after cleaning the cell. In the latter part of the cruise I became so convinced that this bubble does not affect the readings that I stopped noting its presence.

19/12/2014
Obtained 2.5 litres of concentrated HCl from Casey Station. Prepared 2 litres each of 5% and 10% solutions (% of concentrated acid, not absolute %), filled 6 bottles with 5% and 6 with 10% and left to soak overnight. The 10% seemed to do a slightly better job cleaning the bottles, so I used the 2.5 l of HCl to make 25 litres of 10% solution.

Over the next four days, all bottles were acid washed in the following way:

- Rinsed 2x with hot tap water
- Filled to the top with 10% HCl and left to soak overnight
- Half emptied, capped and shaken vigorously for 15 seconds
- Emptied and rinsed 2x with hot tap water
- Rinsed and filled with fresh sea water

The acid solution was re-used twice (washed 3 sets of bottles).

26/12/2014
First day of analysing CTD samples, stations 1-3, run in that order. Station 1 was a test cast with all bottles fired at the bottom.

In the first half of the samples there were 4 or 5 samples that were gave unstable readings. Each individual flush of the salinometer cell would give a stable reading, but the readings varied a great deal (up to 20 counts) from flush to flush. On sample A18 I noticed a very very tiny bubble that seemed to form on one of the coils then get flushed out. I'm guessing the bubble was air degassing from the sample, which would have very high pN2 and pO2 having been warmed from -1 to 21 degrees. From this point on I looked more carefully at the cell before reading counts and did not see any more bubbles, nor did I have any more unstable samples.

During the course running the samples the standby number went from a solid 4947 at the start to changing back and forth from 4947 and 4948 (mostly 4948). I ran a second standard at the end and it was 9 counts high, which translates into 0.0017 PSU. I applied a correction that was a linear interpolation from zero at the start to -0.0017 at the end.

27/12/2014
Bottle F14 (station 4 RP 3) bubble trouble. Removed bottle and rinsed cell 2x with DIW. Rinsed cell 3x with old sample then ran F14 again.

Same procedure as above with D21 (station 5, RP 19).

Same procedure with D17 (station 5 RP9)

D14 (station 5, RP 3) had a bubble that was removed with a DIW rinse, then another bubble that would not come loose with DIW. I filled the cell with cleaning solution (10% triton X, 10% DIW, 80% ethanol) and soaked a few minutes (the bubble was still there) then drained and refilled and the bubble came loose, soaked for 15 minutes then rinsed 10x with DIW and flushed lots of DIW through with cell full, then rinsed 3x with old sample and back to D14.

After running station 5 I filled the cell with DIW and went to dinner. The standby count was 4942 when I left and 4940 when I returned. I started a new sheet with a new standard. **Based on the fact that the standby count changed after I stopped running samples (and before the next standard) I did not apply a drift correction to stations 4 and 5.**

D10 (stn 6, RP 24) violent shaking from icebreaking was sloshing sample out of the bottle as I ran it.

D7 (stn 6, RP 13) sample had a very large headspace – down to the straight cylindrical walls.

At various times the top or bottom most arm of the cell would not fill with water – draining and refilling would always fix it.

D3 (stn 6, RP 5) had to flush 6 extra times to clear bubbles

D1 (stn 6, RP 1) bubble trouble, flushed with DIW then old sample then re-ran

B5 (underway sample) flushed cell 8x to clear bubble

B16 (underway sample) DIW flush (many many times) to clear bubbles

B17 (underway sample) got a bubble after the second reading (needed a 3rd) and could not clear, DIW also did not work. Flushed cell with cleaning solution then tons of DIW.

Unlike yesterday I ran stations 4, 5 and 6 from surface to bottom, thinking it would be easier to go in the order of the log sheet. This becomes a mess when you get more than one station in a crate. From station 7 on they will always be run from the bottom up.

A5, stn 7, RP 15 – got readings with and without the tiny bubble at the very top of the right-most cell arm and readings were identical. I will still not accept readings with this bubble.

A9, stn 7, RP 24 – I had to wash the cell with Triton X/ethanol solution to remove the bubble mentioned in the above comment. Again the readings before and after did not differ significantly (2 counts). This will now be referred to as TRB (top right bubble).

Standard at end of station 7 = 1.99965. Reset Rs for station 8.

A14 & A15, stn 8, RP 9 & RP 11 – for these two samples I accepted readings with the TRB.

A16, stn 8, RP 13 cleaned cell with triton X/ethanol solution to remove TRB after the first readings. Again the readings with and without TRB were the same.

End of station 8 – no standard (stable STBY and short time since last standard).

28/12/2014

A21, stn 9, RP 3 – got TRB on 2nd reading and would not flush out. Filled cell with straight ethanol and it came loose right away. Left ethanol in cell about 5 minutes then rinsed with old standard and back to sample A21. The readings were odd in that the 2nd reading (the one with TRB) was significantly higher than the first (previous sample was higher, not lower) and the readings after cleaning were lower than the first. It may be that TRB affected this reading, and/or that the ethanol was not fully flushed from the system when the final readings were taken (unlikely given their stability).

R3, stn 9, RP 15 Had TRB on first two readings then cleaned cell with ETOH. Flushed first with DIW 2x then 1 fill and soak with ETOH then 3 rinses DIW, 4 rinses old standard then back to sample. This will be the standard ETOH cleaning procedure in the future in not noted otherwise. Also note that the readings were again the same with and without the TRB bubble.

I am now making it standard procedure to read after 2 flushes, where before it was usually 3. Two flushes is sufficient if the change from the previous sample is not too large and I cannot afford to miss a good reading when I never know when a bubble will come in. I will continue to take an additional reading if the consecutive readings differ by 2 or more. Pump speed has been increased from 18 to 20 (30 is "normal").

Station 10 is a TRB test. Samples R7 - R17 I did not get rid of TRB bubbles and noted presence or absence on every run on the log sheet.

R18, stn 11 RP 1 first fill had TRB so did ETOH clean before proceeding.

R22, stn 11, RP 13 – bubble after one reading that would not go away. Flushed it out with DIW and reran sample.

From this point on (to at least station 24) I have been accepting a limited number of runs with the TRB bubble. At this point it appears that I do not have enough ethanol to do anything else, and evidence continues to build that the TRB does not affect the data.

Explanation of notes:

TRB = sample was run with the TRB bubble present for all readings

TRB; ETOH clean after = same as above but cell was cleaned with DIW and ethanol between this sample and the next one. The cleaning process is 2 flushes DIW, fill with ethanol, soak a few minutes, 4 long flushes DIW (allow pump to run for a minute or so after cell is full for each flush), 2 flushes old standard, then on to the next sample.

TRB one flush; none another; same result = pretty self explanatory

29/12/2014
I Started with station 16 and ran a second standard at the end of station 21. The second standard gave a reading just one count above the true value so no correction was applied and I did not touch Rs.

Sometime between the second standard and the end of the day things went bad. More and more samples had unstable readings and the standard at the end of station 24 gave 2.00000 (plus or minus 5 due to instability), which is 0.0060 PSU high. I ran a second bottle to confirm it and the result was the same. I have yet to apply a correction because I don't know exactly when it went off. The standby count and lab temperature were both stable throughout. The unstable readings started to appear in the last couple samples of station 22 where they were only occasional and just got worse and more frequent, leading me to stop where I did.

30/12/2014
The problems late yesterday were most likely caused by the vibrations from icebreaking. I now know not to run in those conditions.

The log sheet for station 25 lists salt bottle J8 for two RPs, 7 and 11, and the total number of samples is one lower than shown on the sheet. In the data file I put question marks for all RPs 7 and above because I don't know which niskin bottle was skipped.

31/12/2014
Over the previous night I soaked the conductivity cell in 10/10/80 Triton X/H2O/ETOH. Flushed very well with DIW (600 ml) afterward. Am now waiting for the ship to break into the Totten polynya before running samples.

01/01/15
Running first samples since 01/30. On starting up the cell seems more prone to bubbles than ever. I am getting bubbles just flushing with old standard. Did an ethanol wash before running the real standard.

Got TRB on the first standard. Set Rs to 462 (STBY 4938/9), did ETOH flush and ran a second standard and got 1.99968. Reset Rs to 464 (STBY 4941/0).

Stations 31 and 32 were very difficult. The ship was perfectly still, lab temp and the standby number were perfectly stable, but many samples had unstable readings. Also lots of bubble troubles.

17:57 local – noted that the lab climate system's "heater bank enable" light was off even though "low ambient" was on. 45 minutes later they were both on again.

17:10 local – running a standard before dinner I got one reading of 1.99966 and then endless bubbles. No correction was applied to this set of samples.

20:20 local – starting up for a second run of samples (station 33 and underway), got TRB on the standard and it would not go away. The reading with TRB was 1.99965. Did ETOH clean and ran a second standard, which gave 1.99960. That number seemed very low so I ran I third standard, which got a TRB bubble on the first through about 7th readings and gave 1.99965 before setting Rs. The TRB bubble finally went away and I got an equivalent reading without it (just under half of the water remained in the standard bottle, so I do not think it was too low). At the end of this set of samples, ca 23:00 - 23:30 local, I ran a standard that had endless bubbles and a reading (with bubbles) of 1.99976. I cleared the bubble with DIW and ran a second standard, which also got bubble trouble but I finally got bubble free readings of 1.99976, which will be used to apply a linear correction.

The stability of the instrument seems to be worse today than previously. I wonder if it endured too much shaking with all the very hard ice breaking yesterday and the day before.

02/01/2015
I could not run samples until 23:00 because we were breaking ice going back to the Dalton Polynya. On start up I immediately got a TRB bubble when flushing with old standard and did an ETOH clean to clear it. I then flushed with old standard without getting any bubbles and got a TRB on the first flush of the real standard. Set Rs with TRB then it went away after about 8 flushes and the reading by then was .0003 counts higher, reset Rs and started running station 34. The first few samples seemed quite unstable. On sample D1 I got four stable readings in a row and then I ran another standard and got 1.99977. I reset Rs to match 1.99970 to this one and continued. At the end, after station 35, I ran another standard which came out spot on at 1.99970. The instability at the beginning was strange. Many of the samples in the first part of station 34 also gave bad repeatability flush to flush. In station 35 I started writing down 4 readings to convince myself that the "good" samples were really stable and not just lucky. I got 9 samples in a row with excellent repeatability on 4 consecutive readings. Bottom line, station 34 = yuk, station 35 = yay. I will do a linear correction for the first four samples of station 34 but it might be better to just ignore them altogether.

03/01/2015
19:45 – Doing a CTD in a lead after ice mooring work all day has kept me from running. Tried to standardize to run some samples and got bubbles on the standard that I could not get rid of. Will wait until the next CTD to try again because there will some ice breaking in between. The readings on the standard with the bubble indicate that it has drifted down substantially since yesterday – reading 1.99950 instead of 1.99970. Also the zero is at -1 where it has been at zero before. Did an ETOH clean to get rid of the bubble then refilled with DIW to wait for the next station. I checked the bath temperature to see if that is causing the shift and it was good at 20.997 (last time it was 20.996).

The stability on stations 36 and early 37 was not great but not as bad as I would call "unstable". Late in station 37 the stability went to hell and the standby count had risen to 1.5 over where it started. The standard at the end of station 37 gave 1.99981 and I reset Rs and continued. For stations 36 and 37 I did a linear correction based on the fact that the standby count was increasing steadily and the zero went from -1 to 0.

Stations 38 and 39 had mixed results stability wise. It's clear that the salinometer is not working as well as it used to. The standard at the end was 1.99971 so no drift and no correction for these stations.

This is the second day in a row that the first set of samples showed substantial drift in the first set of samples and none in the second set.

04/01/2015
At the start of my shift I made a grommet to seal a Hart thermometer probe into the salinometer's bath opening. The plan was to leave the probe installed to see if instability in readings was caused by instability in temperature. In the course of doing this I noticed that the fan cable was once again disconnected from the fan. Amazingly, it must have vibrated loose during the heavy ice breaking a few days ago. I will hold off on installing the temperature probe because it is very likely that the fan being off was the cause of the instability.

18:30 local – Temperature has stabilized, tried to run one station before we enter the ice again but got a bubble that would not flush out, DIW wash and got another bubble when flushing with old standard. Too late now to get a station run before we enter the ice.

Later on I ran stations 41 – 48 with a standard between 44 and 45. The standards were 1.99975 at the middle (then reset Rs) and 1.99965 at the end. In other words it ended right where it started but drifted around in the middle. Most samples were stable but there was a period of bad instability late in station 47 and the first sample of 48. During the latter half of this period I had a Hart thermistor probe in the bath which was very steady at 20.996 or 20.997 – bath temperature variations is not the problem. Station 47 also had heaps of bubble trouble so the two are probably related (to the water itself).

05/01/2015
Stations 49-52 were run between the first two standards and things went pretty well, slowing down at the end with lots of bubble troubles. The standards agreed perfectly so no change to Rs.

Stations 53 – 56 were a nightmare of bubbles that would not clear with anything but ethanol. At one point I spent 3 hours on a box of 12 samples. Some of the bubbles even required two flushes of ethanol to break loose. On sample R18, after getting a bubble when flushing with old standard just after and ethanol wash, I tried soaking the cell for 15 minutes in a 5 to 1 dilution of the Triton X/H2O/ETOH solution. The diluted solution would then be about 2% Triton X, 85% H2O and 13% ETOH. I followed it with one flush of ETOH, soaking for 5 minutes. This seems to have helped a little bit and the bubbles in trouble spots are now washing away with sample or DIW. The final standard came in at 1.99974. No correction was applied.

06/01/2015
I got 1 litre of isopropyl alcohol from Elwood. I started the day with the cleaning procedure as described on the Guildline website, which is detergent solution followed by isopropyl alcohol, followed by DIW, soaking for 15 minutes with each.

When I returned from dinner I ran a replicate of sample G10 and saw a shift so I ran a standard and got 1.99964. Reset Rs. No correction to earlier data as the shift appears to have occurred while I was away.

While running the first sample of station 60 (RP 1, A1) we entered pack ice so I stopped running after this. I did not run a standard because it had not been long since running one. An hour or so later we left the ice and I ran a standard that showed a big shift (Rs went from 484 to 464). I re-ran sample A1 immediately after the standard and got a number 0.002 PSU lower than when it was run the first time and the end of the previous set of samples (the re-run is the one that was reported). There appears to have been significant drift during stations 58 and or 59.

Stations 60-62 have no correction, the standard at the end of this set was 1.99972. I made the small adjustment to Rs before continuing with station 63.

Station 63 went smoothly at first with bubble trouble on the last two samples. The last sample was rerun after a full clean with Triton X followed by isopropanol and a standard was run just after it. The standard was good at 1.99968 – no correction applied and Rs reset to 1.99970.

Station 64 had 3 unstable samples but only one with bubble trouble. After the unstable samples I ran several samples with multiple extra flush/reads to make sure the instability was in the sample and not the system.

Station 65 was a nightmare of bubbles. Sample A22 got a bubble on the second flush and I immediately capped it and did a full clean with Triton X, isopropanol and then ethanol (there was a bubble after the Triton X that the propenol would not remove!). The standard at the end was good so no correction was made.

07/01/2015
The last sample of station 66 (D7) showed constantly increasing counts over about 10 flushes. I ran a standard after this and it was spot on with the starting standard. The cell was cleaned with ETOH just before D7 and I suspect it was not rinsed well enough. I am changing the flushing procedure after an alcohol clean to much more DIW flushing – 2/3 of a 500 ml bottle with about 8 flushes and some soaking time with the pump off, followed by flushes with old standard until the reading is completely stable.

Stations 67 – 71 had 3 alcohol cleans. The latter two of these have “mega-flush” or “MF” in the notes to denote the above flushing procedure. The standard value increased to 1.99978 iver the course of these stations and a linear correction was applied.

08/01/2015
Checked “merged.txt” for typos on all samples with residual >0.0015 up through station 65. Found 4 typos and changed them in “2014-15_AA_V2_CTD_salts.xlsx”. The correct values were recalculated in “typos through station 48.csv” (no typos were found in stations 49 – 65).

09/01/2015
Station 72 is bracketed by identical standards and should be quite good (R14 and R19 were rerun after being opened).

During the course of running stations 73 and 74 the standard value drifted up from 1.9997 to 1.99976 and a linear correction was applied. Rs was reset to 1.99970 and a new sheet was started for stations 75 – 78.

I am becoming sceptical of rerunning samples that have been opened and am now sometimes just doing repeat flushes with the sample until it is half gone. Sometimes this will get rid of the bubbles and I get a reading and sometimes the sample will be lost.

Stations 75 and 76 were bracketed by identical standards so no correction was applied and there was no change to Rs. The next standard was at the end of station 78 and it came out at 1.99963. The vast majority of the time between this and the previous standard was spent on two consecutive cell cleaning operations between samples D3 and D5. For this reason I applied no correction to D1 and D2 and the full correction for the final standard to all samples after D5.

10/01/2015
Stations 79 and 80 ran very smoothly. It was the longest run without bubble trouble that I have ever had. The bubbles started in the middle of station 81 and about 2 hours was spent repeatedly cleaning the cell between samples A4 and A7. The standard at the end of station 81 was 1.99976. I applied the full correction to the samples after the cell cleaning and no correction to those before. Rs was reset and I continued with station 82 and underway samples with no standard (so no correction after the underway samples.

11/01/2015
Commencing station work in Mertz region tonight. No samples to run today.

12/01/2015
Mark plotted the CTD calibration with the last stations from the Totten region and it appears that the salinometer precision has gone completely to hell. It was decided to keep the samples from the Mertz stations that have been sampled up until this afternoon for analysis in Hobart and begin double sampling (one set for Hobart and one for on board). None of the new samples will be at temperature to run today.

13/01/2015
Today I will try to run for the periods that we are on station or not getting vibrations from icebreaking. I plan to use more standards than normal to try and determine if the “drift” that I see often see between standards is really happening on a shorter time scale or not.

I started station 86 when we were in an area of open water. There were troubles with bubbles when flushing with old standard at the very start. I flushed them out with DIW and got a standard and 2 samples run before bubble trouble on the 3rd sample followed by icebreaking put a stop to it. I restarted when we arrived on the next CTD site with a new standard which was spot on at 1.99970 and managed to just finish the station before we got underway and started breaking ice again.
I ran station 87 during the next CTD cast, starting with another new standard. The standard gave 1.99978. This was just two hours after the previous standard and equates to a change in response of 0.0016 PSU.

Station 88 was run about 2 hours after 87 during the following CTD cast with no additional standardization (was told to conserve standards for the SR3 stations).

14/01/2015
Today I ran only half to two thirds of the samples from each station because they are coming in far faster than I can run them with all of the bubble trouble and cell cleaning.

I started with samples from station 89. After calibrating I got 2 samples run before getting bubbles that would not flush out. I cleaned the cell twice with ETOH and both times got bubbles when flushed with old standard after the clean. I then cleaned with Triton X followed by ISOH and DIW, soaking each one for half an hour. Then I got 3 more samples and cleaned with ETOH to finish the station.

Station 90 went relatively smoothly with only one DIW cleaning and one ETOH cleaning. At the end of the station I ran a standard and got 1.99971 and 1.99972 (on the border between the two) and reset Rs to continue with station 91.

During stations 91 – 93 I only cleaned the cell with ETOH a couple of times but spent a lot of time flushing bubbles out with sample water – 10 or more flushes per sample was common. Late in station 93 the bubbles would not go away even after repeated ETOH cleaning so I did another Triton X soak followed by ISOH and DIW. I am conserving standards for SR3 so no standard was run at the end of the day and no correction was made to any samples today.

15/01/2015
On starting up I immediately got a bubble that would not clear when flushing with old standard before standardizing the instrument. This is after doing an extensive cell cleaning procedure at the end of the day yesterday. After this I ran a standard followed by stations 94 – 99. Every ten or so samples I lost one to bubbles and had to clean the cell with ethanol. The bubbles became more problematic toward the end, including on a standard (no good readings so not used) so I cleaned with Triton X and isopropanol.

I then did another standard (1.99973) and ran stations 100 – 105 with no standard at the end. The standby number was steady throughout the run. The first batch of samples were given a very small drift correction to the second standard.

At the end of the day the upper most arm of the cell was not filling about ½ the time so I removed the cell and flushed DIW followed by air through the Teflon tubes at the tops of the cell arms. After that I did a cell cleaning with Triton X and isopropanol.

16/01/2015
Starting up today the standard showed a very large shift since the last standardization – equivalent to about 0.008 PSU (lower). I only got one reading on the standard where I set Rs and before getting bubbles that would not stop. The shift could be due the fact that I have removed and re-installed the cell since the last standardization. However I was not comfortable trusting the standard because of the large shift combined with no readings after setting Rs. I cleaned the cell with ethanol and ran three underway samples to make sure bubbles were not going to be a huge problem, then ran another standard which confirmed that the first one was good (read 1.99970).

Stations 106 – 111 ran very smoothly with no cell cleaning required. A standard after 111 gave 1.99967 (very small drift correction applied), Rs was reset and I continued.

Stations 112 – 116 were back to normal, or worse, as far as bubbles go. I cleaned the cell 5x with ethanol and twice with Triton X. We started breaking ice just as I finished station 116 but the vibrations did not get bad until I was done with the last sample. No standard was run at the end.

17/01/2015
Readings were generally less stable today than normal. On a few occasions I saw the counts jump up or down by 4 or five counts after stabilizing.

During sample R17 (122-3) I noticed a very small bubble on the back side of one of the coils, this may have been there for a few samples before I saw it. After this the bubbles became extremely troublesome. After sample R20 I cleaned the cell multiple times with all types of cleaners only to get bubbles again when flushing with DIW after cleaning. Same thing after trying to run sample R21. All of station 122 is a mess.

I spent the rest of my watch, about 7 hours from when the trouble appeared, cleaning the cell by all means possible and trying to get it flushed with old standard to be able to run a standard and start more samples. At one point I got a standard started and got two bubbles after two flushes and neither bubble would flush out. I read the standard with the bubbles to get an idea if the instrument had drifted a lot since the start of the day. The standard gave 1.99972 with the bubbles – reassuring for the previous samples. I did a final very long (1.5 hour) soak in Triton X solution, cleared that with isopropyl alcohol and DIW before going to bed. For this one I am trying something new where instead of soaking the ISOH and doing lots of flushes of DIW, I just filled it once with ISOH, drained that, filled once with DIW, continued flushing about 400 ml of DIW through without draining and then left that to soak overnight. Just before leaving I saw that a bubble had already formed on middle of the bottom right coil – probably gasses that came out of solution from all of the water passing by. I quickly flushed it with ETOH, filled with DIW and left it like that.

18/01/2015

On starting up today I had the same trouble as yesterday – unable to do anything without bubbles. I decided to remove the cell and clean the cell and electrodes manually. I used a bottle brush with triton solution on the cell, followed by ethanol and acetone. I brushed the coils gently with a pipe cleaner soaked in triton solution and soaked them briefly in dilute HCl. When I restarted the flushing with DIW, old standard and the real standard were all promising but the first sample of station 123 had bubble trouble requiring ethanol. So did the second sample, and the third. After this there was bubble trouble again even with old standard.

19/01/2014

I then decided to take the cell apart and clean it again but this time when I restarted I skipped to station 129, hoping that the water from a different area would be less problematic so that I could clear some sample bottles for the coming SR3 stations. This worked. I still had to flush with ethanol every 5 samples or so but I was able to get some samples done. The standard at the end gave 1.99975, a drift upward of 0.001 PSU. Drift correction was applied.

20/01/2015

I took the cell apart for cleaning again before starting the SR3 stations, which begin with 134. 134 and 135 ran with some difficulty – 3 ethanol flushes and one Triton X cleaning – but the data look good. The standard at the end of 135 was 1.99968 and the very small correction was applied.

Station 136 had more bubble troubles with lots of work cleaning and recleaning the cell but the data look ok. The standard at the end was practically identical to the start so no correction.

I took the cell apart for cleaning once again at the end of the day to get a good start tomorrow.

21/01/2015

Cleaning the cell at the end of the day yesterday seems to have paid off. Stations 137 and 138 ran quite smoothly with just one ethanol flush and one Triton/isopropanol flush. The standard at the end was 1.99967 and the small correction was applied.

Station 139 required a couple of Triton/ISOH flushes to get through it. The standard at the end was 1.99973 and the correction was applied.

From station 139 I started trying a new method where I flush the cell (fill and drain) three times with Triton solution, letting each fill soak for just a few minutes, followed by the usual one fill of alcohol, soaking about 10 minutes, and then the flushing a whole bottle of DIW. I am now using the Triton almost every time I get bubbles – it takes longer than just alcohol but seems to keep the bubbles away for a little while longer. My “ISOH” is now a 50/50 blend of ETOH and ISOH because I am running very low on ISOH.

Just after I started running station 133 (out of order, order is as listed here and in master data file) we left the last CTD station and they fire up both engines, which causes a fair bit of vibration in the sky lab. I looked at the data (133 vs other stations run earlier today) with Mark and it looks fine. Given that the data look ok and that the choice is to run them in these conditions or not at all, we decided to keep running.

Stations 123 – 125 were the last set of the day. The final standard was spot on so no correction.

At the end of the day I dismantled the cell and cleaned it manually again.

22/01/2015

When I started station 140 the ship was running on one engine and the lab was calm. After sample R7 they started the V16 and things started to shake. The readings appear slightly unstable now and then (only +/- 1 in the last digit) but mostly as usual. I looked at stations 140 and 141 with Mark after running them and they are two of the cleanest stations of the whole cruise, so this level of vibration does not seem to be a problem.

140 and 141 mostly ran “as usual” which is cleaning the cell with Triton X then alcohol every 6 samples or so. Toward the end of 141 the bubbles were getting more persistent so I took the cell apart for another manual cleaning after 141.

I next ran station 83. It was a nightmare of bubbles and took 3 hours for 7 samples (two of them bad). Bubbles are sticking in new places.

23/01/2015

I began with dismantling the cell, cleaning it and trying to get the coils positioned well (parallel to the arms). On starting station 84 I got one good sample and then got a big bubble near the top of the 2nd arm that would not go away for anything. Cleaning with Triton and ISOH did not help – the same bubble came back right away when I started flushing with old standard after the clean. I took the cell apart again to try to fix the position of this coil.

I started and standardized again and got a bubble in a new place, centre right of 3rd arm, on the first sample (stn 84 F12). I cleaned the cell with Triton and ISOH and got the same bubble when flushing with old standard.

I took the cell apart for the 3rd time today and took extreme care to get all four coils parallel to the cell arms. I had to remove and re-insert the electrode assembly into the cell many times to get it just right. This finally paid off and I was able to run stations 84 and 85 with only one cell cleaning midway through. The standard at the end of station 85 gave 1.99974 and the correction was applied.

24/01/2015

Today it is warm enough outside that the lab climate control system has switched out of “low ambient” mode, so the temperature is varying over a wider range of 18.5 to 21.0.

I cleaned the cell with Triton X and alcohol before starting. Stations 126 – 128 ran pretty smoothly with just two cell cleanings required to get through them. The standard at the end was almost spot on.

Later in the day I did a final run of the 3 underway samples taken this morning.

Done.

PART 2 MOORING DATA

2.1 INTRODUCTION

A total of 9 oceanographic moorings were recovered on cruise au1402: 6 “Totten” moorings (3 Australian and 3 US, all from around the Dalton Polynya), and 3 Mertz moorings (2 Australian and 1 French) (Figures 2.1 and 2.2), as discussed in the cruise narrative earlier in this report. Additionally in the Totten region, 3 temporary sound source moorings were deployed then recovered on the cruise, while an additional US mooring was deployed and recovered on the original Totten deployment cruise nbp1402 (on the Nathaniel B Palmer). In the Mertz region, a large iceberg prevented recovery of a third Australian mooring. Mooring instrumentation included thermosalinographs (SBE37SM and SBE37SMP-ODO microcats, and SBE16’s) and ADCP’s (Table 2.1). A TOGS gyroscope system was temporarily deployed with each Australian mooring, to determine ADCP landing orientation. Deployment and recovery details are discussed in unpublished cruise mooring reports. Mooring diagrams are shown in Figures 2.3 and 2.4, and mooring station details are summarised in Table 2.2. Data file formats are fully described in the README files included with the data set. This report describes mooring data processing and data quality for the Australian moorings only.

Table 2.1: Instrument types used on Australian Totten and Mertz moorings. For parameters, T=temperature, C=conductivity, O=dissolved oxygen, P=pressure, SPD=current speed, DIR=current direction.

instrument type	parameters measured	recording interval
SeaBird SBE37SM microcat	T,C,P	10 minutes
SeaBird SBE37SMP-ODO microcat (with pump)	T,C,P,O (with pump)	60 minutes
SeaBird SBE16 with Aanderaa optode	T,C,P,O	30 minutes
RDI 76.8kHz Workhorse Long Ranger ADCP, upward looking orientation	SPD,DIR,T,P,pitch,roll	80 minutes
CDL TOGS and CSIRO TOGS logger (temporary deployment with each mooring)	DIR,P,pitch,roll	1 second

2.2 DATA PROCESSING

2.2.1 General

The various instrument types are summarised in Table 2.1. All mooring data were assigned a consistent decimal time scheme, using decimal days as counted from midnight on December 31st 2013 for the Totten moorings, and from midnight on December 31st 2010 for the Mertz moorings. Duration of good data in each time series is summarised in Figures 2.6a and b.

Proximity of instruments to the south magnetic pole makes magnetic variation significant for current measurements, and compromises the functioning of magnetic compasses on instrumentation. A TOGS gyroscope was temporarily deployed with each mooring (and recovered separately), to ascertain the landing orientation of each bottom mounted ADCP. Using this ADCP orientation, all current data have been put into earth coordinates, and local magnetic field deviations therefore do not apply. The TOGS package was mounted on a separate frame, and this frame sat on the anchor tripod

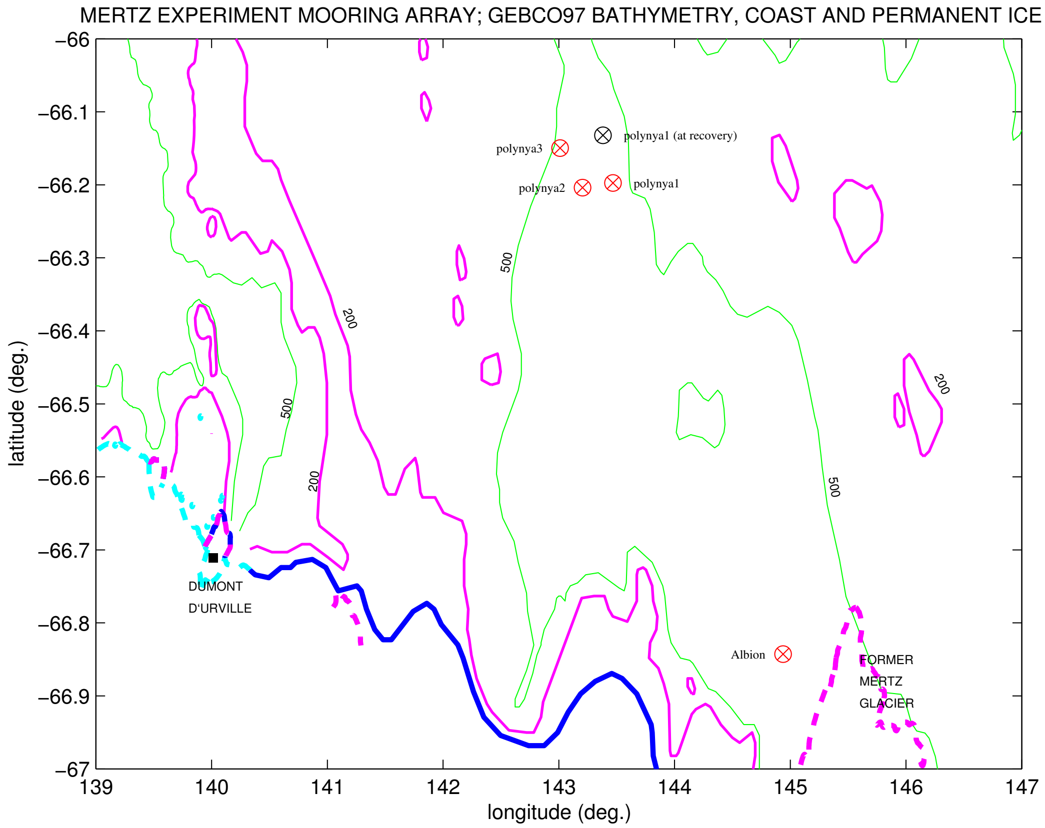


Figure2.1: **Mertz mooring locations (including French mooring Albion, and final position of Polynya1 after dragging by iceberg).**

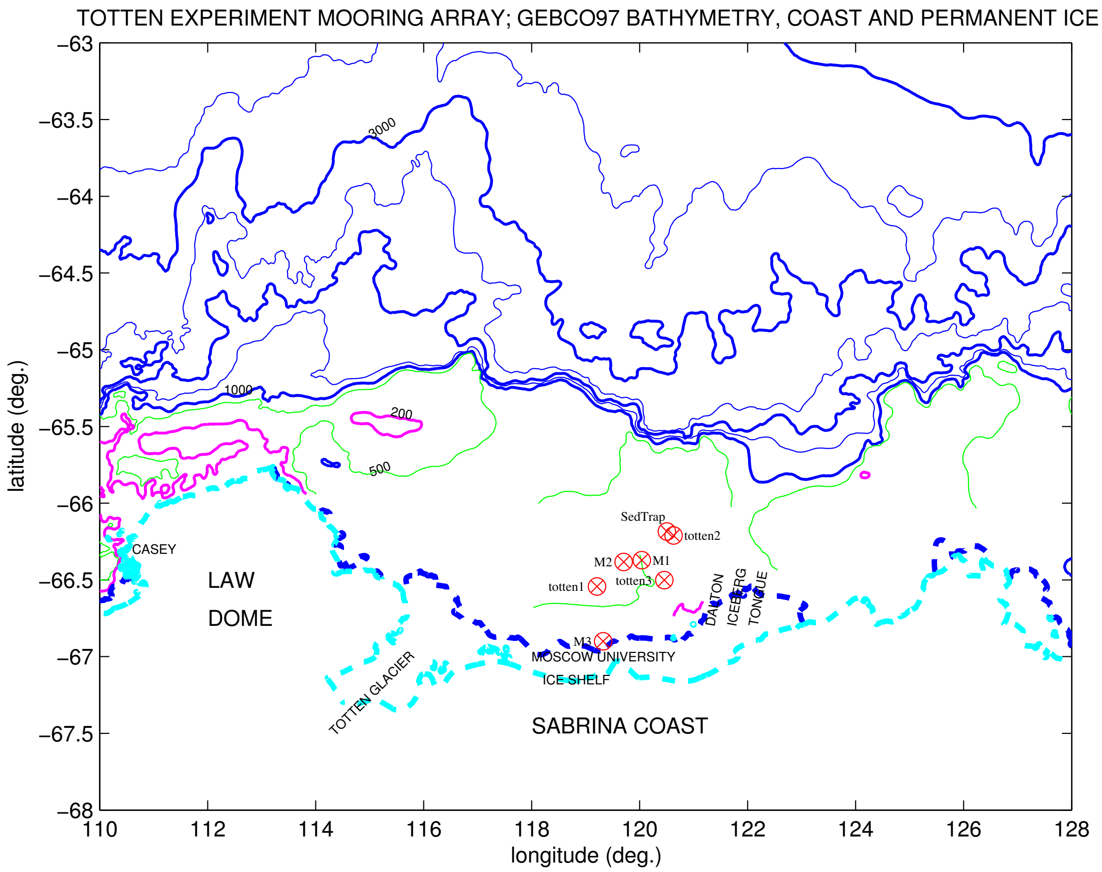


Figure 2.2: **Totten mooring locations (including US moorings M1, M2, M3 and SedTrap).**

Table 2.2: Summary of mooring stations (depths corrected for local sound speeds). Note that POLYNYA3 was not recovered. Note: French ALBION mooring included; US M2, M3 and SedTrap moorings also included (M1 was recovered on the original deployment cruise).

mooring	position		depth (m)	deployment time (UTC)	recovery (release) time (UTC)
Mertz					
[1] POLYNYA1(E)	66° 11.853'S	143° 28.052'E	542	2220, 23/01/2011	-
[2] POLYNYA1(E)	66° 07.934'S	143° 22.907'E	500	-	~0135, 18/01/2015
[3] POLYNYA2(C)	66° 12.235'S	143° 12.334'E	593	2128, 22/01/2011	~0130, 17/01/2015
POLYNYA3(w)	66° 08.976'S	143° 00.684'E	548	0508, 23/01/2011	not released
[4] ALBION	66° 50.567'S	144° 56.245'E	945	? , 23/01/2012	0250, 12/01/2015
Totten					
TOTTEN1	66° 32.558'S	119° 12.685'E	708	1253, 18/02/2014	0538, 03/01/2015
TOTTEN2	66° 12.628'S	120° 37.638'E	501	1300, 22/02/2014	0025, 26/12/2014
TOTTEN3	66° 30.082'S	120° 27.398'E	550	0322, 05/03/2014	2129, 25/12/2014
M2	66° 22.990'S	119° 42.343'E	620	0739, 18/02/2014	2040, 02/01/2015
M3	66° 52.978'S	119° 26.201'E	1051	0752, 20/02/2014	~1830, 29/12/2014
Sediment Trap	66° 11.058'S	120° 30.213'E	547	0345, 04/03/2014	~0600, 26/12/2014

Notes:
[1] POLYNYA EAST original deployment position
[2] POLYNYA EAST position at recovery, after being towed by iceberg
[3] POLYNYA CENTRE exact release time during lasso operation unknown
[4] ALBION supplied position – actual position where mooring found was offset from this by ~200 m

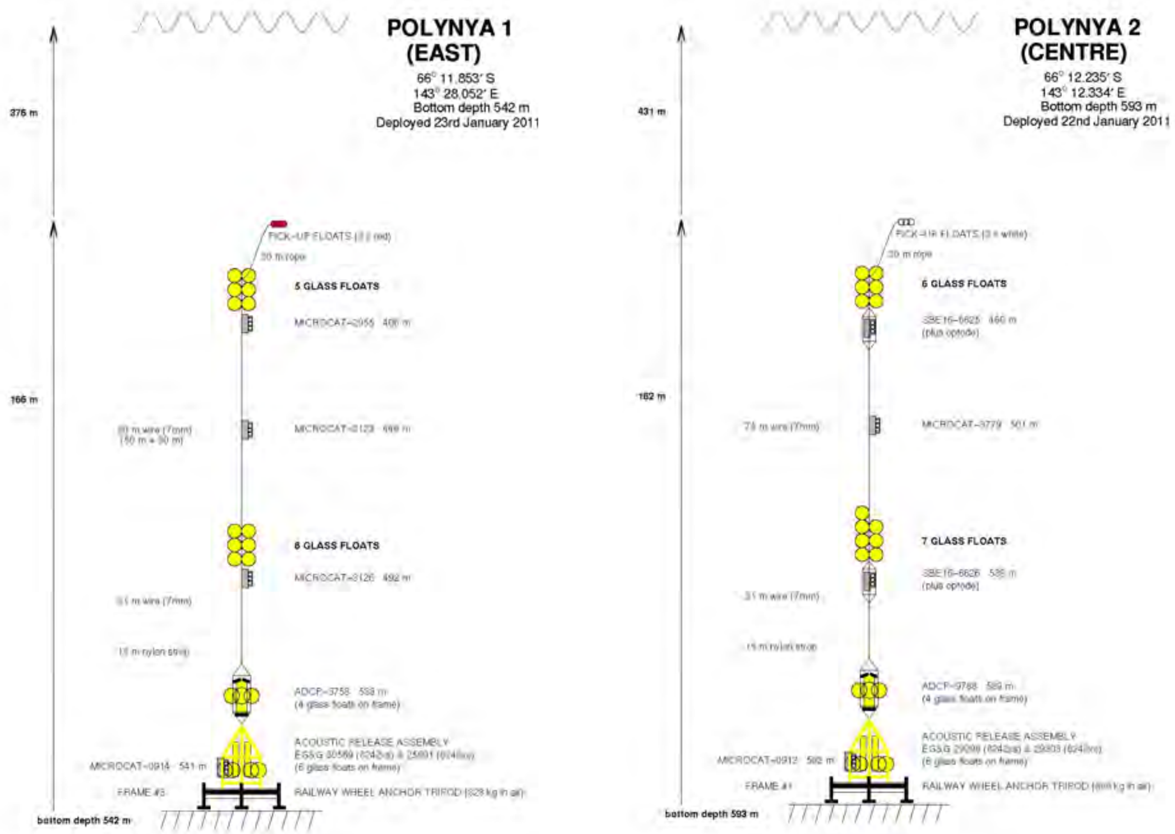
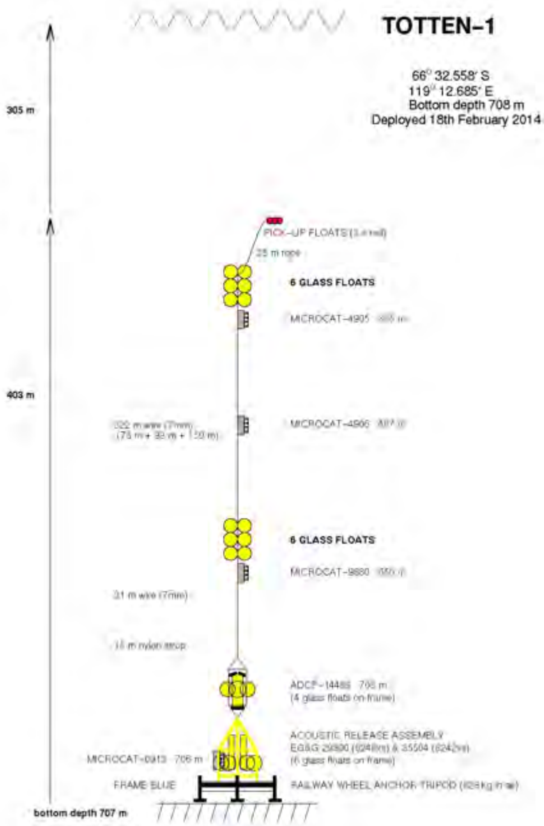
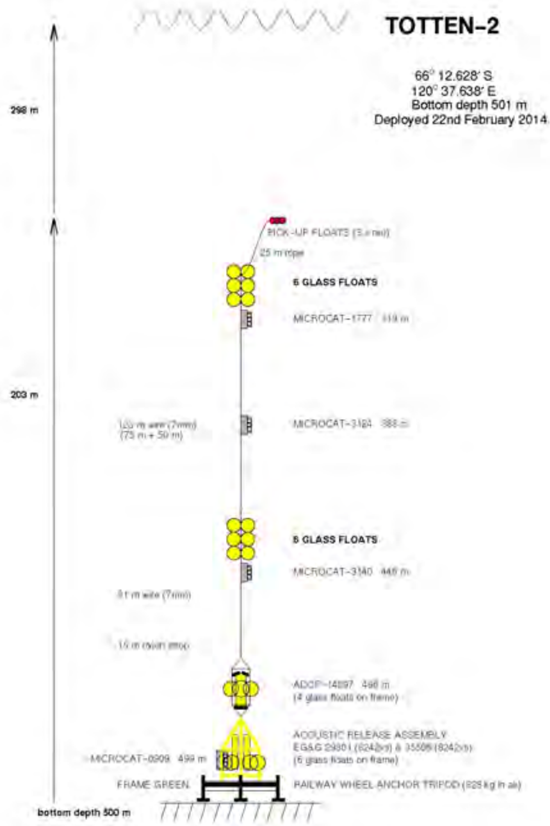


Figure 2.3: Mertz moorings Polynya1 and Polynya2 (not to scale).





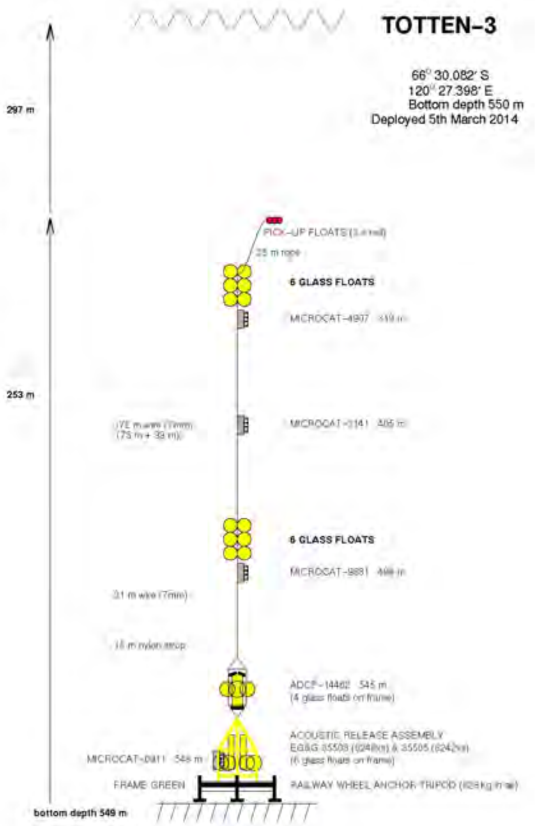


Figure 2.4: Totten moorings Totten1, Totten2 and Totten3 (not to scale).

Table 2.3: **Summary of mooring instrument positions. Positions are for vertical moorings (i.e. no tilt) - these positions are obtained from minimum pressure sensor values, except for ADCP's and bottom mounted SBE37's, where position is from the bottom depth.**

mooring	instrument	instrument position depth (m)	pressure (dbar)	mooring	instrument	instrument position depth (m)	pressure (dbar)
polynya1	SBE37-2955	405.7	410.2	totten1	SBE37-4905	325.2	328.7
	SBE37-3123	446.2	451.1		SBE37-4906	487.0	492.4
	SBE37-3126	491.9	497.4		SBE37ODO-9880	650.0	657.5
	ADCP-3758	538			ADCP-14489	703	
	SBE37-0914	541.0	547.0		SBE37-0913	705.5	713.7
polynya2	SBE16-6625	460.2	465.3	totten2	SBE37-1777	319.1	322.5
	SBE37-3779	500.9	506.5		SBE37-3124	383.1	387.3
	SBE16-6626	538.7	544.8		SBE37-3140	446.1	450.9
	ADCP-9788	589			ADCP-14397	496	
	SBE37-0912	592.0	598.5		SBE37-0909	499.2	504.8
				totten3	SBE37-4907	319.4	322.9
					SBE37-3141	404.9	409.4
					SBE37ODO-9881	494.2	499.7
					ADCP-14462	545	
					SBE37-0911	548.0	554.2

Table 2.4: **Instrument clock errors, and time series length (for good data only). Clock error values marked with * are for instruments with flat batteries, and the values are calculated from previous cruises, over the nominal time series lengths (also marked with *).**

instrument	no. of sec. fast	time (days) between start and clock check
Mertz		
SBE37-2955	835	1518.07483
SBE37-3123	*530	*1518.5
SBE37-3126	*472	*1518.5
ADCP-3758	-	-
SBE37-0914	774	1519.13610
SBE16-6625	72	1518.65911
SBE37-3779	*418	*1518.5
SBE16-6626	96	1518.33550
ADCP-9788	-	-
SBE37-0912	817	1519.06179
Totten		
SBE37-4905	122	338.40231
SBE37-4906	144	338.36875
SBEE37ODO-9880	23	337.64566
ADCP-14489	131	334.89861
SBE37-0913	95	337.59213
SBE37-1777	74	331.92552
SBE37-3124	73	331.93796
SBE37-3140	45	332.76319
ADCP-14397	116	334.89861
SBE37-0909	78	332.82697
SBE37-4907	108	332.85799
SBE37-3141	115	332.89421
SBE37ODO-9881	24	299.99732
ADCP-14462	84	334.89861
SBE37-0911	118	332.92882

for each deployment, held there by a pair of CART releases. After waiting a suitable length of time (anything from 79 to 157 minutes for the different moorings, see mooring deployment reports for full details), the TOGS frame was released from the main mooring and recovered.

Bottom depths at the mooring locations were initially obtained from sounder data from the deployment cruises: for the Mertz data, along track 12 kHz sounder data from Aurora Australis cruise au1121; and for the Totten data, multibeam data from Nathaniel B Palmer cruise nbp1402. TOGS pressure sensor data were used to adjust these values, with the following corrections:

Mertz: TOGS agrees with sounder for Polynya1 and 2
TOGS shallower than sounder by 1 m for Polynya3 (though no data as mooring not recovered)

Totten: TOGS shallower than multibeam by 1.5 m for Totten1
TOGS deeper than multibeam by 3 m for Totten2 and Totten3

Note that these differences are small, and may in fact be due to inaccuracy in both the sounder and TOGS pressure sensor data. TOGS data are used for the final values.

SBE37 and SBE16 minimum pressure sensor data show instrument depths as slightly different to nominal depths calculated from measured mooring wire lengths. The differences found are:

mooring	SBE37/SBE16 serial	instrument difference to mooring diagram
Mertz		
Polynya1	2955	3.1 dbar shallower
Polynya1	3123	3.7 dbar shallower
Polynya1	3126	0.1 dbar deeper
Polynya2	6625	0.7 dbar shallower
Polynya2	3779	1.2 dbar deeper
Polynya2	6626	0.1 dbar shallower
Totten		
Totten1	4905	6.3 dbar shallower
Totten1	4906	7.5 dbar shallower
Totten1	9880	6.4 dbar shallower
Totten2	1777	5.4 dbar shallower
Totten2	3124	4.3 dbar shallower
Totten2	3140	4.4 dbar shallower
Totten3	4907	5.0 dbar shallower
Totten3	3141	7.5 dbar shallower
Totten3	9881	5.2 dbar shallower

These differences can arise from any combination of any of the following:

- wire length error (for instruments at the end of a wire)
- instrument placement error (for instruments clamped to the middle of a wire)
- TOGS pressure sensor inaccuracy

Instrument sensor data (for SBE37's and SBE16's) have been used for all final instrument depth values, except for the bottom mounted SBE37's with no pressure sensor. For these, and for the bottom mounted ADCP's (where pressure sensor data are inaccurate and unreliable), bottom depths are used to assign instrument depths.

Mooring Polynya1 (East) was dragged by an iceberg during the week prior to recovery. It was dragged 4.44 nautical miles towards 332.05°, and deposited at the new location 66° 07.934'S, 143° 22.907'E in water depth 500 m. Unfortunately all instruments had stopped recording by then, so there are no measured data from this dragging event – just the scratch marks and mud on the recovered gear.

2.2.2 SBE37 and SBE16

Data from all the SBE37 microcats were downloaded from the instruments at sea, using the SeaBird terminal program Seaterm (versions 1.59 and 2.2.6). For the two Mertz SBE16's, remaining power in the internal batteries was low, and a repeat download was required ashore with an external power source. When first communicating with each instrument, clock error was noted (Table 2.4), with the exception of Mertz SBE37's serials 3779, 3123 and 3126 – internal batteries were flat for these instruments, and the internal clock reading was lost when new batteries were installed.

Most instruments recorded successfully, however for the Mertz moorings (recovered 2 years later than planned) all SBE37's had long finished recording well before recovery, with either full memory or flat batteries. The two Mertz SBE16's, set for 30 minute recording interval, were still recording on recovery. For future deployments, it's strongly recommended that SBE37's are set to a recording interval no less than 20 minutes, to ensure longer recording life in the case of unplanned delay to recovery.

Pre-deployment temperature, conductivity, pressure and oxygen sensor calibrations were applied internally by the instruments, with calibrations dated between August and December 2010 for Mertz instruments, and between May and November 2012 for Totten instruments (Table 2.5). Calibrations were done by the CSIRO DMAR calibration facility, except for the two Mertz SBE16's and the two Totten SBE37SMP-ODO's: calibrations for these instruments were done by SeaBird. (Note that oxygen optode calibrations were done at CSIRO). After commencement of the data processing, several strange sensor time series were noted, and the problem was traced to incorrect calibration coefficients loaded on the instruments. The coefficients on all instruments were then checked against the correct coefficients from the supplied calibration sheets, and numerous errors were found. For all affected instruments, raw data values were back-calculated and correct sensor data were then recalculated using the correct coefficients. For two of the instruments, the effect of the coefficient errors were particularly significant, as follows.

* microcat 2955 – incorrect conductivity H coefficient led to out of range data, with encoded values truncated and rolled over past the maximum bit range (in this case actually rolled over 3 times). Once the nature of this instrument encoding error had been unravelled, the correct conductivity/salinity data could be recalculated (using the correct H coefficient).

* microcat 3779 – incorrect temperature a0 coefficient led to out of range data, and once the instrument entered the water all temperature values were recorded as -10.000. Raw temperature data could therefore not be back-calculated, and all temperature data were lost. And as a result, correct conductivity/salinity values could not be calculated. The only recoverable data for this instrument was the pressure record – pressure was recalculated using the mean of the temperatures from the instruments above and below microcat 3779. Any resulting pressure error is negligible, as the effect of temperature in the pressure equation is small.

A discussion was held with the CSIRO calibration facility to help improve the methods used for transferring calibration coefficients to instruments, to prevent similar errors in the future.

Following application of all the correct calibration coefficients, the output files were manually edited to remove all out of water data at the start and end of the files, and all deployment/recovery data (i.e. mooring sinking during deployment and mooring rising after release). For the older microcats (serials 0909, 0911, 0912, 0913 and 0914) numerous encoding errors occurred, but these were in most cases recoverable – although in some cases a whole data record was skipped. Also note that these older microcats, all mounted on the bottom frames, had no pressure sensor, and a constant pressure value (Table 2.3) from the TOGS instrument was used to calculate salinities.

A fortran program was then run to pad files at the start and end, calculate decimal times, and check for and fill any data gaps. For Mertz instruments, files were padded to start from the first record on 22/01/2011 and end at the last record on 17/01/2015; for Totten instruments, files were padded to start from the first record on 18/02/2014 and end at the last record on 03/01/2015. Note that times for these padded values at the start were tweaked to match the actual times recorded at the first data record (equal to an average of 8 seconds past the hour for the six Mertz SBE37's; and equal to an average of 58 seconds past the hour for the two Totten SBE37SMP-ODO's).

Table 2.5: SBE37 and SBE16 calibration dates (all pre deployment).

instrument serial	sensor calibration dates temperature	conductivity	pressure	oxygen
Mertz				
0912	14/10/2010	18/10/2010	-	-
0914	14/10/2010	18/10/2010	-	-
2955	04/08/2010	04/08/2010	17/08/2010	-
3123	04/08/2010	04/08/2010	17/08/2010	-
3126	04/08/2010	04/08/2010	17/08/2010	-
3779	04/08/2010	04/08/2010	17/08/2010	-
6625	18/08/2010	18/08/2010	10/08/2010	10/12/2010
6626	19/08/2010	19/08/2010	10/08/2010	10/12/2010
Totten				
0909	10/10/2012	10/10/2012	-	-
0911	21/05/2012	21/05/2012	-	-
0913	21/05/2012	21/05/2012	-	-
1777	12/11/2012	12/11/2012	05/11/2012	-
3124	12/11/2012	12/11/2012	05/11/2012	-
3140	02/08/2012	02/08/2012	03/08/2012	-
3141	02/08/2012	02/08/2012	03/08/2012	-
4905	12/11/2012	12/11/2012	05/11/2012	-
4906	12/11/2012	12/11/2012	05/11/2012	-
4907	12/11/2012	12/11/2012	05/11/2012	-
9880	22/07/2012	22/07/2012	12/07/2012	11/08/2012
9881	22/07/2012	22/07/2012	17/07/2012	11/08/2012

Next, a fortran program was run to correct times for clock drift (Table 2.4). As instruments were running fast, times were linearly compressed over the time series to account for the drift. Note that both corrected and uncorrected times are included in all data files. For the three Mertz SBE37's with flat batteries (serials 3779, 3123 and 3126), clock error could not be measured, and error values calculated from a previous deployment (2007-2009) were used instead.

For SBE16 serial 6626, a few bad patches of pressure data occur from 17 to 26/12/2012; and pressure data are bad from 24/06/2014 onwards. These bad data were replaced by a constant value of 545.5 dbar. Fortunately during these times there was no pushing over of the mooring by any passing iceberg (confirmed by pressure data from the other instruments), and so the resulting pressure errors are only small (1.2 dbar at most, from any mooring blowover). Conductivity and salinity were recalculated for these times, and the resulting error in salinity is at most 0.0007 (PSS78).

For SBE37ODO-9881, a subtle drift in salinity through the time series results in density instability when compared to surrounding instruments (Alessandro Silvano, personal communication), and the latter parts of the times series should be treated with caution.

All data (with the exception of out of water data, deployment/recovery time data, and bad optode data) are included in the data files. The included data flags should be used to extract good data. Data flagged other than good are summarised in Table 2.7.

Sensor drift

All instruments (except for the oxygen optodes on the SBE16's) were sent to the manufacturer for post deployment calibration (March 2015). Post deployment calibrations were not possible for the optodes due to flooding of both sensors. Sensor drifts found between pre and post deployment calibrations are shown in Table 2.6.

For the Mertz SBE16's, sensor_pre – sensor_post for pressure temperature is 0.025 and 0.051^{o}C for instruments 6625 and 6626 respectively. For the Totten SBE37SMP-ODO oxygen sensors (i.e.

<u>Table 2.6:</u> Sensor drifts between pre and post deployment calibrations (i.e. difference = sensor_pre – sensor_post, for sensors T=temperature, C=conductivity, S=salinity, P=pressure).

SBE37/SBE16 serial	Tdiff (^{o}C)	Cdiff (mS/cm)	Sdiff (PSS78)	Pdiff (dbar)
Mertz				
0912	-0.00022	0.0069	0.0098	-
0914	-0.000125	0.0055	0.0079	-
2955	0.00204	0.0185	0.0228	-
3123	0.00122	0.0080	0.0086	1.852
3126	0.00073	0.0146	0.0172	3.5895
3779	-	-	-	-0.644
6625	-0.000365	-0.0100	-0.0135	-0.097
6626	-0.001353	-0.0102	-0.0126	-0.068
Totten				
0909	0.0001	0.0265	0.0349	-
0911	0.0013	0.0108	0.0130	-
0913	-0.0012	0.01064	0.0154	-
1777	0.00046	0.01355	0.0178	0.871
3124	0.0004	0.0141	0.0186	0.685
3140	0.0029	-0.003	-0.0077	0.40
3141	0.0006	0.0072	0.0085	1.14
905	-0.0004	0.0111	0.0153	1.003
4906	-0.0008	0.01118	0.0169	-0.68
4907	-0.00017	0.01165	0.0164	0.143
9880	-0.0003	-0.006	-0.0078	0.331
9881	-0.0012	-0.0078	-0.0089	-0.238

microcat serials 9880 and 9881), manufacturer calibration sheets show drifts of the order 15 µmol/l from the previous calibrations in 2012.

In water pressure data are stable for most instruments (the only exception being for microcat 3779 where a drift of ~1 dbar is evident over the time series), so the above pressure drifts clearly do not apply to the data from the deployments. With this in mind, calibration drifts were ***not*** applied to data from the other sensors. There is mostly no evidence when the above drifts would have occurred (e.g. during the deployment, during cleaning after recovery etc), so application of any drift corrections may result in errors of the same order as the drifts themselves. The above drifts should be used as a guide only to potential sensor drifts over the deployment record. Unfortunately any CTD data from the deployment and recovery cruises are not sufficiently coincident with mooring data for obtaining any useful calibration information. In summary: the pre deployment calibrations were used for all sensor data.

The manufacturer quotes the following sensor stabilities:

0.003 mS/cm per month for conductivity
0.0002^{o}C per month for temperature
0.004% of full scale per month for pressure

Practical field experience of sensor drifts was obtained from previous deployments in the Mertz region (1998-2000). Comparison of pre and post deployment data for this earlier ~2 year deployment revealed sensor drifts with mean values of 0.0003 (PSS78) per month for salinity (i.e. 0.0036 per year), and 0.0005^{o}C per year for temperature. So for the 4 year Mertz deployment we might expect total drifts of 0.014 (PSS78) for salinity and 0.002^{o}C for temperature. These values are in line (ballpark) with the mean drifts found in Table 2.6. For the ~1 year Totten deployment, this temperature drift value is in line (ballpark) with the mean temperature drift from Table 2.6; the conductivity value however is smaller. Note again that there is mostly no indication from the deployment time series of when drift actually occurs.

Optode

Dissolved oxygen data were measured on mooring Polynya2 (Centre) with Aanderaa optodes attached to the SBE16's (optodes serial 1335 and 1346 on SBE16's 6625 and 6626 respectively). In both cases the optode flooded ~13 months into the deployment. Bad values that are way off scale have been removed from the data files. Flooding optodes have been experienced before, with optodes attached to the shipboard CTD on cruises au1121 and au1203. On both these cruises the flooded optode crashed the entire CTD system. Fortunately a similar crash did not occur on the moored SBE16's, and all other sensors continued to record good data.

Raw optode data are converted to dissolved oxygen values as follows:

step 1

T (^{o}C) = [(Vtemp x 45) / 5] – 5

Dphase = (Vphase x 12) + 10

Bphase = (Dphase – AC0) / AC1

for Vtemp, Vphase = raw voltages measured by the optode
T = temperature
AC0, AC1 = internal coefficients programmed to the optode

step 2

O2 = [(C4 + C5.T)/(C6 + C7.Bphase) – 1] / (C1 + C2.T +C3.T^2)

for C1, C2, C3, C4, C5, C6, C7 = calibration coefficients obtained at CSIRO
O2 = dissolved oxygen concentration in fresh water (µmol/l)

step 3

salinity and temperature correction (from the Aanderaa optode manual: TD 218 operating manual, April 2007, page 32):

O2c = O2 . e^{corr}

where corr = S.(B0 + B1.Ts + B2.Ts^2 + B3.Ts^3) + C0.S^2

Ts = ln [(298.15 – T) / (273.15 + T)]

for O2c = corrected dissolved oxygen concentration in salt water (µmol/l)
T, S = temperature (^{o}C) and salinity (PSS78) measured by the SBE16
B0 = -6.24097e-03
B1 = -6.93498e-03
B2 = -6.90358e-03
B3 = -4.29155e-03
C0 = -3.11680e-07

note: requires salinity setting in the optode set to 0; if other than 0, then the S term in corr becomes S-S0, and the S^2 term in corr becomes S^2-$S0^2$, for S0 = the salinity setting in the optode *step 4*

pressure correction (from the Aanderaa optode manual, TD 218 operating manual, April 2007, page 32):

O2cc = O2c . [1 + (0.032.P/1000)]

for O2cc = final corrected dissolved oxygen concentration (µmol/l)
P = pressure (dbar) measured by the SBE16
and where the 0.032 value comes from Uchida et al. (2008).

From step 1 above, under normal circumstances AC0, AC1 should be set to 0,1 (i.e. ancoeff in the internal optode settings), and therefore Bphase = Dphase. Unfortunately this was not the case for the deployment. For optode 1346 (on SBE16 6626), the flooded optode was resurrected, allowing a dump of the internal setup: ancoeff had been set to -40.0, 0.991574, so no problem applying the correct values in step 1. However for optode 1335 (on SBE16 6625), the flooded optode could not be resurrected so no setup dump was possible. An old scrap of paper was found with supposed ancoeff values, however for optode 1346 these values did not correspond with the internal values from the setup dump.Therefore the values used for optode 1335, from the scrap of paper, are only used with 50% degree of confidence, leaving a possible error for 1335 oxygens of the order 10%. Note that the issue could not be resolved by comparison to the nearest CTD data.

Table 2.7: Data flagged in the SBE37 and SBE16 files. For conductivity/salinity data spikes, only the large obvious ones have been flagged. For flag values: 3 = suspect, 4 = bad, 7 = see data quality note in data report.

instrument	parameter	flag	data point numbers	reason
Mertz				
2955	cond/sal	3	64404-64415, 171960-2	fouling spikes
3123	cond/sal	3	24270-2, 121814	fouling spikes
3126	cond/sal	3	88582-3	fouling spike
6625	cond/sal	3	18595-18638	fouling spike
6625	oxygen	3	19758-22319	optode starting to flood
6625	oxygen	4	22320-end	optode flooded
3779	temp,cond,sal	4	all	temperature data all bad (and therefore cond and sal)
3779	press	7	all	pressure recalculated using mean of 6625 and 6626 temperatures
6626	press, cond, sal	7	numerous	bad pressures reset to 545.5 dbar, and cond/sal recalculated
6626	oxygen	3	19758-30224	optode starting to flood
6626	oxygen	4	30225-end	optode flooded
0912	cond/sal	3	16406	fouling spike
Totten				
4905	cond/sal	3	13292, 15686-15696, 18799-18800	fouling spikes
4906	cond/sal	3	26260	fouling spike
1777	cond/sal	3	10312-3, 40844-5	fouling spikes
0911	cond/sal	3	8508-9	fouling spike
9880	oxygen	3	25-26	initial oxygen spike

2.2.3 ADCP

ADCP's on the moorings were set up with the following logging parameters:

Mertz
no. of bins = 35
bin length = 16 m
ensemble interval = 80 minutes
pings per ensemble = 15 (so 1 ping every 5min 20sec)
blank after transmit = 7.04 m
distance to centre of first bin = 24.66 m

Totten
no. of bins = 37
bin length = 16 m
ensemble interval = 80 minutes
pings per ensemble = 15 (so 1 ping every 5min 20sec)
blank after transmit = 7.04 m
distance to centre of first bin = 24.81 m

ADCP's were set to record data in "instrument coordinates" (i.e. an XYZ coordinate system fixed with respect to the ADCP). In this mode, compass readings from the ADCP are not used, and current measurements are derived directly from beam measurements and are therefore independent of the earth's magnetic field. Specifically, the RDI instrument set-up command used for ADCP beam coordinate transformation was EX01111, which includes all pitch and roll corrections (from the ADCP tilt sensor). Conversion of current directions to an earth coordinate system relies on measurements from the TOGS instrument. When the bottom frames for each mooring were built at CSIRO, mounting of the TOGS was carefully surveyed in for each frame, with the TOGS heading reference physically aligned with the ADCP heading reference (i.e. the middle of beam 3).

The ADCP frames were nominally fixed to the anchor tripods with respect to horizontal rotation, but in practice there was a small amount of rotational play in the physical connection. High frequency variation of the ADCP magnetic compass headings are believable (Figure 2.5), even if the quantitative values cannot be trusted so close to the magnetic pole (the decreasing trends throughout the time series should also not be trusted).

Raw data were downloaded from the instruments at sea, using the RDI program WinSC. For the Totten instruments, a ping was listened for on deck prior to download, to assess clock drift. This was not possible for the Mertz instruments as batteries were flat. The RDI program WinADCP was used to export data from the raw files into matlab, with data in engineering units. A matlab routine was then run to change the format of matlab matrices and vectors, calculate decimal time, replace null values with NaN, convert all direction/attitude/temperature parameters to degrees and speed/velocity parameters to cm/s, and delete out of water and deployment data at the start. Mertz files start at 0000 on 10/01/2011, while Totten files start at 0000 on 04/02/2014. Clock drift was relatively small (Table 2.4), and thus no drift correction was applied. All data were averaged by the instruments over the 80 minute ensemble time (i.e. average of the 15 pings); times in the data files are at the start of each ensemble.

Several threshold tests were applied to each vertical data bin, as follows:

> if average beam correlation < 64, bin is bad
> if error velocity > 20 cm/s, bin is bad
> if percentgood1 + percentgood4 < 10, bin is bad
> if average echo amplitude difference between bin x and bin x+1 > 30,
> then surface interference is deemed to commence from bin x+1
> and up, and these bins are bad

If any of these tests failed, the main flag for all current speed, direction, and u, v and w components was given a "bad" value (i.e. 4). Note that for the last of these tests, the last good bin is obvious when looking at the data by eye, and last good bins are as follows:

adcp3758   - bin 30
adcp9788   - bin 33
adcp14489 - bin 37
adcp14397 - bin 27
adcp14462 - bin 30

Exceptions to these are when large icebergs pass overhead, lowering the last good bin. Additional flagging was done by eyeballing the whole data set (Table 2.8).

Lastly, all data were converted into earth coordinates, using the TOGS heading data from the temporary TOGS deployments at each location. Mean sound speed values were calculated at each ADCP, from microcat data. These values were very close to values used internally by the ADCP's, so no sound speed correction was required.

ADCP pressure and temperature calibration histories are unknown, and data from these sensors are unreliable. Data from the pressure sensors in particular are obviously wrong as they do not match the known instrument depths (i.e. from the deployment information); and the variation of the sensor values is beyond any expected mooring tilt.

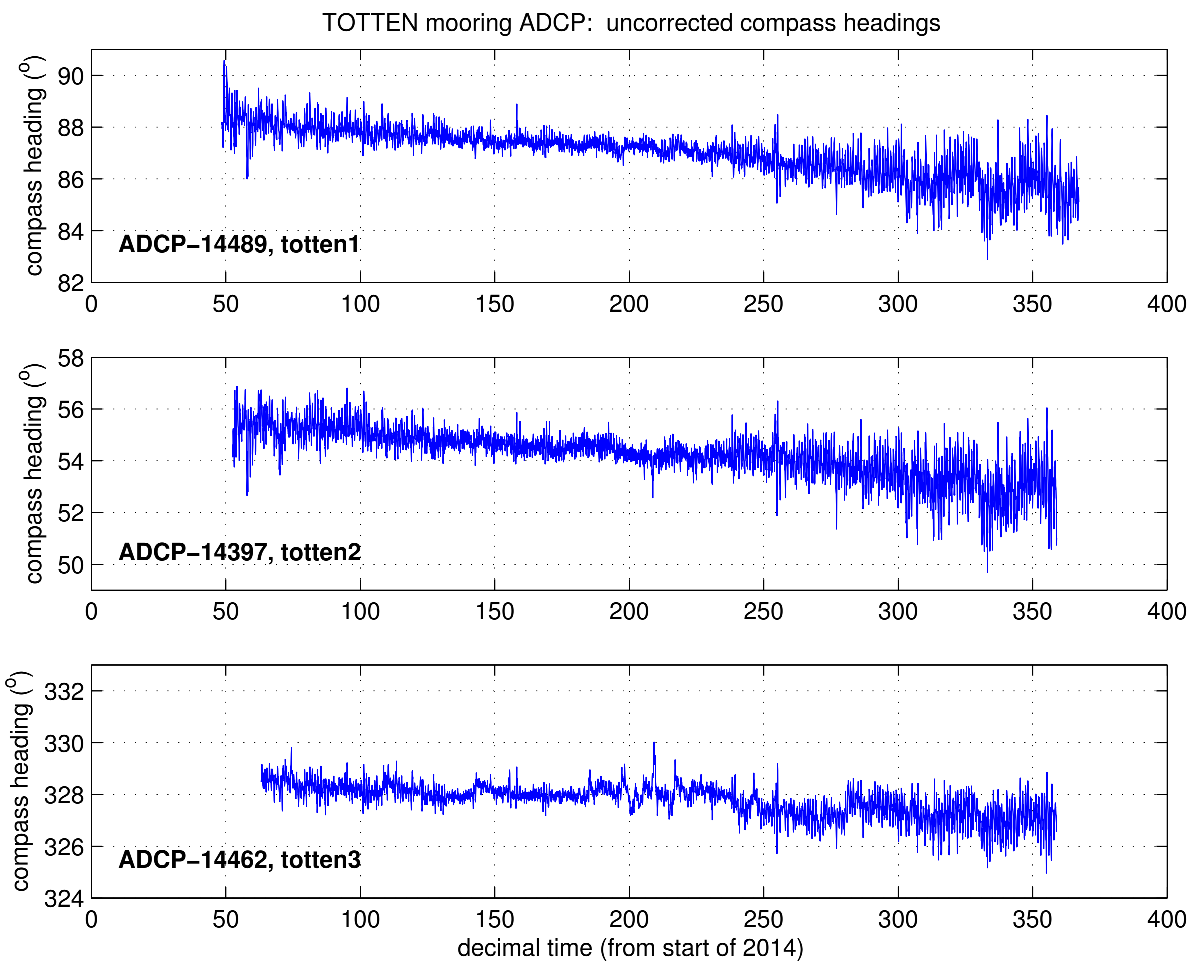


Figure 2.5: Uncorrected ADCP compass heading from the bottom mounted instruments, showing believable high frequency variation.

Both Mertz ADCP's failed after only a few days in the water. The most likely cause is a bad batch of batteries.

For the Totten data, interesting features include passing of icebergs over the moorings, clearly observed as spikes in the average echo amplitude. Iceberg draughts can be measured from these data. In addition there's often a strong diurnal signal in the raising and lowering of the last good bin of data (i.e. the last bin with flag = 1). This could be migration of organisms up and down; or it could conceivably be migration of ice crystals, density surfaces, bubbles, or in fact any layer of potential scatterers, over the diurnal cycle. This diurnal signal can sometimes also be seen in the vertical migration of a bulge in echo amplitude data.

All data (with the exception of out of water data and deployment/recovery time data) are included in the data files. The included data flags should be used to extract good data. Data flagged other than good are summarised in Table 2.8.

<u>Table 2.8:</u> Additional data flagged in the ADCP files (i.e. additional to the threshold test failures). For flag values: 3 = suspect, 4 = bad.

instrument	ensemble	bin	flag	reason
Mertz				
3758	254	28	3	suspect
3758	266	30	3	suspect
3758	278	29-30	3	suspect
Totten				
14489	625	30-37	3	something passes overhead
14489	697-700	29-37	4	iceberg
14489	821-825	27-37	4	something passes overhead
14489	874	30	3	suspect
14489	1289	32-37	4	something passes overhead
14489	1292	31-37	4	something passes overhead
14489	3718-3719	27-37	4	iceberg
14489	4672	28-37	3	something passes overhead
14489	5188	26	3	suspect
14397	500-507	15-27	4	iceberg
14397	1315-1316	12-37	4	iceberg
14397	3073-3090	25-27	4	something passes overhead
14397	3229-3230	27	3	some kind of interference
14397	3389	6-10	3	something swims over?
14397	4777-4790	25-27	4	something passes overhead
14397	4906-4918	25-27	4	something passes overhead
14397	5343-5345	19-27	3	interference at top
14397	5396-5405	19-27	4	something passes overhead
14397	5406-5417	19-27	3	interference at top
14462	577-578	17-30	4	possible iceberg
14462	975	18-30	3	suspect
14462	4465	26	3	suspect
14462	4801	19-30	3	something passes overhead
14462	5168	26	3	suspect
14462	5202-5209	24-30	3	something passes overhead

TOGS

The full 1 second TOGS data, as logged by the CSIRO logger, was used to pick final values. TOGS heading values typically converge on (or oscillate around) a final stable value, and these values were only obtainable by eye from plots of the data. In some cases a final stable value had not been reached by the time the TOGS package was released from the bottom, and final heading values were extrapolated. Overall the final heading values should only be considered accurate to ~1.5^{o} (this assessment of accuracy therefore applies to final corrected ADCP current direction). Final TOGS heading values, applied to ADCP data to convert into earth coordinates, are as follows:

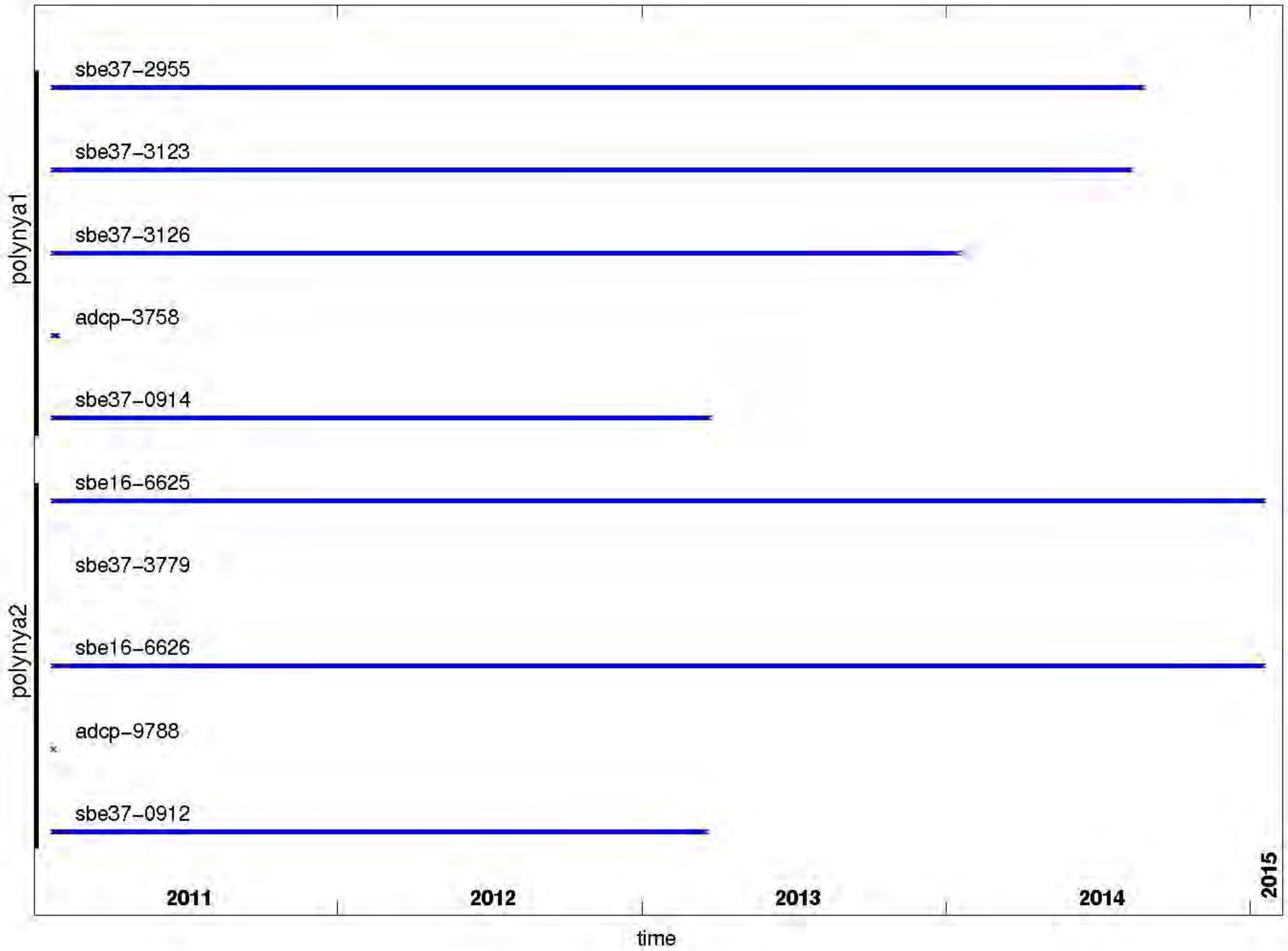
polynya1: 291.7^{o}
polynya2: 2.5^{o}
polynya3: 178.5^{o} (main mooring not recovered)
totten1: 334.0^{o}
totten2: 295.2^{o}
totten3: 191.3^{o}

Depth data recorded by the CSIRO logger were converted internally from pressure sensor data, using a density calculation with a pre-programmed density value slightly too low. Pressures were back calculated, and new depth recalculated using the UNESCO 1983 routine. These are the values used to calculate all final bottom depths (Table 2.2), and depths of bottom mounted instruments (Table 2.3).

Close inspection of TOGS tilt sensor data after the package had landed on the bottom (see mooring deployment reports) showed the following angles:

polynya1: pitch = 4.1^{o}, roll = 0.1^{o}
polynya2: pitch = 0.1^{o}, roll = -0.7^{o}
polynya3: pitch = 3.9^{o}, roll = 1.7^{o}
totten1: pitch = -1.5^{o}, roll = 4.5^{o}
totten2: pitch = 1.0^{o}, roll = 1.5^{o}
totten3: pitch = -8.0^{o}, roll = 6.0^{o}

indicating bottom anchor tripods were never sitting perfectly level on the bottom.



<u>Figure 2.6a:</u> Duration of good data in each time series for Mertz deployments (optode data not included).

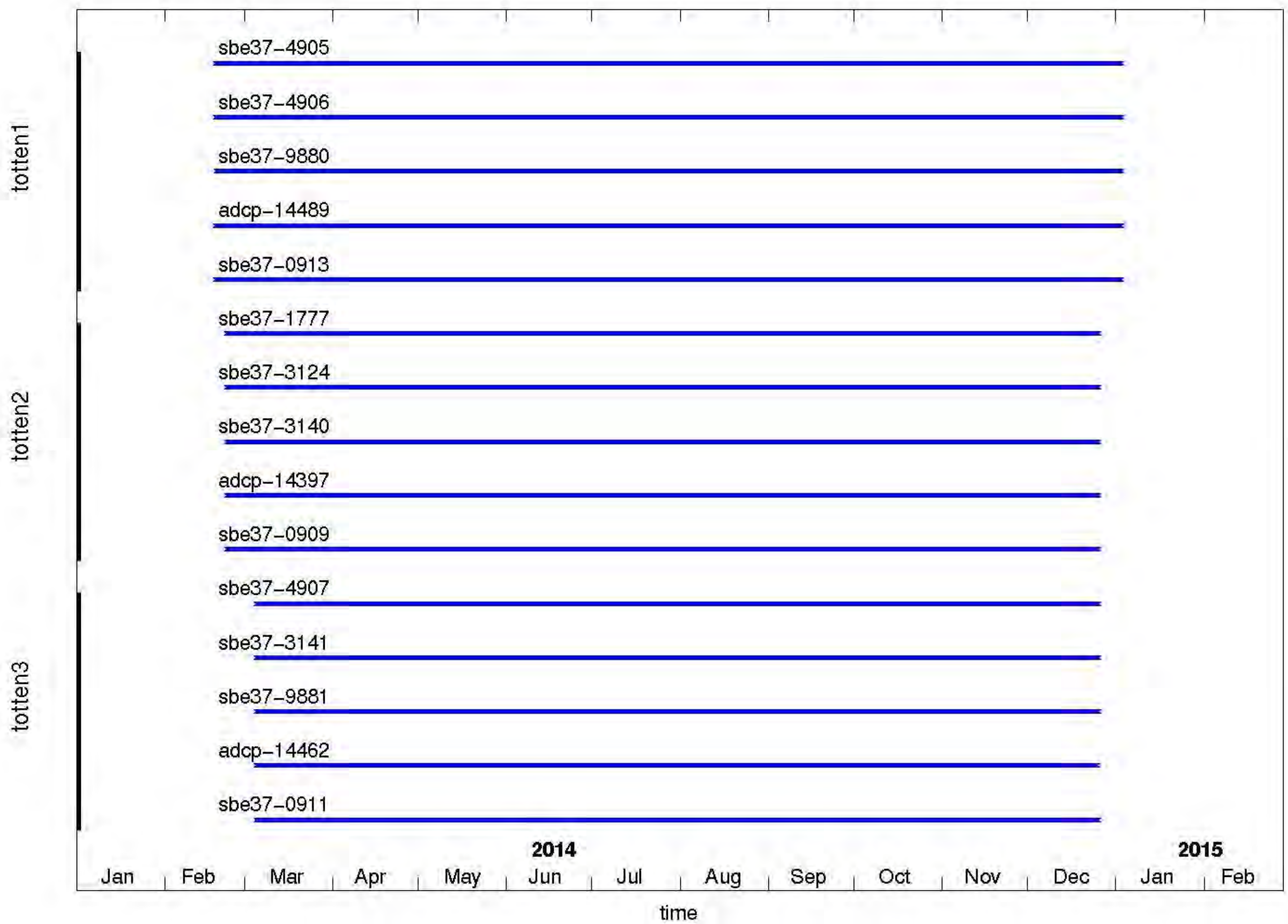


Figure 2.6b: **Duration of good data in each time series for Totten deployments.**

REFERENCES

Rosenberg, M., Fukamachi, Y., Rintoul, S., Church, J., Curran, C., Helmond, I., Miller, K., McLaughlan, D., Berry, K., Johnston, N. and Richman, J., unpublished. *Kerguelen Deep Western Boundary Current Experiment and CLIVAR I9 transect, marine science cruises AU0304 and AU0403 - oceanographic field measurements and analysis.* ACE Cooperative Research Centre, unpublished report. 78 pp.

Rosenberg, M. and Rintoul, S., unpublished-1. *Aurora Australis marine science cruise AU1121 – oceanographic field measurements and analysis.* ACE Cooperative Research Centre, September 2011, unpublished report. 45 pp.

Rosenberg, M. and Rintoul, S., unpublished-2. *Aurora Australis marine science cruise AU1203 – oceanographic field measurements and analysis.* ACE Cooperative Research Centre, November 2012, unpublished report. 30 pp.

Uchida, H., Kawano, T., Kaneko, I. and Fukasawa, M. In situ calibration of optodebased oxygen sensors. *Journal of Atmospheric and Oceanic Technology, vo. 25, pp. 2271-2281, 2008.*

ACKNOWLEDGEMENTS

Thanks to all scientific personnel who participated in the cruise, to the oceanography team for a great job collecting the data, and to the crew of the RSV Aurora Australis. Special thanks to the crew in particular for the dedication required to reach many of the mooring sites, and for the hard work and imagination required for the numerous mooring recovery methods.

CCHDO Data Processing Notes

- **File Online** **Carolina Berys**

09AR1402_woceexchange_version11oct2017.zip.gz (download) #4626a
Date: 2020-08-26
Current Status: unprocessed

- **File Submission** **Mark Rosenberg**

09AR1402_woceexchange_version11oct2017.zip.gz (download) #4626a
Date: 2020-08-26
Current Status: unprocessed
Notes

```
TOTTEN/DALTON/MOSCOW UNIVERSITY ICESHELF REGION, MERTZ REGION and SR3 TRANSECT,
 VOYAGE AU1402 (i.e. 09AR1402) CTD and BOTTLE DATA
------------------------------------------------------------------------------
- data version 9th May 2017, WHPO "exchange" format

Here's the latest version of the CTD and Niskin bottle data for voyage au1402
(i.e. 09AR1402) (Totten/Dalton/Moscow university Iceshelf region, Mertz region,
and southern end of SR3 transect),Aurora Australis Voyage 2 2014/2015, 5th Dec
2014 to 25th Jan 2015.

NOTE: all data here are finalised

The data originators (ACE CRC, Australia) should be acknowledged in any
publication,including internal reports, published reports, journal articles,
presentations etc. The following reference can be used for the data:

Rosenberg, M. and Rintoul, S. (unpublished) Aurora Australis Marine Science
Cruise AU1402, Totten and Mertz CTD's and Moorings - oceanographic field
measurements and analysis. ACECRC, Hobart, 2015 unpublished report, 69 pp.

The above data report, in the file a1402.pdf, gives important details on data
processing and data quality.

Please do not distribute these data without this README file.

Thanks very much.


regards,
         Mark Rosenberg
        ACECRC
         mark.rosenberg@utas.edu.au


The CTD stations are as follows:
```

```
1          TEST
2-82       TOTTEN/DALTON/MOSCOW UNIVERSITY ICESHELF REGION
83-133     MERTZ REGION
134-141    SR3
```

```
Data files:

*.ctd = CTD 2 dbar data
*.sea = bottle data
*.sum = station information
```

- **File Online** **Carolina Berys**

au1402.zip (download) #3f4be
Date: 2020-08-18
Current Status: unprocessed

- **File Submission** **Jerry Kappa for Mark Rosenberg**

au1402.zip (download) #3f4be
Date: 2020-08-18
Current Status: unprocessed
Notes

```
TOTTEN AND MERTZ VOYAGE AU1402 CTD and BOTTLE DATA  - data version 2nd June
2015
--------------------------------------------------

Here's the latest version of the CTD and Niskin bottle data for voyage au1402
(Totten/Dalton plus Mertz region), Aurora Australis Voyage 2 2014/2015, 5th Dec
2014
to 25th Jan 2015.

The data originators ACE CRC Australia should be acknowledged in any
publication, including internal reports, published reports, journal articles,
presentations etc. The following reference can be used for the data:

Rosenberg, M. and Rintoul, S. (unpublished) Aurora Australis Marine Science
Cruise AU1402, Totten and Mertz CTD's and Moorings - oceanographic field
measurements and analysis. ACECRC, Hobart, 2015 unpublished report, 69 pp.

The above data report, in the file a1402.pdf, gives important details on data
processing and data quality.

Please do not distribute these data without this README file.

Thanks very much.


regards,
         Mark Rosenberg
```

mark.rosenberg@utas.edu.au

The CTD stations are as follows:

1	TEST
2-82	TOTTEN/DALTON REGION
83-133	MERTZ REGION
134-141	SR3

CTD DATA
----

* SeaBird CTD 704 was used for the entire cruise.

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

```
a14024010.all -  a = Aurora Australis
                14 = year of first CTD
                02 = cruise number (i.e. voyage 2 in this case)
                 4 = CTD instrument number
               010 = CTD cast number
```

* Post-processed bathymetry data for the cruise are included in the file headers and station data file. All bottom depths are corrected for the local sound speed at each station.

* The CTD 2 dbar files consist of a 15 line header with station info, followed by the data in column format, as follows:

column 1 - pressure (dbar)
column 2 - temperature (degrees C, T90 scale)
column 3 - conductivity (mS/cm)
column 4 - salinity (PSS78)
column 5 - dissolved oxygen (umol/l)
column 6 - fluorescence (manufacturer supplied calibration giving units ug/l)
column 7 - photosynthetically active radiation (PAR) (manufacturer supplied calibration giving units uEinsteins/m2.sec)
column 8 - transmittance (% transmittance, referenced to clean water value)
column 9 - number of data points used in the 2 dbar bin
column 10 - fluorescence, upcast data
column 11 - PAR, upcast data
column 12 - transmittance, upcast data
column 13 - number of data points used in the 2 dbar bin, upcast data

* CTD data are all 2 dbar averaged values, for each even valued pressure bin.

* columns 2 to 9 are downcast data; columns 10 to 13 are upcast data (both downcast and upcast data are supplied for fluorescence, PAR and transmittance).

* All files start at 2 dbar, and there is a line for each 2 dbar bin.

Any missing data are filled by the null value -9.0

* Temperature/conductivity/salinity data are from the primary temperature and conductivity sensor pair for all CTD casts.

* Station information contained in the headers is described below in the section on station data, with the addition of:
lastbin = deepest 2 dbar pressure bin (dbar) for the cast
pressure (dbar) at the minimum altimeter value
local sound speed (m/s) used for correction of bottom depths

* Note that all oxygen values are volumetric (i.e. umol/l).

* Note that deeper fluorescence data are slightly negative in value, due to the calibration coefficients supplied.

* Note that maximum transmittance values are slightly less than the expected 100%, due to a small calibration error.

BOTTLE DATA
----
* All bottle oxygen data are finalised

* Note that all nutrient and oxygen values are volumetric (i.e. umol/l).

* The bottle data (hydrochemistry) are contained in the a1402.bot text file, with the following columns:

column 1 - cast number
column 2 - ctd pressure (dbar)
column 3 - ctd temperature (deg. C, T90 scale)
column 4 - null data (i.e. -9.0)
column 5 - ctd conductivity (mS/cm)
column 6 - ctd salinity (PSS78)
column 7 - bottle salinity (PSS78)
column 8 - phosphate (umol/l)
column 9 - nitrate (umol/l) (i.e. total nitrate+nitrite)
column 10 - silicate (umol/l)
column 11 - bottle dissolved oxygen (umol/l)
column 12 - bottle flag (1=good,0=suspicious,-1=bad, relevant to salinity values for CTD calibration i.e. not applicable to other bottle data)
column 13 - niskin bottle number
column 14 - ctd fluorescence (units as per CTD note above)
column 15 - ctd photosynthetically active radiation (PAR) (units as per CTD note above)
column 16 - ctd transmittance (units as per CTD note above)

* Columns 2, 3, 5, 6, 14, 15 and 16 are all the averages of CTD upcast burst data (i.e. averages of the 10 seconds of CTD data from 5 seconds prior to 5 seconds after each bottle firing).

Temperature, conductivity and salinity data are from the primary sensor pair.

* Any missing data are filled by the null value -9.0

STATION INFORMATION

A summary of the station information is contained in the a1402.sta file (this station information is also included in the matlab file a1402.mat). All times are UTC. The data columns for each cast are:

CTD cast number
date (dd Mmm yyyy), start of downcast
time (hhmmss), start of downcast
latitude (degrees and decimal minutes), start of downcast
longitude (degrees and decimal minutes), start of downcast
water depth (m), start of downcast
time (hhmmss), bottom of cast
latitude (degrees and decimal minutes), bottom of cast
longitude (degrees and decimal minutes), bottom of cast
water depth (m), bottom of cast, calculated from pressure and altimeter at bottom of cast
time (hhmmss), end of cast
latitude (degrees and decimal minutes), end of cast
longitude (degrees and decimal minutes), end of cast
water depth (m), end of cast
altimeter (m) - minimum altimeter value
maximum pressure (dbar) for the cast
decimal time, start of downcast
decimal time, bottom of downcast
decimal time, end of downcast

* All times are UTC

* Decimal times are decimal days from 2400 on 31st Dec. 2013 (so, for example, midday on 2nd January 2015 = decimal time 366.5).

* Any missing values are filled by a blank

MATLAB FORMAT

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

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

* In the matlab CTD file, profiles are padded down to 4400 dbar.

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

* CTD data are in matlab format in the file a1402.mat, which includes station info.
The array names have the following meaning:
all times are UTC
"start" refers to start of cast
"bottom" refers to bottom of cast
"end" refers to end of cast
"dectime" is decimal days from 2400 on 31st Dec. 2013 (so, for example, midday on 2nd January 2015 = decimal time 366.5).
"lat" is latitude (decimal degrees, where -ve = south)
"lon" is longitude (decimal degrees, where +ve = east)
"time" is hhmmss time
"botd" is ocean depth (m)
maxp = maximum pressure of the CTD cast (dbar)
lastbin = deepest 2 dbar pressure bin (dbar) for the cast
ctdunit = instrument serial number
"ctd" is the CTD 2dbar averaged data, for the parameters:
   cond=conductivity (mS/cm)
   fluoro=fluorescence
   npts=number of data points used in the 2 dbar bin
   ox=dissolved oxygen (umol/l)
   par=photosynthetically active radiation
   press=pressure (dbar)
   sal=salinity (PSS78)
   temp=temperature (deg.C T90)
   trans=transmittance
   fluoro_up=upcast fluorescence
   par_up=upcast photosynthetically active radiation
   trans_up=upcast transmittance
   npts_up=upcast version of npts
date is ddmmyyyy date
altimeter = minimum altimeter value (m)
press_alt = pressure (dbar) at the minimum altimeter value

* Bottle data are also in matlab format in the file called a1402bot.mat, which includes some of the station info.
The array names have the following meaning:
"ctdbot" refers to upcast CTD burst data, for the parameters:
   cond=conductivity (mS/cm)
   fluoro=fluorescence
   par=photosynthetically active radiation
   press=pressure (dbar) (also in array hyd_press)
   sal=salinity (PSS78)
   temp=temperature (deg.C T90)
   trans=transmittance
"hyd" refers to bottle data, for the parameters:
   ox=dissolved oxygen (umol/l)
   sal=salinity (PSS78)
flag = the bottle flag described under the bottle data section
niskin = niskin bottle number
nitrate (i.e. total nitrate+nitrite),phosphate,silicate = umol/l
station = CTD cast number
note that hyd_press is the same as ctdbot_press

WOCE EXCHANGE FORMAT - xxxnot done yetxxx

CTD and bottle data are also available on request in WOCE "Exchange" format, as follows:

*.ctd = CTD data
a1402.sea = bottle data
a1402.sum = station information

* All oxygen and nutrient data in these files are in gravimetric units (i.e. umol/kg).

* Any missing data are filled by the null value -999.0

BRIEF DATA QUALITY NOTES

* The following CTD 2 dbar data are suspect (not removed from the data files) (this same information is in the file sussctd.dat):

stn	parameter	pressure (dbar)	comment
54	temp/cond/sal/ox	2-18	sensors possibly frozen
94	ox	4-20	possibly high by ~6umol/l

* Bad salinity bottle samples are listed in the file:
  badsalbtl.dat

* The following nutrient data are suspect (not removed from the data files) (this same information is in the file sussnut.dat):

phosphate

stn	Niskin bottle	
18	5	low by ~3.5%
37	17,9	low by ~3%
54	5	low by ~2.5%
62	15	low by ~3%
79	24,1	low by ~3%
90	5	low by ~2%
141	2	low by ~2%

nitrate

stn	Niskin bottle
-	-

silicate

stn	Niskin bottle
-	-

```
* For Antarctic shelf data (stn 1-133), when lowering or raising of the CTD
slowed down
in regions of significant vertical structure, high variability was at times
evident in the profile data.
Examples of this are sensor spikes near the bottom of stations 50, 55 and 72.
This variability was also evident as sensor drift during bottle stops. In all
these cases
any unusual features can be seen in both the primary and secondary sensor data,
however
the primary and secondary sensor data mismatch is more than usual. Possible
reasons are:
- highly variable ocean structure (more likely)
- sensor time constants (possible contributor)
- interference from ice crystals forming as the CTD slows (speculative)
These data are not flagged as suspect, but are perhaps at the limit what the
CTD can accurately
measure in a highly variable environment.

* Many shelf stations were taken around highly variable bottom topography, and
in a few cases
(e.g. stations 3 and 114) a mismatch occurred between bottom depth from the 12
kHz sounder and
bottom depth as measured by the CTD (i.e. pressure at bottom of cast +
altimeter reading).
Clearly the CTD does not always lie in the measurement cone of the sounder; and
bottom picking
of sounder data (during the quality control) can be difficult in highly
variable topography.

* 2 dbar upcast fluorescence and transmittance data do not always match the
fluorescence and
transmittance upcast 10 sec burst data - due to the difference between 2 dbar
and
10 second averageing on what is often highly featured data.

* A full data report is in the file a1402.pdf.
```

- **File Online** **Carolina Berys**

09AR20141205_woceexchange_version01.csv (download) #6bb37
Date: 2020-08-18
Current Status: unprocessed

- **File Online** **Carolina Berys**

09AR20141205_woceexchange_version01.csv (download) #c4790
Date: 2020-08-18
Current Status: unprocessed

- **File Submission** **Bronte Tilbrook**

[09AR20141205_woceexchange_version01.csv (download)] #6bb37
Date: 2020-08-17
Current Status: unprocessed
Notes

```
 submitted this on 13 August and cleaned up the file header information a bit.
This only fixes a couple of issues with The comments following # at teh file
beginning and teh data remains the same.
http://cchdo.ucsd.edu/submit/confirm/eb32800d-1356-4be5-8de5-4c135253f81c
```

- **File Submission** **Bronte Tilbrook**

[09AR20141205_woceexchange_version01.csv (download)] #c4790
Date: 2020-08-13
Current Status: unprocessed
Notes

```
We thought this was submitted. The attached has final carbon data added to the
referenced CTD dat
```