Marine National Facility

RV *Investigator*

CTD Processing Report

Voyage #:	IN2015_E03
Voyage title:	Acoustics and pelagic ecosystems
Depart:	Hobart, 0636 Thursday, 16th April 2015
Return:	Hobart, 1600 Tuesday, 22 April 2015
Report compiled by:	Steven Van Graas

Contents

1 Summary

These notes relate to the production of quality controlled, calibrated CTD data from RV Investigator voyage IN2015_E03, from 16 Apr 2015 – 22 Apr 2015.

Data for 7 deployments were acquired using the Seabird SBE911 CTD 20, fitted with 24 ten litre bottles on the rosette sampler. CSIRO -supplied calibrations were applied to the temperature, pressure and conductivity data. The data were subjected to automated QC to remove spikes and out-of-range values. Acquisition software was needed to be restarted during cast 6, and as such the numbering for deployments in the acquisition software as incremented. Deployment 7 is represented as deployment 8 in the data presented here.

The cabling for the primary and secondary Oxygen sensors was unknowingly swapped at the beginning of the voyage – this has been corrected through post voyage re-processing of the raw data.

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 0.0015 PSU, within our target of ‘better than 0.002 PSU’. The standard product of 1dbar averaged were produced using data from the secondary sensors.

The dissolved oxygen data calibration fit had a S.D. of 0.45uM. The agreement between the CTD and bottle data was good.

A Chelsea fluorometer, the Wet Labs Transmissometer, the Biospherical Photosynthetically Active Radiation (PAR) sensor were also installed on the auxiliary A/D channels of the CTD.

2 Voyage Details

2.1 Title

Acoustics and Pelagic Ecosystems trials voyage.

2.2 Principal Investigators

Dr Rudy Kloser and Tim Ryan.

2.3 Voyage Objectives

The scientific objectives for IN2015_E03 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

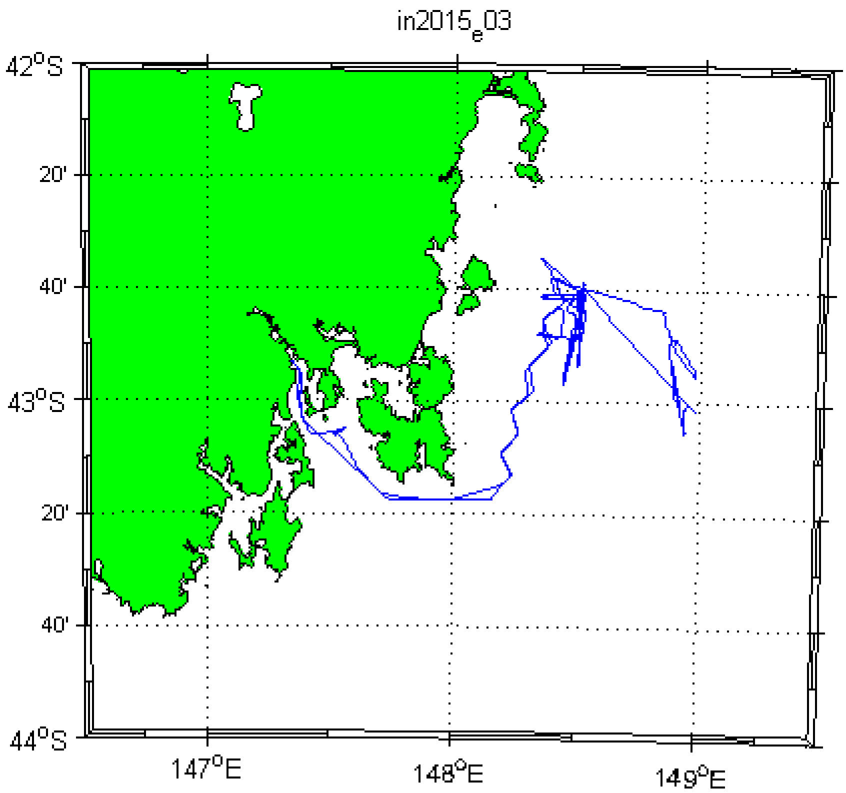

FIGURE 1. Area of operation for IN2015_E03

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.

The CTD was additionally fitted with SBE43 dissolved oxygen sensors, Transmissometer, fluorometer, PAR and altimeter. These sensors are described in Table 1 below.

Description	Sensor	Serial No.	A/D	Calibration Date	Calibration Source
Pressure	Digiquartz 410K-134	552	P	8/4/2015	CSIRO 3144 P - dbar
Primary Temperature	Seabird SBE3*plus*	4722	T0	27/2/2015	CSIRO 3109 T
Secondary Temperature	Seabird SBE3*plus*	4522	T1	27/2/2015	CSIRO 3106 T
Primary Conductivity	Seabird SBE4C	3868	C0	26/2/2015	CSIRO 3102 C
Secondary Conductivity	Seabird SBE4C	3168	C1	26/2/2015	CSIRO 3098 C
Primary Dissolved Oxygen*	SBE43	1794	A1	11/2/2015	CSIRO3055DO
Secondary Dissolved Oxygen*	SBE43	1239	A0	11/2/2015	CSIRO 3054DO

Altimeter	PSA-916T	2306	A2	30/10/2014	
Transmissometer	C-Star	CST-1421DR	A3	18/6/2014	Wet Labs 25cm
Fluorometer	Chelsea Aquatracka	065941001	A4	23/9/2014	
PAR	QCP PAR	70111	A5	23/8/2013	Manufacturer calibration
PSci Pressure Temperature			PT	8/4/2015	CSIRO 3144 P

*Dissolved oxygen primary and secondary sensor cabling was inadvertently swapped . Scan files were re-created from raw data using CAP in order to apply correct calibration.

TABLE 1. CTD Sensor configuration on IN2015_E03

Water samples were collected using a Seabird SBE32, 24-bottle rosette sampler. Sampling was from 24 ten litre bottles which were fitted to the frame. There were 7 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.

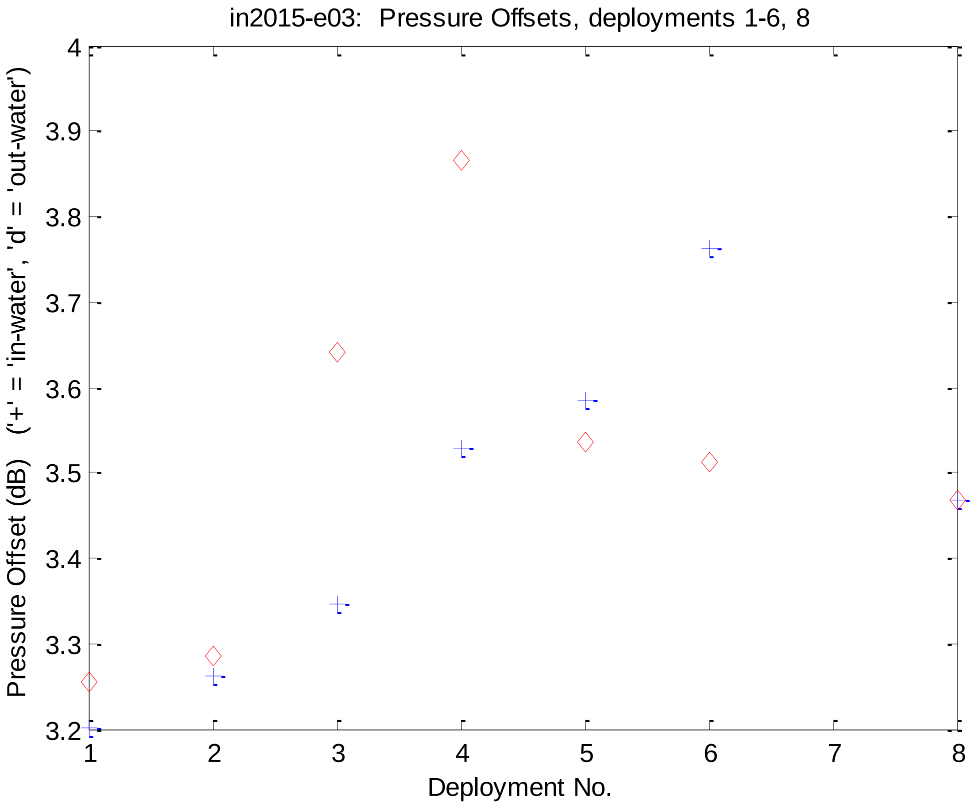

FIGURE 2. CTD pressure offsets

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.

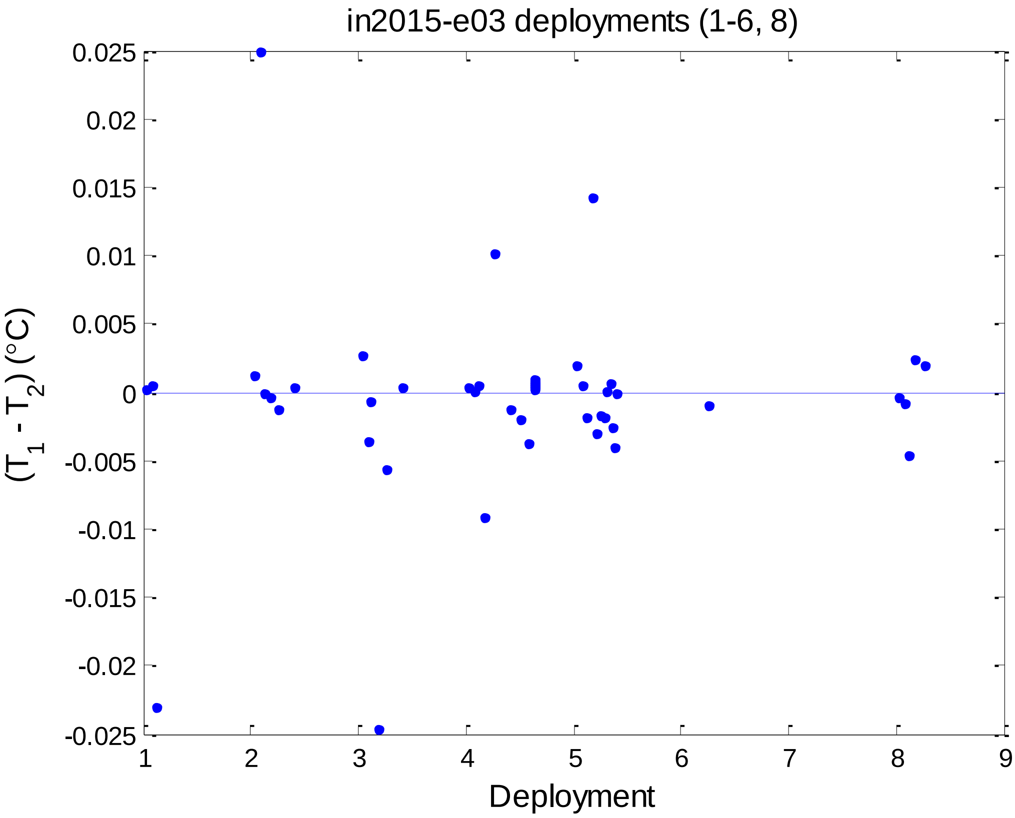

FIGURE 3. .Mean difference between primary and secondary temperature sensors

3.3 Conductivity Calibration

Discrepancies and possible sampling problems between bottle and CTD salinities for the 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 7 of the total of 7 samples taken during deployments (the outliers marked in Figure 4 below with the red '+' and magenta diamonds are excluded from the calibration).

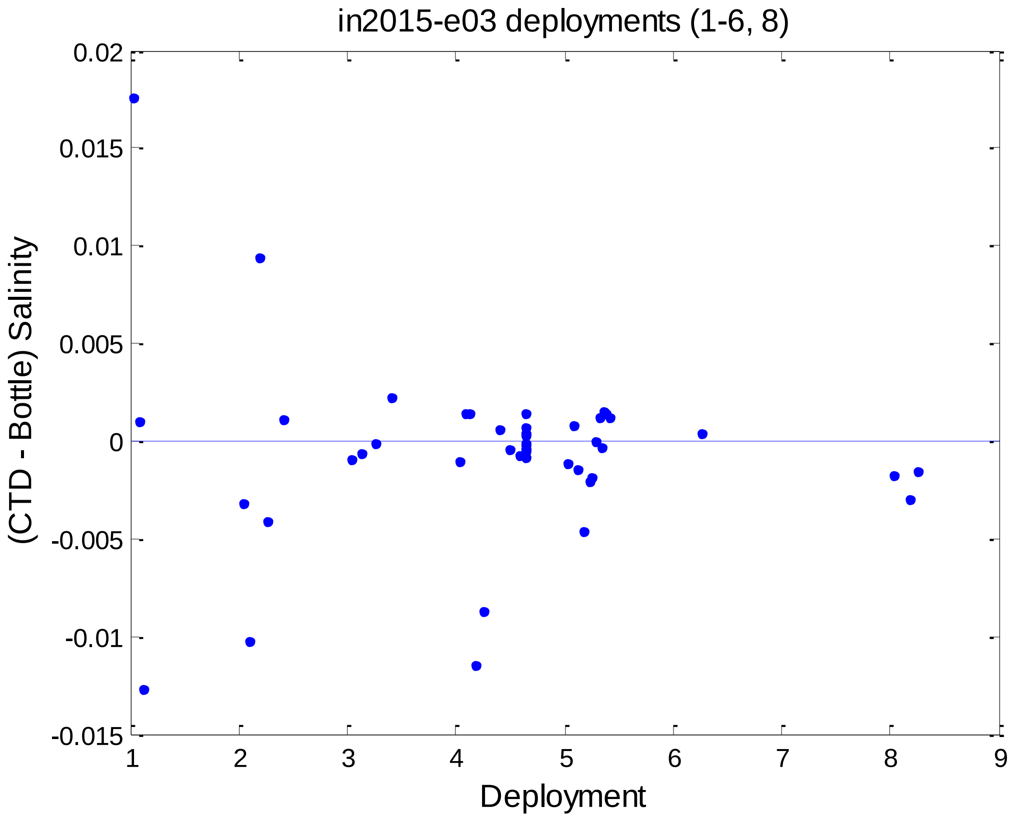

FIGURE 4. CTD - bottle salinity plot.

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.

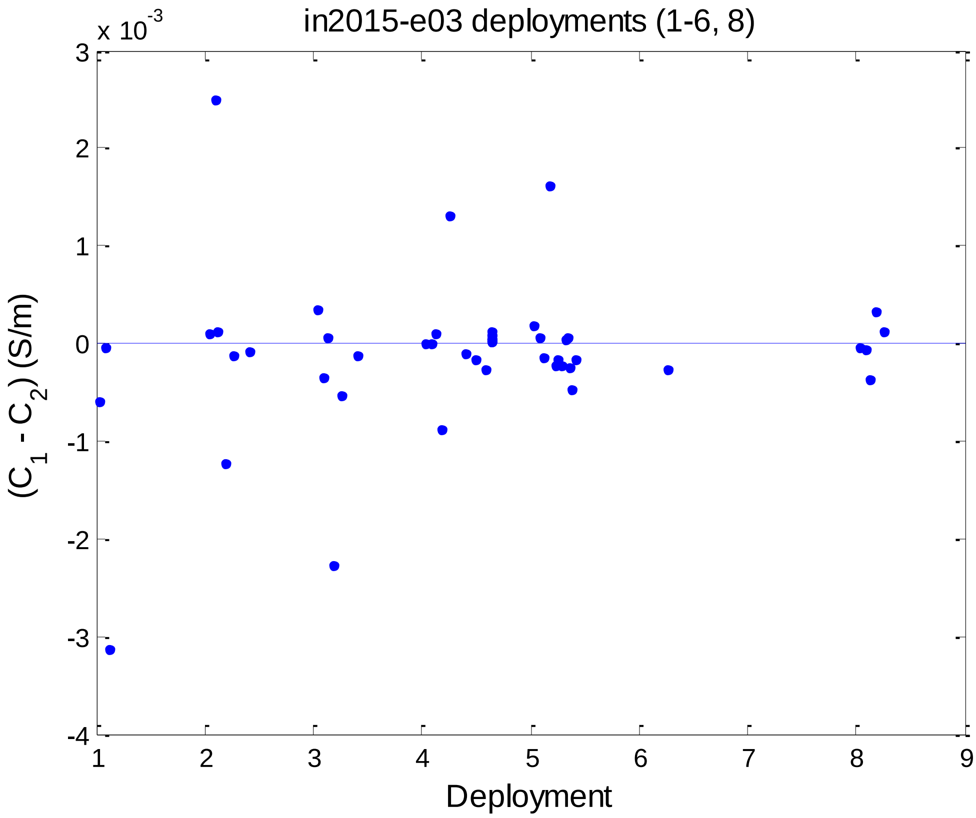

FIGURE 5. Mean difference between primary and secondary conductivity sensors

The final result for the primary conductivity sensor was –

Scale Factor (a1)	0.99946915	wrt. Manufacturer's calibration
Offset (a0)	0.00064238349	ditto
Calibration S.D. (Sal)	0.0024872 PSU	

The calibration using the secondary conductivity sensor was –

Scale Factor (a1)	0.99958665	wrt. Manufacturer's calibration
Offset (a0)	0.00066229292	ditto
Calibration S.D. (Sal)	0.0015328 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. There were 5 of the 41 oxygen analyses performed excluded from the calculations. The plot below is of CTD - bottle oxygen differences for both upcast and downcast data (red indicates 'bad' data; diamond for upcast and round for downcast).

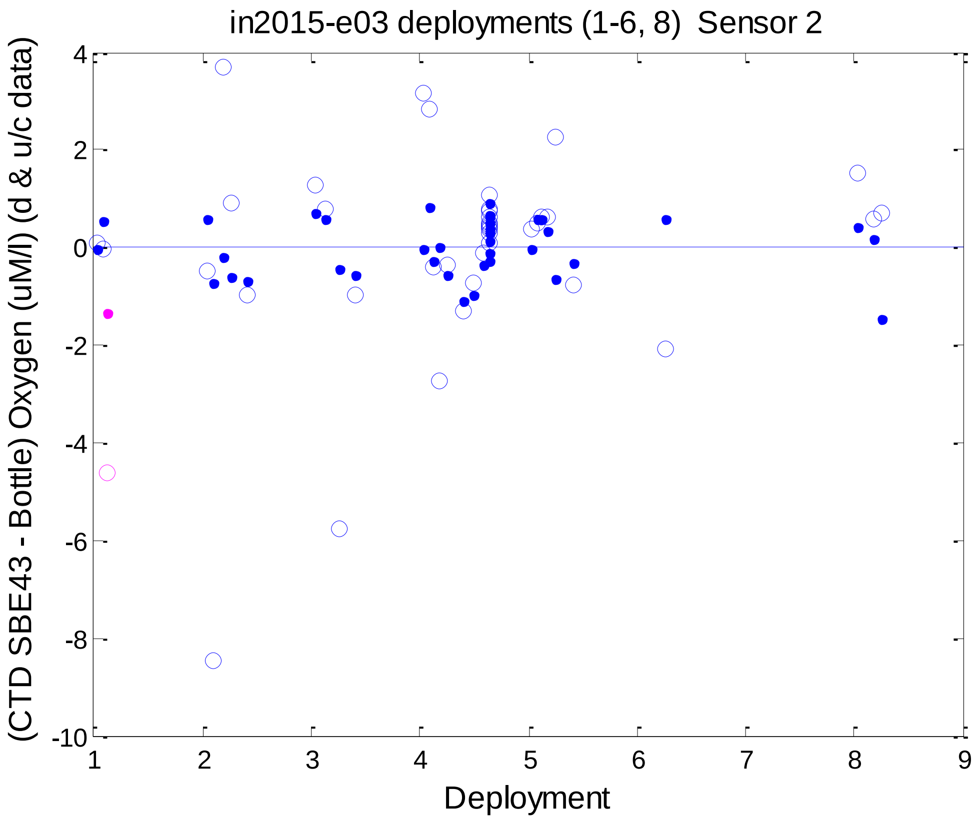

FIGURE 7. (SBE43 - Bottle) Oxygen Difference with upcast CTD data

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	-0.45454067	-0.49046919	-0.49355856
Soc	0.50939087	0.51196573	0.52696456	0.52518484
Fit SD (uM)	-	0.45297	-	0.58684

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. The output is a nominal 0-5 volts. 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
PAR	-5.0	5000	50.0
fluorometer	0	100	0.5

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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Kolser, R 2015: The RV Investigator. Voyage Plan IN2015_E03 - http://www.cmar.csiro.au/datacentre/process/data_files/cruise_docs/Investigator/in2015_e03_plan.pdf

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Sea-Bird Electronics Inc., 2010c: Application Note No 64-3: SBE 43 Dissolved Oxygen (DO) Sensor - Hysteresis Corrections. http://www.seabird.com/pdf_documents/ApplicationNotes/Appnote64-3Feb10.pdf