CSIRO
MARINE RESEARCH

CTD Processing Notes

R V Southern Surveyor Voyage SS2007/04

10 May - 6 June 2007

Data processing completed by Pamela Brodie
September 2007

1. Summary

These notes relate to the production of QC'ed, calibrated CTD data from RV Southern Surveyor voyage SS 2007/04, from 10 May to 6 June, 2007.

Data for 111 deployments were acquired using a Seabird SBE911 CTD, fitted with 18 ten litre bottles on the rosette sampler. Pressures and preliminary conductivity values were computed using the Seabird-supplied calibration factors and calibrations provided by the CSIRO Marine and Atmospheric Research Calibration Facility were used to compute the water temperatures. The data was subjected to automated QC to remove spikes

The final conductivity calibration was based on a main deployment grouping of casts 6-111, with three stations excluded from the processing. The calibration has a standard deviation of 0.0022 p.s.u., which is a satisfactory result, although not quite within our target of 'better than 0.002 psu'.

The quality of the dissolved oxygen data is good. An AAnderraa optode was used, installed on an auxilliary A/D channel. The optode phase data were processed using the foil constants and these oxygen (optodeDO) values appear in the averaged files.

The Chelsea fluorometer, the Wet Labs transmissometer and ISUS Nitrate sensors were installed on the CTD's auxiliary A/D channels. The fluorometer has been calibrated to output 0-100 fsd. A new Biospherical Instruments QCP-2300 Cosine Irradiance Collector, which measures PAR between 400 and 700 nm, was mounted on the rosette. It has a rating of maximum depth 6800m, enabling it to be installed for all casts, although values for night time casts will be spurious. This auxiliary channel data has been subjected to the same de-spiking as the standard CTD data, but it is currently released in volts, essentially, uncalibrated. Appendix 1 details the calibrated output options available.

2. Voyage details

2.1 Title

The title of the Voyage Plan was 'Pelagic ecosystem productivity and dynamics off the West coast of Western Australia'.

2.2 Principal Investigators

Peter Thompson of CMAR was the Chief Scientist, Principle Investigators were John Keesing and Martin Lourey also from CMAR, and Lynnath Beckley of Murdoch University.

2.3 Voyage objectives

The scientific objectives for SS04/2007 were outlined in the Voyage Plan -

- To examine late autumn/early winter seasonal intensification of the Leeuwin Current and regional extent of the associated increased chloryphyll and key drivers for primary production;
- examine plankton food web structure;
- observe benthic productivity and nutrient recycling on the shelf;
- and map eddy features.

For further details, refer to the Voyage Plan (Thompson, 2007) which can be viewed on the CSIRO Marine and Atmospheric Research web site (http://www.marine.csiro.au/nationalfacility/voyagedocs/2007/planSS04-2007.pdf). The Voyage Summary report is also published on this site (http://www.marine.csiro.au/nationalfacility/voyagedocs/2007/SummSS04-2007.pdf).

2.4 Area of operation

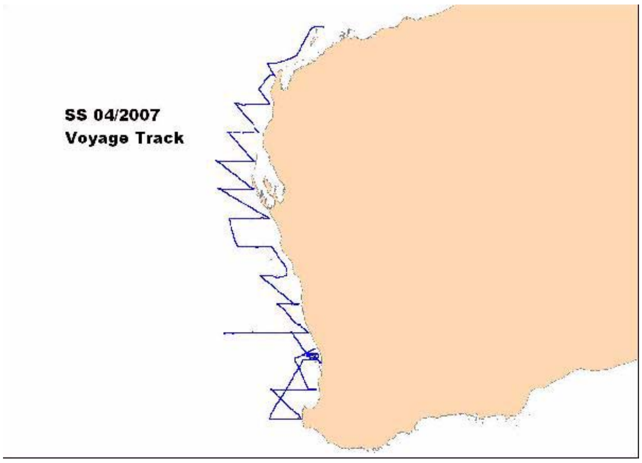

Figure 1. Area of Operation

3. Processing Notes

Data for 108 of the 111 deployments were successfully processed. Station 89 was aborted. Stations 8 and 10 had surface information problems.

CTD Processing Notes

3.1 Background Information

The data were acquired with CSIRO's CTD unit #20, a Seabird SBE911 with dual conductivity and temperature sensors, and an Optode oxygen sensor, the Aanderraa 3716 Optode was used on an auxilliary channel.

Also connected to the SBE911 auxiliary A/D channels was the new Biosperical Instruments QCP-2300, a deep water PAR sensor, the Chelsea AquaTracka fluorometer and the Wetlabs C-Star transmissometer. Two A/D channels were occupied by the ISUS Nitrate sensor concentration and auxiliary channels. This sensor could not be deployed at casts where depth would be greater than 1000m, so it was removed and replaced on the package accordingly.

The above configuration used a greater number of A/D channels than previously, and some aspects of the processing software, procCTD, required extending. The software changes were supported most effectively from Hobart. Bob Beattie is to be thanked for his efforts.

Water samples were collected using a Seabird SBE32, 24-bottle rosette sampler. Only 18 bottles could be fitted to the frame as externally fitted A/D instruments and the LADCP transducers used the remaining locations.

During cast 74 bottle firing was compromised by a worn trigger unit on the rosette. The unit from ctd 21 was installed to replace it and was used without fault from cast 76 onwards.

Station 89 was aborted.

There were two changes to conductivity sensors during the voyage as shown by * in the table below. There had been an indication from the sensor difference plots that there was a problem with a pump. The problem was solved by replacing the unit.

TABLE 1. Conductivity Sensor Changes

	Temperature		**Conductivity**	
Casts	**Primary**	**Secondary**	**Primary**	**Secondary**
1-2	2751	4522	2235	2312
3-4	2751	4522	*3169**	2312
5-111	2751	4522	3169	*2235**

The raw CTD data was converted to scientific units and written to netCDF format files for processing using the Matlab-based, procCTD package. This procCTD application is described in the *procCTD Procedures Manual* (Beattie, 2007).

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, where necessary, manually adjusted to the correct values.

The bottle sample data was used to compute final conductivity and oxygen calibrations. These were applied to the data, after which, files of binned, averaged data were produced.

3.2 Pressure and temperature calibration

Pressures were computed using the Seabird-supplied calibrations. The primary temperature sensor was calibrated on 7th May 2007 at the CSIRO Marine and Atmospheric Research Calibration Facility and the secondary temperature sensor was calibrated 1 August 2006 at theSeabird Laboratories.

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).

The pressure sensor shows slight hysteresis in its response, with the out-of-water offsets (red diamond) being typically 0-0.5 dB less than the in-water offsets (blue ‘+’). However, there were few major changes in offset, which implies that the sensor had a consistent calibration throughout the voyage

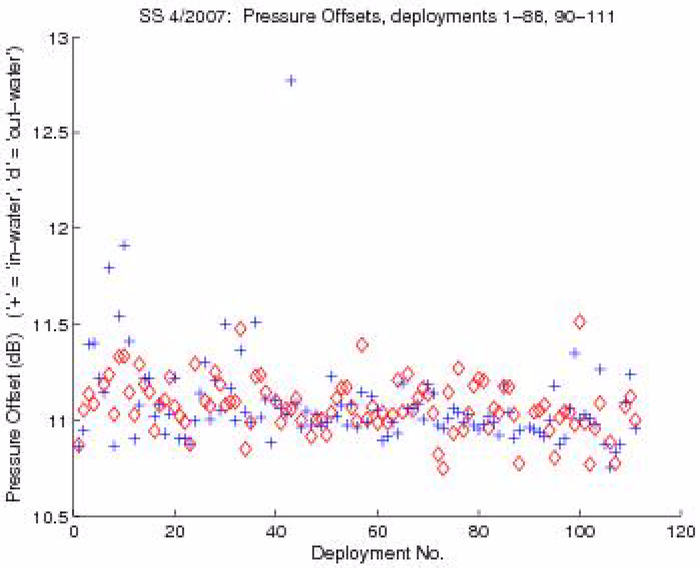

Figure 2. Pressure Offsets

The mean difference between the primary and secondary temperature sensors is plotted in Figure 3.

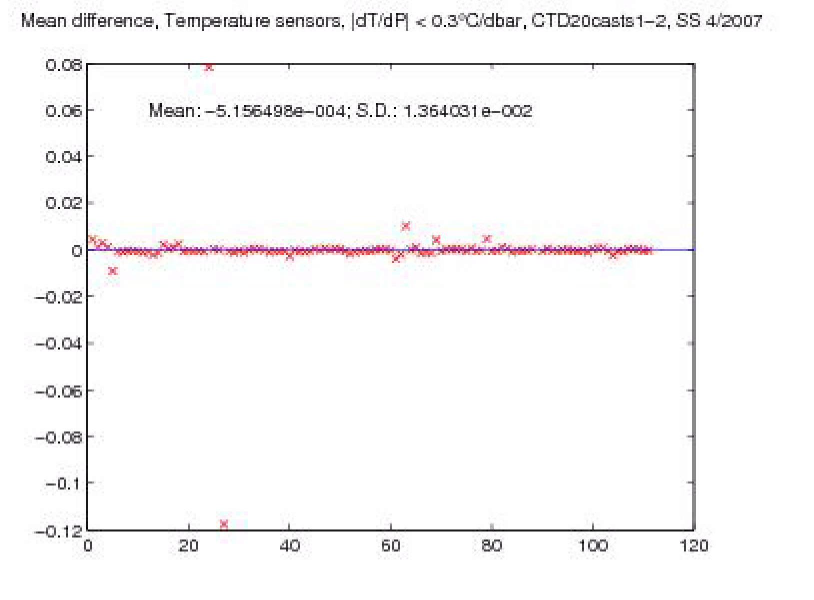

Figure 3. Mean temperature difference between the two sensors for each deployment

Most deployments plot within ±1.5 mDeg C of the mean. However this is a larger range than normal (e.g. ±0.2 mDeg C for Fr2001/05). The sensor differences show no particular drift after a problem sensor was removed before deployment 5. For two stations a marked divergence was noted. As shown later in Section 3.3 there is also a conductivity difference for these deployments. This suggested the effect of a pump malfunction on the secondary sensors.

3.3 Conductivity calibration

For this voyage effectively a single calibration was produced. The calibration was based upon the sample data for deployments 6-11,13-23,26-42,44-48,50-111. There were some discrepencies, probably sampling problems, between bottle and CTD salinities as shown in the plots of calibrated (CTD - Bottle) conductivity (Figure 4 below). The 29 samples plotted with a red '+' in Figure 4 were manually marked as 'bad' and excluded from the calibration.

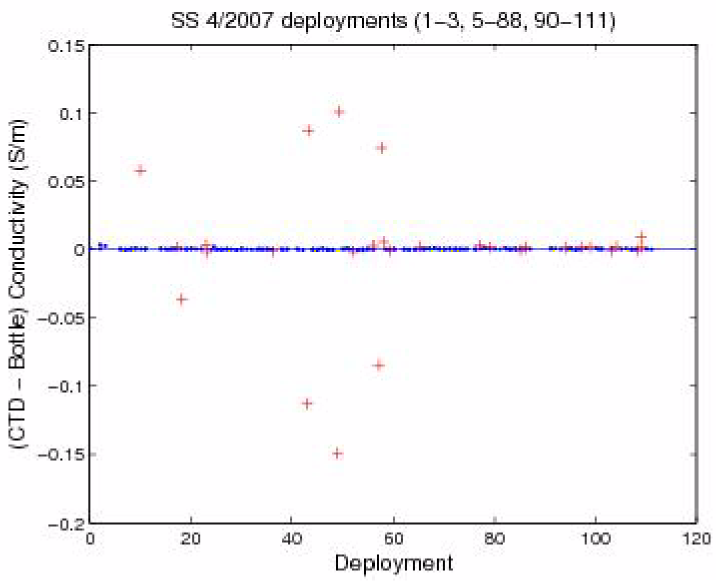

Figure 4. CTD - bottle conductivity difference

The plot of uncalibrated (Primary - Secondary) conductivity for pressures > 20 dB (Figure 5) shows that in the early deployments the conductivity cell responses diverged and the sensors were swapped and replaced as in Table 1 above. A further divergence was noted at stations 24 and 27. This was also evident in the temperature sensors for these deployments and suggested a pump malfunction. The pump was replaced.

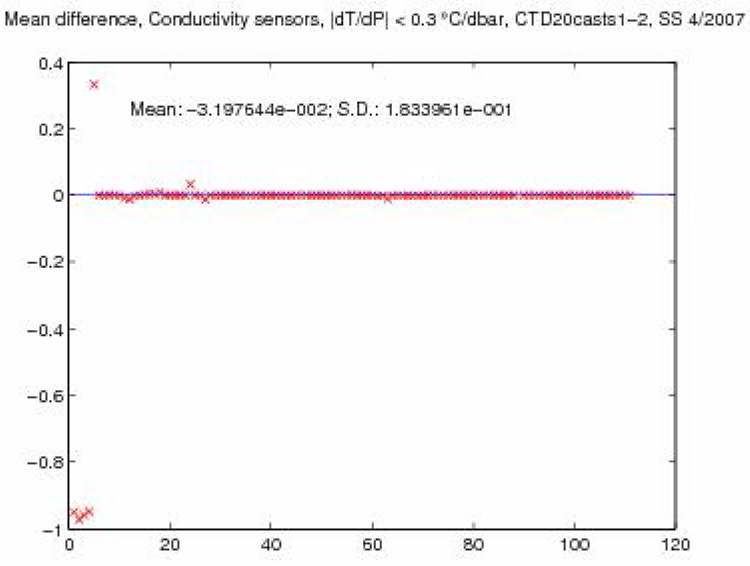

Figure 5. Mean conductivity difference between the dual sensors for each deployment

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There were 184 salinity calibration samples collected at 101 stations during the voyage. As mentioned above, 29 samples were excluded from the calculation.

The resulting calibration was applied to casts 6 -111 as follows:

Scale Factor (a1)	1.0000347	w.r.t. M/facturer's calibration
Offset (a0)	-2.620211E-05	ditto
Calibration S.D. (Sal)	0.00290 psu	

for the primary conductivity sensor and

Scale Factor (a1)	1.0001753	w.r.t. M/facturer's calibration
Offset (a0)	-7.025801E-04	ditto
Calibration S.D. (Sal)	0.00217 psu	

for the secondary sensor, a slightly better result.

This is a satisfactory calibration. We normally aim for a S.D. of 0.002 p.s.u. for 'typical' voyages. The above calibration factors were applied to deployments 6-111. The secondary sensor data was used to produce the averaged files.

For the early casts 2-4, where primary sensors were changed, a separate calibration was performed for the secondary sensor and applied to casts 1-5 as follows.

Scale Factor (a1)	1.007485	w.r.t. M/facturer's calibration
Offset (a0)	-0.99962	ditto
Calibration S.D. (Sal)	0.000685 psu	

The secondary sensor was used for all casts to create the binned, averaged output files (see Section 3.6).

3.4 Aanderaa Optode Oxygen Sensor Calibration

The Aanderaa series 3975 optode was used, serial number 716 with foil 4804. It was set up for compensated phase output using the Aanderaa Oxyview software (command - 103). The Aanderaa web site (see References) contains a pdf detailing the optode specifications. Several advantages are claimed compared with electro-chemical sensors including better stability, the optode is less affected by pressure, has a faster response time and it consumes no oxygen.

The sensor functions on the principle of dynamic fluorescence quenchers, using a platinum porphyrin complex embedded in a gas permeable foil which is exposed to the seawater. The foil is excited through a sapphire window by modulated blue light. The phase of a returned red light is measured. Temperature-compensated phase data is used with the calibration coefficients for the foil to determine the absolute O_2 concentration (uM/l) in the water.

The optode has a slow response time and a lag filter was applied with the following settings - a0=1.0; b0=1.0; delay=-330 scans.

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There were a somewhat sparse162 oxygen samples from 90 stations available for use in the calibration. Of these 22 outliers were excluded. These were possibly sampling outliers. The data were calibrated in two deployment groups which included the stations for which samples were taken: the first calibration was for stations 1-60. The second calibration comprised stations 61-111. See Figure 6 (Upcast CTD-bottle) oxygen plots. Note there were no oxygen samples taken on station 1, stations 12 to 13, and, due to analyser problems for stations 59 to 75 and stations 89 and 90.

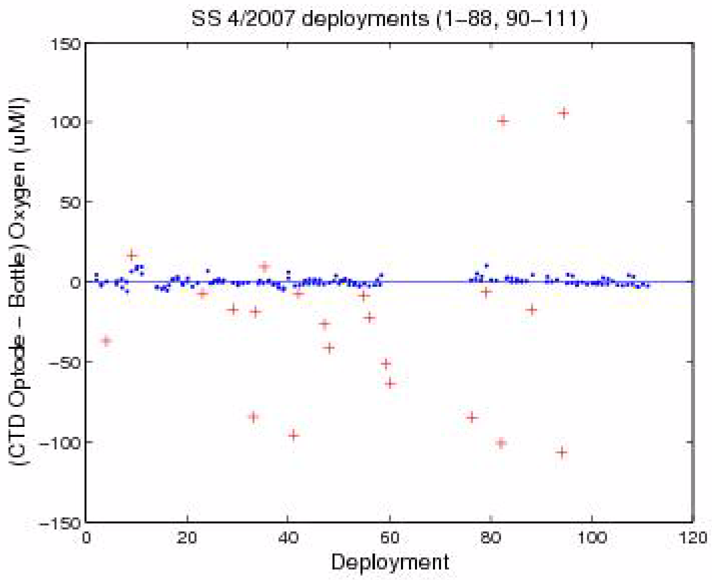

Figure 6. Optode - bottle oxygen differences

The following calibrations were applied.

Deployment grouping	**1-60**
Scale Factor (a1)	0.946249
Offset (a0)	0.23715
Calibration S.D.	3.0125

Deployment grouping	**61-111**
Scale Factor (a1)	0.946874
Offset (a0)	0.68021
Calibration S.D.	2.5196

3.5 Other sensors

The SBE911 auxilliary A/D channels were fully used as follows.

The Satlantic MBARI-ISUS Nitrate sensors for concentration and auxiliary were on the first two A/D channels, output in volts. These were only on the package where it was to be lowered to less than 1000 dB.

The Chelsea fluorometer and the Wetlabs Transmissometer were used for all deployments. They have been calibrated to give nominal outputs of 0-100 fsd. The optode phase was also used for all casts, as described above.

The new deep water PAR sensor was also used for all deployments (see Appendix 1). It is a Biospherical Instruments QCP-2300 Cosine Irradiance Collector, which measures PAR between 400 and 700 nm. The output is in volts. This data channel has been included in the output files for all deployments. If most or all of the values for a deployment are near zero, it was a night-time cast. For deployments where PAR profiles have sub-surface maxima the sensor may have been shaded by the ship.

3.6 Binned data files

The calibrated data was ‘filtered’ to remove pressure reversals and binned into 2dB 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 **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. The QC Flag for derived quantities, such as salinity is taken to be the worst of the estimates for the parameters from which they are derived.

4. References

Aanderaa Data instruments Optode Specifications -

http://www.aanderaa.com/docs/Oxygen_Optode_3830_3930_3975_D335.pdf

Beattie, R.D., 2006: procCTD CTD Processing Procedures Manual. http://www.marine.csiro.au/~dpg/opsDocs/procCTD.pdf. FrameMaker 7.0 source document: /net/fdcs/opt/fdcs/src/ctd/doc/procCTD.fm

Beattie, R.D, 2004: Computing Report for R.V. Southern Surveyor Voyage Ss2004/07, 23 Jul - 6 Aug, 2004 (unpub.).

Johnson. K, Coletti, L., 2002: In situ ultraviolet spectrophotometry for high resolution and long-term monitoring of nitrate, bromide and bisulfide in the ocean. Deep Sea Research I 49 2002.

Pender, L., 2000: Data Quality Control Flags. http://www.marine.csiro.au/datacentre/ext_docs/DataQualityControlFlags.pdf

Thomas, S, 2007: Marine Instrumentation Voyage Report for RV Southern Surveyor Voyage SS2007/04, 2007 (unpub.).

Satlantic Operation Manual , 2003: (Document Number SAT-DNN-294).

Thompson, P: The RV Southern Surveyor. Voyage Plan No SS04/2007. http://www.marine.csiro.au/nationalfacility/voyagedocs/2007/plan_SS04-2007.pdf.

5. Appendix 1: Details on Instruments with Voltage Output

5.1 PAR

Light is now measured in PAR on an auxilliary A/D channel using the new Biospherical Instruments QCP-2300 Cosine Irradiance Collector. This has a spectral response between 400 and 700 nanometers. It can be calibrated with constants for microEinsteins/cm**2.sec per volt or for quanta/cm**2.sec per volt.

The calculation uses a dark reading of 4091 counts. This was taken after the voyage in early July 2007.

irradiance = 6.03E-06 * (10^value - 10^0.005)

5.2 Nitrate

Nitrate concentrate and auxilliary were measured with the Satlantic MBARI-ISUS (*in situ* ultra violet spectrophotometer), an instrument borrowed for this voyage from Brian Griffiths.

Johnson and Coletti (2002) describe the response of the instrument. Calibration of the output voltages is documented in the Satlantic Operation Manual (2003).

The ISUS/CTD Calibration instructions which apply to this instrument are on page J-6 of a later, 2007, version of the Satlantic Operation Manual found at:

http://www.satlantic.com/documents/998198_SAT-DN-426_Operation_Manual_ISUS-X_V3_RevA1.pdf

