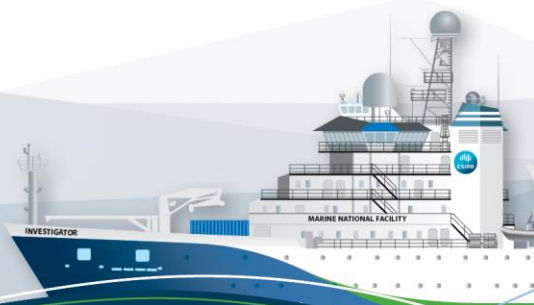
Marine National Facility

RV *Investigator*

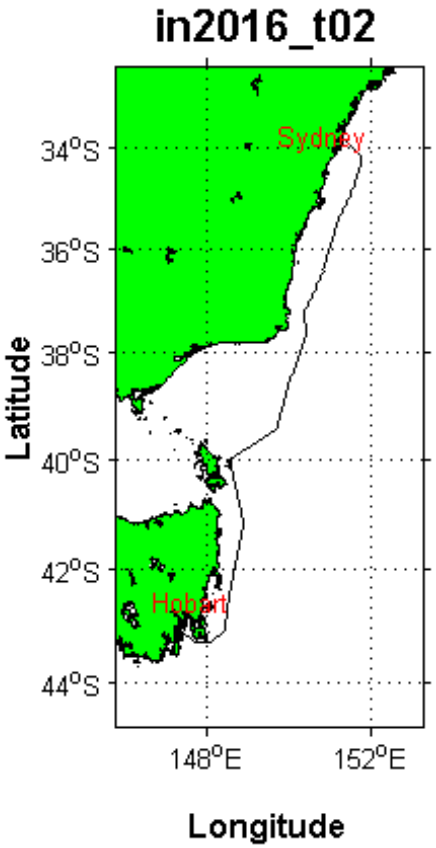
Underway Data Processing Summary Report

Voyage #:	**in2016_t02**
Voyage title:	Transit – Hobart to Sydney
Depart:	Hobart, 1000 Thursday, 25 August 2016
Return:	Sydney, 1000 Monday, 29 August 2016
Data dates:	25-Aug-2016 01:12:35 to 29-Aug-2016 00:02:05 UTC
Chief Scientist:	A/Prof Andrew Bowie
Data processed by:	Hiski Kippo, CSIRO Oceans and Atmosphere Flagship, Hobart, Tasmania.



1.1 Table of Contents

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 sensors, 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.

See 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 6th April 2017 by running the Java application UWYMerger with data time range of 25-Aug-2016 01:12:35 to 29-Aug-2016 00:02:05 UTC.

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 ISAR SST radiometer.

For further description of instruments and Underway netCDF variables please refer to the appendix at the end of this report. Instrument serial numbers may be found in the voyage Instrumentation Report (R. Palmer and S Thomas , 2016).

1.4 Completeness and Data Quality

Navigation data (latitude, 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 pyrometers, 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 becomes noticeable during 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 sides is equalised in relation to this sensor. This has improved the data quality and therefore the data has been QCed as good. Visual examination of a time series plot of atmospheric pressure where the vessel was undergoing 180 degree turns whilst traversing a grid pattern indicated a consistent error of the order of 3 hPA.

Air Temperature: A number of discrepancies between the port and starboard air temperature sensors were noted, otherwise both sensors gave very close reading with the mean absolute difference of 0.1 degrees and a maximum absolute difference of about 1.4 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 during periods of little wind, during or following periods of rainfall, as the result of a change in the ship speed or the result of hot ship's engine exhaust gases being blown over the sensors.

Humidity: A similar discrepancy between the port and starboard humidity sensors was observed with the mean absolute difference of about 4% RH and a maximum differences of about 12% RH. The recorded values are within instrument tolerance. However, both maximum difference and more importantly the mean absolute difference between the two sensors are greater than the past historical statistics.

In the voyage instrumentation report it was noted that the two sensors were off set more than the usual and that the sensors should be sent for servicing. In discussion with CSIRO instrumentation engineers it was stated that the starboard sensor calibration was subsequently found to be out of specification. 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, 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 marked as suspect and set to {'suspect','none','hardwareError'}.

Wind Speed and Direction: The port and starboard vane type wind sensors produced erroneously large wind speed values when the relative wind dropped to very close to zero. These were investigated by the CSIRO instrumentation team and attributed to a fault at the instrument controller interface. The spurious wind speed spikes were marked as bad for port and starboard vane type wind sensors. Both relative and true wind speed and direction parameters and their related QC flags were set to {bad, 'none', 'operatorFlagged'}.

Between 0000 hours 26-Aug-2016 and 2300 hours 26-Aug-2016 the ship was surveying a mapping site and was undergoing repeated 180 degree turns. During periods of rapidly changing direction the lateral movement of the ship affected the wind sensors such that they no longer represented the actual wind properties. The effect is of the order of up to 20 times the inherent noise level of wind speed values. Severe peaks were marked as bad and were NANed.

The absolute mean difference between starboard and port relative wind speed is about 2.1 knots and max absolute difference about 17.7 knots.

The absolute mean difference between starboard and port true wind speed is about 2.0 knots and max absolute difference about 16.9 knots.

CourseOG:

When the ship is stationary, or nearly stationary, courseOG values are not representative of a true course. This is a feature of the current acquisition system arising from computational errors due to small changes in latitude and longitude values.

Where speed over ground was less than about 0.5 knot, course over ground was marked ‘bad’ and the value set to NAN.

PAR: (uE/m^2/s). It was noted that values recorded by the port and starboard Photosynthetically Active Radiation (PAR) sensor had a mean absolute difference of 30.3 uE/m²/s and a maximum absolute difference of 1094 W/m2..

Pyranometer: The values recorded by the port and starboard pyranometers had a mean absolute difference of 12.9 W/m2 and a maximum absolute difference of 549 W/m2.

Radiometer: The port and starboard radiometers had a mean absolute difference of 3.0 W/m2 and a maximum absolute difference of 24.7 W/m2.

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.

The mean absolute difference between port and starboard sensors and the ultrasonic sensor were 1.6 and 2.9 knots respectively.

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’.

Suspect spikes were manually marked as ‘bad’ and the value set to NAN.

TSG:

The serial number of the TSG used on this voyage was 2567 (Palmer and Thomas, 2016).

There was no CTD versus TSG calibration performed on this voyage. Therefore, the TSG calibration data from voyage in2016_v04 was used (since the same TSG unit was in operation for both voyages). The TSG conductivity scaling factor of 0.999954821485292 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’}.

Erroneous and suspect TSG salinity data were manually NaNed and the QC flag set to {'bad', 'none', 'operatorFlagged'}.

Examination and comparison of the TSG water temperature profile against the sea surface water temperature showed a lag of approximately about 155 seconds between the two data sets and a mean thermal increase of 0.16C, and a maximum increase of 1.09C, 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 2.17 minutes, the salinity measurements could be for a location about 670 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 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 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.

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
in2016_uwy10sec.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,	10 seconds

	portRadiometerQC, stbdPyranometer, stbdPyranometerQC, portPyranometer, portPyranometerQC,ultrasonicRelWindSpeed, ultrasonicRelWindSpeedQC, ultrasonicRelWindDir, ultrasonicRelWindDirQC, ultrasonicTrueWindSpeed, ultrasonicTrueWindSpeedQC, ultrasonicTrueWindDir, ultrasonicTrueWindDirQC, salinity, salinityQC, waterTemp, waterTempQC,	
in2016_uwy5min.csv	Ditto 10 second data	5 minutes

1.7 References

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

"Seagoing Instrumentation Report IN2016_T02", R. Palmer and S Thomas , 2016, Marine National Facility internal report.

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	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 (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)				

			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