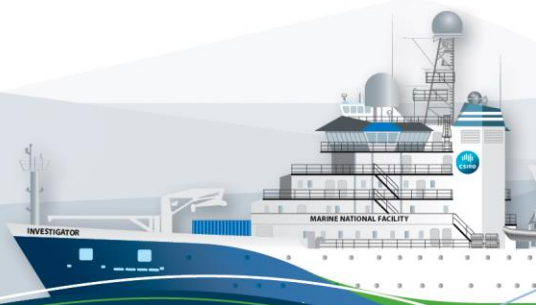
RV *Investigator*

Underway Data Processing Summary Report

Voyage #:	IN2018_t02
Voyage title:	'Harmful Algal Blooms and their long term sediment record in East Coast Tasmanian waters'
Depart:	Brisbane, Sunday 13th May 2018
Return:	Hobart, 0900 Monday, 21st May 2018
Data dates:	13-May-2018 22:04:55 To:20-May-2018 22:26:35 (UTC)
Chief Scientists:	Prof. Gustaaf Hallegraeff
Data processed by:	Bernadette Heaney CSIRO Oceans and Atmosphere, Hobart, Tasmania (completed February 2019)



1.1 Table of Contents

1.2 Voyage Track

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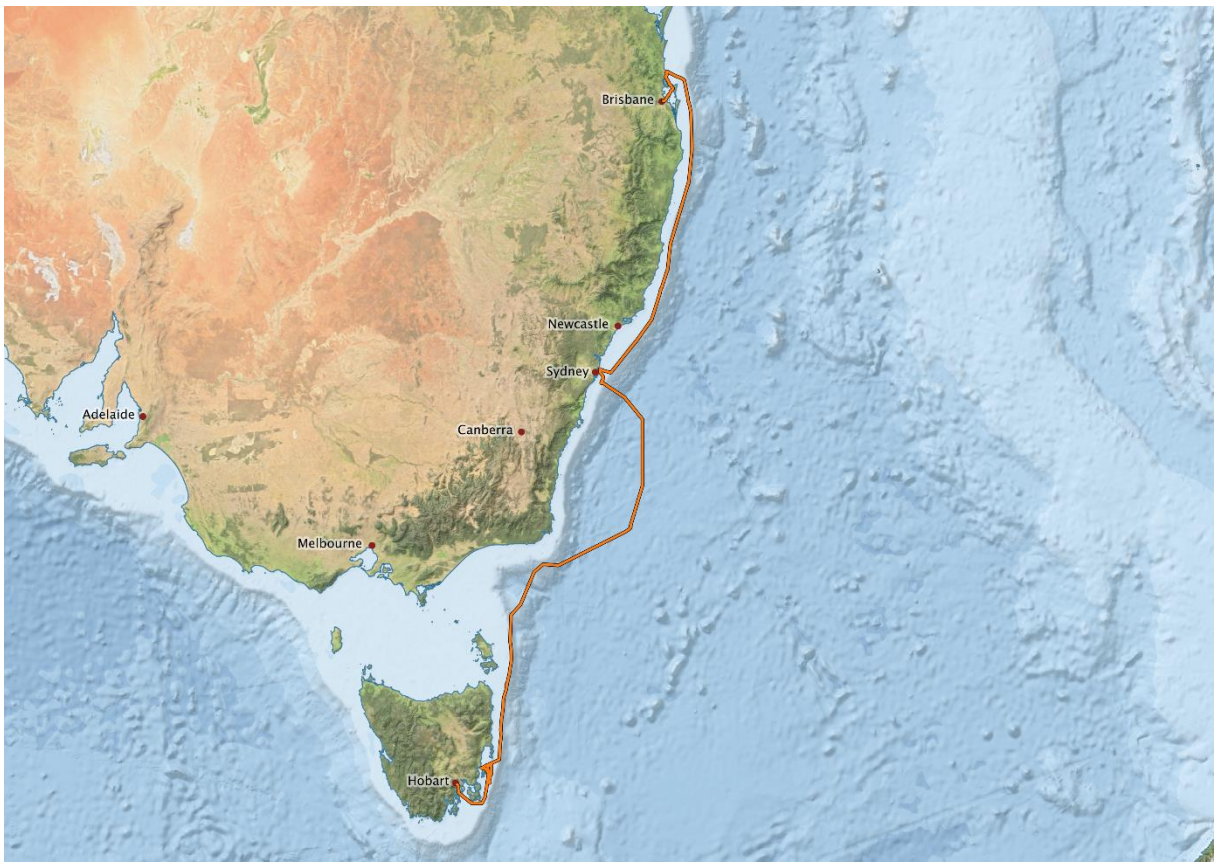

Figure 1 In2018_t02 voyage track

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, rain gauges, 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 22 August 2018 by running the Java application UWYMerger with data time range of 13-May-2018 22:04:55 - 20-May-2018 22:26:35 (UTC).

It should be noted that the merged data file usually 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, 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 or Kongsberg EM710 multibeam.

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

Navigation Data: The Seapath system was shut down to change to POR (Pacific Ocean Sat Beam); resulting in a gap in the latitude, longitude, courseOG and speedOG for 19-05-2018 21:13 – 19-05-2018 21:59. During this time shipHeading values had been substituted with gyro heading values.

Course over ground (courseOG): Position and velocity (speedOG) are measured by differential GNSS using phase-smoothed pseudo-range and Doppler observations. When using high precision differential corrections a world wide accuracy of 10 -20 cm is possible.

Course Over Ground (COG) describes the direction of motion with respect to the ground that a vessel has moved relative to geographic north pole. Accordingly, should a vessel be stationary, it is not travelling a course (e.g., at the wharf).

Under conditions where a vessel is experiencing leeway (wind, current), a vessel’s heading and COG may differ. This difference will typically be largest for vessels moving at slow speeds. When the ship speed is less than 0.5 knots (25.7 cm/s) course over ground values are seen to fluctuate and are highly variable.

Course and speed overground were recomputed from 5 second latitude and longitude values (truncated to 7 decimal places, .000001 degree = 11.112 cm).

The resulting course overground values were compared to the original GPS derived values and agreed well, (i.e. a slight smoothing was achieved when the ship was underway and when the ship was almost stationary the result was similarly variable). The course overground data for this voyage has not been filtered and has been flagged as good.

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 1.2 degrees), otherwise both sensors gave very close reading with the mean absolute difference of about 0.045 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.

Rain: The port and starboard rain gauges agreed.

Humidity: There was a maximum difference of 9.23 between the two sensors, with a mean absolute value of 1.269 %. The recorded values are within instrument tolerance.

Wind Speed: The mean difference between starboard and port relative wind speed is about 1.2 knots and max absolute difference of 22.9 knots.

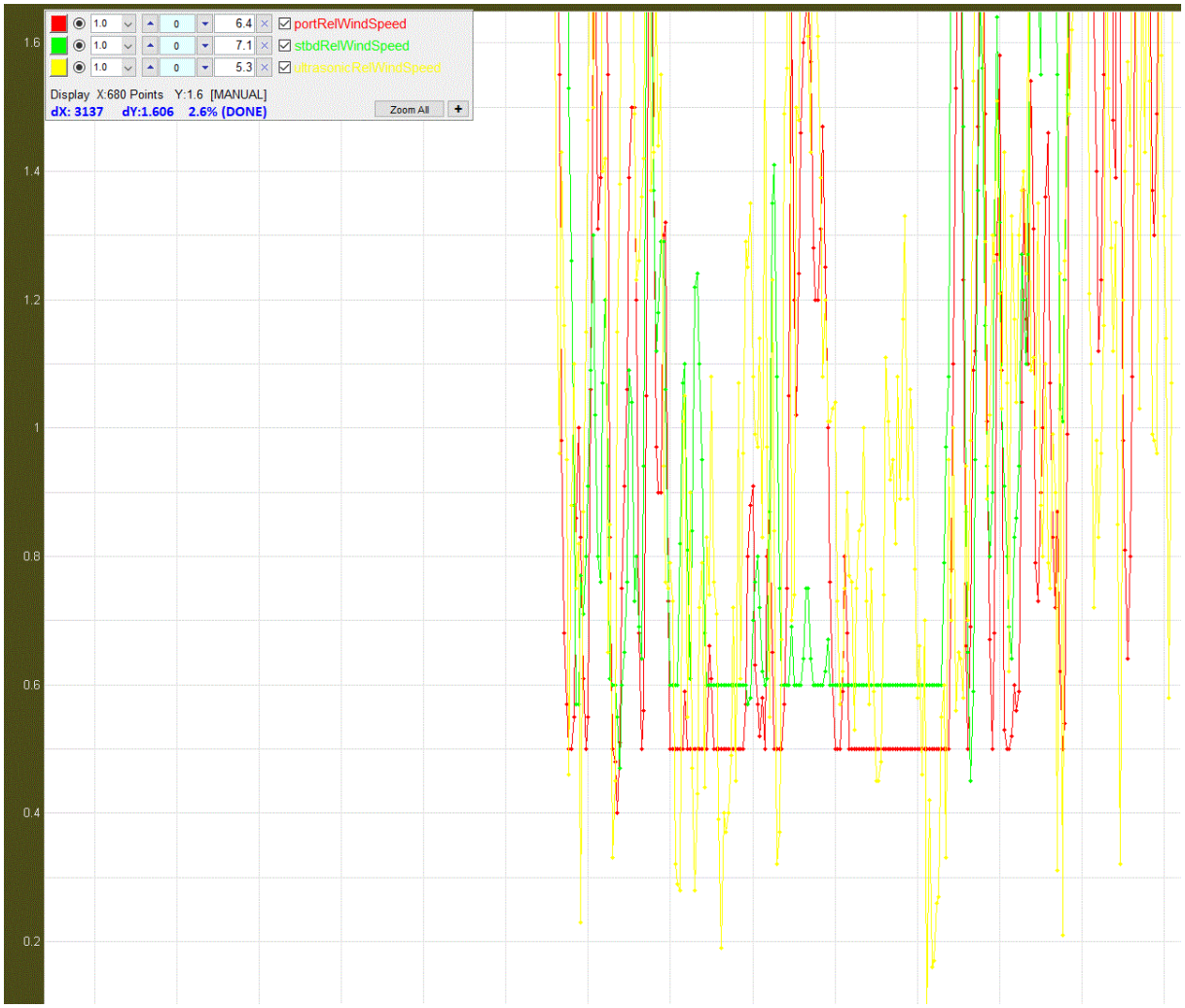

Figure 2 Example of low wind values

The vane type wind sensors have a 'starting threshold around 2 knots, due to the friction in the bearings, requiring a slight amount of wind to get started. The exhibited minimum wind speed of about 0.5 knots is due to the calibration line of best fit (y=mx+c) having a small but non-zero 'c' value. For periods of relative wind below 2 knots the "flat-lined" values can be regarded as good data (Figure 2).

It should be noted that periodically starboard wind speed showed greater variation from the port and ultrasonic wind speed. These variations were greater than past observations however, they were not significant enough to require removal and have therefore been allowed to remain in the data set.

Ultrasonic Wind Speed: The ultrasonic wind speed (and the port wind speed to a lesser extent) were observed to be less than the starboard wind speed values when the starboard relative wind direction was from 130-160. This is most likely because of the position of the sensors in front and to the port of the mast.

Ultrasonic Wind Direction: As above spikey relative ultrasonic wind direction values may be observed when the relative wind is from the starboard side and slightly aft. This probably causes insufficient samples to be recorded and skews the resultant 5 second average value.

Port, Starboard and Ultrasonic true Wind Speed and Directions and Maximum Wind Gust: data for 19-May-2018 21:13 – 21:59 are set to NaN as corrections are not possible when there was no Seapath navigation data available. A problem with "Techsas" data recorder onboard resulted in Port, Starboard and Ultrasonic relative Wind Speed and Directions not being available for this time. All these values have been set to NaN and flagged as missing or no data (-123).

PAR: It was noted that values recorded by the port and starboard Photosynthetically Active Radiation (PAR) sensor had a mean absolute difference of about 61.75 (uE/m²/s).

Pyranometers: The values recorded by the port and starboard Pyranometers had a mean absolute difference of 32.25 W/m^2

Radiometers: The port and starboard radiometers had a mean absolute difference of 1.26 W/m^2

Water Temperature: Erroneous or suspect data has been NaNed and its flag set to {'bad', 'none', 'operatorFlagged'}.

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

TSG Calibration: No bottle samples were analysed on this transit. Conductivity coefficients calculated on adjacent voyages were averaged to calibrate the salinity data.

In2018_v03 19 Apr – 10 May 1.00010178

In2018_c01 28 May – 8 Jun 1.00008553

Average = 1.00009365

After calibration the salinity QC flag was set to {'good','manually adjusted','no error'}. Thermosalinograph unit 3439 was used throughout this voyage.

TSG Lag: Examination and comparison of the TSG water temperature profile against the sea surface water temperature showed a lag of approximately 2 minutes between the two data sets and a mean

thermal increase of 0.1517 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 minutes, the salinity measurements could be for a location about 617 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.

Raw Data: 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.

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
48	48	Good	Good	Manually adjusted	No error
0	0	Good	Good	None	No error, data is good
-53	203	not QC'd	No QC	None	Preliminary processing (calibration) only
-115	141	Data missing	Bad	None	No data, missing for unknown reason
-123	133	Bad (data is NaNed)	Bad	None	Error Flagged by processor
-135	121	Operator adjusted	Suspect	Manually adjusted	Data out of range
-187	69	Suspect (data unchanged)	Suspect	None	Error flagged by processor

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

In2018_t02uwy10.csv	latitude, latitudeQC, longitude, longitudeQC, speedOG, speedOGQC, courseOG, courseOGQC, shipHeading, shipHeadingQC, portAirTemp, portAirTempQC, stbdAirTemp, stbdAirTempQC, portHumidity, portHumidityQC, stbdHumidity, stbdHumidityQC, atmPressure, atmPressureQC, portRain, portRainQC, stbdRain, stbdRainQC, 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,ultrasoniRelWindSpeed, ultrasonicRelWindSpeedQC, ultrasonicRelWindDir, ultrasonicRelWindDirQC, ultrasonicTrueWindSpeed, ultrasonicTrueWindSpeedQC, ultrasonicTrueWindDir, ultrasonicTrueWindDirQC, salinity, salinityQC, waterTemp, waterTempQC,	10 seconds
IN2018_t02uwy5min.csv		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

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
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 (°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 (all zero values)	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 pCO_2 system measuring surface water CO_2 mole fraction	Underway Seawater Lab				
			equTemp	No	Equilibrator water temperature	Degree Celsius (°C)
			XCO2	No	XCO2 (not on this transit)	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	**Oxygen Sensor**	**Underway Seawater Lab**				
			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
Met Instruments:						
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				
			portRain	Yes	Accumulated hourly rain	mm
			stbdRain	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/m²
Eppley PIR	Precision Infrared Radiometer	Monkey Island (Port)				
			portRadiometer	Yes	Measure radiation in the band 4-100 micron, longwave radiation	W/m²
Eppley PSP	Precision Spectral Pyranometer	Monkey Island (Starboard)				
			stbdPyranometer	Yes	Measure radiation in the band 0.2 - 4 micron, shortwave radiation	W/m²
Eppley PSP	Precision Spectral Pyranometer	Monkey Island (Port)				
			portPyranometer	Yes	Measure radiation in the band 0.2 - 4 micron, shortwave radiation.	W/m²
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/m²/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/m²/s
Uni-Southampton ISAR SST	Radiation sea surface temperature	Bridge Wing (Port)				

			isarWaterTemp	No	Not installed on this voyage	Degree Celsius (°C)
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 (all NAN values)	ug/m³
			airFlow	No	Air flow rate (all NaN values)	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

Water Depth Systems						
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