Marine National Facility

RV *Investigator*

CTD Processing Report

Voyage #:	In2015_c02
Voyage title:	GAB deep-water pelagic and benthic ecosystem study
Depart:	Port Lincoln, 1000 Monday, 30 November 2015
Return:	Fremantle, 0800 Tuesday, 22 December 2015
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Contents

1 Summary

These notes relate to the production of quality controlled, calibrated CTD data from RV Investigator voyage in2015_c02, from 29 Nov 2015 – 21 Dec 2015 UTC.

Data for 34 deployments were acquired using the Seabird SBE911 CTD 20, fitted with 36 ten litre bottles on the rosette sampler. Sea-Bird-supplied calibration factors were used to compute the pressures and preliminary conductivity values. CSIRO -supplied calibrations were applied to the temperature data. The data were subjected to automated QC to remove spikes and out-of-range values.

The final conductivity calibration was based on a single deployment grouping. The final calibration from the secondary sensor had a standard deviation (S.D) of 0.0021961 PSU, within our target of 'better than 0.002 PSU'. The standard product of 1dbar binned averaged were produced using data from the secondary sensors.

The dissolved oxygen data calibration fit had a S.D. of 0.71105 uM for secondary sensor. The agreement between the CTD and bottle data was good.

The Biospherical photosynthetically active radiation (PAR) sensor, Chelsea fluorometer and Tritech altimeter were also installed on the auxiliary A/D channels of the CTD.

2 Voyage Details

2.1 Title

GAB deep-water pelagic and benthic ecosystem study

2.2 Principal Investigators

Drs, Paul van Ruth, Jason Tanner, Alan Williams, Rudy Kloser (chief scientist).

2.3 Voyage Objectives

The scientific objectives for 2015_c02 were outlined in the Voyage Plan.

For further details, refer to the Voyage Plan and/or summary which can be viewed on the CSIRO Marine and Atmospheric Research web site.

2.4 Area of operation

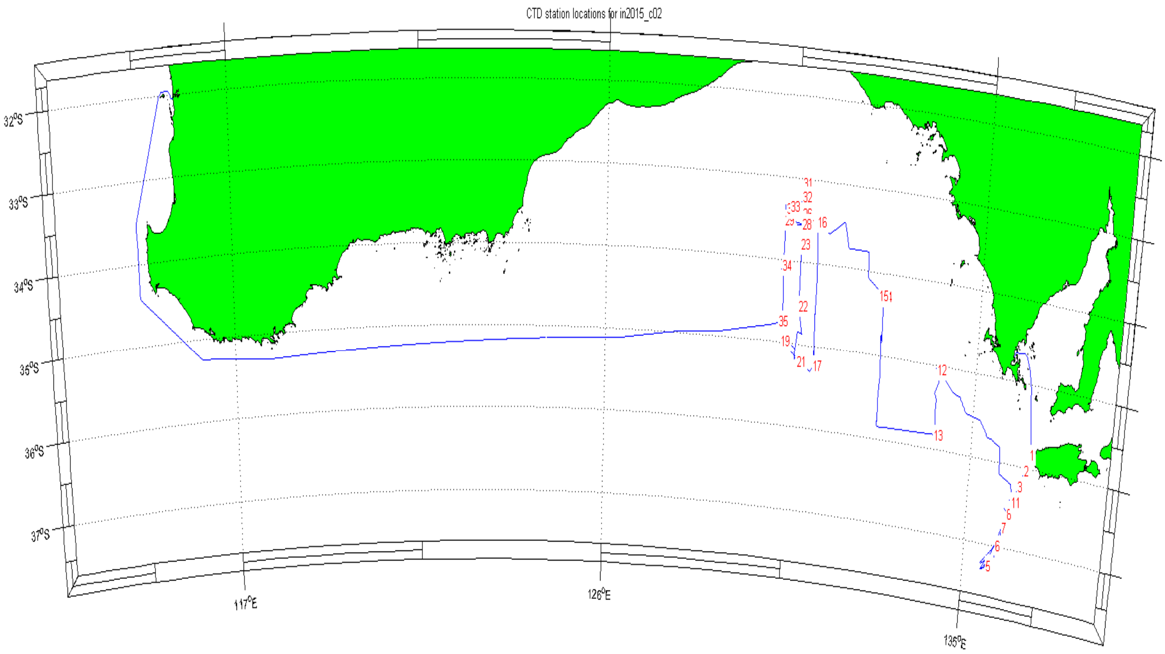

FIGURE 1. Area of operation for 2015_c02

3 Processing Notes

3.1 Background Information

The data for this voyage were acquired with the CSIRO CTD unit 20, a Seabird SBE911 with dual conductivity and temperature sensors. There were 35 CTD stations however as cast 10 was abandoned due to the CTD wire snapping before in water deployment, there is only 34 deployments.

The CTD was additionally fitted with secondary SBE43 dissolved oxygen sensor and photosynthetically active radiation (PAR) sensor, Chelsea fluorometer and an altimeter were also installed on the auxiliary A/D channels of the CTD. These sensors are described in Table 1 below.

Description	Sensor	Serial No.	A/D	Calibration Date	Calibration Source
Pressure	SBE9 *plus*	552	P	8/4/2015	CSIRO 3144 P-dbar
Primary Temperature	Seabird SBE3*plus*	4722	T0	27/2/2015	CSIRO 3109T

Secondary Temperature	Seabird SBE3*plus*	4522	T1	27/2/2015	CSIRO 3106T
Primary Conductivity	Seabird SBE4C	3868	C0	26/2/2015	CSIRO 3102C
Secondary Conductivity	Seabird SBE4C	3168	C1	26/2/2015	CSIRO 3098C
Primary Dissolved Oxygen	SBE43	1794	A0	11/2/2015	CSIRO 2374DO
Secondary Dissolved Oxygen	SBE43	3159	A1	6/6/2015	Manufacturer
Altimeter	PA500/6	228403	A3	22/5/2015	0-50
Fluorometer	Chelsea Aquatracka	065941001	A4	23/9/2015	0-100
PAR	QCP2300	70111	A2	25/8/2013	Manufacturer R12343

TABLE 1. CTD Sensor configuration on 2015_c02

Water samples were collected using a Seabird SBE32, 36-bottle rosette sampler. Sampling was from 36 ten litre bottles which were fitted to the frame. There were 34 in water deployments

The raw CTD data were 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, 2010).

The procCTD software was used to apply 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.

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

3.2 Pressure and temperature calibration

The pressure offsets are plotted in Figure 2 below. The 'crosses' refer to initial out-of-water values and the 'diamonds' the final out-of-water values.

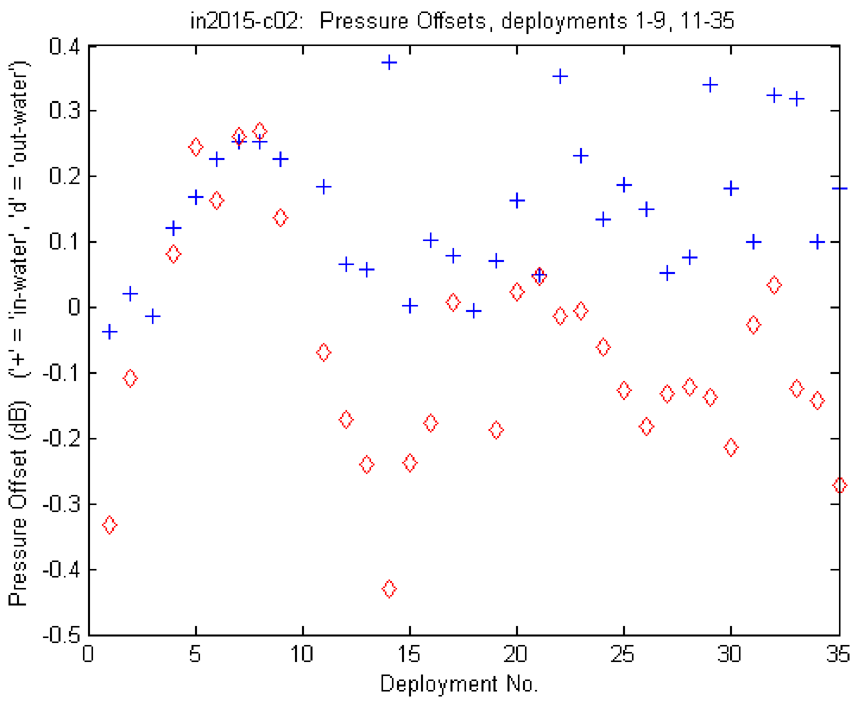

FIGURE 2. CTD pressure offsets

The difference between the primary and secondary temperature sensors at the bottle sampling depths is plotted below. Most deployments plot within ±1 m°C of zero – outliers result from sampling in regions of high vertical temperature gradient as supported by the similarity between the temperature and conductivity difference shown in figure 5. This indicates neither sensor has drifted significantly from its calibration.

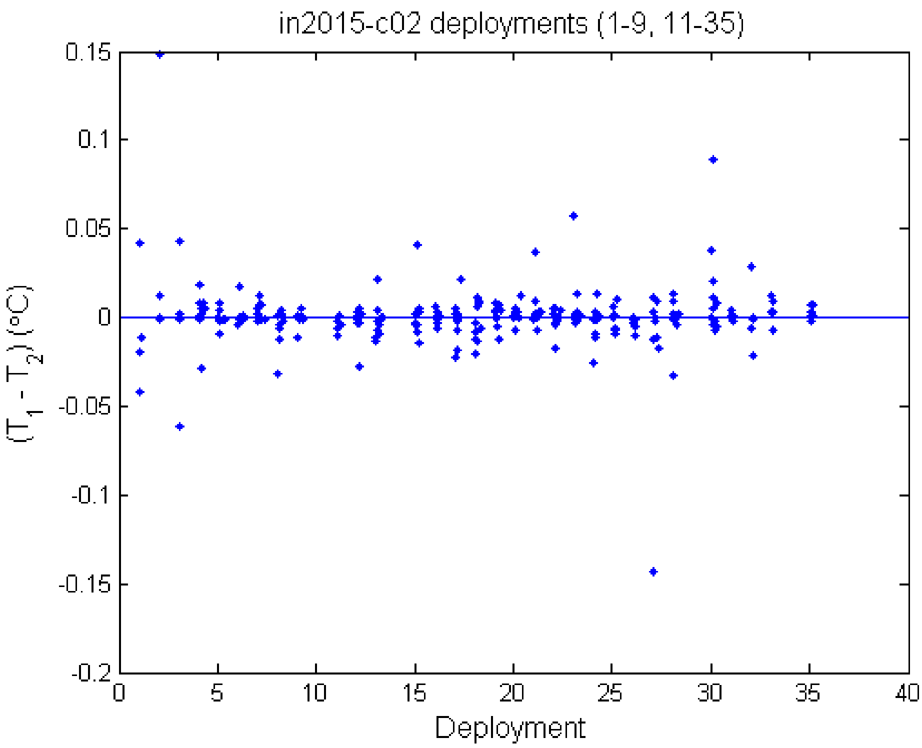

FIGURE 3. .Mean difference between primary and secondary temperature sensors

3.3 Conductivity Calibration

Discrepancies and possible sampling problems between bottle and CTD salinities for the secondary conductivity sensor would show in Figure 4, the plot of calibrated (CTD - Bottle) salinity below. The calibration was based upon the sample data for 115 of the total of 140 samples taken during deployments (the outliers marked in Figure 4 below with the red '+' and magenta diamonds are excluded from the calibration).

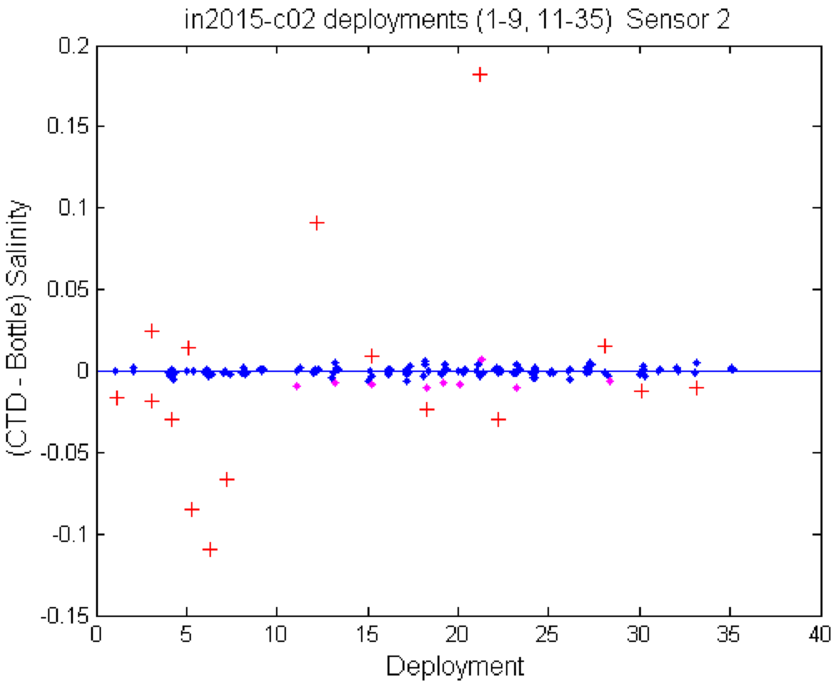

FIGURE 4. CTD - bottle salinity plot.

The plot of calibrated mean (primary - secondary) downcast conductivities at the bottle sampling depths for all deployments in Figure 5 shows that the calibrated conductivity cell responses corresponded very well.

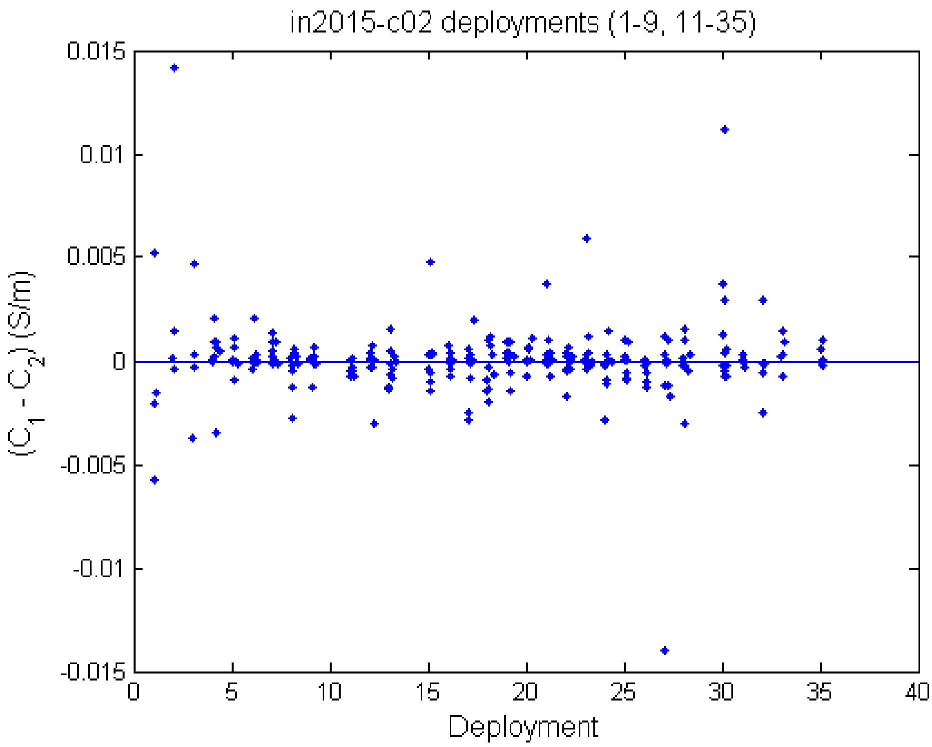

FIGURE 5. Mean difference between primary and secondary conductivity sensors

The final result for the primary conductivity sensor was –

Scale Factor (a1)	0.9993667	wrt. Manufacturer's calibration
Offset (a0)	0.0011832191	ditto
Calibration S.D. (Sal)	0.0025888 PSU	

The calibration using the secondary conductivity sensor was –

Scale Factor (a1)	0.99938564	wrt. Manufacturer's calibration
Offset (a0)	0.0011730638	ditto
Calibration S.D. (Sal)	0.0021961 PSU	

This is a good calibration. We normally aim for a S.D. of 0.002 psu for 'typical' oceanographic voyages. The above calibration factors were applied to all deployments.

Data from the secondary conductivity and temperature sensors were used to produce the averaged salinities.

3.4 Dissolved Oxygen Sensor Calibration

3.4.1 SBE calibration procedure

Sea-Bird (2010a) describes the SBE43 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 SBE43 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 (2010b) to produce new estimates of the calibration coefficients Soc and Voffset. These new coefficients are used, along with the other, manufacturer-supplied coefficients, to derive oxygen concentrations from the sensor voltages.

Results

Deeper casts (>1000m) are known to be affected by pressure-induced hysteresis with this sensor. This is corrected automatically within procCTD using the method discussed by Sea-Bird (2010c).

There is a small mismatch between downcast and upcast dissolved oxygen due to the response time of the sensor. No correction for the sensor lag effect has been applied.

A single calibration group was used with the associated SBE43 up-cast data to compute the new Soc and Voffset coefficients. The plot below is of CTD - bottle oxygen differences for both upcast and downcast data for secondary oxygen sensor (red indicates 'bad' data; + for upcast and square for downcast).

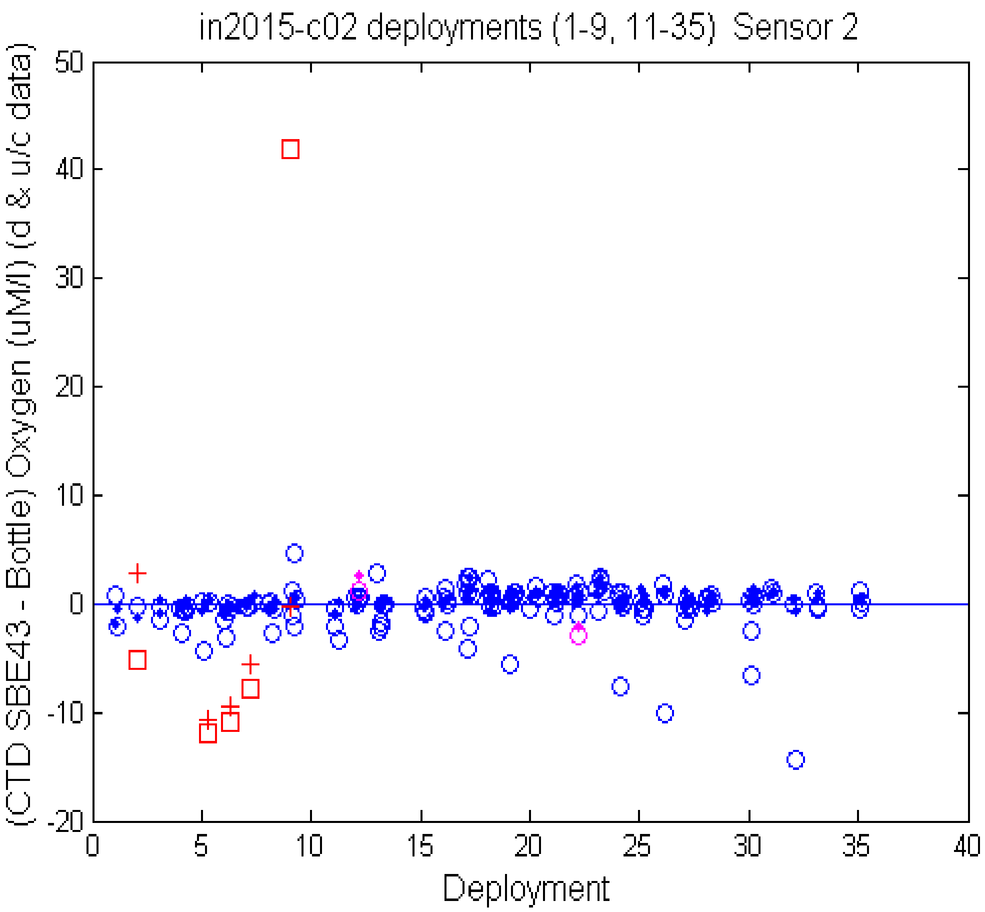

FIGURE 7. (SBE43 - Bottle) Oxygen Difference with upcast and downcast CTD data

The old and new Soc and Voffset values for DO sensors are listed in Table 2 below. The Soc value is a linear slope scaling coefficient; Voffset is the fixed sensor voltage at zero oxygen. As expected, over time, the increasing Soc scale factors show the SBE43 sensor is losing sensitivity.

The calibrations were applied for each sensor and the averaged files were created using the result from the secondary sensor.

	Manufacturer's calibration of primary sensor	**primary sensor calibration**	**Manufacturer's calibration of secondary sensor**	**secondary sensor calibration**
Voffset	-0.49151738	-0.46260602	-0.5016	-0.47617507
Soc	0.50939087	0.51301949	0.5521	0.57831084
Fit SD (uM)		1.5581		0.71105

TABLE 2. Dissolved oxygen calibrations

3.5 Other sensors

The Chelsea fluorometer was used for all deployments. The fluorometer has been calibrated to give nominal outputs of 0-100 fsd (full scale deflection).

The Biospherical PAR sensor was also used for all deployments. This data channel has been included in the output files for all deployments. Clearly, time of day and environmental factors such as sea state and cloud cover impact on these readings. If most or all of the values for a deployment are near zero it indicates a night-time cast. In deployments where the PAR profiles have sub-surface maxima the CTD may have been shaded by the ship.

3.6 Bad data detection

The limits for each sensor are configured in the CAP the CTD acquisition software and are written to the netCDF scan file. Typical limits used for the sensor range and maximum second difference are in Table 3 below. The rejection rate is recorded in the procCTD processing log file.

Sensor	**Range min**	**Range max**	**Max Second Diff**
temperature	-2	40	0.05
conductivity	-0.01	7	0.01
oxygen	-1	500	0.5
fluorometer	0	100	0.5
PAR	-5	5000	50

TABLE 3. Sensor limits for bad data detection

3.7 Averaging

The calibrated data were 'filtered' to remove pressure reversals and binned into the standard product of 1dbar averaged netCDF files. The binned values were calculated by applying a linear, least-squares fit as a function of pressure to the sensor data for each bin, using this to interpolate the value for the bin mid-point. This method is used to avoid possible biases which would result from averaging with respect to time.

Each binned parameter is assigned a QC flag. Our quality control flagging scheme is described in Pender (2000).

The QC Flag for each bin is estimated from the values for the bin components. The QC Flag for derived quantities, such as Salinity and Dissolved Oxygen are taken to be the worst of the estimates for the parameters from which they are derived.

4 References

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