Marine National Facility

RV *Investigator*

CTD Processing Report

Voyage #:	IN2017_C01
Voyage title:	GAB deep water geological and benthic ecology program
Depart:	Hobart, 0844 Tuesday, 11 April 2017
Return:	Hobart, 0800 Thursday, 27 April 2017
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1 Summary

These notes relate to the production of quality controlled, calibrated CTD data from RV Investigator voyage IN2017_C01, from 11 Apr 2017 – 27 Apr 2017.

Data for 10 deployments were acquired using the Seabird SBE911 CTD 23, fitted with 25 twelve litre bottles on the rosette sampler. Deployments 3 – 5 were aborted due to electrical issues and the data for these casts will not be included in the processed data set. Sea-Bird and O&A calibration lab 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 primary sensor had a standard deviation (S.D) of 0.0029597 PSU, outside our target of 'better than 0.002 PSU'. The standard product of 1dbar binned averaged were produced using data from the primary sensors.

The dissolved oxygen data calibration fit had a S.D. of 1.0974uM. The agreement between the CTD and bottle data was good.

Four fluorimeters, a transmissometer and a Franatec CH4 sensor were also installed on the auxiliary A/D channels of the CTD.

2 Voyage Details

2.1 Title

GAB deep water geological and benthic ecology program

2.2 Principal Investigators

Dr Asrar Talukder, Charlotte Stalvies, Alan Williams, Andrew Ross

2.3 Voyage Objectives

The scientific objectives for IN2017_C01 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 in2017_C01

3 Processing Notes

3.1 Background Information

The data for this voyage were acquired with the CSIRO CTD unit 23, a Seabird SBE911 with dual conductivity and temperature sensors.

The CTD was additionally fitted with SBE43 dissolved oxygen sensors, four fluorimeters, a transmissometer and a Franatec CH4 sensor. An Eco-Triplet was attached to the auxiliary serial channel and logged using the Triaxis logging script, this data is not included as part of the processed data set.

The secondary oxygen sensor was swapped out for the altimeter after the second cast. When the configuration was changed the secondary conductivity sensor was accidently removed meaning no data was recoded for this sensor after cast 2. These sensors are described in Table 1 below.

Unit	Data Channel	SBE9 Connector	Model	Serial Number	Casts
CTD 23			SBE9+ V2	1312	1-10
Deck Unit			SBE11 V2	0513	1-10
Primary Temperature		JB1	SBE3T	4722	1-10
Primary Conductivity		JB2	SBE4C	4425	1-2
Primary Pump		JB3	SBE5	8344	1-10
Secondary Temperature		JB4	SBE3T	6024	1-10
Secondary Conductivity		JB5	SBE4C	4426	1-10
Secondary Pump		JB3	SBE5C	8345	1-10

Primary Oxygen	A0	JT2	SBE43	1794	1-10
Secondary Oxygen	A1	JT2	SBE43	3159	1-2
Altimeter	A1	JT2	PA916	52306	3-10
Franatech CH4	A2	JT3	Franatech		1-10
Transmissometer	A3	JT3	Wetlabs	1735	1-10
Fluorimeter MNF	A4	JT5	Aquatraka	11-8206-01	1-10
Fluorimeter V3	A5	JT5	UV Aquatracka	16-0129-001	1-10
Fluorimeter V5	A6	JT6	Aquatracka MKIII (nephelometer)	11-8199-001	1-10
Fluorimeter V2	A7	JT6	UV Aquatracka (Hydrocarbon)	10-7629-001	1-10
Eco-Triplet	Serial	JT4	BBFLB2	2K-4049	1-10

Table 1 CTD Configuration

Water samples were collected using a Seabird SBE32, 36-bottle rosette sampler. Sampling was from 25 twelve litre bottles which were fitted to the frame. There were 10 deployments CTD deployments and 2 on-deck TSG calibration runs. CTD deployments 3 – 5 were aborted due to electrical issues and are not included as part of the final data set.

Raw data was acquired using SeaSave data acquisition software. The raw SeaSave .hex files were converted to scientific units using SeaSave data processing software as well a python script to convert the additional two fluorimeters. The resulting .CNV files were run though a low pass filter using SeaSave data processing. The final .CNV files were converted to CAP scan files using a python conversion script.

The CAPpro 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 blue line refers to initial out-of-water values and the red line the final out-of-water values. The second figure shows the difference between the out-of-water values for the up and down cast. No downcast out-of-water value is available for cast one as data acquisition was not started till the CTD was already submerged.

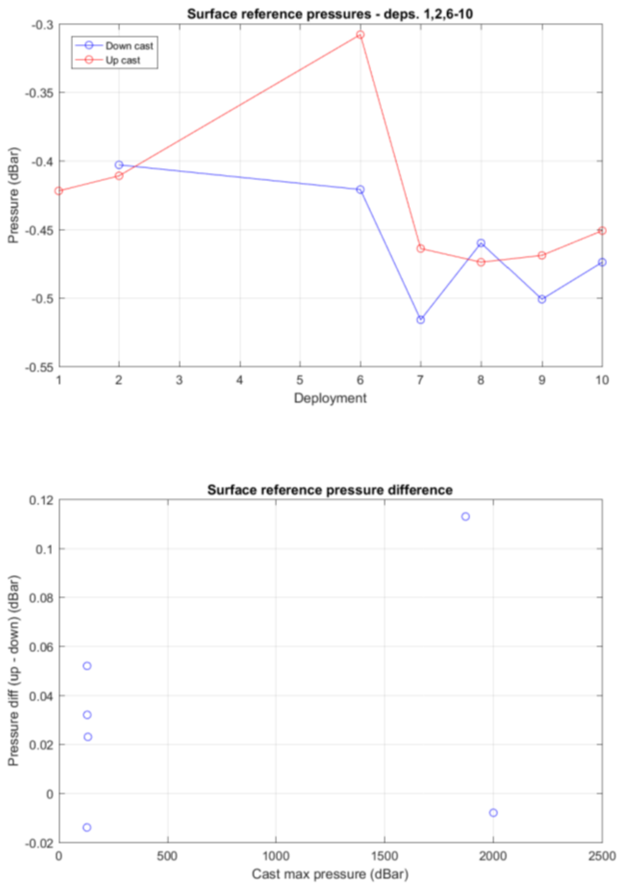


Figure 2 CTD pressure offsets

The difference between the primary and secondary temperature is plotted below. All deployments plot within ±1 m°C of. This indicates neither sensor has drifted significantly from its calibration.

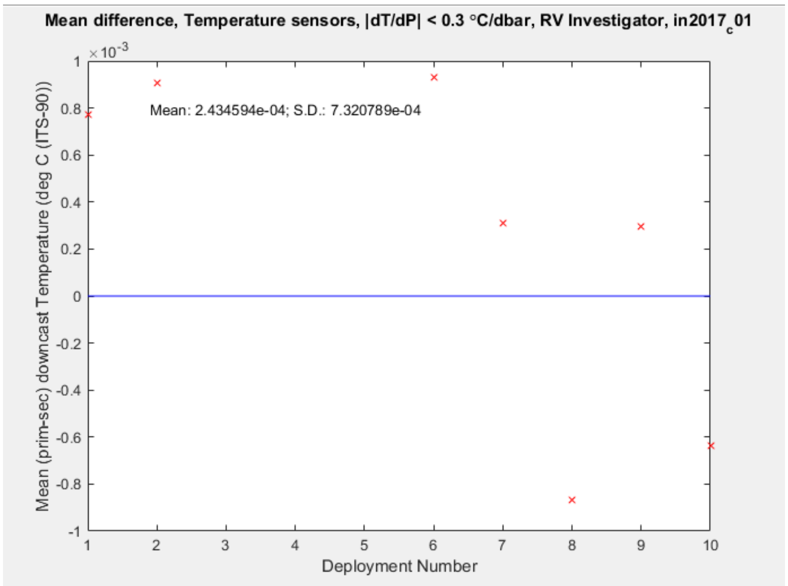
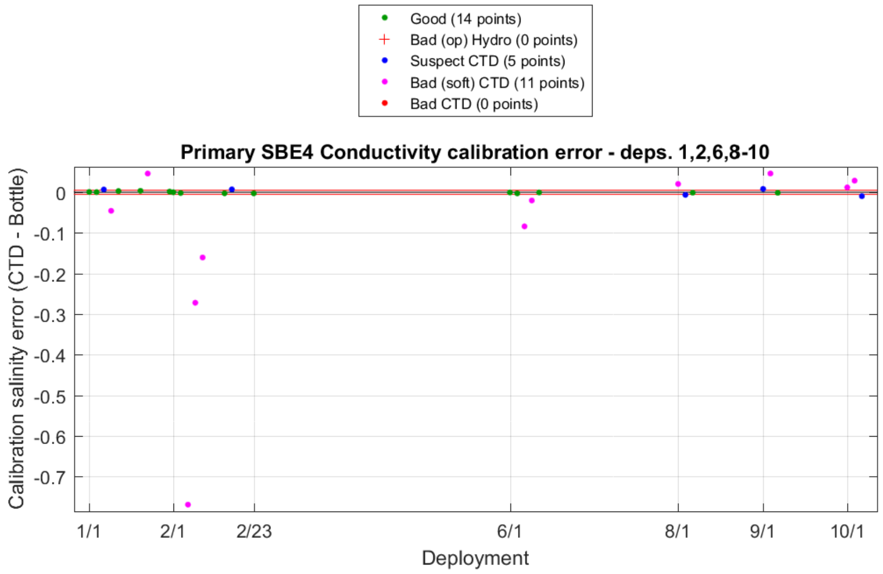


Figure 3 Mean difference between primary and secondary temperature sensors

3.3 Conductivity Calibration

Discrepancies and possible sampling problems between bottle and CTD salinities for the primary conductivity sensor would show in Figure 4, the plot of calibrated (CTD - Bottle) salinity below. The calibration was based upon the sample data for 19 of the total of 30 samples taken during deployments (the outliers marked in Figure 4 below with the red '+' and magenta circles are excluded from the calibration).



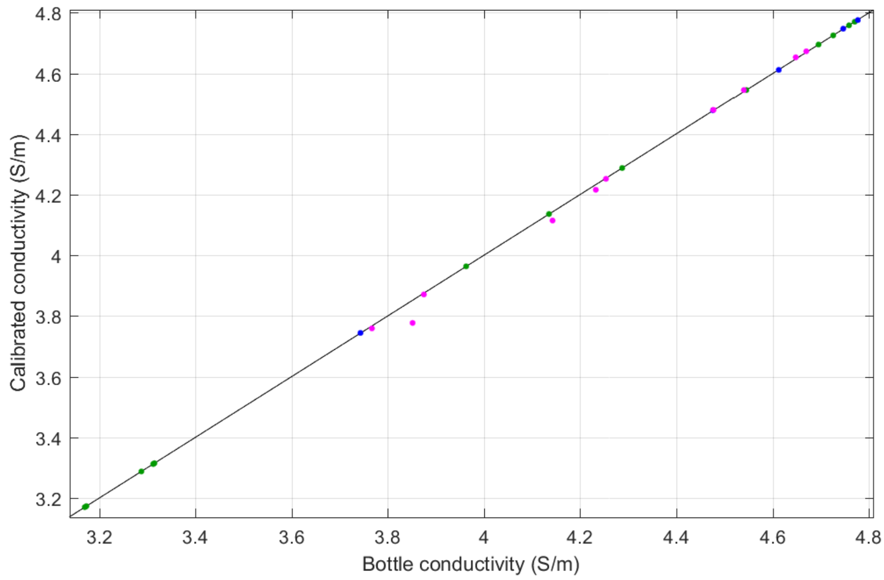


Figure 4 CTD Bottle salinity plot

The final result for the primary conductivity sensor was –

Scale Factor (a1)	0.99977	wrt. Manufacturer's calibration
Offset (a0)	-5.7917e-05	ditto
Calibration S.D. (Sal)	0.0029597 PSU	

The calibration using the secondary conductivity sensor was not performed as secondary conductivity was only recorded for the first two casts.

This is a marginal 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 primary 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.

3.4.2 Results

Deeper casts (>1000m) are known to be affected by pressure-induced hysteresis with this sensor. This is corrected automatically within CapPro 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 (magenta indicates 'bad' data).

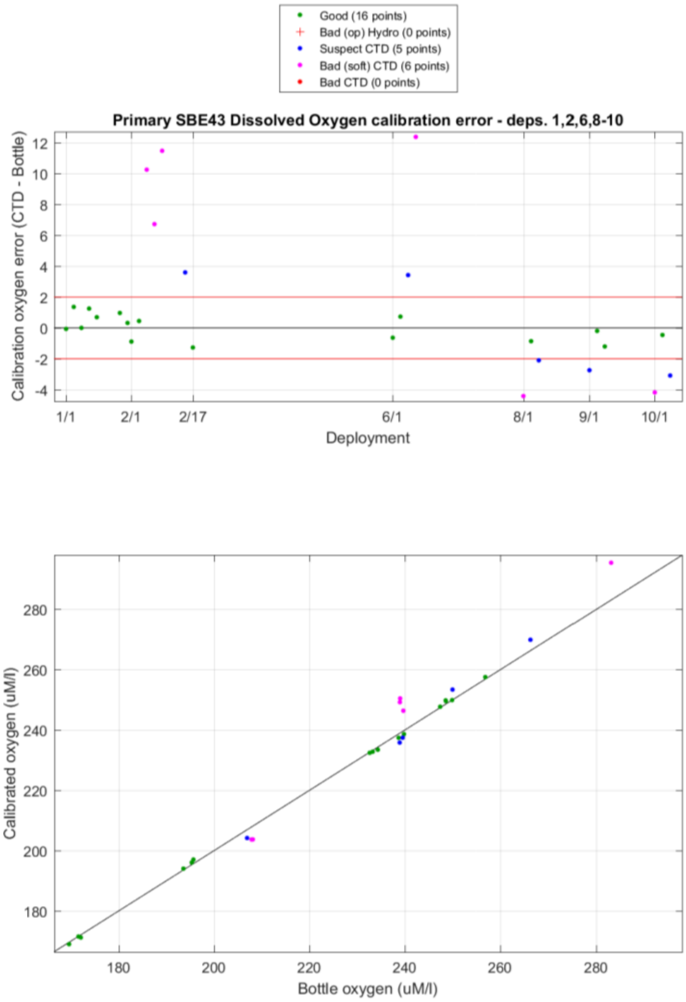


Figure 5 Oxygen difference with upcast CTD daa

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 the primary sensor and the averaged files were created using the result from the primary sensor. Calibrations were not performed for the secondary sensor as it was removed after the second cast.

	Manufacturer's calibration of primary sensor	**primary sensor calibration**
Voffset	-0.50255678	-0.46564
Soc	0.50265777	0.50923
Fit SD (uM)		1.0974

Table 2 Dissolved oxygen calibrations

3.5 Other sensors

3.5.1 Fluorimeters

Four Chelsea fluorimeters were used for each deployment. They have nominally been labelled as the ‘MNF fluorimeter’, ‘v2’, ‘v3’ and ‘v5’. See Table 1 for further details.

The following conversion algorithm was used on all fluorimeters:

$$[conc|FTU] = \left(slope * 10^{volts}\right) - offset$$

Equation 1 flurometer volts to value

Where:

Conc. = florophor concentrations in µg/l

FTU = turbidity in FTU

Fluorimeter v5 output is FTU and all other fluorimeters output concentrations.

The following calibration factors were used as supplied by the manufacture:

	Slope	**Offset**
MNF Fluorimeter	0.008169	0.012336
V2	0.001204	0.016760
V3	0.001055	0.006185
V5	0.015157	0.081251

Table 3 fluorimeter calibrations

The fluorimeters are specialised as follows:

MNF fluorimeter: Calibrated with Chlorophyll-a dissolved in acetone.

V2 fluorimeter: Ultraviolet stimulation fluorimeter sensitive to hydrocarbons. Calibrated using Carbazole dissolved in pure water

V3 fluorimeter: Ultraviolet simulation fluorimeter sensitive to dissolved Gelbstoffe. Calibrated using Perylene dissolved in pure ethanol.

V5 fluorimeter (nephelometer): Calibrated by placing known suspensions of Formazine (prepared according to BD 6068 part 2.13) in a glass cell in front of the instrument.

3.5.2 Franatech CH4

A Franatech laser methane sensor was attached as an axillary sensor. This instrument requires no calibration. The Franatech was configured as a user polynomial sensor in the Seabird acquisition software using the below formula to calculate engineering units from the raw voltage.

$$ppmv = -250 + (2500 * Volts)$$

Equation 2 Franatech volts to value

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 4 below.

Sensor	Range min	Range max	Max Second Diff
temperature	-2	40	0.05
conductivity	-0.01	7	0.01
oxygen	-1	500	0.5

Table 4 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

Talukder, A., 2017: The RV Southern Surveyor. Voyage Plan in2017_C01 - http://www.mnf.csiro.au/~/media/Files/Voyage-plans-and-summaries/Investigator/Voyage%20Plans%20summaries/2017/IN2017_C01%20Voyage%20plan%2020170322.ashx

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

Sea-Bird Electronics Inc., 2012: Application Note No 64-3: SBE 43 Dissolved Oxygen SensorCalibration and Data Corrections. http://www.seabird.com/document/an64-2-sbe-43-dissolved-oxygen-sensor-calibration-and-data-corrections