CTD Processing Notes

R V Southern Surveyor Voyage SS2008/09

24 July - 11 August 2008

Data processing completed by Bob Beattie
July 2009

1. Summary

These notes relate to the production of quality controlled (QC'ed), calibrated CTD data from RV Southern Surveyor voyage SS 2008/09 (24 July - 11 August, 2008).

Data for 208 deployments was acquired using a Sea-Bird SBE911 CTD, fitted with a 24 bottle rosette sampler. Sea-Bird-supplied calibration factors were used to compute the pressures, water temperatures and preliminary conductivity values. The data was subjected to automated QC to remove spikes and out-of-range values.

The calibration for the primary conductivity was based on a deployment grouping of all deployments. The secondary conductivity was only calibrated for deployments 1-143, as the secondary data for the later deployments was unusable due to a pump failure. Approx. 685 of the available 729 salinity samples were used to compute the conductivity calibrations. These resulted in calibration standard deviations S.D.'s of 0.00514 and 0.00356 p.s.u. resp. for the primary and secondary sensors. These are well outside our target of 'better than 0.002 p.s.u.', but are considered to be 'adequate', given the shallow depths of most of the stations. The averaged files were produced using data from the primary sensors.

The SBE 43 oxygen data was calibrated as a single deployment grouping. 720 of the available 745 oxygen analyses were used to produce the calibration, which had a fit SD of 1.413 uMol/l, a much better result than we have previously obtained using Beckman or Optode sensors. The is generally good agreement between the CTD and bottle data. Lindsay Pender's hysteresis corrections have greatly improved the deeper data, but there is probably a need for a correction for the sensor's slow response time and possibly for some residual hysteresis effects.

Optode Oxygen was calibrated by back-calculating the bottle oxygen to the equivalent Optode Phase and producing a linear fit of these values to the CTD sample bursts. The resulting calibrated Optode Phase was used to compute the downcast dissolved oxygen. The calibrations for the two sensors used were performed as separate deployment groups The calibration SDs for the two groups were 1.53 and 2.69 uMol/l, which were respectively 'slightly worse than' and 'almost double' the result obtained for the SBE 43 sensor. The Optode data is significantly degraded by the sensor's long response time, of approx. 30 secs, and was not included in the averaged files.

A Chelsea Aquatracker fluorometer, SeaTech transmissometer, Biospherical Photosynthetically Active Radiation (PAR) sensor and an AMT pH electrode were installed on the CTD's

auxiliary A/D channels. This auxiliary data has been subjected to the same de-spiking as the standard CTD data, but it is essentially uncalibrated, with only nominal or manufacturer's calibrations having been applied.

The final products were:

- 1 and 2dB, netCDF files of averaged temperature, salinity, (SBE 43) oxygen, fluorescence, transmissometer, PAR and pH.
- csv files of the station and sample-burst data. One sample-burst csv file contains the calibrated data for the 'standard' sensors and another has the 'standard' sensors, plus the data for the fluorometer, transmissometer, PAR and pH channels.
- Multi-parameter profile plots of the averaged data and of the downcast oxygen + bottle data. These have been included in the ctd/local_docs directory for the processed voyage data.

2. Voyage details

2.1 Title

'Carbon Chemistry of the Great Barrier Reef'

2.2 Principal Investigators

Dr. Bronte Tilbrook (Chief Scientist) and Dr. Richard Matear, both from Centre for Australian Weather and Climate Research, CSIRO-BOM

2.3 Voyage objectives

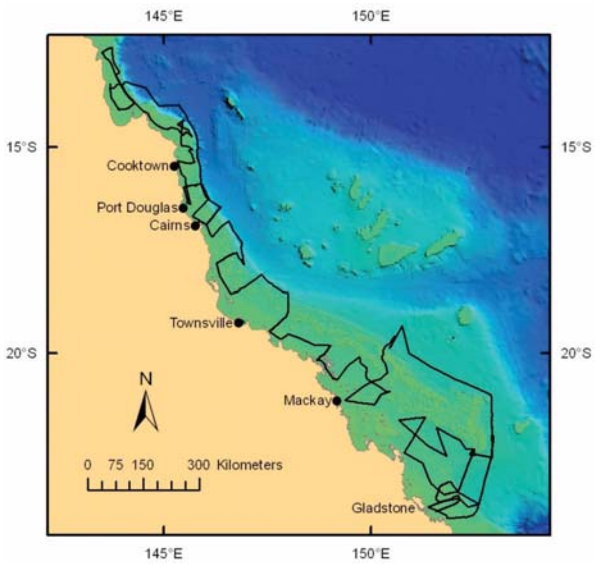
The Voyage Summary Report (Tilbrook & Matear, 2008) states that:

" The voyage was designed to provide data
needed to study the regional-scale carbonate chemistry of the Great Barrier Reef. This is the first detailed baseline data of the carbonate chemistry through the region during the dry season in late July/early August. These measurements are significant for investigations of the vulnerability of the reef system to ocean acidification. They provide input to biogeochemical modelling and allow an assessment to be made of how the carbonate chemistry of the region is influenced by the production and calcification on the reef and in the adjacent Coral Sea, the source waters of the GBR."

If you require further details, please refer to the Summary, which can be viewed at http://www.marine.csiro.au/nationalfacility/voyagedocs/2008/MNF_SS09-08_sum.pdf.

2.4 Area of operation

The area of operation is shown in the adjacent map, taken from Tilbrook and Matear (2008).



3. Processing Notes

Data for 208 deployments were processed. Preliminary processing of the Conductivity data commenced during the voyage, but SBE 43 oxygen processing had to await the completion of its calibration routines.

There were an number of issues with the format of the scan files, which meant that they had to be re-generated ashore. The new files replaced the original scan files in the voyage's raw data archive. The procedures involved in regenerating the files are documented in archive/ctd/README.ctdFiles in the ss200809 raw data archive.

The regenerated scan files were transferred to shore-based processing work area, ~dpg/ctd/ss2008-09/scan_partProc. The SBE 43 data was reprocessed in June/July, to take advantage of Lindsay Pender's hysteresis correction routines. At this time, I also re-did the conductivity calibrations, removing additional sample outliers so as to improve the quality of the calibration fits.

3.1 Background Information

The data was acquired with the Marine National Facility's CTD unit #21, a Sea-Bird SBE911-Plus, with dual conductivity and temperature sensors. A number of auxiliary sensors were connected via the Sea-Bird's A2D inputs.

The sensor details, listed in Table 1 below, have been compiled from Macdonald (2008), the CTD log sheets, the output of the CTDSensorReport Matlab script, the CTD netCDF scan files and from the sensor calibration reports.

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TABLE 1. CTD Sensor Configuration

Sensor	Serial No.	SBE911 A/D #	Calibration date	Calibration source
DigiQuartz Pressure			2007-01-18	Sea-Bird
Primary Temperature	4718		2007-01-04	Sea-Bird
Primary Conductivity	3309		2007-01-18	Sea-Bird
Secondary Temperature	4722		2007-01-18	Sea-Bird
Secondary Conductivity	3311 (to dep 211) 2312 (dep 212 > ?)		2007-01-18 ? (See Notes)	Sea-Bird ?
PAR (Biospherical QCP2300)	70111	A0	2006-06-12	Biospherical
Fluorometer (Chelsea Aquatracka)	06-5941-01	A1		
PSA-916 Altimeter	1270	A2		
AMT pH Electrode Removed after dep #57		A3		
Aanderaa Oxygen Optode 3975A. (#835 used dep 78 onwards)	716/Foil 4804 835/Foil 3853	A4		Aanderaa
SeaTech Transmissometer	247D	A5		
Sea-Bird SBE 43 oxygen	1239	A6	2007-05-25	Sea-Bird

Important Notes re Secondary Conductivity:

The CTD Configuration Table from the ss2008/09 Voyage Electronics Report (MacDonald, 2008) notes that the secondary conductivity cell s/n 2312 was swapped in, in place of #3311, prior to deployment 212. This is contrary to my recollections, and to the notes that I made, at the time, in the *procCTD Procedures Manual* (Beattie, 2009)

1. The CTD’s secondary pump failed after deployment #143, but the problem was not recognized until 10th August (Macdonald, 2008), when we had processed the data.

   The failure symptoms are illustrated in Fig 2 on the following page.

2. The problem was initially mis-diagnosed as a conductivity cell failure, and a new sensor was swapped in.

3. Shortly after conductivity cell was replaced, we realized that the problem was due to a pump failure and replaced the pump. Macdonald (2008) notes that this was done prior to deployment 212, and this is confirmed by conductivity plots for this deployment. It is my recollection that we also re-installed the original conductivity sensor, probably at the same time.

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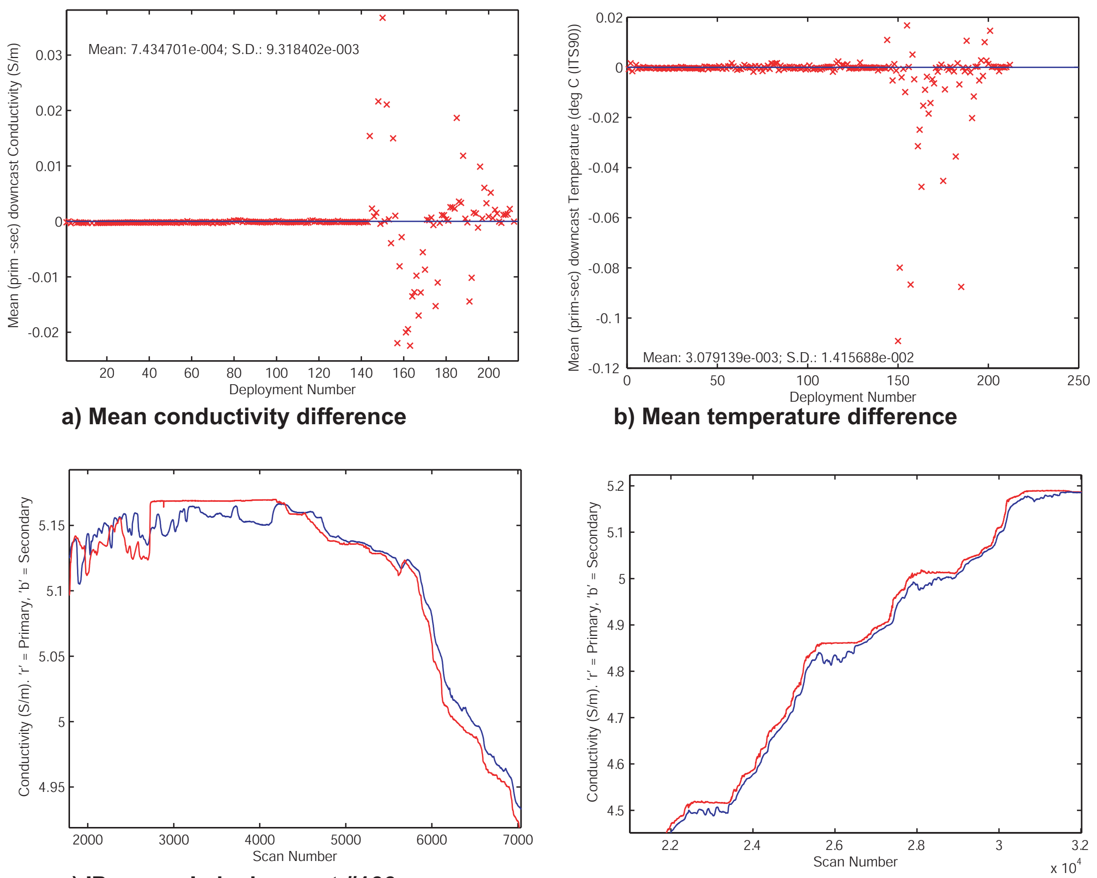
Fig 2: CTD Secondary pump failure, SS2008-09



a) Mean conductivity difference

b) Mean temperature difference

c) 'Pump on', deployment #166

d) 'Upcast', deployment #158

During SS2008-09, the Secondary pump failed after deployment #143 and was replaced before #212

The following additional comments can be made regarding the CTD sensor configuration:

- There is no reference to conductivity sensor or pump changes on any of the CTD deployment log sheets. I admit that I also omitted to make reference to any changes in my Data Acquisition & Computing Report (Beattie, 2008)
- The netCDF scan files show that the calibration coefficients for conductivity cell #2312 were never entered into CAP. i.e., the coefficients for 3311 were used for the entire voyage.
- The Electronics report for the subsequent transit voyage, st2008/03 (Mills, 2008a) is not clear re which conductivity cell was used as the secondary sensor. In the CTD Configuration Table (CTD CT), it says that sensor #2312 was used, but the Equipment Information Table (EIT) says that both #2312 and #3311 were used.
- The CTD CT for ss2008/10 (Suthers) (Mills, 2008b) lists #2312, but the EIT lists #3311.

- For ss2008/12 (Boyd) (Dunn, 2008), #3311 is listed in both the CTD CT and the EIT and there is no record of the secondary cell having been changed.

It is quite possible that #3311 was used for ss2008/09 and all subsequent 2008 voyages. e.g., the mean (primary - secondary) conductivity for deployment #212 is within < 1.0e-04 S/m of the values for the deployments immediately preceding the pump failure. It is unlikely that the agreement would have been this close if #2312 was installed, given that the secondary conductivity was computed using #3311's calibration.

The issue may become a little clearer once the data from the subsequent voyage, st2008/03, has been processed.

In the interim, the data from the secondary sensors should not be used for deployments 144 onwards, primarily due to the pump failure, but also because of the uncertainty re the secondary calibration factors. The situation also emphasizes the need for making notes whenever any changes are made to the system configuration or any malfunctions are experienced.

Water samples were collected using a Sea-Bird SBE32, 24-bottle rosette sampler.

This voyage marked the first use of Lindsay Pender's CAP software. This package writes the CTD data directly to netCDF files, which can be processed using the Matlab-based, procCTD package. procCTD is described in the *procCTD Procedures Manual* (Beattie, 2009).

procCTD applied automated QC and preliminary processing to the data. This included spike removal, identification of water entry and exit times, conductivity sensor lag corrections and the determination of the pressure offsets. It also loaded the hydrology data and computed the matching CTD sample burst data.

The automatically-determined pressure offsets and in-water points were inspected and manually adjusted to the correct values, where necessary.

The bottle sample data was used to compute final conductivity and SBE 43 and Optode dissolved oxygen calibrations. These were applied to the data, after which, files of binned, 1 and 2dB averaged data were produced.

3.2 Pressure and temperature calibration

Pressures and temperatures were computed using the Sea-Bird-supplied calibrations.

An additional pressure offset correction was computed for each deployment by assuming a linear drift between the pre and post-deployment, out-of-water pressures. These offsets are plotted in Figure 2 (below).

Note:
The Sea-Bird's DigiQuartz pressure sensor reads absolute pressure. The offset values include the atmospheric pressure, plus an instrumental component due to the deviation from the manufacturer-supplied calibration factors.

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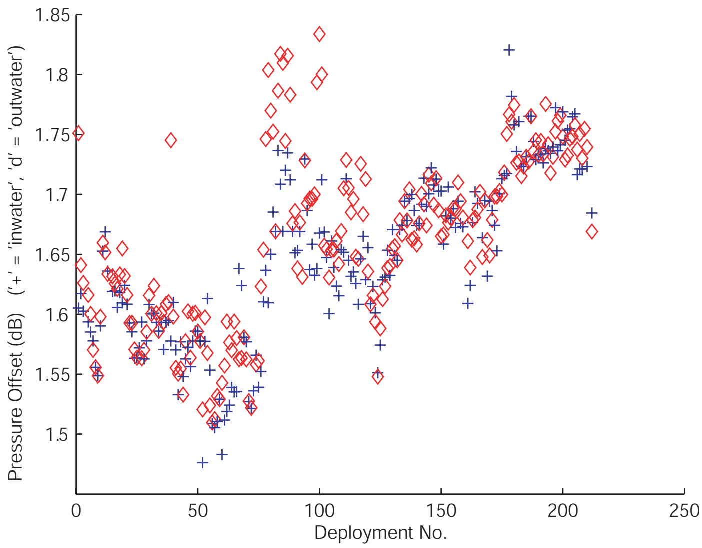


Fig 3: Pressure Offsets, deployments 1-3, 5-13, 15-159, 161-210, 212

The pressure sensor shows slight hysteresis in its response for the deeper deployments (1, 39, 79-89 & 99-101), with the out-of-water offsets for these deployments typically being up to 0.1 dB greater than the in-water offsets. There is a drift of approx. 0.2dB over the period of the voyages. Apart from this, there were no major changes in offset, which implies that the sensor had a consistent calibration throughout the voyage

The mean difference between the downcast primary and secondary temperatures is plotted in Figs 2 b) and 4)[1]. If deployments which were affected by the secondary pump failure, the mean of the mean differences is -0.06 mDeg C, with an SD of 0.67 mDeg C. This implies that neither sensor drifted significantly from its laboratory calibration during the voyage.

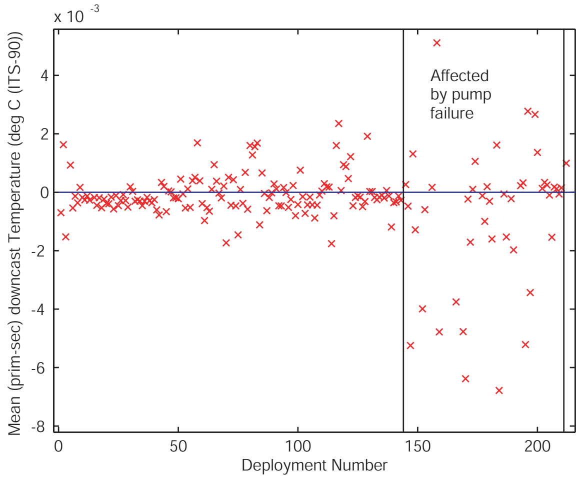


Fig 4: Mean temperature difference with outlying values excluded

1. In Figure 4, all outlying values >0.6 mDeg C or <-0.8 mDeg C were excluded from the plot. All of the outliers were affected by the pump failure

3.3 Conductivity calibration

The mean, calibrated, (Primary-Secondary), downcast conductivity differences for all deployments has been plotted in Figs 2a) and 5).

The non-pump-affected deployments have a mean of the mean values of -1.77e-05 S/m and most deployments plot within a range of ±2.0E-04 S/m of the mean. There was a very small, 2 - 3e-04 S/m relative drift between the sensors during the voyage.

The conductivity calibration was performed using the procedures documented in Beattie(2009).

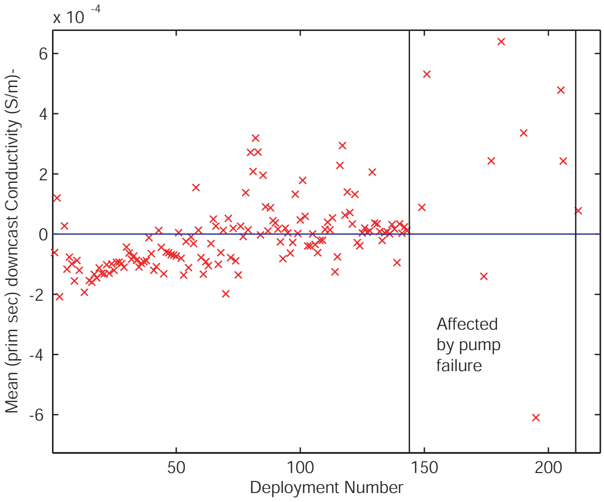
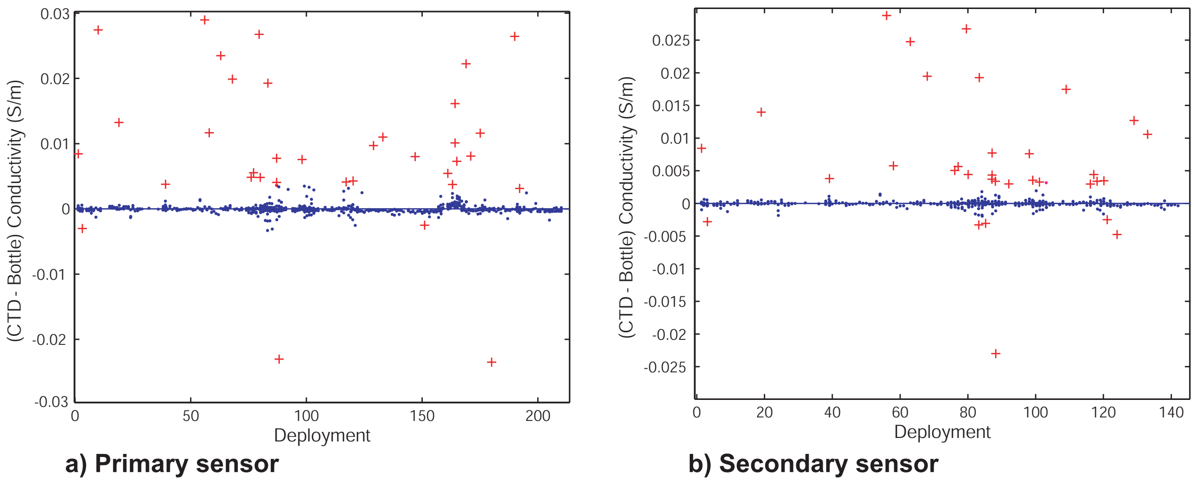


Fig 5: Mean conductivity difference (outlying values excluded)

The calibration is computed as a gain and offset that is applied to the conductivity. It is assumed that there is no time-dependent component in the sensor calibration.

729 conductivity calibration samples were collected for the 208 deployments. Their calibrated (CTD - Bottle) conductivity differences are plotted in Fig. 6.



Samples flagged as 'Bad' are shown as red '+'s. Differences > ~0.03 S/m have been excluded from the plots

Fig 6: Calibrated (CTD - Bottle) Conductivity

The majority of the samples plot reasonably close to 0.0, and there is no evidence that either sensor had significant drift during the voyage.

A total 55 sample ‘outliers’, listed in the Appendix, were excluded from the calibration calculations. Approximately half were surface samples, which can have erroneous CTD readings due to the ingestion of bubbles into the conductivity cells. The rejected, sub-surface samples probably have water sampling or analytical problems, especially if they were rejected for both the primary and secondary sensor calibrations.

All deployments were used to calibrate the primary conductivity. This resulted in calibration factors of:

Scale Factor (a1)	1.0001613	w.r.t. M/facturer's calibration
Offset (a0)	-3.12549e-04	ditto
Calibration S.D. (Sal)	0.00514 psu	

Deployments 1 - 143 were used to produce the secondary sensor calibration:

Scale Factor (a1)	1.0000926	w.r.t. M/facturer's calibration
Offset (a0)	-1.43143e-04	ditto
Calibration S.D. (Sal)	0.00356 psu	

This calibration was also applied to deployment 212

The primary and secondary calibration Standard Deviations (S.D.s) of 0.00514 and 0.00356 p.s.u. resp. are 'adequate', given that majority of the deployments don't go below the highly-variable surface zone, but they are well outside our target S.D. of 0.002 p.s.u. for 'typical', oceanographic voyages.[1]

The primary conductivity and temperature were use to compute the averaged salinities, given the secondary data for deployments 144 - 210 was unusable because of the failure of the secondary pump. (The secondary data for deployments 144 - 210 was not calibrated.)

3.4 Dissolved Oxygen Sensor Calibration

The CTD was fitted with both Sea-Bird SBE 43 and Aanderaa Optode 3975 dissolved oxygen sensors. The data for both sensors was calibrated, but only the SBE 43 oxygen was included in the averaged files.

3.4.1 SBE 43 Calibration procedure

Sea-Bird (2008a) describe the SBE 43 as "a polarographic membrane oxygen sensor having a single output signal of 0 to +5 volts, which is proportional to the temperature-compensated current flow occurring when oxygen is reacted inside the membrane. A Sea-Bird CTD that is equipped with an SBE 43 oxygen sensor records this voltage for later conversion to oxygen concentration, using a modified version of the algorithm by Owens and Millard (1985)."

Calibration involves performing a linear regression, as per Sea-Bird (2008b) to produce new estimates of the calibration coefficients Soc and Voffset. These new coefficients are used, along

1. My initial rejection of around 30 'obvious' outliers resulted in S.D.s in the range 0.0076 - 0.0084 psu. This was judged to be unsatisfactory, and additional, less obvious, outliers were rejected, reducing the calibration S.D.s to more acceptable values.

with the other, manufacturer-supplied coefficients, to re-compute oxygen concentrations from the sensor voltages.

Deeper casts are affected by pressure-induced hysteresis effects.[1] Lindsay Pender (pers. comm.) has used data from voyage ss2009/01 to compute hysteresis correction coefficients for our sensor. These were applied to the sensor voltages, prior to the computation of the CTD sample bursts and during the application of the new calibration to the scan file SBE 43 oxygen values.

Results

All deployments were included in a single calibration group, as there was no evidence of any significant changes in sensor calibration during the voyage. 720 bottle oxygens, along with the associated SBE 43 up-cast data, were used to compute the new Soc and Voffset coefficients. 25 sample outliers, listed in the Appendix, were excluded from the calculations.

The old and new Soc and Voffset coefficients are listed in Table 2

TABLE 2.

	Manufacturer's calibration	New calibration
Voffset	-0.4809	-0.5146
Soc	0.3603	0.3841
Fit SD (uMol/l)		1.413

In particular, the new value for the Soc scaling factor suggest that the sensor has lost approximately 6.5% sensitivity since its initial manufacturer's calibration.

The calibrated (CTD SBE 43 - Bottle) oxygen is plotted in Fig 7. The majority of the data plots close to 0.0, with no evidence of gross changes in calibration during the voyage.

Fig 7 b) includes the down-cast (CTD -Bottle) oxygen for the equivalent pressures to the up-cast data. These have been assigned the same QC flags as the associated up-cast samples. Most of the 'Bad' down-cast values plot with the good data. This suggests that most of the bottle oxygen analyses are good, and that the 'Bad' up-cast values arise because of CTD instrumental problems. 80% of the rejected values are surface samples. It therefore seems likely that bubble-induced, bad conductivity values may be the major source of the incorrect CTD oxygen values.

1. Sea-Bird (2009) note that "Under extreme pressure, changes can occur in gas permeable Teflon membranes that affect their permeability characteristics. Some of these changes (plasticization and amorphous/crystallinity ratios) have long time constants and depend on the sensor's time-pressure history. These slow processes result in hysteresis in long, deep casts." They recommend applying hysteresis corrections for profiles with depths exceeding 1000m.

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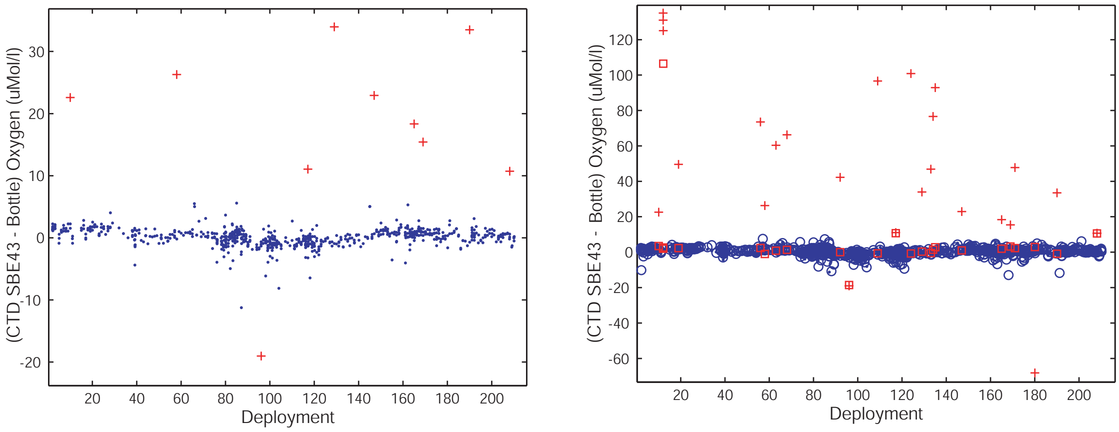

a) Up-cast CTD data

b) Down and up-cast CTD data

'+' = 'bad' up-cast data & '□' = 'Bad' down-cast CTD data
'Bad' differences > 30 uMol/l have been excluded from a)

Fig 7: (SBE 43 - Bottle) Oxygen Difference

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The plots of the calibrated for deployment 99, one of the deeper stations (Fig 8) shows that there is still a slight mis-match between the down and up-cast data. This could be due to a combination of lag effects resulting from the sensor's slow response time and possible, residual hysteresis effects in the deeper portion of the cast.

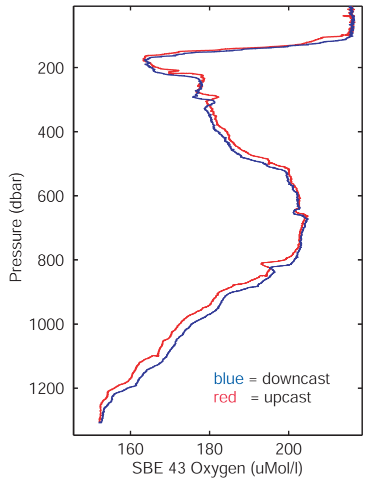


Fig 8: SBE 43 Profiles (depl #99)

NOTE:
No attempt was made to correct for sensor lag during the SBE 43 processing and calibration. (In unpublished tests on ss2008/02 data, I found that a lag correction of -6 secs significantly improved the match between the down and up-casts for the top 800m or so of the casts.)

3.4.2 Optode calibration procedure

According to the 3975 data sheet (Aanderaa, 2006) the Aanderaa oxygen optode is based on the ability of selected substances to act as dynamic fluorescence quenchers. The sensor foil is excited by modulated blue light, and the phase of the returned red light is measured. The dissolved oxygen concentration is a function of pressure, temperature, salinity, optode phase and the manufacturer-supplied foil calibration constants.

Our calibration procedure produces calibrated optode phase. The bottle oxygen is back calculated to the equivalent phase, and the bottle phase is linearly fitted to the CTD optode phase, producing an offset and scale correction (calibration) for the CTD Optode Phase data.

Results

The output quality of the Optode oxygen sensor was much less satisfactory than that obtained from the Sea-Bird SBE 43. This is primarily due to the slow (~30 sec) response time of the 3975 Optode, which results in large mis-matches between the up and down-cast profiles (Fig 9).

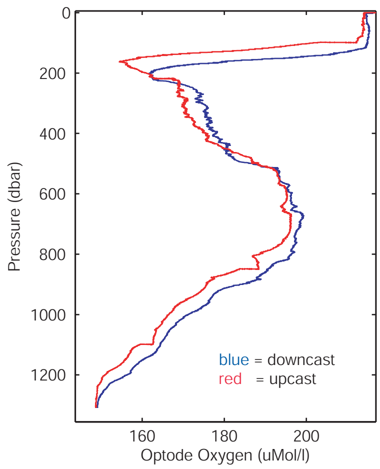


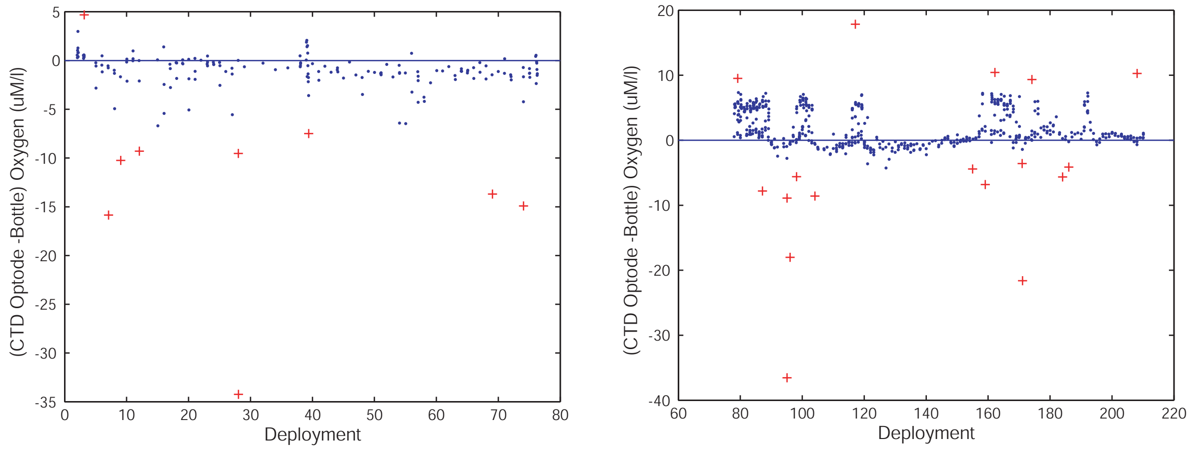
Fig 9: Optode profiles, depl #99

The following calibration factors were obtained for the Optode Phase

TABLE 3.

	Dep 1 - 77	Dep 78 - 212
# samples included	173	546
# rejected (excl) samples	9	17
Scale	0.89793	0.98471
Offset	1.73208	-1.51067
Oxygen Stnd. Dev. (uMol/L)	1.53	2.69

The fit SDs of 1.53 and 2.69 uMol/l are significantly worse than the 1.413 uMol/l obtained for the SBE 43



a) Deployments 1 - 77 **b) Deployments 78 - 212**

Fig 9: Calibrated (CTD Optode - Bottle) Oxygen

3.5 Other (auxiliary) sensors

The Chelsea fluorometer, SeaTech transmissometer and the Biospherical PAR were attached for all deployments. The AMT pH sensor was used for deployments 1 - 57.

The data from these sensors has not been subjected to any processing, apart from the automated procCTD QC procedures for removing out-of-range data and spikes. To facilitate future calibration &/or processing of the auxiliary sensor data, the sample burst data from the bottle firings has been exported to ss0809Aux.csv.

A nominal calibration was applied to the fluorometer and transmissometer data to give them ranges of 0 - 100% in air. I have not examined this data, but from a casual examination of several averaged plots, both sensors appeared to be producing sensible results.

The calibration for the Biospherical PAR output is uE/m^2/sec. Users of the PAR data should be aware that it may have been affected by factors such as atmospheric conditions, shadowing by the ship and sea state.

3.6 Binned data files

The calibrated data was ‘filtered’ to remove pressure reversals and binned into 2 dB averaged netCDF files. The binned values were calculated by applying a linear, least-squares fit to the bin data and using this to interpolate the value for the bin mid-point. This is more accurate than simply taking the mean of the data.

Each binned parameter in each bin is assigned a QC flag. Our flagging scheme is described in Pender (2000) (**http://www.marine.csiro.au/datacentre/ext_docs/DataQualityControlFlags.pdf)**.

The QC Flag for each bin is estimated from the values for the bin components. (We haven’t yet documented this. For the moment, refer to the comments in matlab function **matlab/toolbox/local/dpg/util/@QCFlag/estimate.m** (or ‘*help estimate*’).) The QC Flag for derived quantities, such as Salinity and Dissolved Oxygen is taken to be the worst of the estimates for the parameters from which they are derived.

The uncalibrated Fluorescence, Transmissometer, PAR, pH, are included in the binned files as:

Sensor	**Netcdf variable**	**NetCDF variable attribute: type**	**NetCDF variable attribute: name**	**Units**
Chelsea fluorescence	fluorescence	Fluorescence	“Primary Fluorescence”	Nominal 0 - 100
Biospherical PAR	par	PAR	PAR	uE/m^2/sec
SeaTech transmissometer	transmissometer	Transmissometer	Transmissometer	Nominal %
AMT pH	pH	pH	AMT pH	pH

NOTE:
The averaged files also include the CTD altimeter as netCDF variable ‘altitude’, but this data should be ignored

4. References

Aanderaa, 2006: Oxygen Optode 3830/3930/3975. Data Sheet D335, Oct. 2006. http://www.aadi.no/Aanderaa/Document Library/1/Data Sheets/Oxygen Optode.pdf

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Sea-Bird Electronics Inc., 2008b: Application Note No 64-2: SBE 43 Dissolved Oxygen Sensor Calibration and data Corrections using Winkler Titrations. http://www.seabird.com/pdf_documents/ApplicationNotes/appnote64-2Apr08.pdf

Sea-Bird Electronics Inc., 2009: Application Note No 64-3: SBE 43 Dissolved Oxygen (DO) Sensor - Hysteresis Corrections. http://www.seabird.com/pdf_documents/ApplicationNotes/appnote64-3.pdf

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http://www.marine.csiro.au/nationalfacility/voyagedocs/2008/MNF_SS09-08_sum.pdf.

5. Appendix

Sample outliers for a particular sensor can be manually flagged as 'Bad' to exclude them from the calibration calculations.

5.1 Rejected samples, Conductivity calibration

729 salinity samples were analysed by the Hydro Chemists. A total of 55 of these were flagged as bad, 44 for the primary conductivity and 38 for the secondary sensor.

In the following table, rejected samples have a QC flag of '-1' and good samples have a flag of '0'. There are no flags for deployment 144 onwards for the secondary sensor, as the secondary data for these deployments was not calibrated.

Bad, non-surface samples may be due to sampling or analytical problems, especially if they were flagged for both the primary and secondary sensors. Surface samples can be affected instrumental issues, typically the ingestion of bubbles into the conductivity cells.

TABLE 4. Rejected Conductivity Samples [a]

Deployment No.	Rosette position	Niskin bottle No.	Sample depth	Primary flag	Secondary flag
1	15	15	1105.1	-1	-1
3	3	3	137.9	-1	-1
10	3	1019	1.1	-1	-1
12	1	1066	21.6	-1	0
12	2	1053	9.0	-1	0
12	3	1019	1.7	-1	0
19	4	4	0.6	-1	-1
39	9	9	138.6	-1	-1
56	3	1064	1.0	-1	-1
58	2	1053	1.5	-1	-1
63	4	1057	1.0	-1	-1
68	2	1053	0.8	-1	-1
76	7	1058	97.5	-1	-1
77	6	1067	118.0	-1	-1
79	1	1066	1919.3	-1	-1
80	11	1061	47.2	-1	-1
83	2	1053	747.6	-1	-1
83	6	1067	297.6	0	-1
85	6	1067	288.6	0	-1
87	1	1066	1000.0	-1	-1
87	2	1053	848.0	-1	-1

CTD Processing Notes

TABLE 4. Rejected Conductivity Samples [a]

Deployment No.	Rosette position	Niskin bottle No.	Sample depth	Primary flag	Secondary flag
87	8	1060	122.4	-1	-1
87	9	1065	97.7	-1	-1
87	10	1059	77.7	0	-1
88	3	1064	323.0	-1	-1
88	8	1060	97.8	0	-1
92	2	1053	35.1	0	-1
98	4	1057	117.7	-1	-1
99	8	1060	97.9	0	-1
101	8	1060	97.8	0	-1
109	2	1053	0.7	-1	-1
116	6	1067	98.2	0	-1
117	5	1063	158.2	-1	-1
118	5	1063	98.1	0	-1
120	1	1066	135.7	-1	-1
121	1	1066	72.8	0	-1
124	2	1053	1.0	0	-1
126	3	1064	1.0	-1	-1
129	2	1053	0.7	-1	-1
133	3	1064	0.5	-1	-1
134	3	1064	0.5	-1	-1
135	4	1057	0.6	-1	-1
147	2	1053	0.5	-1	
151	2	1053	27.4	-1	
161	6	1067	72.3	-1	
163	5	1063	97.4	-1	
164	1	1066	307.0	-1	
164	2	1053	247.9	-1	
165	8	1060	0.8	-1	
169	5	1063	0.5	-1	
171	3	1064	1.0	-1	
175	3	1064	92.2	-1	
180	3	1064	1.0	-1	
190	2	1053	0.4	-1	
192	4	1057	122.6	-1	

a. QC Flags: ‘-1’ = ‘sample rejected’, ‘0’ = ‘sample accepted’

5.2 Rejected samples, SBE 43 Oxygen calibration

745 Oxygen samples were analysed. 25 were excluded from the SBE 43 oxygen calibration. Rejected surface samples may be due to bad conductivity readings, rather then to sampling or analytical problems.

TABLE 5. Rejected SBE 43 Oxygen samples

Deployment No.	Rosette position	Niskin bottle No.	Sample depth
10	3	1019	1.1
12	1	1066	21.6
12	2	1053	9.0
12	3	1019	1.7
19	4	4	0.6
56	3	1064	1.0
58	2	1053	1.5
63	4	1057	1.0
68	2	1053	0.8
92	3	1064	1.4
96	2	1053	42.7
109	2	1053	0.7
117	6	1067	132.8
124	2	1053	1.0
129	2	1053	0.7
133	3	1064	0.5
134	3	1064	0.5
135	4	1057	0.6
147	2	1053	0.5
165	8	1060	0.8
169	5	1063	0.5
171	3	1064	1.0
180	3	1064	1.0
190	2	1053	0.4
208	1	1066	88.5

5.3 Rejected samples, Optode Oxygen calibration

745 oxygen samples were analysed. 25 of them were excluded from the Optode Oxygen calibration. Rejected surface samples may be due to bad conductivity readings, rather then to sampling or analytical problems.

TABLE 6. Rejected Optode Oxygen samples

Deployment No.	Rosette position	Niskin bottle No.	Sample depth
3	3	3	137.9
7	1	1	38.0
9	1	1	18.6
12	1	1066	21.6
28	1	1066	22.8
28	2	1053	9.6
39	1	1	991.3
69	1	1066	17.4
74	1	1066	32.3
79	10	1059	147.7
87	8	1060	122.4
95	1	1066	49.2
95	2	1053	32.2
96	2	1053	42.7
98	4	1057	117.7
104	2	1053	37.7
117	6	1067	132.8
155	3	1064	0.6
159	1	1066	68.1
162	1	1066	266.8
171	1	1066	79.8
171	3	1064	1.0
174	2	1053	107.4
184	1	1066	20.6
186	1	1066	27.1
208	1	1066	88.5