RV *Investigator*

Underway Data Processing Summary Report

Voyage #:	**in2017_v03**
Voyage title:	Sampling the Abyss, latitudinal biodiversity patterns along the base of Australia's eastern continental margin
Depart:	Bell Bay TAS, 20:00 Monday 15th May 2017 AEST
Return:	Brisbane, 10:00 Friday 16th June 2017 AEST
Data dates:	15-May-2017 10:04:15 To: 16-June-2017 00:06:35 UTC
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Data processed by:	Vito Dirita, CSIRO Oceans and Atmosphere, Hobart, Tasmania.

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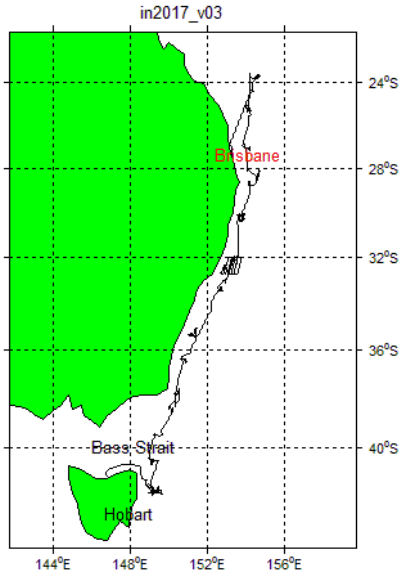
1.2 Voyage Track



1.3 Underway Data

Navigation data is acquired using the Seapath 330 plus position and reference unit, which is also differentially corrected by data from the FUGRO marine cstar 3610 receiver.

The Meteorological data consists of two port/starboard relative humidity and temperature sensors, vane type wind sensor, licor light sensor and a barometer.

Thermosalinograph data is acquired with a Seabird SBE21 TSG and remote temperature by SBE38. Data from a flow meter is also recorded.

Digital depth data is recorded from a Simrad EK60 sounder.

Data from the Integrated Marine Observing System sensors (IMOS) are also included. The sensors are port and starboard radiometers and pyranometers, ultrasonic wind speed and direction.

Refer to the Electronics report for this voyage for instruments used and their serial numbers.

Navigation, meteorological, thermosalinograph, IMOS and depth data are preliminary quality controlled by combining all data from hourly recorded files to 5 second values in a netCDF formatted file. The combined data is referred to as: “underway data”.

A combined file was made on 5th March 2018 by running the Java application UWYMerger with data time range of 15-May-2017 10:04:15 to 16-June-2017 00:06:35 UTC , Techsas2 was used as the data source.

It should be noted that the merged data file contains additional underway instrument sensor data that are not quality controlled or processed and is provided for completeness only. This includes data from the air sampling instruments (i.e. two Ozone sensors, Absorption Photometer, Picarro and sampling inlet bearing), pCO2, Drop keel position, gyro and Doppler log.

For further description of instruments and Underway netCDF variables please refer to the appendix at the end of this report.

1.4 Completeness and Data Quality

Navigation data (latitude and longitude, speed over ground, ship heading and course over ground); meteorological data (port and starboard air temperature, port and starboard humidity, port and starboard relative and true wind direction and speed, maximum wind gust, port and starboard PAR light, atmospheric pressure and rain) and IMOS data (port and starboard radiometers and pyranometers, ultrasonic relative wind direction and speed), Thermosalinograph (salinity and water temperature) data were evaluated and quality controlled.

1.5 Processing Comments

Atmospheric Pressure: In previous voyages, the atmospheric pressure values (atmPressure) showed unusual characteristics. Minor increases and decreases in pressure values were noted. These were investigated for previous voyages and a direct correlation with changing of wind direction was noted. It is believed that due to the position of the intake of the atmospheric pressure sensor on the ship's superstructure, the values from this sensor are influenced by the prevailing wind and this effect (Bernoulli effect) becomes noticeable during notable wind direction changes. To overcome this phenomena, a Y section was introduced in the configuration of the intake to the sensor to ensure that that the effect of the wind direction on the port and starboard is equalised in relation to this sensor. This has improved the data quality noticeably and therefore the data has been QCed as good.

Air Temperature: A number of minor discrepancies between the port and starboard air temperature sensors were noted (max differences of about 2.00 degrees Celsius), otherwise both sensors gave very close reading with the mean absolute difference of about 0.075 degrees. These discrepancies occurred usually during periods of rapid temperature change. This phenomenon has probably come about due to the rapid warming of the ship's metal structure and air due to the ship becoming stationary or cooling of the air temperature due to the ship speeding off from stationary or due to the evaporation of rain water around the sensor housing. Furthermore, they also seem to relate to when the ship is stationary with little wind or during/following periods of rainfall or as the result of a change in the ship speed that could be the result of hot exhaust gases being blown over the sensors depending on the wind direction.

Rain: The siphoning rain gauge was believed to be generating invalid data in which the rain level would randomly rise and fall. It is unknown how long this behaviour has been prevalent as sample data from the end of the previous voyage had a similar result. There were also negative drops on the daily accumulation from unknown causes. The sensor was inspected at the completion of IN2017_V03 and discovered to be damaged. As such, the entire data has been marked as suspect.

Humidity: No issues found. Good correlation between the port and starboard humidity sensors, mean absolute difference of 0.76 and max difference of about 25.07.

Wind Speed: The mean difference between starboard and port relative wind speed is about 1.31 knots and max absolute difference of 23.00 knots.

Wind Direction: An automated filter was implemented to remove data spikes and was applied to both the port and starboard (true and relative) wind direction. The filter was applied only in a few selected regions which appeared to be very noisy or spiky. The majority of the spikes appeared to have been correctly flagged and removed. However with automated filtering it is possible that a very small percentage of data points may have been misidentified. The filter uses a second difference (with a magnitude of 50.0 degrees), values greater than 50.0 are subsequently NaNed.

CourseOG: The courseOG values when the ship is stationary are not true values as the ship is not travelling a course. The current GPS and acquisition system generated values for such period are not true courseOG, this is a feature of the current system. The data has been manually QC'd (NaNed) when the speedOG was less than 1.0 Knots. This resulted in 19.46% of the data being marked as bad.

PAR: It was noted that values recorded by the Port and starboard PAR (Photosynthetically Active Radiation) sensors had a mean absolute difference of about 26.10 (uE/m^2/s) respectively.

Pyranometer: No issues found with the Pyranometer sensor. The values recorded by the port and starboard Pyranometer had a mean absolute difference of 9.59 W/m^2 respectively.

Radiometer: No issues found with the Radiometer sensor. The mean absolute difference of 3.41 W/m^2 between the port and starboard Radiometer.

Ultrasonic Wind Speed: The ultrasonic wind speed generally reads slightly lower than either the port/starboard vane type wind sensors, this is likely to be due to the lower height mounting on the foremast compared to the other two sensors.

Ultrasonic Wind Direction: The relative wind direction values for the ultrasonic wind sensor showed unusual characteristics. This was investigated and it appears that when the wind, more or less, is on the stern of the ship the ultrasonic wind direction values exhibit wild variations (i.e. large spikes) which are not manifested by the two vane type wind sensors to the same extend. It is our belief that this characteristic is most likely caused by the interaction of the ships superstructure/foremast/ship motion and the wind in relation to the ultrasonic wind sensor.

The averaging for the ultrasonic relative and true wind direction implemented in the TECHSAS acquisition system had incorrectly used linear averaging as opposed to directional averaging, this resulted in incorrect calculation of values when the ultrasonic relative and true wind direction oscillate around the zero mark (i.e. between 359&1 degrees passing through zero). To resolve this problem, the original NMEA 1-second data strings were imported from the originally logged raw METEO data files and appropriate vector directional averaging applied to both the Relative and True ultrasonic wind direction data, converted to 5 second data and inserted back into the underway .nc file. This resulted in clean and good quality ultrasonic wind direction data.

Water Temperature: Erroneous or suspect data has been NaNed and its flag set to {'bad', 'none', 'operatorFlagged'}. Spikes have been naned and flagged as Bad.

Salinity: No issues found with the salinity data. Spikes greater than 0.01PSU have been removed. TSG S/N 2753 was used for the first half of the voyage and 2567 for the second part. The TSG salinity QC flag was set to {'good', 'manually adjusted', 'no error'}.

TSG Calibration: There were no TSG calibrations for this voyage. For the first half of the voyage TSG-2753 was used, the salinity was calibrated by using the results from the prior voyage IN2017_C01 in which a conductivity scaling factor of 0.999684657960147 was calculated and applied (please refer to the underway processing report for IN2017_C01). For the second half of the voyage, TSG-2567 was used, no calibration was required as the instrument has recently been Lab calibrated (on 23/02/2017) and had been in service for only 3 weeks prior to the voyage.

TSG Lag: Examination and comparison of the TSG water temperature profile against the sea surface water temperature showed a lag of approximately about 2.5 minutes between the two data sets and a mean thermal increase of 0.133C^{o} from the intake to the TSG. This lag is due to the time taken for the water to travel from the water intake on the port drop keel (where sea surface water temperature is measured) to the TSG located in the CTD area on the ship (where the TSG sensor temperature and the conductivity is measured). When the precise location for the TSG salinity measurement is critical, this lag would need to be taken into account in order to determine the exact geolocation of the sampled value. For example, assuming a ship cruising speed of 10 knots and a lag of 2.5 minutes, the salinity measurements could be for a location about 772 meters away from the current ship location.

Depth: Finally, the Depth data is no longer processed as part of the underway data set. The non QC'd data is available in the underway data. The QC'd depth data could be obtained from processed GSM dataset (centre beam) for this voyage.

It should be noted that the underway netCDF file contains the raw unQC'd data. Therefore even though the QC'd variable may have been NaNed or otherwise adjusted or filtered, the raw data variable is always available in the netCDF underway file. This is useful if the end user wishes to apply a different QCing or filtering methodology.

Commonly Used QC Flags: The datasets include quality control (QC) flags which are described in more detail in the references provided, normally however only a small subset is used, below are the most commonly used qc flags. Please note that on some systems and file formats, eg. netCDF, it is not possible to store unsigned byte values. In this case, flags greater than 127 are stored as negative numbers. To convert them to unsigned integers, simply add 256.

Signed	Unsigned	Description	Data State	Operation Type	Error Type
-123	133	Bad (data is NaNed)	Bad	None	Error Flagged by processor
0	0	Good	Good	None	No error, data is good
-187	69	Suspect (data unchanged)	Suspect	None	Error flagged by processor
-135	121	Operator adjusted	Suspect	Manually adjusted	Data out of range
-115	141	Data missing	Bad	None	No data, missing for unknown reason
-53	203	not QC'd	No QC	None	Preliminary processing (calibration) only

1.6 Final Underway Data

The navigation, meteorological and thermosalinograph data will be entered into the O&A divisional data warehouse. All data timestamps are in UTC.

Filename	Parameters	Resolution
in2017_v03uwy10sec.csv	latitude, latitudeQC, longitude, longitudeQC, speedOG, speedOGQC, courseOG, courseOGQC, shipHeading, shipHeadingQC, portAirTemp, portAirTempQC, stbdAirTemp, stbdAirTempQC, portHumidity, portHumidityQC, stbdHumidity, stbdHumidityQC, atmPressure, atmPressureQC, rain, rainQC, portPAR, portPARQC, stbdPAR, stbdPARQC, portRelWindDir, portRelWindDirQC, portTrueWindDir, portTrueWindDirQC, portRelWindSpeed, portRelWindSpeedQC, portTrueWindSpeed, portTrueWindSpeedQC, stbdRelWindDir, stbdRelWindDirQC, stbdTrueWindDir, stbdTrueWindDirQC, stbdRelWindSpeed, stbdRelWindSpeedQC, stbdTrueWindSpeed, stbdTrueWindSpeedQC, maxWindGust, maxWindGustQC, stbdRadiometer, stbdRadiometerQC, portRadiometer, portRadiometerQC, stbdPyranometer, stbdPyranometerQC, portPyranometer, portPyranometerQC,ultrasonicRelWindSpeed, ultrasonicRelWindSpeedQC, ultrasonicRelWindDir, ultrasonicRelWindDirQC, ultrasonicTrueWindSpeed, ultrasonicTrueWindSpeedQC, ultrasonicTrueWindDir, ultrasonicTrueWindDirQC, salinity, salinityQC , waterTemp, waterTempQC	10 seconds
in2017_v03uwy5min.csv	Ditto 10 second data	5 minutes

1.7 References

Subversion repository version of DPG Matlab generic tools 3974

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

1.8 Appendix

The table below contains the description of Ship sensors and Underway netCDF variables.

Underway Data Instrument and Identifier	Sensor Description	Position	netCDF variable	QC	Variable Description	Variable units
Navigation Instruments:						
Seapath 330+ with Seatex MRU 5+ and FUGRO Seastar 3610 DGNSS receiver	DGPS system providing position, attitude, velocity, acceleration and timing information.	Monkey Island & Bridge equipment room				
			longitude	yes	Longitude	Degree East
			latitude	yes	Latitude	Degree North
			speedOG	yes	Ship speed over ground	Knot
			courseOG	yes	Ship course over ground	Degree
			shipHeading	yes	Heading of the ship	Degree
			alt	no	Altitude re: mean sea level (geoid)	Metres
Northrup Grumman Sperry 4914-CA Navigat X MK1	Gyrocompass	Bridge				
			gyroHeading	No	Gyro Heading	Degree
Kongsberg Maritime Skipper DL850	3 Axis doppler log - measuring vessel speed through water	Gondola				
			longitudinalWaterSpeed	No	Longitudinal water speed	knot
			transverseWaterSpeed	No	Transversal water speed	knot
			longitudinalGroundSpeed	No	Longitudinal ground speed	knot
			transverseGroundSpeed	No	Transversal ground speed	knot
		lockOnWater		No	Lock on water flag	n/a
			lockonGround	No	Lock on ground flag	n/a
Sea Water Instruments:						
Sea-Bird-SBE 21 TSG	Thermosalinograph (TSG)	CTD Space				
			salinity	Yes	Measures sea surface salinity	Practical Salinity Units (PSU)
			tsgSensorTemp	No	Water temperature measurement in the TSG canister	Degree Celsius (degC)
Burkert 8045	Flow meter	CTD space				
			tsgFlow	No	Flow rate of sea water through the TSG	l/min
Burkert 8045	Flow meter	Underway Seawater Lab				
			labMainFlow	No	Underway lab main seawater flow rate	l/min
Kobold MIK-C	Flow meter	Underway Seawater Lab				
			labBranchFlow	No	Underway lab branch seawater flow rate	l/min
Sea-Bird - SBE 38	Remote Temperature Probe	Port Drop Keel				

			waterTemp	Yes	Sea surface water temperature measurement	Degree Celsius (degC)
Wet Labs Wetstar Fluorometer	Fluorometer	Underway Seawater Lab				
			fluorescence	No	Measures active phytoplankton biomass and chlorophyll concentrations	Percentage of the full scale voltage
CSIRO Hobart pCO2	Underway pCO_2 system measuring surface water CO_2 mole fraction	Underway Seawater Lab				
			equTemp	No	Equilibrator water temperature	Degree Celsius (degC)
			XCO2	No	XCO2	ppm
			waterVapour	No	Water vapour	mmol/mole
			licorPressure	No	Licor pressure	hPa
			equPressure	No	Equilibrator pressure	hPa
			waterFlow	No	Water flow	l/min
			licorFlow	No	Licor flow	ml/min
			ventFlow	No	Vent Flow	ml/min
			condTemp	No	Condenser Temperature	Degree Celsius (degC)
			pumpSpeed	No	CO2 Pump Speed	l/min
Aanderaa Oxygen Optode 3835	**Oxygen Sensor**	**Underway Seawater Lab**				
			do		oxygen	uM/L
			doSaturation		Air saturation	Percentage (%)
			optodeWaterTemp		Optode water temperature	Degrees Celsius (degC)
CSIRO Drop keel sensor	Measuring drop keel draft	Port & starboard				
			portKeelExtension		Port drop keel extension	meters
			starboardKeelExtension		Starboard drop keel extension	meters
Met Instruments:						
Vaisala T&RH HMT333	Temperature and Humidity Sensor	Foremast (Starboard)				
			stbdAirTemp	Yes	Starboard air temperature measurement	Degree Celsius (degC)
			stbdHumidity	Yes	Starboard humidity measurement	Percentage (%)
Vaisala T&RH HMT333	Temperature and Humidity Sensor	Foremast (Port)				
			portAirTemp	Yes	Port air temperature measurement	Degree Celsius (degC)
			portHumidity	Yes	Port humidity measurement	Percentage (%)
Vaisala Ship's Barometer PTB330	Atmospheric pressure	Bridge Wing				
			atmPressure	Yes	Atmospheric pressure measurement	Millibar (mbar)
RM Young Wind Sensor Type 05107	Vane type wind sensor	Foremast (Port)				
			portRelWindSpeed	Yes	Wind speed relative to the ship	knot
			portRelWindDir	Yes	Wind direction relative to the ship	Degree

			portTrueWindSpeed	Yes	True wind speed, corrected for ship speed	knot
			portTrueWindDir	Yes	True wind direction, corrected for ship heading	Degree
			maxWindGust	Yes	True maximum wind gust corrected for ship speed	knot
RM Young Wind Sensor Type 05108	Vane type wind sensor	Foremast (Starboard)				
			stbdRelWindSpeed	Yes	Wind speed relative to the ship	knot
			stbdRelWindDir	Yes	Wind direction relative to the ship	Degree
			stbdTrueWindSpeed	Yes	True wind speed, corrected for ship speed	knot
			stbdTrueWindDir	Yes	True wind direction, corrected for ship heading	Degree
Gill WindObserver II	Ultrasonic Wind Sensor	Foremast (Port)				
			ultrasonicRelWindSpeed	Yes	Wind speed relative to the ship	knot
			ultrasonicRelWindDir	Yes	Wind direction relative to the ship	Degree
			ultrasonicTrueWindSpeed	Yes	True wind speed, corrected for ship speed and direction	knot
			ultrasonicTrueWindDir	Yes	True wind direction, corrected for ship speed and heading	Degree
RM Young Rain Gauge type 50202	Syphoning Rain Sensor	Foremast				
			rain	Yes	Accumulated hourly rain	mm
Eppley PIR	Precision Infrared Radiometer	Monkey Island (Starboard)				
			stbdRadiometer	Yes	Measure radiation in the band 4-100 micron, longwave radiation	W/m^2
Eppley PIR	Precision Infrared Radiometer	Monkey Island (Port)				
			portRadiometer	Yes	Measure radiation in the band 4-100 micron, longwave radiation	W/m^2
Eppley PSP	Precision Spectral Pyranometer	Monkey Island (Starboard)				
			stbdPyranometer	Yes	Measure radiation in the band 0.2 - 4 micron, shortwave radiation	W/m^2
Eppley PSP	Precision Infrared Radiometer	Monkey Island (Port)				
			portPyranometer	Yes	Measure radiation in the band 0.2 - 4 micron, shortwave radiation.	W/m^2
LI-COR LI-190 Quantum Sensor	Photosynthetically Active Radiation	Monkey Island (Starboard)				
			stbdPAR	Yes	measures radiation in the photosynthetically active region of 0.4-0.7 micron	uE/m^2/s
LI-COR LI-190 Quantum Sensor	Photosynthetically Active Radiation	Monkey Island (Port)				
			portPAR	Yes	measures radiation in the photosynthetically active region of 0.4-0.7 micron	uE/m^2/s

Uni-Southampton ISAR SST	Radiation sea surface temperature	Bridge Wing (Port)	Not installed on this voyage			
			isarWaterTemp	No	ISAR Water Temperature	Degree Celsius (degC)
Air Sampling Systems:						
CSIRO air sampling inlet	Air inlet controller	foremast				
			inletBearing	No	Air sampling inlet bearing	degree
			trackingBearing	No	Tracking target bearing	degree
Thermo Scientific MAAP Model 5102	Multi-angle Absorption Photometer (MAAP)	Aerosol Lab (air sampling inlet)				
			blackCarbonConc	No	Concentration of black carbon	ug/m^3
			airFlow	No	Air flow rate	Litre per Hour (L/h)
Thermo Scientific Model 49i Ozone Analyzer	Ozone Monitor					
			o3Ozone1	No	Ozone measurement	ppb
			ozone1Meterflags	No	Instrument specific quality flag	n/a
Thermo Scientific Model 49i Ozone Analyzer	Ozone Monitor					
			o3Ozone2	No	Ozone measurement	ppb
			ozone2Meterflags	No	Instrument specific quality flag	n/a
Picarro Model G2301 CRDS Analyzer	Greenhouse Gas Spectrometer CO2, CH4, H2O Near IR Laser					
			co2Dry	No	CO2 dry concentration	ppm
			ch4Dry	No	CH4 dry concentration	ppm
			H2O	No	Water concentration percentage	Dimensionless