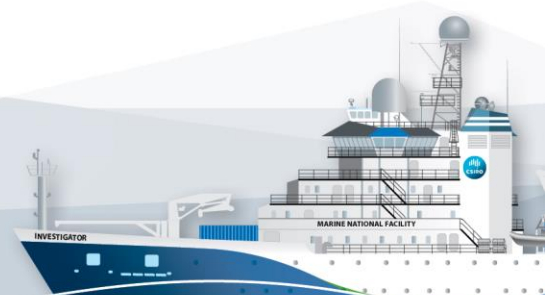


RV Investigator

Triaxus Processing Report

Voyage ID:	IN2018_V03
Voyage title:	Integrated Marine Observing System: monitoring of East Australian Current property transports at 27 degrees south
Depart:	Brisbane, 0700 Thursday 19 April, 2018
Return:	Brisbane, 1200 Thursday, 10 May 2018
Report compiled by:	Steven Van Graas



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1 Summary

These notes relate to the production of quality controlled Triaxus data from RV Investigator voyage IN2018_V03, from 19 Apr 2018 – 10 Oct 2018.

Data for 6 Triaxus deployments were acquired in Seasave CTD acquisition software using the Seabird SBE911 CTD 23. The deployments were conducted with a standard tow speed of between 7 to 10 knots and wire out ranged from 1100 to 1250 m.

Sea-Bird-supplied calibration factors and CSIRO supplied calibrations were used to compute the pressures, conductivity and temperature data. The data were subjected to automated QC to remove spikes and out-of-range values.

Dissolved oxygen sensors, Transmissometer and Cosine Photosynthetically Active Radiation (PAR) sensor were also installed on the auxiliary A/D channels of the CTD. In addition to the auxiliary channels, ECO Triplet, Nitrate, FIRE and LOPC were mounted on the Triaxus as attached payloads.

The standard data product (1 decibar/10 second binned averaged) was produced using data from the secondary sensors to produce an along-track time-series dataset for each CAP scan files. These scan files were grouped into legs, each containing a section of the Triaxus deployment and in each leg, vertical casts were created with interpolated values from the along-track time-series binned dataset with a maximum interpolation distance of 3 casts. These generated the along-track and vertical cast section data products for each Triaxus deployment.

2 Voyage Details

2.1 Title

Integrated Marine Observing System: monitoring of East Australian Current property transports at 27 degrees south.

2.2 Principal Investigators

Dr Bernadette Sloyan, CSIRO.

2.3 Voyage Objectives

The scientific objectives for IN2018_V03 were outlined in the Voyage Plan (Sloyan 2018).

For further details, refer to the Voyage Plan and/or summary which can be viewed on the Marine National Facility Plans and Summaries [web site](#).

2.4 Area of operation

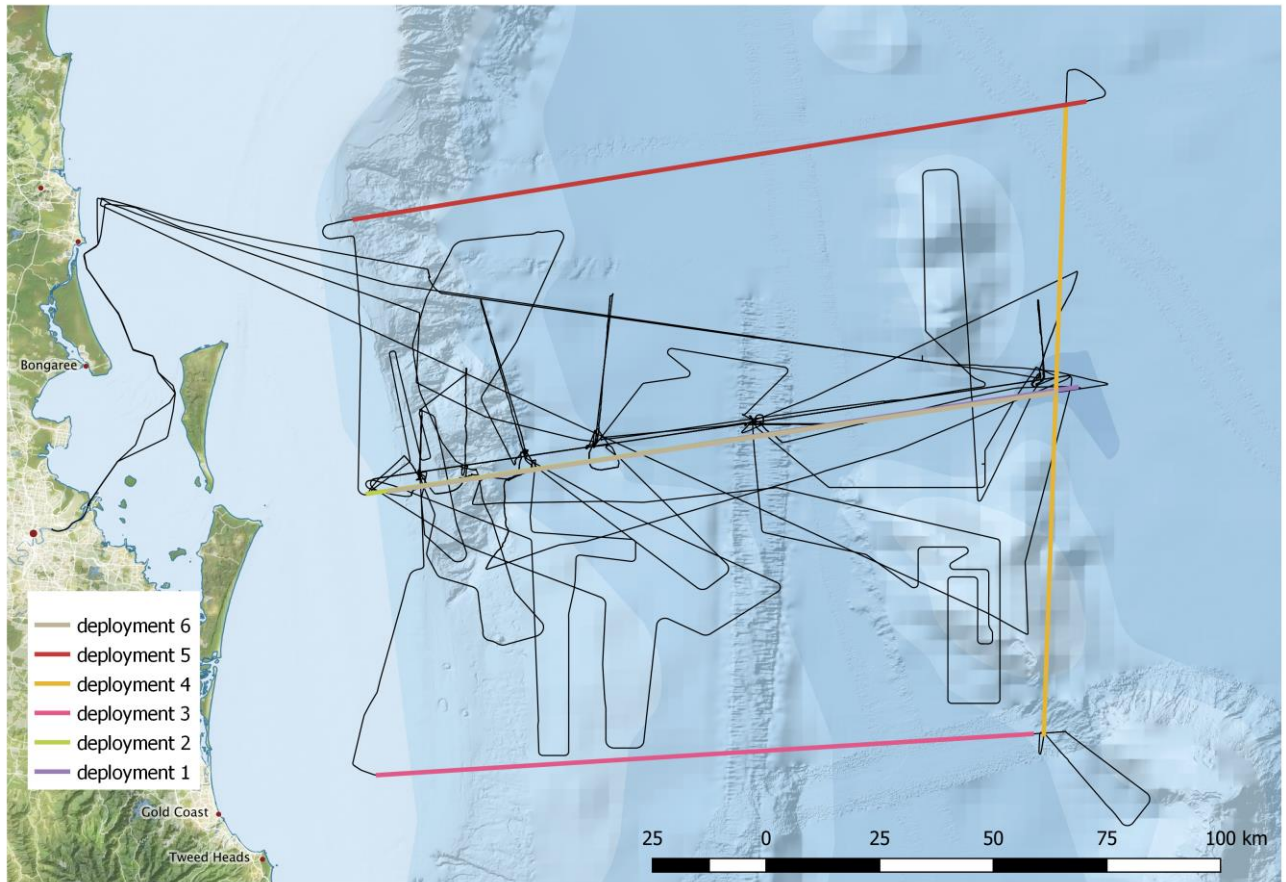


Figure 1. Area of operation for IN2018_V03 with Triaxus deployments highlighted in colour

3 Processing Notes

3.1 Background Information

Six Triaxus deployments were conducted, divided in the CTD acquisition software SeaSave and converted into 6 scan files. Flight data from the MacArtney Triaxus were logged containing pitch, roll, altimeter, cable length, ship water depth and ship speed.

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, Transmissometer, Cosine Photosynthetically Active Radiation (PAR) sensor, ECO Triplet, Nitrate and LOPC. These sensors are described in Table 1, with changes in Primary and Secondary Conductivity and Oxygen sensors for deployments 5 and 6.

Description	Sensor	Serial No.	A/D	Cal. Date	Cal. Source
Pressure	Digiquartz 410K-134	1312	P	05-Dec-2017	CSIRO
Primary Temperature	Seabird SBE3plus	6024	T0	11-Jul-2017	CSIRO
Secondary Temperature	Seabird SBE3plus	6022	T1	27-Feb-2018	CSIRO
Primary Conductivity	Seabird SBE4C	4426	C0	11-Jul-2017	CSIRO
Secondary Conductivity	Seabird SBE4C	4425 (1-4)	C1	25-Jul-2017	CSIRO
Secondary Conductivity	Seabird SBE4C	4664 (5-6)	C0	02-May-2017	Sea-bird
Primary Dissolved Oxygen	Seabird SBE43	3199 (1-4)	A4	26-Feb-2018	CSIRO
Primary Dissolved Oxygen	Seabird SBE43	3542 (5-6)	A4	26-Feb-2018	CSIRO
Secondary Dissolved Oxygen	Seabird SBE43	1794	A5	01-Aug-2017	Sea-bird
Transmissometer	Wetlabs C-Star	CST-1735DR	A1	27-Feb-2018	Wetlabs
PAR	Biospherical QCP-2300HP	70562	A0	26-Jun-2017	Biospherical
ECO Triplet	Wetlabs FLBBCD-2K	5038	Payload 2	10-Apr-2018	Wetlabs
Nitrate	Satlantic SUNA V2	449	Payload 3		
LOPC	Rolls-Royce LOPC-1xT-3	11480	Payload 7		

Table 1 CTD Sensor configuration on IN2018_V03

The raw CTD data were collected in SeaSave version 7.26, converted to scientific units using SBE Data Processing version 7.26 and written to NetCDF format files with CNV_to_Scan for processing using the Matlab-based, CapPro package.

The CapPro 2.9 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.

Data were binned into 1 decibar/10 second averaged bins for each deployment along track in NetCDF format.

3.2 Sensor Correction

3.2.1 Pressure Sensor Location

The location of the pressure sensor relative to the T/C sensors is defined through orthogonal axes XYZ (origin at T/C sensors) with the vehicle travelling along the X axis (if zero pitch), Z vertically up and Y to port. The pressure sensor location is given by a distance to sensor along the X axis (+ve pressure forward of T/C), and Y axis (positive values indicate pressure sensor is to port of T/C) and Z axis (positive value indicates pressure above T/C).

Using pitch (rotation around Y axis, positive nose up) and roll (rotation around X axis, positive clockwise looking forward) from the Triaxus flight data it is possible to correct the pressure at sensor locations.

Note that the pressure sensor location correction were **not applied** in this instance and for reference, Conductivity and Temperature sensor location for IN2018_V03 were as follows (measured in metres):

	Vertical location	Fore / Aft	Port / Starboard
Primary C/T	0.3	-0.45	-1.68
Secondary C/T	0.3	-0.45	-0.05

Table 2 Pressure sensor location relative to the T/C sensors

3.2.2 Thermal Inertia Correction

The temperature of the boundary layer water passing through the conductivity cell lags the temperature of the in-situ water due to the thermal mass of the cell. Since derived salinity is strongly dependent upon temperature, in order to derive correct salinity the true apparent temperature of the water in the cell is required. To derive the apparent temperature given the in-situ temperature we assume a fraction, beta, of the water (belonging to the boundary layer) is lagged with a time constant, tau. After extensive testing it has been determined that good correction is achieved using two time constants 7 and 1 seconds with beta factors 0.013 and 0.007 respectively.

3.3 Other sensors

The Wetlabs C-Star Transmissometer was used for all deployments. The Transmissometer has been calibrated to give nominal outputs of 0-100% transmission. Transmissometer sensor readings for deployments 5 and 6 are far from the expected range and should be treated as suspect.

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.

The Eco Triplet sensor array, SUNA and LOPC were used for all deployments. Only Eco Triplet data has been merged into the averaged data products.

3.4 Bad data detection

The range limits and maximum second difference for sensors connected to the SBE9+ A/D channels are configured in CAP and are written to the NetCDF scan file. Typical limits used for the sensor range and maximum second difference are in Table 3 below.

Sensor	Range minimum	Range maximum	Max. Second Difference
Pressure	-7	6500	0.5
Temperature	-10	40	0.05
Conductivity	-0.01	7	0.01
Oxygen	150	280	0.5
Transmissometer	0	100	0.5
PAR	-5	5000	100
CDOM	0	2	0.8
OBS	0	1e-3	3e-4
Chlorophyll	0	3.5	1

Table 3 Sensor limits for bad data detection

Data found to be out of range or having a second difference above the maximum second difference were flagged as bad and filtered by CAPPro.

3.5 Averaging

The data were ‘filtered’ and binned into the standard product of 1 decibar / 10 second averaged NetCDF deployment files containing the time-series data. 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.

3.5.1 QC flags

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.

3.5.2 Vehicle Position Correction

Typically to provide a better estimate of the Triaxus’ actual position, the recorded flight data is used to recalculate a location for the averaged data, using the wire out, pressure, the ships current location. Due to errors in the ingested wire data this has been disabled and no correction to the Triaxus position have been applied to any deployment.

3.5.3 Vertical Cast Creation

'Vertical casts' were created from the along track average files. A vertical cast represents a vertical column of data points geographically located at the minimum and maximum pressure points of an undulation. Data for a vertical cast is derived by interpolating between the binned data points on the upcast and downside of either side of the vertical cast.

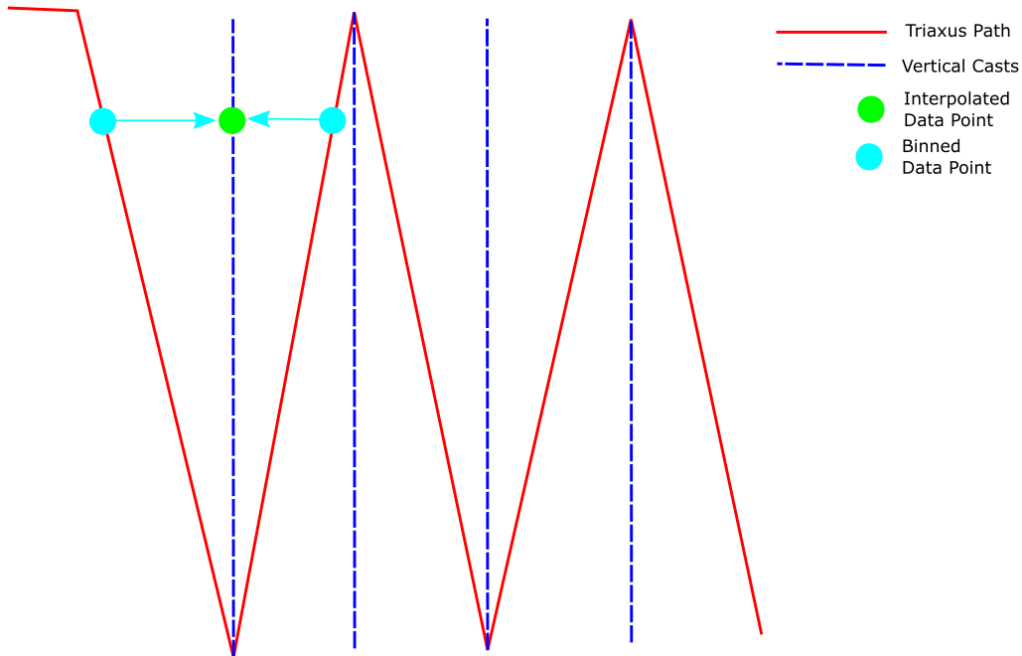


Figure 2. Vertical Cast Creation

3.6 Triaxus Deployments

Dep.	Leg	Scan File	Start time	End time	Start lat.	Start long.	End lat.	End long.
1	-	1	2018-04-23T08:36:43Z	2018-04-23T19:13:56Z	27 07.522S	155 22.280E	27 19.358S	154 04.473E
2	-	2	2018-05-03T08:01:49Z	2018-05-03T21:33:07Z	27 21.827S	153 47.011E	27 08.563S	155 17.214E
3	-	3	2018-05-06T09:24:34Z	2018-05-06T22:23:43Z	27 59.632S	153 48.376E	27 54.111S	155 16.283E
4	-	4	2018-05-07T05:01:14Z	2018-05-07T17:14:34Z	27 54.159S	155 17.899E	26 30.196S	155 20.885E
5	-	5	2018-05-07T20:11:09Z	2018-05-08T10:55:57Z	26 29.191S	155 23.327E	26 44.974S	153 45.183E
6	-	6	2018-05-08T16:22:43Z	2018-05-09T05:34:17Z	27 21.513S	153 49.943E	27 08.211S	155 19.582E

Table 4 Triaxus deployment grouping

CAP scan files were grouped for each Triaxus deployment/leg as shown in Table 4 above. This was followed by the creation of vertical casts at the top and bottom apex along the flight path. Using the binned time-series data, these vertical casts were filled by interpolation to a maximum of three casts' distance. These were then connected along-track to provide an along-track section profile. Section plots for each deployment/leg can be found in Appendix I: Section Plots, each containing plots for the Primary Temperature, Salinity, Oxygen and PAR. Along with Chlorophyll, CDOM, OBS and Transmission plotted as an along track distance.

Deployment/Legs were then exported as both vertical casts and along-track data products in NetCDF format.

4 References

Sloyan, B., 2018: The RV Investigator. Voyage Plan IN2018_V03 - http://www.mnf.csiro.au/~media/Files/Voyage-plans-and-summaries/Investigator/Voyage%20Plans%20summaries/2018/IN2018_V03%20Voyage%20Summary.ashx

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

Sea-Bird Electronics Inc., 2013: Application Note No 64: SBE 43 Dissolved Oxygen Sensor -- Background Information, Deployment Recommendations, and Cleaning and Storage. <http://www.seabird.com/sites/default/files/documents/appnote64Jun13.pdf>

5 Glossary

Deployment – relates to one instance of the Triaxus entering the water, being towed for a period of time and followed by retrieval from the water.

Leg – relates to a ‘section’ of the deployment containing a feature of interest, whether it be an eddy, geographic region etc. This can be part of or the whole deployment.

Scan file – a file structure containing data collected from the deployment of the CTD and auxiliary sensors.

6 Appendix I: Section Plots

