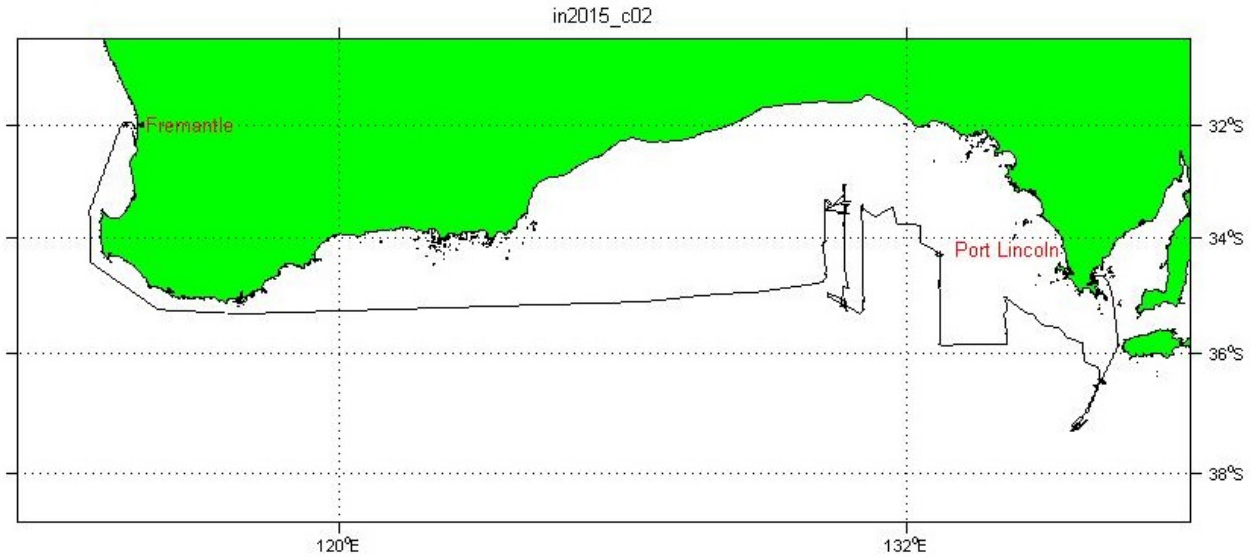
RV *Investigator*

Underway Data Processing Summary Report

Voyage #:	IN2015_C02
Voyage title:	GAB Deep-Water Pelagic and Benthic Ecosystem Study
Depart:	Port Lincoln, 1000 Monday 30th November 2015
Return:	Fremantle, 0800 Tuesday, 22nd December 2015
Data Dates:	From: 29-Nov-2015 23:30:30 To: 21-Dec-2015 23:39:00 UTC
Chief Scientist:	Rudy Kloser (CSIRO O&A)
Data processed by:	Vito Dirita and Anoosh Sarraf (CSIRO O&A), Hobart, Tasmania.
Report Last updated:	24 July 2017

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 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.

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 and rain. Optical rain was not collected on this voyage.

Refer to the Electronics report for this voyage relating to 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 23rd March 2017 by running the Java application UWYMerger with data time range of 29-Nov-2015 23:30:30 to 21-Dec-2015 23:39:00 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), Optode, Absorption Photometer, Picarro, Aerodyne and sampling inlet bearing), pCO_2, Drop keel position, gyro, and doppler log.

The ISAR SST radiometer and opticalRain was not installed on this voyage.

For further description of instruments and Underway netCDF variables please refer to the appendix 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. Note than on this particular voyage data logged from techsas1 was used to fill a section of a missing data block in the techsas2 underway data set.

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 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 9.30 degrees Celsius), otherwise both sensors gave very close reading with the mean absolute difference of about 0.15 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 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. Nevertheless these discrepancies are very mild and the data quality good.

Humidity: A similar discrepancy (max differences of about 33.39%) between the port and starboard humidity sensors was observed with the mean absolute difference of about 0.58%. The recorded values are within instrument tolerance.

Wind Speed: The mean difference between starboard and port relative wind speed is about 1.14 knots and max absolute difference of 13.44 knots.

CourseOG: The courseOG values when the ship is stationary cannot be determined as the ship is not traversing a course, this being a feature of the current acquisition system. The courseOG values during the stationary periods are usually at the start, mid-voyage and end of the voyage, these are manually NaNed and flagged as bad.

PAR: It was noted that values recorded by the Port and starboard PAR (Photosynthetically Active Radiation) sensors had a mean absolute difference of about 28.41 (uE/m^2/s) respectively. Sections of data which are either noisy or spiky have been flagged as suspect but left unchanged.

Pyranometer: The values recorded by the port and starboard Pyranometer had a mean absolute difference of 13.47 W/m^2 respectively.

Radiometer: Similarly the values recorded by the port and starboard Radiometer had a mean absolute difference of 2.49 W/m^2 respectively and in particular the starboard Radiometer values were generally slightly higher than the portside Radiometer.

Optical Rain: The optical rain gauge sensor (which provides 'opticalRainRate', 'opticalRain') was not installed during this voyage. Therefore the variables 'opticalRainRate', 'opticalRain' are not present in the underway netCDF file. The variable 'rain' is however present.

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. In sections where the wind speed and direction measurement completely flatlined (ie. missing data), this was flagged as bad and data NaNed.

Ultrasonic wind direction: The relative wind direction values for the ultrasonic wind sensor showed unusual characteristics. This was investigated and it appears that when the wind, more or less, is on the stern of the ship the ultrasonic wind direction values exhibit wild variations (i.e. large spikes) which are not manifested by the two vane type wind sensors. It is our belief that this characteristic is most likely caused by the interaction of the ships superstructure/foremast/ship motion and the wind in relation to the ultrasonic wind sensor.

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 relative and true wind direction oscillate around the zero mark (i.e. between 359&1 degrees passing through zero). These were manually QCed and NaNed with the QC flag set to bad. However due to the enormity of the bad points, a filter was implemented described below and applied to the dataset. Therefore, it is possible that some good points may have been inadvertently NaNed. It should however be noted that the raw UNQCed data is available in the netCDF file for reference.

Filter: The statistical characteristics of the ultrasonic wind direction in relation to the port side vane type wind direction was utilised in order to implement a QCing mechanism to handle the spiky portions of the ultrasonic wind direction data. The noisy portions of ultrasonic wind direction data have therefore been:

1. NaNed when the difference between the ultrasonic wind direction and port vane type wind direction values is equal or greater than four times the mean difference between the two sensors and its QC flag set to {'bad', 'none', 'operatorFlagged'}.
2. Left untouched when their difference is equal or greater than twice the mean difference between the two sensors and its QC flag set to {'suspect', 'none', 'operatorFlagged'}
3. If the ultrasonic and port wind direction is close to but on either side of the zero (or 360) mark then the filter above was not applied.

TSG: The CTD calibration data for the secondary conductivity sensor was obtained from the voyage CTD file with the scale factor of 0.999385635619183 and Offset of 0.00117306378575432 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 in2015_c02001Ctd.nc and in2015_c02003Ctd.nc with the TSG lag of -23, an average TSG conductivity scaling factor of 0.999958144514048 was calculated against the secondary 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’}. Erroneous and suspect TSG salinity data was 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 2.1 minutes between the two data sets and thermal increase of 0.16C 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 2.1 minutes, the salinity measurements could be for a location about 650 meters away from the current ship location.
Temperature and salinity spikes have been NaNed and flag set to bad.

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, 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
IN2015_C02uwy10.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
IN2015_C02uwy5min.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

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
	Optical rain gauge	Foremast				

			opticalRain	Yes	Accumulated hourly rain	mm
			opticalRainRate	Yes	Rate of rain fall	mm/h
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