

RV INVESTIGATOR

HYDROCHEMISTRY DATA PROCESS REPORT

Voyage:	IN2018_v03
Chief Scientist:	Dr. Bernadette Sloyan
Voyage title:	Integrated Marine Observing System: monitoring the East Australian Current property transports at 27°S
Report compiled by:	Christine Rees. Julie Janssens



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1 Executive Summary

The main objective of the voyage was to recover and re-deploy an array of six full-depth current meter and property (temperature, salinity and pressure) moorings from the continental slope to the abyssal waters off Brisbane (27°S). Also to collect and analyse salinity, oxygen and nutrient samples from the CTD stations conducted at each mooring location.

Triaxus and ship ADCP measurements were made along sections of the mooring line, and surrounding the mooring array.

Five nutrients were analysed; silicate, phosphate, nitrate + nitrite, nitrite and ammonium. Certified reference materials for nutrients in seawater were within the specified limits of the certified value.

The Guildline salinometers were problematic at sea, samples from CTD 12, 13, 14, the underway thermosalinograph and Triaxus samples were collected in crimped top bottles and brought back to Hobart for analysis.

High quality data was produced for the three measured parameters.

All finalized data can be obtained from the CSIRO data centre Contact: DataLibrariansOAMNF@csiro.au.

2 Itinerary

Brisbane to Brisbane 19 April 2018 to 10 May 2018



3 Key Personnel List

Name	Role	Organisation
Bernadette Sloyan	Chief Scientist	CSIRO
Stephen McCullum	Voyage Manager	CSIRO
Christine Rees	Hydrochemist	CSIRO
Julie Janssens	Hydrochemist	CSIRO

4 Summary

4.1 Hydrochemistry Samples Analysed

Analysis	Number of Samples
	298 CTD
Salinity (Guildline Salinometer)	42 TSG
	3 Triaxus
	274 CTD
Dissolved Oxygen (automated titration)	4 Triaxus
Nutrients (AA3)	274 CTD

Note:

- Conductivity Temperature Density (CTD); samples collected from NISKIN bottles on the CTD rosette.
- TSG samples collected from underway lab for calibration of thermosalinograph
- For sample TSG sample information refer to the Hydrochemistry eLog from the voyage.
- Triaxus samples collected using a long hose connected to the seawater tap in the dirty wet lab and going through the sensors on the Triaxus. Dissolved oxygen samples should be interpreted keeping that in mind. Refer to table 8.5 in the appendix and the Hydrochemistry underway eLog for information.

4.2 Rosette and CTD

- 14 CTD stations were sampled with a 36 bottle rosette, mounted with only 24 NISKIN bottles (12L).
- See in2018_v03_HYD_VoyageReport.pdf (voyage report) for more details on sample collection.

4.3 Data Procedure Summary

The procedure for data processing is outlined here:



Figure 1: The processing steps following sample assay on board the *RV Investigator*. CAP: CTD Acquisition Program, D.O.: dissolved oxygen, Nut: nutrient, Temp: temperature, OSIL: Ocean Scientific International Ltd, SIO: Scripps Institution of Oceanography.

5 Salinity Data Processing

5.1 Salinity Parameter Summary

Details			
HyPro Version	5.3 & 5.5 on shore.		
Instrument	Guildline Autosal Laboratory Salinometer 8400(B) – SN 72151 and SN 71613		
Software	OSIL Data Logger ver 1.2		
Methods	Hydrochemistry Operations Manual + Quick Reference Manual		
Accuracy	± 0.001 practical salinity units		
Analyst(s)	Julie Janssens and Christine Rees		
Lab Temperature (±0.5°C)	22.0-24.5°C during analysis.		
Bath Temperature	24.01°C		
Reference Material	Osil IAPSO - Batch P161 (see appendix 8.1) was used at sea and P158 was also used in the Hobart fee for service lab.		
Sampling Container type	200 ml volume OSIL bottles made of type II glass (clear) with disposable plastic insert and plastic screw cap.		
Sample Storage	Samples held in Salt Room for 6 -12 hrs to reach 22°C before analysis		
Comments	Both instruments were used interchangeably and were problematic, due to unstable measurements. The last 3 CTD's were collected in the OSIL type bottles with crimped lids, to be analysed back on shore in the Hobart fee for service lab.		

5.2 Salinity Method

The method uses a high precision laboratory salinometer (Guildline Autosal 8400B) which is operated in accordance with its technical manual.

Practical salinity (S), is defined in terms of the ratio (K_{15}) of the electrical conductivity measured at 15°C 1atm of seawater to that of a potassium chloride (KCl) solution of mass fraction 32.4356 x 10⁻³.

The Autosal is calibrated with standard seawater (OSIL, IAPSO) of known conductivity ratio against which the samples are measured. The Autosal is calibrated before each batch run of samples.

Salinity samples are collected into 200ml OSIL bottles –from the bottom via a PTFE straw filled till overflowing. The sample is decanted to allow a headspace of approximately 25cm³. A plastic insert is fitted, the bottle inverted and rinsed then capped and stored cap-down

until measured. To measure, the salinometer cell is flushed three times with the sample and then measured after the fourth and fifth flush. Further flush-measurement cycles are done where the initial values are more than 3 digits different. The conductivity ratio data is captured by the Osil data logger v1.2 program which then calculates the practical salinity.



5.3 CTD Salinities vs Hydrochemistry Salinities Plot

5.4 OSIL Salinity Standard PSU across the Voyage

Practical salinity (PSU) of P161 is 34.995 and P158 is 34.988, the blue line is the mean of all standards measured which were used to standardise the salinometers.



Missing or Flagged Salinity Data and Actions

Data is flagged based on notes from CTD sampling log sheet, observations during analysis, and examination of depth profile and waterfall plots.

CTD	RP	Run	Flag	Reason for Flag or Action	
1	All	sal001	69	All samples were offset from the CTD salinity. Although samples towards end of the run did improve. Due to instability of instrument.	
2	20	sal002	133	Very different to CTD salinity data and other points, outlier on profile.	
7	All	sal007	69	All samples were offset from the CTD salinity. Due to instability of instrument and maybe be due to the way samples were edited by removing highest value.	
8	34	sal008	133	Very different to CTD salinity data and other points, outlier on profile.	
10	26	sal010	69	Different to CTD salinity data and other points, outlier on profile.	
11	25	sal014	133	Very different to CTD salinity data and other points, outlier on profile. Niskin misfire.	
13	32	sal017	133	Very different to CTD salinity data and other points, outlier on profile.	

6 Dissolved Oxygen Data Processing

Details				
HyPro Version	5.3 & 5.5, 5.6 on shore.			
Instrument	Automated Photometric Oxygen system			
Software	SCRIPPS			
Methods	SCRIPPS			
Accuracy	0.01 ml/L + 0.5%			
Analyst(s)	Julie Janssens and Christine Rees			
Lab Temperature (±1°C)	Variable, 19.5 - 22.0°C			
Sample Container type	Pre-numbered glass 140 mL glass vial w/stopper, sorted into 18 per box and boxes labelled A to S.			
Sample Storage	Samples were stored within Hydrochemistry lab under the forward starboard side bench until analysis. All samples were analysed within ~48 hrs			
Comments	24 samples were collected from each deployment. Software was problematic losing communication with the 1 ml dosimat continuously throughout the voyage.			

6.1 Dissolved Oxygen Parameter Summary

6.2 Dissolved Oxygen Method

SCRIPPS method used. The method is based on the whole-bottle modified Winkler titration of Carpenter (1965) plus modifications by Culberson *et al* (1991).

Manganese chloride followed by alkaline iodide, is added to the sample, and the precipitated manganous hydroxide is distributed evenly throughout the bottle by shaking. At this stage, the dissolved oxygen oxidizes an equivalent amount of Mn (II) to Mn (IV). Just before titration, the sample is acidified, converting the Mn (IV) back to the divalent state liberating an amount of Iodine equivalent to the original dissolved oxygen content of the water. The Iodine is auto-titrated with a standardised thiosulphate solution using a Met Rohm 665 Dosimat with a 1 ml burette. The endpoint is determined by measuring changes in the UV absorption of the tri-iodide ion at 365 nm. The point at which there is no change in absorbance is the endpoint.

The thiosulphate solution is standardised by titrating a 10 ml aliquot of potassium iodate primary standard. The blank correction is determined from the difference between two consecutive titres for 1 ml aliquots of the same potassium iodate solution.



6.3 CTD Dissolved Oxygen vs Hydrochemistry Dissolved Oxygen Plot

6.4 Dissolved Oxygen Thiosulphate Normality and Blanks across Voyage

Red lines indicate \pm 0.0005 N either side of the mean titrant (thiosulfate) concentration and the blank concentration. The titrant should not vary more than 0.0005 N between analyses.



6.5 Missing or Flagged Dissolved Oxygen Data and Actions

Data is flagged as Good, Suspect or Bad in HyPro based on notes from CTD sampling log sheet, observations during analysis, and examination of depth profile and waterfall plots.

CTD	RP	Run	Flag	Reason for Flag or Action	
3	7	oxy002	N/A	Over titrate function used.	
4	5	oxy003	N/A	bubble near lid	
4	20	oxy003	N/A	Not pretty end point	
8	34	oxy007	N/A	Over titrate function used.	
10	14	oxy007	133	Titration end point bad, outlier in vertical profile plot.	
11	7	oxy008	N/A	Over titrate function used.	
11	13	oxy008	N/A	Over titrate function used.	
11	22	oxy008	N/A	Over titrate function used.	
11	25	oxy008	133	Outlier in vertical profile plot. Niskin misfire.	
11	32	oxy008	N/A	Over titrate function used.	
13	8	oxy010	N/A	Over titrate function used.	
13	32	oxy010	133	Outlier in bottle data vs CTD data error plot as well as profile.	
14	2	oxy011	N/A	Over titrate function used.	
14	8	oxy011	133	Over titrate function used. Outlier compared to sensor profile.	
14	14	oxy011	133	Over titrate function used. Outlier compared to sensor profile.	
14	29	oxy011	N/A	Over titrate function used.	

7 Nutrient Data Processing

7.1 Nutrient Parameter Summary

Details						
HyPro Version	5.3 & 5.5 on	shore.				
Instrument	AA3					
Software	Seal AACE 6	.10				
Methods	AA3 Analysi	s Methods inte	rnal manual			
Nutrients analysed	⊠ Silicate	⊠ Silicate ⊠ Phosphate ⊠ Nitrate + ⊠ Nitrite ⊠ Ammonia Nitrite				
Concentration range	140 µmol l ⁻¹	3 µmol l ⁻¹	42.0 μmol l ⁻¹	1.4 µmol l ⁻¹	2.0 µmol l ⁻¹	
Method Detection Limit* (MDL)	0.2 μmol l ⁻¹	0.02 µmol l⁻¹	0.02 µmol l ⁻¹	0.02 µmol l⁻¹	0.02 µmol l ⁻¹	
Matrix Corrections	N	Ν	Ν	Ν	Ν	
Analyst(s)	Julie Jansser	ns and Christine	e Rees			
Lab Temperature (±1°C)	Variable, 19	.5 – 22.0°C				
Reference Material	RMNS – BW	and CD				
Sampling Container type	50 ml HDPE screw cap lids for CTD samples					
Sample Storage	< 2 hrs at room temperature or ≤ 12 hrs @ 4°C					
Pre-processing of Samples	None					
Comments						

7.2 Nutrient Methods

CSIRO Oceans and Atmosphere Hydrochemistry nutrient analysis is performed with a segmented flow auto-analyser – Seal AA3 HR – to measure silicate, phosphate, nitrite, nitrate plus nitrite (NOx), and ammonium

Silicate: colourimetric, molybdenum blue method. Based on Armstrong et al. (1967). Silicate in seawater is reacted with acidified ammonium molybdate to produce silicomolybdic acid. Tartaric acid is added to remove the phosphate molybdic acid interference. Tin (II) chloride is then added to reduce the silicomolybdic acid to silicomolybdous acid and its absorbance is measured at 660 nm.

Phosphate: colourimetric, molybdenum blue method. Based on Murphy and Riley (1962) with modifications from the NIOZ-SGNOS Practical Workshop 2012 optimizing the antimony catalyst/phosphate ratio and the reduction of silicate interferences by pH. Phosphate in seawater forms a phosphomolybdenum complex with acidified ammonium molybate. It is then reduced by ascorbic acid and its absorbance is measured at 880 nm.

Nitrate: colourimetric analysis, Cu-Cd reduction – Naphthylenediamine photometric method. Based on Wood et.al (1967). Nitrate is reduced to nitrite by first adding an ammonium chloride buffer then sending it through a copper - cadmium column. Sulphanilamide is added under acidic conditions to form a diazo compound. This compound is coupled with 1-N-naphthly-ethylenediamine di-hydrochloride to produce a reddish purple azo complex and its absorbance is measured at 520 nm.

Nitrite: colourimetric analysis, Naphthylenediamine photometric method. As per nitrate method without the copper cadmium reduction column and buffer.

Ammonium: fluorescence analysis, ortho-phtaldiadehyde method. Based on Roger Kérouel and Alain Aminot, IFREMER (1997 Mar.Chem.57). Ammonium reacted with ortho-phtaldialdehyde and sulphite at a pH of 9.0-9.5 to produce an intensely fluorescent product. Its emission is measured at 460 nm after excitation at 370nm.

Detailed SOPs can be obtained from the CSIRO Oceans and Atmosphere Hydrochemistry Group on request.

7.3 Instrument Calibration and Data Parameter Summary

All instrument parameters and reagent batch compositions are logged for each analysis run. This information is available on request.

The raw data from each analysis run on the Seal AA3HR is imported into HyPro for peak height determination, constructing the calibration curve, deriving the sample results and applying drift and carry-over corrections.

Following standard procedures, the operator may choose to not include bad calibration points (see section 7.7 for edited data). Below are the corrections and settings that HyPro applied to the raw data.

All runs have a corresponding "AA3_Run_Analysis_sheet" to record the following: sample details, LNSW batch, cadmium column, working standards, reagent information, instrumentation settings, and pump tube hours. The nut## file numbers that correspond to each analytical run and the CTD samples analysed are in table 8.4 in the appendix. The nut### file numbers for underway and experimental samples are available upon request. Calibration summary data for each analysis run are in the voyage documentation and available upon request.

Result Details	Silicate	Phosphate	Nitrate + Nitrite Aı Nitrite		Ammonia
Data Reported as	µmol l ⁻¹	µmol l ⁻¹	µmol l⁻¹	μmol l ⁻¹ μmo	
Calibration Curve degree	Linear	Linear	Quadratic	Quadratic	Quadratic
Forced through zero?	N	N	Ν	N	N
# of points in Calibration	7	6	7	6	6
Matrix Correction	N	N	Ν	N	N
Blank Correction	Ν	Ν	Ν	Ν	Ν
Carryover Correction (HyPro)	rover Correction Y Y Y ro)		Y	Y	
Baseline Correction (HyPro)	Y Y Y Y		Y	Y	
Drift Correction (HyPro)	Y	Y	Y	Y	Y
Data Adj for RMNS	N N N				Ν
Window Defined*	HyPro HyPro HyPro HyPro		HyPro	HyPro	
Medium of Standards	LNSW (bulk on deck of Investigator) collected on 28/9/2016. Sub-lot passed through a 10 micron filter and stored in 20 L carboys in the clean dry laboratory at 22°C.				
Medium of Baseline	18.2 Ω MQ				
Proportion of samples in duplicate?	Samples were collected in duplicate at the greatest depth either RP01 or RP02 on the CTD rosette.				
Comments	Calibration and QC data that was edited or removed is located in the table within section 7.7. The reported data is not corrected to the RMNS. Per deployment RMNS data can be found in appendix 8.4.				

7.4 Accuracy - Reference Material for Nutrient in Seawater (RMNS) Plots

Japanese KANSO certified reference materials (RMNS) for silicate, phosphate, nitrate and nitrite in seawater was used in each nutrient analysis run to determine the accuracy. For each analysis run, a new RMNS bottle was opened and used. The RMNS was assayed in quadruplicate after the calibration standards.

RMNS lots BW and CD were used. Their stated values in μ mol/kg are converted to μ mol l⁻¹ at 21°C and are listed below. RMNS do not have certified ammonium values.

RMNS	NO ₃	NOx	NO ₂	PO ₄	SiO ₄
BW	25.18 ± 0.20	25.25 ± 0.22	0.069 ± 0.010	1.58 ± 0.014	61.45 ± 0.43
CD	5.63 ± 0.05	5.65 ± 0.06	0.018 ± 0.005	0.46 ± 0.008	14.26 ± 0.10

Table 1: RMNS BW and CD concentrations with expanded uncertainty (µmol/L) at 21°C

The submitted nutrient results do <u>NOT</u> have RMNS corrections applied.

RMNS Correction

Ratio = Certified RMNS Concentration/Measured RMNS Concentration in each run Corrected Concentration = Ratio x Measured Nutrient Concentration

Or for smoothing data

Ratio = Average RMNS Concentration across voyage/Measured RMNS Conc. in each run Corrected Concentration = Ratio x Measured Nutrient Concentration

The following plots show RMNS values within 1% (green lines), 2% (pink lines) and 3% (red lines) of the published RMNS value except for nitrite. The nitrite limit is set to $\pm 0.020 \mu$ M (MDL) as 1% is below the method MDL. The GO-SHIP criteria (Hyde *et al.*, 2010), appendix 8.3, specifies using 1-3% of full scale (depending on the nutrient) as acceptable limits of accuracy. The assayed RMNS values per CTD deployment are reported in the table in appendix 8.4.



7.4.1 Silicate RMNS Plot



7.4.2 Phosphate RMNS Plot



7.4.3 Nitrate + Nitrite (NOx) RMNS Plot

7.4.4 Nitrite RMNS Plot

7.5 Analytical Precision

The CSIRO Hydrochemistry method measurement uncertainty (MU) has been calculated for each nutrient based on variation in the calibration curve, calibration standards, pipette and glassware calibration, and precision of the RMNS over time (Armishaw 2003).

	Silicate	Phosphate	Nitrate + Nitrite (NOx)	Nitrite	Ammonia
Calculated MU* @ 1 µmol I ⁻¹	±0.017	±0.024	±0.019	±0.137	±0.296 [¥]

*The reported uncertainty is an expanded uncertainty using a coverage factor of 2 giving a 95% level of confidence.

^{*}The ammonia MU precision component does not include data on the RMNS.

Method detection limits (MDL) achieved during the voyage were much lower than the nominal detection limits, indicating high analytical precision at lower concentrations. RMNS and MDL precision data listed below. Results are μ mol l⁻¹.

MDL	Silicate	Phosphate	Nitrate + Nitrite (NOx)	Nitrite	Ammonia
Nominal MDL*	0.20	0.02	0.02	0.02	0.02
Standard Dev. Min	0.009	0.004	0.000	0.002	0.002
Standard Dev. Max	0.254	0.028	0.010	0.012	0.004
Standard Dev. Mean	0.064	0.013	0.006	0.005	0.003
Standard Dev. Median	0.050	0.012	0.007	0.004	0.003
Precision of MDL (stdev)	0.065	0.007	0.003	0.003	0.004

*MDL is based on 3 times the standard deviation of Low Nutrient Seawater (LNSW) analysed in each nutrient run.

Published RMNS CD (µmol I ⁻¹)	14.26	0.46	5.65	0.018	-
w/std deviation	± 0.009	± 0.001	± 0.004	± 0.001	-
RMNS Min	14.05	0.46	5.51	0.030	1.54
RMNS Max	14.11	0.47	5.55	0.039	1.72
RMNS Mean	14.07	0.47	5.53	0.034	1.60
RMNS Median	14.06	0.47	5.52	0.033	1.55
RMNS Std Dev	0.03	0.003	0.02	0.005	0.10

Published RMNS BW (µmol I ⁻¹)	61.45	1.58	25.25	0.069	-
w/std deviation	± 0.123	± 0.003	± 0.040	± 0.002	-
RMNS Min	61.11	1.58	25.19	0.059	0.96
RMNS Max	61.65	1.61	25.36	0.081	1.49
RMNS Mean	61.40	1.60	25.31	0.074	1.23
RMNS Median	61.45	1.60	25.31	0.077	1.19
RMNS Std Dev	0.13	0.01	0.05	0.007	0.18

7.6 Sampling Precision

Duplicate samples were collected during CTD deployments from the NISKIN bottle in rosette position 01 or 02 to measure the sample precision. The multiple measurements are reported in the data as an average, when all measurements are flagged GOOD. The sampling precision is deemed good if the difference between the concentrations is below the MDL for silicate, phosphate and nitrite and within 0.06 µM for nitrate.

7.6.1 Silicate Duplicate/Replicates Plot

7.6.2 Phosphate Duplicate/Replicates Plot

7.6.3 Nitrate + Nitrite (NOx) Duplicate/Replicates Plot

7.6.4 Nitrite Duplicate/Replicates Plot

7.6.5 Ammonia Duplicate/Replicates Plot

7.6.6 Redfield Ratio Plot (14.0)

Plots consists of phosphate versus NOx, best fit ratio = 14.17.

The table below identifies all flagged data by HyPro. The calibration curve is fitted to the standards by performing several passes over each standard point and weighting its contribution to the curve depending on the magnitude of the difference between its measured and calculated value. The larger the difference, the less weighting is given to the standard's contribution towards the curve construction. The cut-off limits for good calibration data are

• ±0.5% of the concentration of the top standard for silicate and nitrate+nitrite (as per WOCE).

CTD	Peak	Run	Analysis	Reason for Flag or Action
2	Cal 1	Nut002	NH4	2 nd point suspect, less weighting in calibration curve.
3	Cal 2 & 3	Nut003	NH4	<70% of calibration peaks are within calibration limits.
				Cal 2 & 3 suspect less weighting in calibration curve.
4	Cal 4	Nut004	PO4	1 st point suspect, less weighting in calibration curve.
5		Nut005	NOx	Cd column efficiency 96.75%
5	Cal 4	Nut005	PO4	Bad (MAD) peak shape and suspect in calibration error plot.
5	Cal 2,3,4	Nut005	NH4	<70% of calibration peaks are within calibration limits.
				Cal 2, 3, 4 suspect less weighting in calibration curve.
6	Cal 5	Nut006	PO4	2 nd point suspect, less weighting in calibration curve.
6	Cal 4	Nut006	NH4	Both points suspect, less weighting in calibration
				curve.
6	Cal 3&4	Nut005	NH4	<70% of calibration peaks are within calibration limits.
				Cal 3 & 4 suspect less weighting in calibration curve.
7	Cal 4	Nut006	NH4	Cal 4 both points suspect, less weighting in calibration
				curve.
8	Cal 2	Nut008	PO4	1 st point suspect, less weighting in calibration curve.
9 & 10	Cal 1	Nut009	NH4	Both points Bad not used in calibration curve.
11	Cal 4	Nut010	NOx	1 st point suspect, less weighting in calibration curve.
13	Cal 1	Nut012	NH4	Cal 1 both points suspect, less weighting in calibration
				curve.
14	Cal 2	Nut013	PO4	1 st point suspect, less weighting in calibration curve.

• 0.02uM for phosphate, nitrite and ammonium.

7.8 Missing or Flagged Nutrient Data and Actions

The table below identifies all flagged data and any samples that had repeated analyses performed to obtain GOOD data. Data that falls below the detection limit, Flag 63, is not captured in this table. All GOOD data is flagged 0 in the .csv and .netcdf files. Data that is flagged BAD is not exported within the .csv files. Suspect data (Flag 69) is exported in the .csv file. Refer to Appendix 8.2 for flag explanations.

CTD	RP	Run	Analysis	Flag	Reason for Flag or Action
9	1	Nut009	NH4	69	Duplicate measurement suspect as much higher than other measurement - likely
					contamination.
11	25	Nut010	All	133	Outlier on profiles. Niskin misfire.

7.9 Temperature & Humidity Change Over Nutrient Analyses

The temperature and humidity within the AA3 chemistry module was logged using a temperature/humidity logger QP6013 (Jaycar) placed on the deck of the chemistry module.

Refer to "in2018_v03_hyd_voyagereport.docx" for room temperature graphs, nutrient samples were placed on XY3 auto sampler at the average room temperature of 21.0°C.

8 Appendix

8.1 Salinity Reference Material

Osil IAPSO Standard Seawater						
Batch	P161	P158				
Use by date	03/05/2020	25/03/2018				
K ₁₅	0.99987	0.99970				

8.2 HyPro Flag Key for CSV & NetCDF file

Flag	Meaning
0	Data is GOOD – nothing detected.
192	Data not processed.
63	Below nominal detection limit.
69	Data flagged suspect by operator. Set suspect by software if Calibration or Duplicate data is outside of set limits but not so far out as to be flagged bad.
65	Peak shape is suspect.
133	Error flagged by operator. Data is bad – operator identified by # in slk file or by clicking on point.
129	Peak exceeds maximum A/D value. Data is bad.
134	Error flagged by software. Peak shape is bad - Median Absolute Deviation (MAD) analysis used. Standards, MDL's and Duplicates deviate from the median, Calibration data falls outside set limits.
141	Missing data, no result for sample ID. Used in netcdf file as an array compiles results. Not used in csv file.
79	Method Detection Limit (MDL) during run was equal to or greater than nominal MDL. Data flagged as suspect.

8.3 GO-SHIP Specifications

- Salinity Accuracy of 0.001 is possible with Autosal[™] salinometers and concomitant attention to methodology, e.g., monitoring Standard Sea Water. Accuracy with respect to one particular batch of Standard Sea Water can be achieved at better than 0.001 PSS-78. Autosal precision is better than 0.001 PSS-78. High precision of approximately 0.0002 PSS-78 is possible following the methods of Kawano (this manual) with great care and experience. Air temperature stability of ± 1°C is very important and should be recorded.¹
- O₂ Target accuracy is that 2 sigma should be less than 0.5% of the highest concentration found in the ocean. Precision or reproducibility (2 sigma) is 0.08% of the highest concentration found in the ocean.
- SiO₂ Approximately 1-3% accuracy[†], 2 and 0.2% precision, full-scale.
- PO₄ Approximately 1-2% accuracy[†], 2 and 0.4% precision, full scale.
- NO₃ Approximately 1% accuracy[†], 2 and 0.2% precision, full scale.
- Notes: + If no absolute standards are available for a measurement then *accuracy* should be taken to mean the *reproducibility* presently obtainable in the better laboratories.

1 Keeping constant temperature in the room where salinities are determined greatly increases their quality. Also, room temperature during the salinity measurement should be noted for later interpretation, if queries occur. Additionally, monitoring and recording the bath temperature is also recommended. The frequent use of IAPSO Standard Seawater is endorsed. To avoid the changes that occur in Standard Seawater, the use of the most recent batches is recommended. The bottles should also be used in an interleaving fashion as a consistency check within a batch and between batches.

2 Developments of reference materials for nutrients are underway that will enable improvements in the relative accuracy of measurements and clearer definition of the performance of laboratories when used appropriately and the results are reported with the appropriate meta data.

Analysis Run	CTD #	SiO4	PO4	NO2	NOx
		measured	measured	measured	measured
BW certified		61.45	1.58	0.069	25.25
2	2	61.49	1.60	0.063	25.19
3	3	61.34	1.58	0.066	25.28
3	3	61.32	1.6	0.072	25.27
4	4	61.37	1.60	0.077	25.36
5	5	61.11	1.60	0.076	25.30
6	6	61.45	1.61	0.078	25.28
7	7	61.32	1.60	0.080	25.36
8	8	61.47	1.60	0.081	25.31
9	9 & 10	61.45	1.59	0.081	25.35
10	11	61.45	1.61	0.077	25.36
11	12	61.48	1.61	0.059	25.33
12	13	61.65	1.60	0.070	25.28
13	14	61.30	1.61	0.077	25.36
CD certified		14.264	0.457	0.018	5.648
2	2	14.049	0.469	0.030	5.518
3	3	14.060	0.463	0.033	5.509
13	14	14.109	0.468	0.039	5.553

8.4 RMNS Values for Each CTD Deployment

8.5 Triaxus Samples

Bottle ID	Analysis	Experimental Prefix	Real Date & Time	Salinity (PSU)	D.O. (μM)
J01	salinity	exp1	01/05/2018 11:42:11	35.4895	N/A
J02	salinity	exp2	01/05/2018 13:11:17	35.3418	N/A
J03	salinity	exp3	01/05/2018 14:22:38	35.3601	N/A
187*	dissolved oxygen	901 01 01	01/05/2018 11:42:11	N/A	215.579
193	dissolved oxygen	901 01 02	01/05/2018 11:47:37	N/A	214.194
194	dissolved oxygen	901 01 03	01/05/2018 13:13:09	N/A	211.514
197	dissolved oxygen	901 01 04	01/05/2018 14:23:53	N/A	211.782

*Suspect, as bubbles were seen during collection.

9 References

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