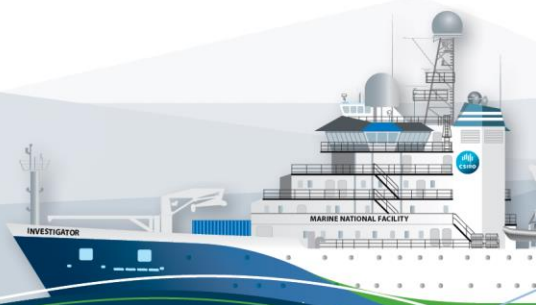
Marine National Facility

RV *Investigator*

Underway Data Processing Summary Report

Voyage :	IN2016_v01
Voyage title:	HEOBI: Heard Earth-Ocean-Biosphere Interactions
Depart:	Fremantle, 14:30 Friday, 8 January 2016
Return:	Hobart, 0800 Saturday, 27 February 2016
Data dates:	08-Jan-2016 05:29:40 to 26-Feb-2016 20:35:05 UTC
Chief Scientist:	Professor Millard (Mike) Coffin
Data processed by:	Anoosh Sarraf, Bernadette Heaney, CSIRO Oceans and Atmosphere, Hobart, Tasmania, (completed October 2017)



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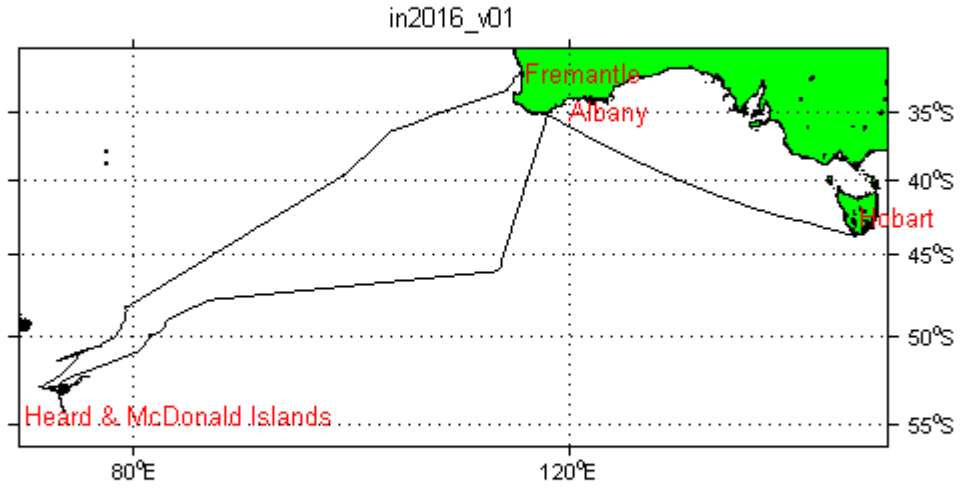
1.2 Voyage Track



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.

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 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 23-June-2016 by running the Java application UWYMerger with data time range of 08-Jan-2016 05:29:40 to 26-Feb-2016 20:35:05 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, Doppler log, ISAR SST radiometer and depth data. The depth data is derived in order of availability from the Kongsberg EM122 multibeam, Kongsberg EM710 multibeam or Simrad EK 60 sounders.

For further description of instruments and Underway netCDF variables please refer to the 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: A small gap in the data is noted 23-Jan-2016 02:59:45 – 23-Jan-2016 03:00:55

Air Temperature: A number of minor discrepancies between the port and starboard air temperature sensors were noted (max difference of about 9.97 degrees), otherwise both sensors gave very close reading with the mean absolute difference of about 0.21 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.

Humidity: A similar discrepancy (max difference of about 36.3%) between the port and starboard humidity sensors was observed with the mean absolute difference of about 1.9%. The recorded values are within instrument tolerance.

Port and starboard humidity sensors recorded values in excess of 100% with a max sensor value of about 106 and 110% respectively. The instrument has a tolerance of +- 5% and it appears that under certain conditions (probably due to heavy fog) it has recorded values outside of spec. In any event, any values above 100% has been adjusted back to 100% and its QC flag marked accordingly to {'good','adjusted','range'}.

Wind Speed: The port and starboard vane type wind sensors produced erroneously large wind speed values when the relative wind dropped to very close to zero (19-Jan-2016 18:55 – 18:59). These were investigated by the CSIRO instrumentation team and attributed to a fault at the instrument controller interface. The spurious wind speed spikes were NaNed for both vane type wind sensors and related QC flags set to {'bad', 'none', 'operatorFlagged'}. The true wind direction values that used wind speed for their derivation calculation were affected by the spurious spikes and were therefore NaNed for the same periods. The relative wind direction values were unaffected by the spurious spikes.

There were gaps in the vane type wind sensor data between 16-Jan-2016 22:55:50 - 17-Jan-2016 01:35:05

Wind Direction: Spikes were removed from the port and starboard relative and true wind direction values.

Navigation data: There were a few bad data points for the ship NAV data which has been NaNed and their QC flag set to {'bad', 'none', 'operatorFlagged'}.

In particular the ship heading values deviated away notably from Gyro heading and courseOG and were therefore appeared to be inaccurate. The heading data for such period has been NaNed and its QC flags set to {'bad','none','operatorFlagged'}. The sensor values for 'portTrueWindDir', 'stbdTrueWindDir' and 'ultrasonicTrueWindDir' which require ship heading for their calculation have similarly been NaNed.

Course over ground: The courseOG values when the ship is stationary are not true values. The current GPS and acquisition system generated values for such periods are not true courseOG, this is a feature of the current system. The courseOG sensor values for such period have been NaNed and the QC flags set to {'bad', 'none', 'operatorFlagged'} with the remainder set as good. However this feature should be noted if the values during the stationary periods are to be used. The courseOG values for the stationary periods during port stops were also manually NaNed and QC flag set to {'bad', 'none', 'operatorFlagged'}.

PAR: It was noted that values recorded by the Port and starboard PAR sensor had a mean absolute difference of about 27.97 (uE/m²/s).

Radiometers and Pyranometers: Similarly the values recorded by the port and starboard Radiometer and Pyranometer had a mean absolute difference of 2.56 and 12.33 W/m^2. The port Radiometer values were mostly smaller than the starboard side sensor.

Ultrasonic Wind Speed and Direction: 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 has resulted in incorrect calculation of values when the ultrasonic wind direction oscillate around the zero marker (i.e. between 359&1 degrees passing through zero).

Ultrasonic wind direction and speed values were read from the .METEO files. The data was interpolated to 5 second values (rawUltrasonicRelWindDir, rawUltrasonicRelWindSpeed, ultrasonicRelWindDir and ultrasonicRelWindSpeed). Corrected ultrasonic wind speed and direction were computed and the values were incorporated back into the netcdf file (ultrasonicTrueWindDir and ultrasonicTrueWindSpeed). The ultrasonic relative wind speed and direction and true wind speed and direction data has been flagged as {'good', 'none', 'none'}. Where there were gaps in the true wind and direction which resulted from missing values (courseOG, speedOG or shipHeading) when processWind was run, this data has been flagged as 'bad', 'none', 'userDefined'

Water Temperature: Data until 08-Jan-2016 06:11:45 was set from zero to NaN and flagged as bad. There is a gap in the data from 22-Jan-2016 03:30:55 – 24-Jan-05:51:00; this was due to the 0194 board having an anomalous reading, and required rebooting.

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

The CTD calibration data for the primary conductivity sensor was obtained from a processed CTD file, a scale factor of `0.999039709485273` and offset `0.00229846491350486` with respect to the manufacturer's calibration, the values were checked against values in the CTD processing report. This data was then used to derive the TSG salinity calibration against the calibrated CTD data. Using CTD/TSG calibration run in2016_v01002Ctd.nc, in2016_v01003Ctd.nc and in2016_v01004Ctd.nc with the TSG lag of 20, an average TSG conductivity scaling factor of `0.999835506472158` was calculated against the primary CTD conductivity cell. This was then 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 10 seconds between the two data sets. This lag is caused due to the time it takes 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). Where 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 geo location of the sampled values.

For example, assuming a ship cruising speed of 10 knots and a lag of 2 minutes 10 seconds, the salinity measurements could be for a location about 668 meters away from the ship location.

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.

Filename	Parameters	Resolution
IN2016_v01uwy10sec.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
IN2016_V01uwy5min.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

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	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	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
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 (°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/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 Infrared Radiometer	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	ISAR Water Temperature	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	ug/m³
			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
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
Simrad EK 60, 18 kHz sounder		Port drop keel	depth (if not provided by either of above)	no	Water depth	metres