RV *Investigator*

CTD Processing Report

Voyage #:	in2015_v02
Voyage title:	Sustained monitoring of the East Australian Current: Mass, heat and freshwater transports
Depart:	Sydney , 2015 Friday, 15 May 2015
Return:	Brisbane , 1300 Tuesday, 26 May 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_v02, from 15 May 2015 – 26 May 2015.

Data for 18 deployments were acquired using the Seabird SBE911 CTD 20, fitted with 24 ten litre bottles on the rosette sampler. During cast 2 one Niskin bottle (rosette bottle 7) was found to be broken upon recovery. Each subsequent cast was performed with 23 bottles. 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.

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 0.00149 PSU, within our target of 'better than 0.002 PSU'. The standard product of 1 dbar binned averaged were produced using data from the secondary sensors.

The dissolved oxygen data calibration fit had a S.D. of 1.4092 uM.

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

An upwards facing 300kHz LADCP and a downwards facing 150kHz LADCP were attached for each cast. An RBR Concerto was also attached for 7 of the 18 CTD casts. The data collected from these instruments do not form part of this report.

2 Voyage Details

2.1 Title

Sustained monitoring of the East Australian Current: Mass, heat and freshwater transports.

2.2 Principal Investigators

Dr Bernadette Sloyan.

2.3 Voyage Objectives

The scientific objectives for in2015_v02 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

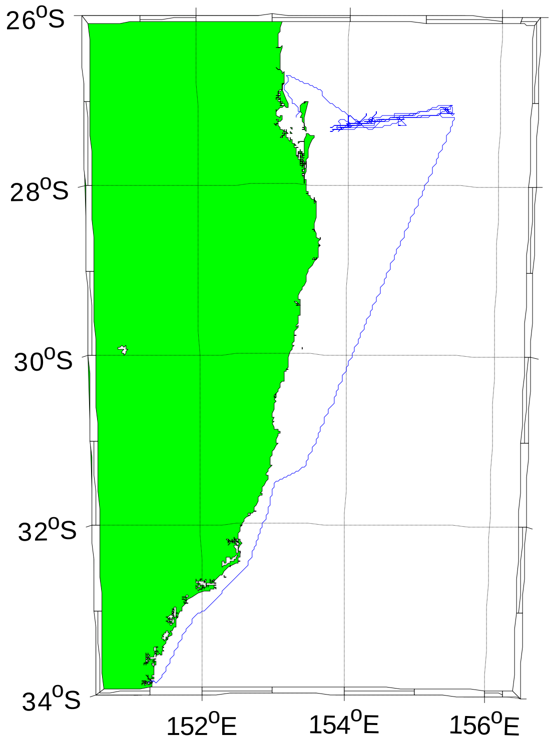

FIGURE 1. Area of operation for in2015_v02

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, PAR, and Fluorometer. 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 cal report 3144 P - dbar
Primary Temperature	Seabird SBE3*plus*	4722	T0	27/2/2015	CSIRO cal report 3109 T
Secondary Temperature	Seabird SBE3*plus*	4522	T1	27/2/2015	CSIRO cal report 3106 T
Primary Conductivity	Seabird SBE4C	3868	C0	26/2/2015	CSIRO cal report 3102 C
Secondary Conductivity	Seabird SBE4C	3168	C1	26/2/2015	CSIRO cal report 3098 C

Secondary Dissolved Oxygen	SBE43	1239	A0	11/2/2015	CSIRO cal report 3054DO
Primary Dissolved Oxygen	SBE43	1794	A1	11/2/2015	CSIRO cal report 3055DO
Altimeter	PSA-916	41023	A2	22/5/2014	Manufacturers calibration
Transmissometer	C-Star	CST-1421DR	A3	18/6/2014	Wet Labs 25cm
Fluorometer	Aquatracka	065941 001	A4	23/9/2014	Manufacturers calibration
PAR	QCP-2300HP	70111	A5	10/6/2014	Manufacturers calibration

TABLE 1. CTD Sensor configuration on in2015_v02

Water samples were collected using a Seabird SBE32, 24-bottle rosette sampler. Sampling was from 23 ten litre bottles which were fitted to the frame – deployment 1 was performed with 24 bottles. There were 18 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.

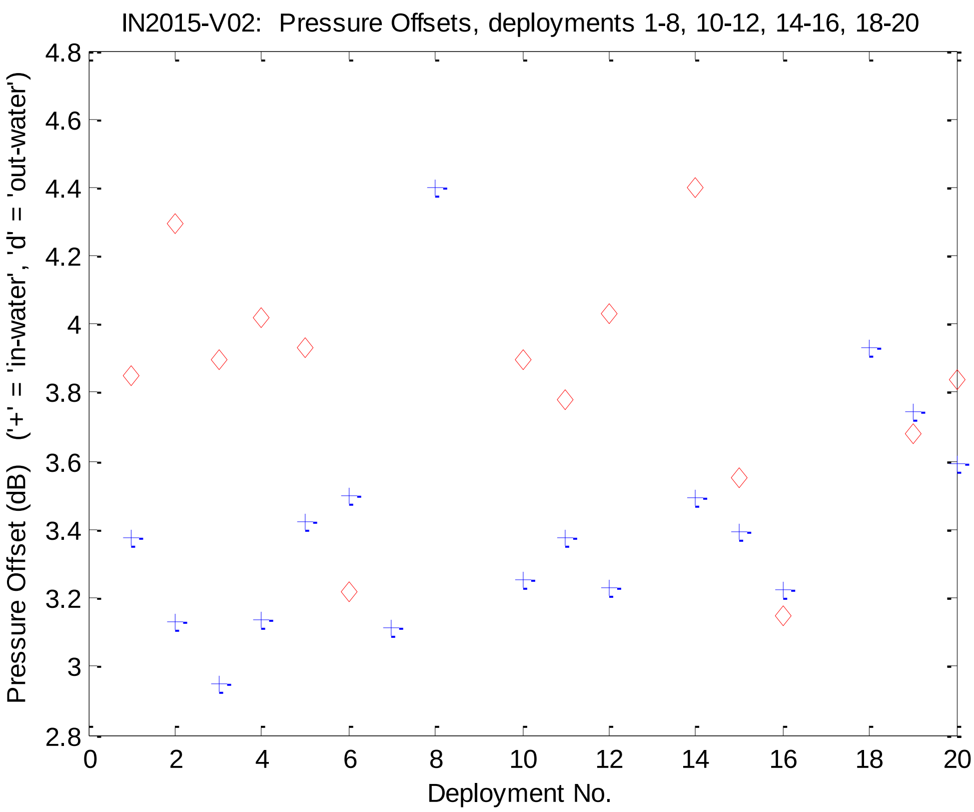

FIGURE 2. CTD pressure offsets

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.

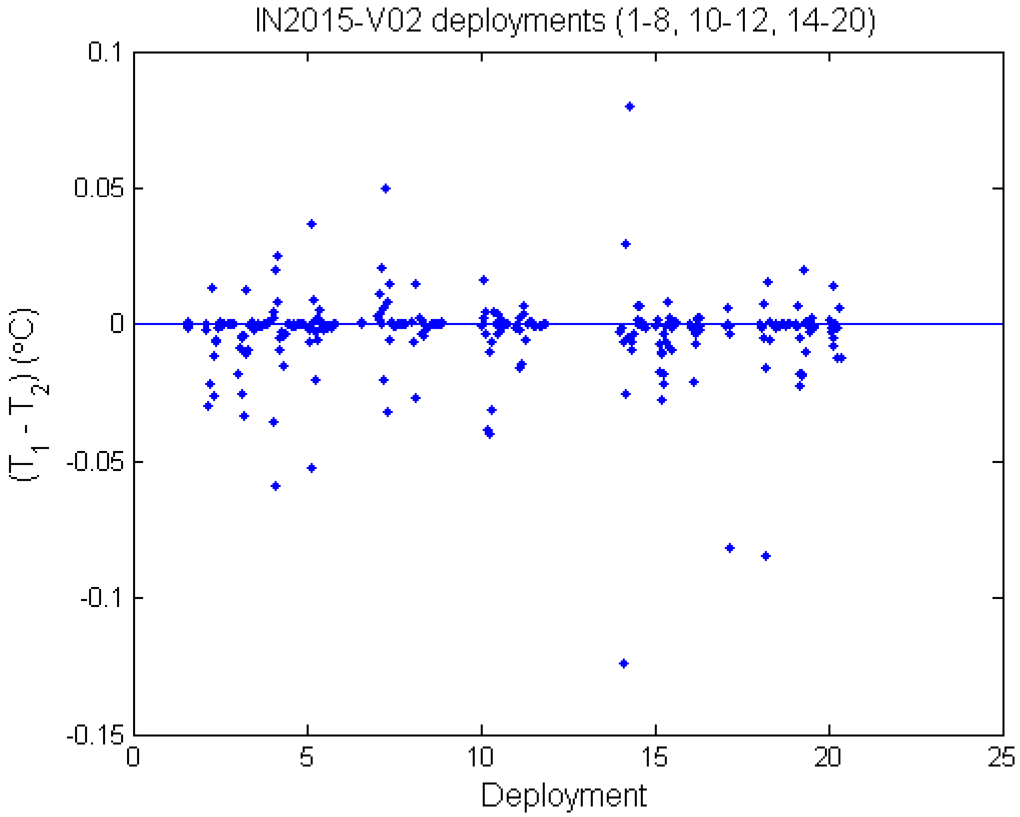

FIGURE 3. .Mean difference between primary and secondary temperature sensors

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 all of the 24 samples taken during deployments (the outliers marked in Figure 4 below with the red '+' and magenta diamonds are excluded from the calibration).

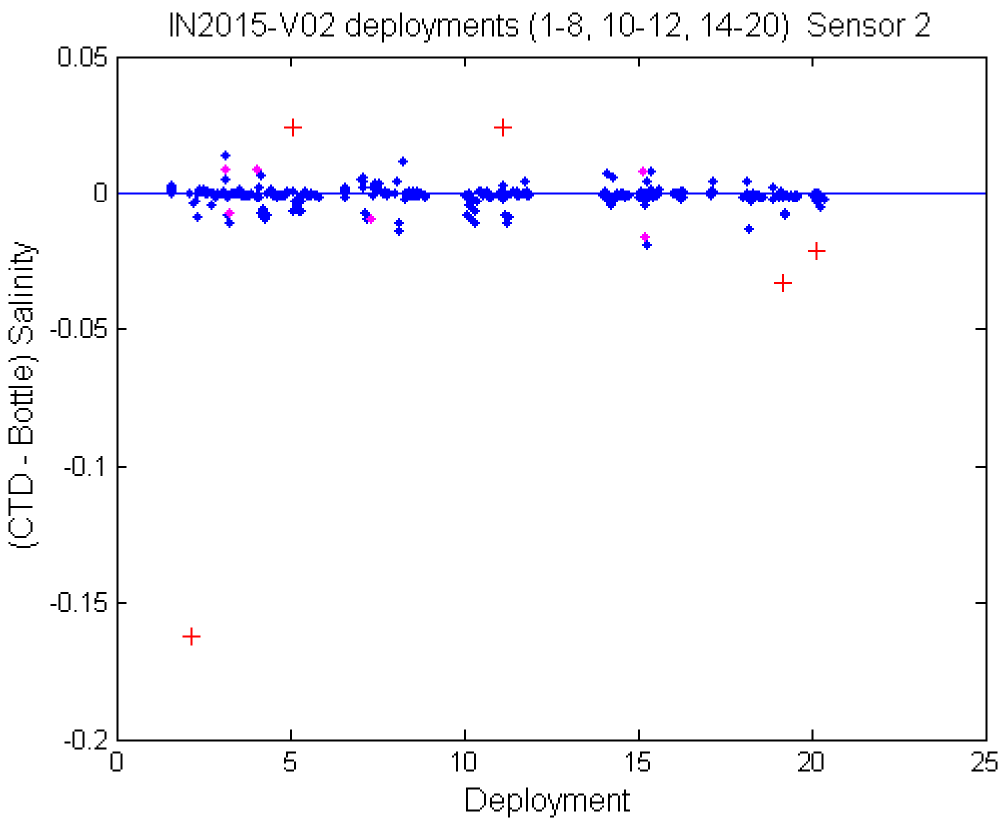

FIGURE 4. CTD - bottle salinity plot.

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 well.

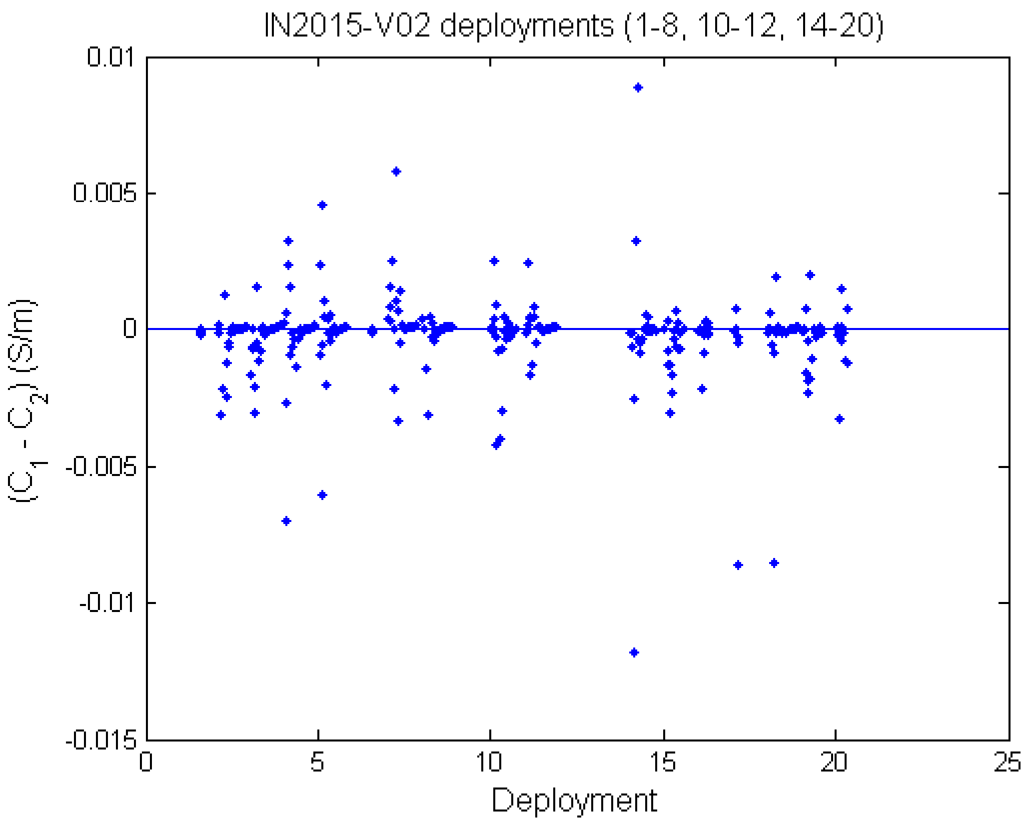

FIGURE 5. Mean difference between primary and secondary conductivity sensors

The final result for the primary conductivity sensor was –

Scale Factor (a1)	0.99940647	wrt. CSIRO Calibration
Offset (a0)	0.00073604328	ditto
Calibration S.D. (Sal)	0.0020068 PSU	

The calibration using the secondary conductivity sensor was –

Scale Factor (a1)	0.99944076	wrt. CSIRO calibration
Offset (a0)	0.0010035382	ditto
Calibration S.D. (Sal)	0.0014868 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 (2013) 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 (2012) 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 (2014).

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 (red indicates 'bad' data; + for upcast and square for downcast).

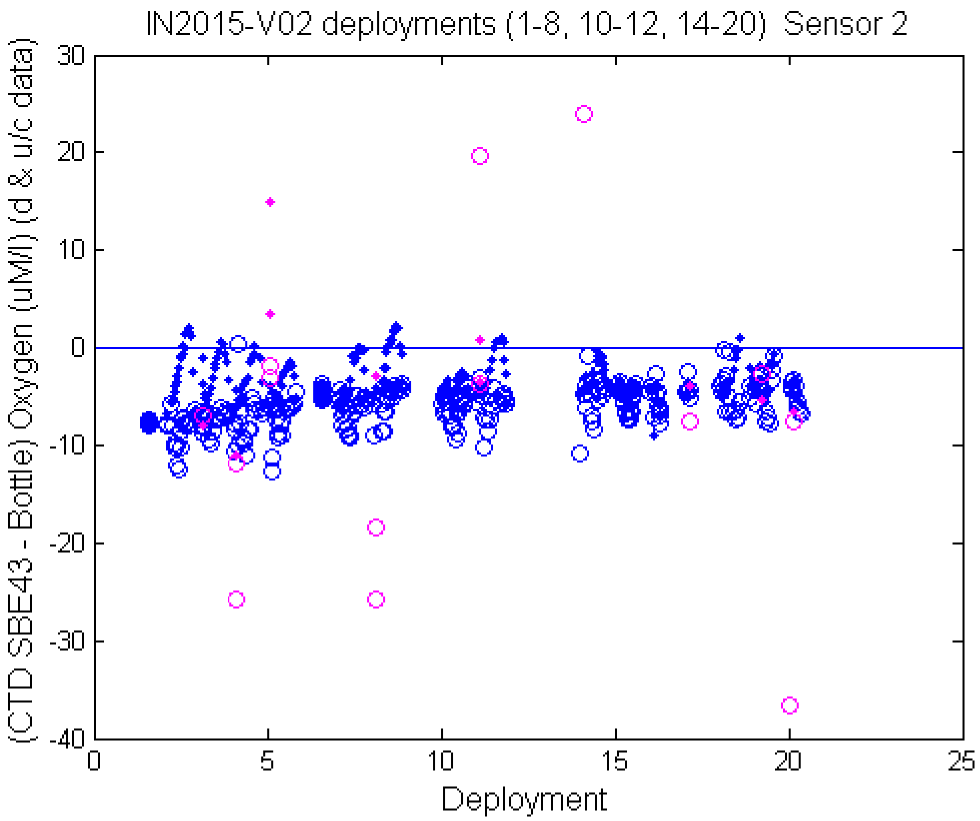

FIGURE 7. (SBE43 - Bottle) Oxygen Difference with upcast CTD data

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	-0.38618067	-0.49046919	-0.46160283
Soc	0.50939087	0.44982655	0.52696456	0.50246522
Fit SD (uM)		3.2135		1.4092

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. 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

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

Beattie, R.D., 2010: procCTD CTD Processing Procedures Manual. http://www.marine.csiro.au/~dpg/opsDocs/procCTD.pdf.

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