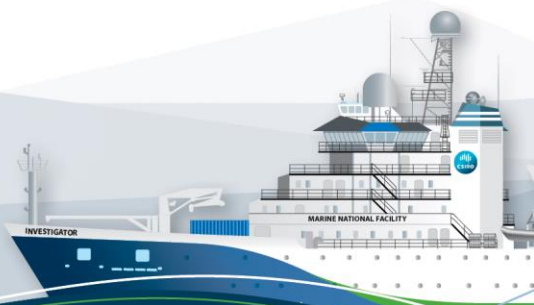
RV *Investigator*

# Underway Data Processing Summary Report

| | |
|---|---|
| **Voyage #:** | IN2017_t02 |
| **Voyage title:** | Collaborative Australian Postgradute Sea Training Alliance Network Pilot Voyage 1 |
| **Depart:** | Henderson (Fremantle), Tuesday, 14 November 2017 |
| **Return:** | Hobart, 08:00, Sunday, 26 November 2017 (Local times) |
| **Data dates:** | 14-Nov-2017 02:35:10 To:25-Nov-2017 20:35:35 (11.750 days) (utc) |
| **Chief Scientists:** | A/Prof Jochen Kaempf, Macquarie University |
| **Data processed by:** | Bernadette Heaney<br>CSIRO Oceans and Atmosphere, Hobart, Tasmania<br>(completed November 2018) |



## 1.1 Table of Contents

## 1.2 Voyage Track

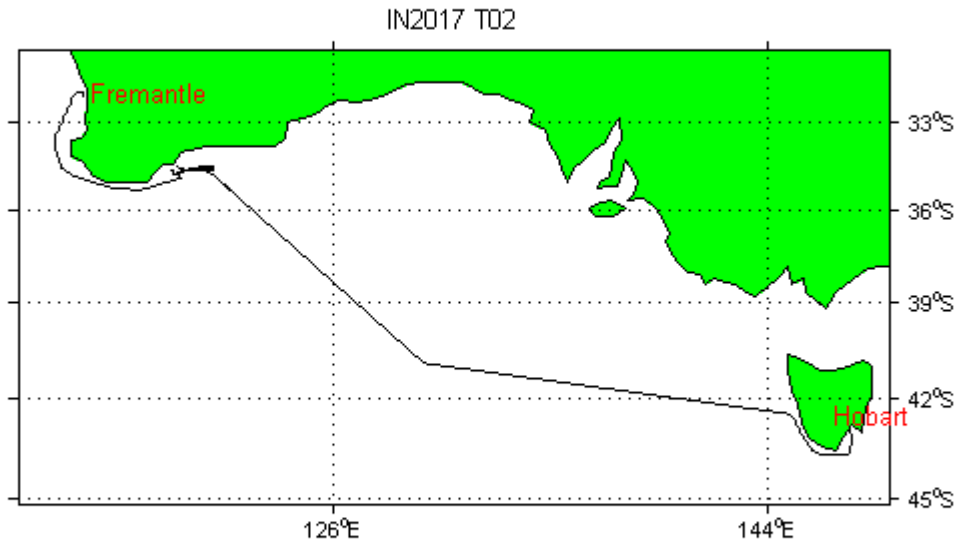



*Figure 1 Voyage Track - ending in Hobart*

## 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 04-May-2018 by running the Java application UWYMerger with data time range of 14-Nov-2017 02:35:10 to 25-Nov-2017 20:35:35 (UTC time).

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, 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, 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 and true 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 5.35 degrees), otherwise both sensors gave very close

reading with the mean absolute difference of about 0.078 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:** There was a maximum difference of 31.560 between the two sensors, with a mean absolute value of 1.876 %. The recorded values are within instrument tolerance.

**Rain:** No issues found with the siphoning rain gauge.

**Wind Speed**: The mean difference between starboard and port relative wind speed is 1.190 knots and max absolute difference of 17.72 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 detects and removes single data spikes in which the wind changes by more than 25 degrees in one direction and then immediately followed by 25 degrees (or more) in the opposite direction. Changes near the 360 mark are ignored.

**Maximum Wind Gust :** No issues were found with the Maximum Wind Gust data.

**CourseOG:** When the ship is on station the course over ground can differ from the actual ship heading (e.g. when the ship is drifting with the current)

**Ship Heading:** No issues were found with the Ship Heading data.

**PAR:** It was noted that values recorded by the port and starboard Photosynthetically Active Radiation (PAR) sensor had a mean absolute difference of 45.68 (uE/m²/s).

**Pyranometers:** The values recorded by the port and starboard Pyranometers had a mean absolute difference of 40.19 $W/m^2$

**Radiometers:** The port and starboard radiometers had a mean absolute difference of 2.36 W/m$^2$


*Figure 2: ultrasonic and port wind speed anomaly when the relative wind is from starboard side and slightly aft*

**Ultrasonic Wind Speed**: The ultrasonic wind speed and the port wind speed were observed to be less than the starboard wind speed values when the starboard relative wind direction was from 100-120. 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.

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

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

**TSG Calibration:** Throughout the voyage, triplicate bottle samples were taken by hydrochemistry personnel. Samples are taken when the ship is stationary, 17 bottle samples were taken on 5 different occasions. The date, time and resultant salinity values were recorded.
These values were compared with the underway salinity measured by the TSG at the same date and time, this salinity difference was used to calculate scaling coefficients using the method of Least Squares. This resulted in a scale coefficient of 1.00097303. The residual had a standard deviation (S.D) of -0.00130036 PSU. After calibration the salinity QC flag was set to {'good','manually adjusted','no error'}. Thermosalinograph unit 2567 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 about 2 minutes 5 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 5 seconds, the salinity measurements could be for a location about 642 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 |
|---|---|---|
| In2017_t02uwy10.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_t02uwy5min.csv | Ditto 10 second data | 5 minutes |

In2017_t02_UWY_ProcessingReport

## 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 |
| 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 | | | | |
| | | | 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 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 |