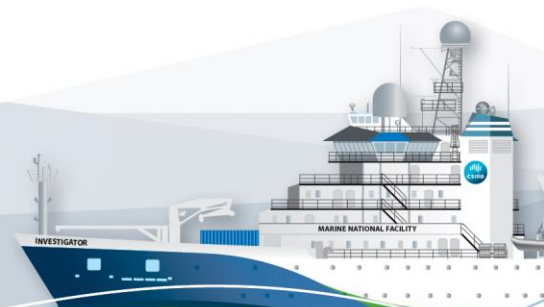


*RV Investigator*

**Underway Data Processing Summary Report**

<b>Voyage #:</b>	IN2016_V04
<b>Voyage title:</b>	“Influence of temperature and nutrients supply on biogeochemical function and diversity of ocean microbes”
<b>Depart:</b>	Sydney, 14:00, Wednesday, 31 August, 2016 (local time)
<b>Return:</b>	Brisbane, 12:00, Thursday, 22 September, 2016 (local time)
<b>Data dates:</b>	31-Aug-2016 04:08:45 – 22-Sep-2016 02:40:50 UTC
<b>Chief Scientists:</b>	Martina Doblin, University of Technology, Sydney
<b>Data processed by:</b>	CSIRO Oceans and Atmosphere, Hobart, Tasmania (completed February, 2018, Hiski Kippo and Bernadette Heaney)



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## 1.2 Voyage Track

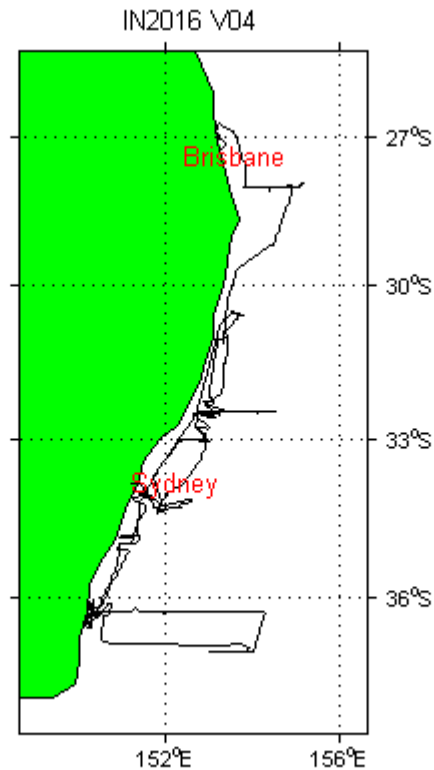


Figure 1 . Voyage Track

## 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.

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.

See Electronics report for this voyage for instruments used and their serial numbers.

Navigation, meteorological, thermosalinograph and IMOS data are preliminary quality controlled by combining all data from "Techsas" 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 18-Aug-2017 by running the Java application UWYMerger with data time range of 31-Aug-2016 04:08:45 – 22-Sep-2016 02:40:50 (UTC time): UWYMerger reads 5 second data from netcdf files which have been written by “TECHSAS” during acquisition.

There is a gap in most data sets 19-Sep-2016 19:55:15 - 19-Sep-2016 19:57:30.

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), PCO<sub>2</sub>, Drop keel position, gyro, Doppler log and ISAR SST radiometer and Aanderaa optode oxygen sensor and depth data. The depth data is derived in order of availability from the Kongsberg EM122 multibeam, Kongsberg EM710 multibeam or Simrad EK60 sounders.

For further description of instruments and Underway netCDF variables please refer to Appendix 1 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 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 9.37 degrees), otherwise both sensors gave very close reading with the mean absolute difference of about 0.07 degrees. These discrepancies occurred usually during periods of rapid temperature change. This phenomenon has probably come about due to the rapid warming of the ships 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. Larger than expected discrepancies in air temperature and corresponding humidity data for both starboard and port instruments have been flagged as {'suspect','none','operatorFlagged'}, and the data values left as is.

**Humidity:** There was a maximum difference of 29.25% between the two sensors, with a mean difference of 3.86 %. The starboard sensor calibration has since been found to be incorrect. Therefore, the starboard humidity sensor values have been marked as suspect. It should be noted that whilst quantitatively the starboard humidity sensor values may be suspect however, qualitatively they appear to follow the same trend as the port side and therefore the data has been left in the data set but its QC flag has been marked as suspect and set to {'suspect','none','hardwareError'}. Starboard humidity also had a few locations where the data was greater than 100%. These were adjusted back to down to 100% and flagged as {'suspect','adjusted','range'}. Larger than expected discrepancies in air temperature and corresponding humidity data for both starboard and port instruments have been flagged as {'suspect','none','operatorFlagged'}, and the data values left as is.

**Wind Speed and Directions:** A second difference filter (with a magnitude of 45) was run on portRelWindDir and stbdRelWindDir values to remove data spikes, setting the data to NaN and flagging it as {'bad','none','anomalousSpike'}. Further bad points were set to NaN and flagged as {'bad','none','operatorFlagged'}. There were 3 large increases in starboard relative and true wind speed which were NaNed and flagged as {'bad','none','operatorFlagged'}.

**Maximum Wind Gust:** No processing was necessary.

**CourseOG:** The courseOG values when the ship is stationary are not true 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 acquisition system. The QC flags have been set as good however this feature should be noted if the values during the stationary periods are to be used.

No processing was done except for setting the gap data to NaN and flagging as bad.

**Ship Heading:** No processing was done except for setting the gap data to NaN and flagging as bad.

**PAR:** It was noted that values recorded by the port and starboard Photosynthetically Active Radiation (PAR) sensor had a mean absolute difference of 29.04 (uE/m<sup>2</sup>/s).

**Pyranometers:** The values recorded by the port and starboard Pyranometers had a mean absolute difference of 14.36 W/m<sup>2</sup>

**Radiometers:** The port and starboard radiometers had a mean absolute difference of 4.29 W/m<sup>2</sup>

**Ultrasonic Wind Direction:** The ultrasonicRelWindDir has been incorrectly computed by Techsas. Comparing portRelWindDir, stbdRelWindDir and ultrasonicRelWindDir shows a linear averaging instead of a directional averaging had been used for the ultrasonicRelWindDir.

Ultrasonic wind speed and direction were extracted from the \$WIMMV nmea strings in .METEO files. The ultrasonic wind speed values appear to be low and ultrasonic wind direction values erratic when the relative wind direction is around 100° to 120° which could be due to the placement of the instrument on the lower yardarm to the port side. There are also gaps in the ultrasonic data at that wind direction.

Initial despiking of the ultrasonic wind speed and ultrasonic wind direction data was done by using a weighted average over a 20 second span.

5 second values were interpolated (using matlab interp1 and nearest method) and inserted into the underway netcdf file.

The ultrasonicTrueWindDir and ultrasonicTrueWindSpeed were recomputed.

The ultrasonicRelWindSpeedQC, ultrasonicRelWindDirQC, ultrasonicTrueWindDirQC and ultrasonicTrueWindDirQC values were set to 'good', 'none', 'No error' where there was data.

Where there was no data in the WIMMV nmea string, the data value is NaN and the QC flag set to 'bad', 'none', 'noData'.

**Water Temperature:** Two spikes in the data were interpolated across and set to {'good', 'interpolated', 'anomalousSpike'}.

**Thermosalinograph (TSG):** Erroneous and suspect TSG salinity data was manually NaNed and the QC flag set to {'bad', 'none', 'operatorFlagged'}.

The CTD calibration data for the primary conductivity sensor was obtained from the CTD processing report (off set -0.0010908255328452 and scale 1.00029056099328) with respect to the manufacturer's calibration. This data was then used to derive the TSG salinity calibration against the calibrated CTD data. Using CTD/TSG calibration run file in2016\_v04\_tsg002Ctd.nc, with the TSG lag of (-23), a TSG conductivity scaling factor of 0.999954821485292 was calculated against the primary CTD conductivity cell. This was applied to the TSG conductivity data to derive calibrated TSG salinity. The TSG salinity QC flag was set to {'good', 'manually adjusted', 'no error'}.

Examination and comparison of the TSG water temperature profile against the sea surface water temperature showed a lag of approximately about 2 minutes and 15 seconds between the two data

sets. 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 minutes 15 seconds, the salinity measurements could be for a location about 694 meters away from the current ship location.

**Depth:** The Depth data is no longer processed as part of the underway data set. The non QCed data is available in the underway data. The QCed 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 UNQCed data. Therefore even though the QCed variable may have been NaNed or otherwise adjusted, 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 methodology.

## 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.

The following files have been created.

Filename	Parameters	Resolution
IN2016_V04uwy10.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,	10 seconds

	ultrasonicTrueWindSpeedQC, ultrasonicTrueWindDir, ultrasonicTrueWindDirQC, salinity, salinityQC, waterTemp, waterTempQC,	
IN2016_V04uwy5min.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](http://www.marine.csiro.au/datacentre/ext_docs/DataQualityControlFlags.pdf)



## Appendix 1

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
<b>Navigation Instruments:</b>						
Seapath 330+ with Seatex MRU 5+ and FUGRO Seastar 3610 DGNS 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
<b>Sea Water Instruments:</b>						
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 (°C)
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 (°C)
Wet Labs Wetstar Fluorometer	Fluorometer	Underway Seawater Lab				
			fluorescence	No	Measures active phytoplankton biomass and chlorophyll concentrations	Dimensionless
CSIRO Hobart pCO2	Underway pCO2 system measuring surface water CO2 mole fraction	Underway Seawater Lab				
			equTemp	No	Equilibrator water temperature	Degree Celsius (°C)
			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 (°C)
			pumpSpeed	No	CO2 Pump Speed	l/min
Aanderaa Oxygen Optode 3835	<b>Oxygen Sensor</b>	<b>Underway Seawater Lab</b>				
			do	No	oxygen	uM/L
			doSaturation	No	Air saturation	Percentage (%)
			optodeWaterTemp	No	Optode water temperature	Degrees Celsius (°C)
CSIRO Drop keel sensor	Measuring drop keel draft	Port & starboard				
			portKeelExtension	No	Port drop keel extension	meters
			starboardKeelExtension	No	Starboard drop keel extension	meters
<b>Met Instruments:</b>						
Vaisala T&RH HMT333	Temperature and Humidity Sensor	Foremast (Starboard)				
			stbdAirTemp	Yes	Starboard air temperature measurement	Degree Celsius (°C)
			stbdHumidity	Yes	Starboard humidity measurement	Percentage (%)
Vaisala T&RH HMT333	Temperature and Humidity Sensor	Foremast (Port)				
			portAirTemp	Yes	Port air temperature measurement	Degree Celsius (°C)
			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 <sup>2</sup>
Eppley PIR	Precision Infrared Radiometer	Monkey Island (Port)				
			portRadiometer	Yes	Measure radiation in the band 4-100 micron, longwave radiation	W/m <sup>2</sup>
Eppley PSP	Precision Spectral Pyranometer	Monkey Island (Starboard)				
			stbdPyranometer	Yes	Measure radiation in the band 0.2 - 4 micron, shortwave radiation	W/m <sup>2</sup>
Eppley PSP	Precision Infrared Radiometer	Monkey Island (Port)				
			portPyranometer	Yes	Measure radiation in the band 0.2 - 4 micron, shortwave radiation.	W/m <sup>2</sup>
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 <sup>2</sup> /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 <sup>2</sup> /s
Uni-Southampton ISAR SST	Radiation sea surface temperature	Bridge Wing (Port)				

			isarWaterTemp	No	ISAR Water Temperature	Degree Celsius (°C)
<b>Air Sampling Systems:</b>						
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 <sup>3</sup>
			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 CO <sub>2</sub> , CH <sub>4</sub> , H <sub>2</sub> O Near IR Laser					
			co2Dry	No	CO <sub>2</sub> dry concentration	ppm
			ch4Dry	No	CH <sub>4</sub> dry concentration	ppm
			H2O	No	Water concentration percentage	Dimensionless
<b>Water Depth Systems</b>						

Kongsberg EM122 multibeam sounder		Gondola	depth	No	Water depth	metres
Kongsberg EM710 multibeam sounder		Gondola	depth (if not provided by EM122)	No	Water depth	metres
Simrad EK 60, 18 kHz sounder		Port drop keel	depth (if not provided by either of above)	No	Water depth	metres