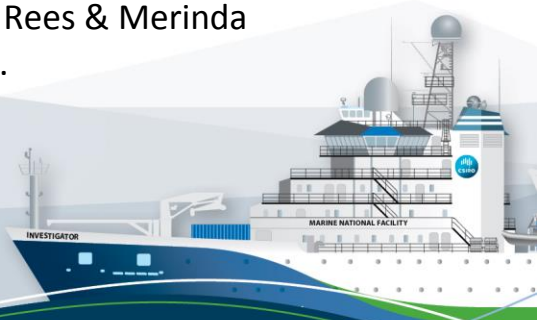
RV *INVESTIGATOR*

HYDROCHEMISTRY DATA PROCESSING REPORT

Voyage:	in2018_v06
Chief Scientist:	Alan Williams
Principal Investigators:	Dr Nic Bax, Dr Malcom Clark & Dr Thomas Schlacher
Voyage title:	Status and Recovery of deep-sea coral communities on seamounts in iconic Australian marine reserves.
Supplementary Project:	Spatial and temporal variability in the distribution and abundance of seabirds.

Report compiled by: Stephen Tibben, Christine Rees & Merinda McMahon.



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1 Executive Summary

The main objectives of the voyage were to determine the extent, ecological characteristics, and conservation status of deep-sea coral reefs on Tasmanian seamounts inside and outside of existing reserves. Measure recovery trajectories and dynamics of deep-sea coral communities (multi-species and successional changes) following cessation of bottom trawling. Provide the first set of empirical data on conservation status, resilience and recovery potential to enhance management and conservation of deep-sea coral habitats nationally. Also to collect and analyse salinity, oxygen and nutrient samples from the CTD at each seamount.

Water samples collected during the voyage were assayed in the ship's hydrochemistry laboratory for nutrients, dissolved oxygen, and their salinity measured. The samples came from deployments of the CTD rosette.

High quality data was produced for the three measured parameters. 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.

Underway thermosalinograph (TSG) samples were collected and analysed during the voyage.

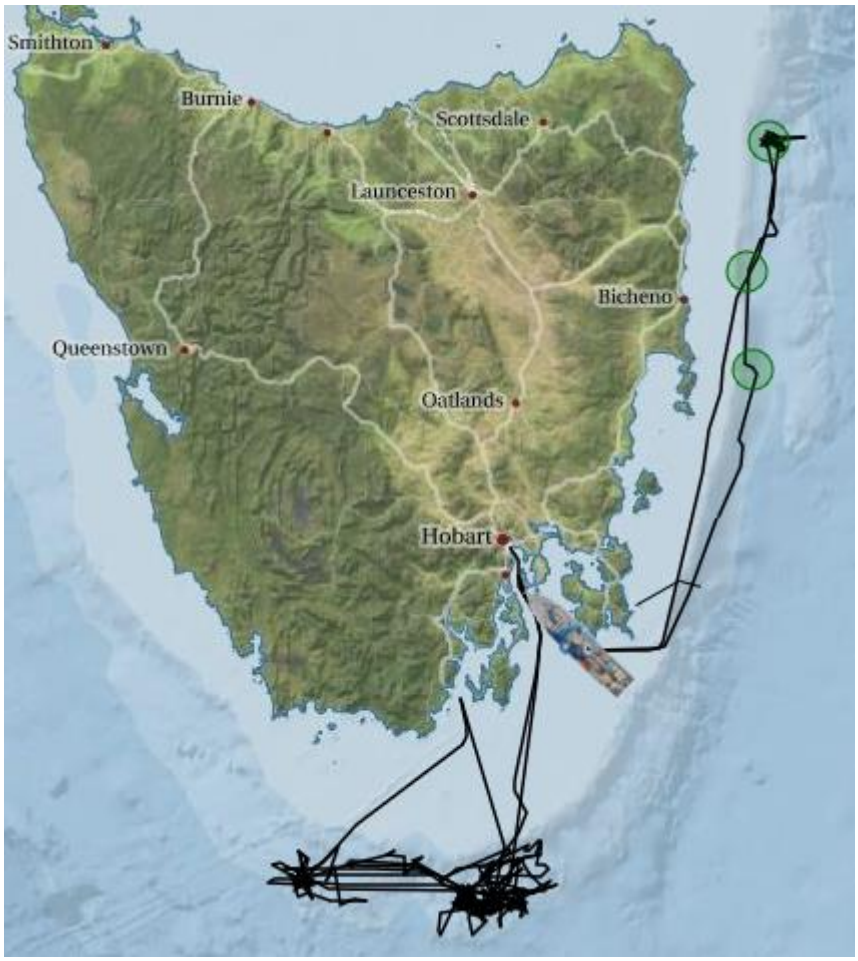
Final hydrology data, analytical methods, and related log sheets and processing notes can be obtained from the CSIRO data centre.

Contact: DataLibrariansOAMNF@csiro.au

Itinerary

Hobart to Hobart, November 23rd – December 19th, 2018.

Voyage Track:



2 Key personnel list

Name	Role	Organisation
Alan Williams	Chief Scientist	CSIRO
Max McGuire	Voyage Manager	CSIRO
Stephen Tibben	Hydrochemist	CSIRO
Christine Rees	Hydrochemist	CSIRO
Merinda McMahon	Hydrochemist	CSIRO

3 Summary

3.1 Sample Type and Number Assayed

Analysis (instrument)	Number of Samples
Salinity (Guildline Salinometer)	156 CTD
	24 TSG
Dissolved Oxygen (automated titration)	156 CTD
Nutrients (Seal AA3HR)	157 CTD

3.1.1 CTD (Conductivity, Temperature, Density)

- Sampling point, 36 bottle rosette with 12L Ocean Test Equipment bottles (Niskin) deployed at depth for water collection.
- 12 CTD deployments in total. Deployments 1 through 12 sampled by Stephen Tibben, Christine Rees, Tiffany Sih, Cath Sampson, Alexandra Weber, Kylie Maguire, Candice Untiedt, Ricky-Lee Ericson, Cassie Layton and Merinda McMahon.

3.1.2 TSG (Thermosalinograph)

- 24 Samples collected by hydrochemistry from underway lab for calibration of thermosalinograph.

For TSG sample information refer to the eLog's from the voyage.

3.2 Data Processing Overview

The sample meta-data, measured bottle salinity results, dissolved oxygen assay results and the nutrient assay raw data are processed by the CSIRO program HyPro. The final output is the hydrology data set. An overview of this process is illustrated in figure 1.

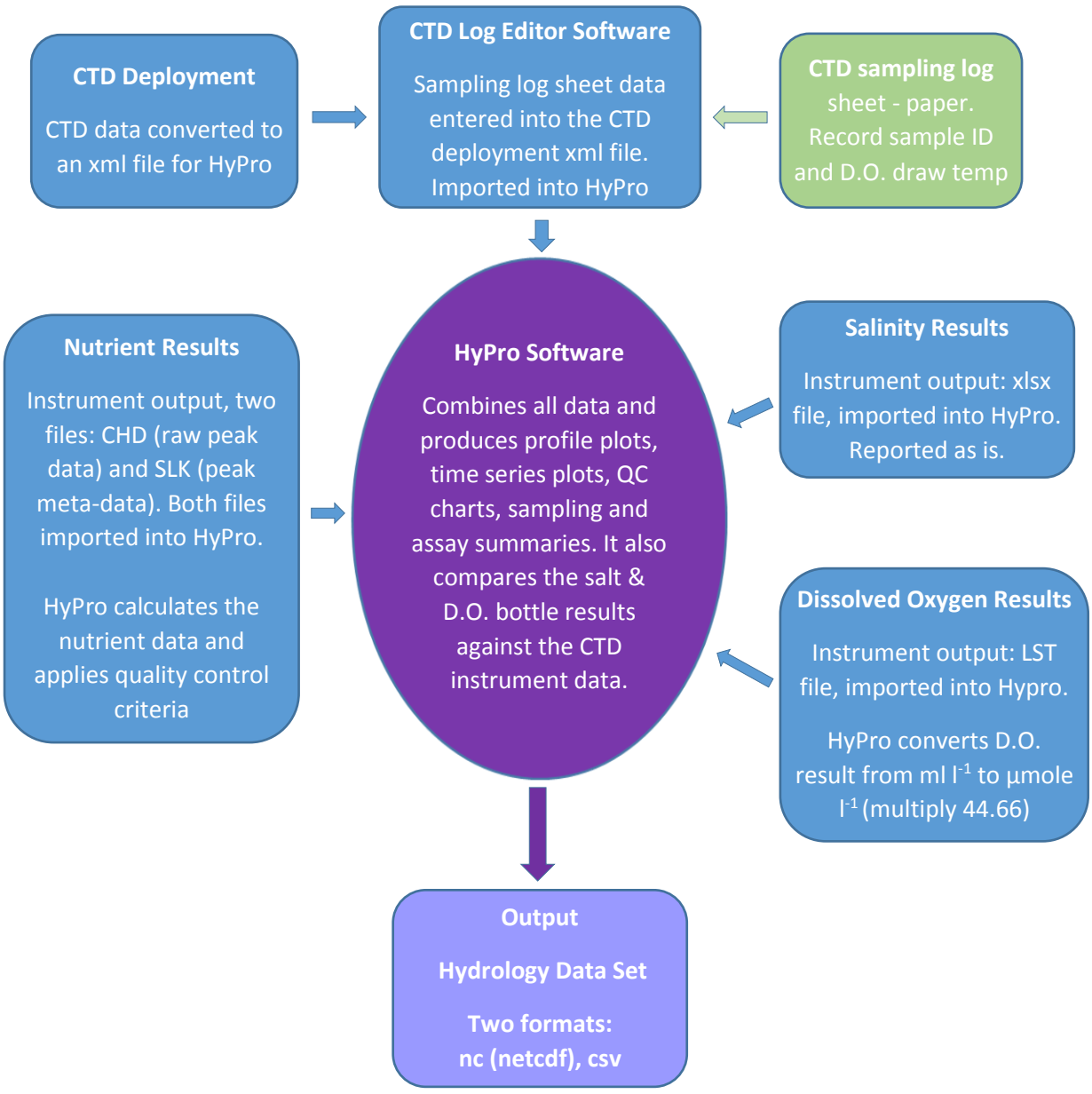


Figure 1: Hydrology Data Processing Flow Diagram.

4 Salinity Data Processing

4.1 Salinity Parameter Summary

Details	
HyPro Version	5.7
Instrument	Guildline Autosal Laboratory Salinometer 8400(B) – SN 72151
Software	OSIL Data Logger ver 1.2
CSIRO Hydrochem Method.	Sampling: WI_Sal_002 Measurement: SOP006
Accuracy	± 0.001 practical salinity units
Analysts	Christine Rees & Merinda McMahon
Lab Temperature (±0.5°C)	20.5 -23.7°C during analysis.
Bath Temperature	24.01°C
Reference Material	Osil IAPSO - Batch P161, use by 03/05/2020, K_{15} = 0.99987
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 stored in the Salt lab for a minimum of 8 hrs before measurement.
Comments	None.

4.2 Salinity Method

Salinity samples are measured on 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}.

Before each batch of sample measurements, the Autosal is calibrated with standard seawater (OSIL, IAPSO) of known K_{15} ratio. A new bottle of OSIL solution is used for each calibration.

Method synopsis: Salinity samples are collected into 200ml OSIL bottles, filled from the bottom, via a PTFE straw, till overflowing. The bottle is removed from the straw and the sample is decanted to allow a headspace of approximately 25cm^3. A plastic insert is fitted, the bottle inverted and rinsed with water then capped and stored cap-down until measured. To measure, the Autosal 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 Osil Data logger software captures the conductivity ratio and calculates the practical salinity.

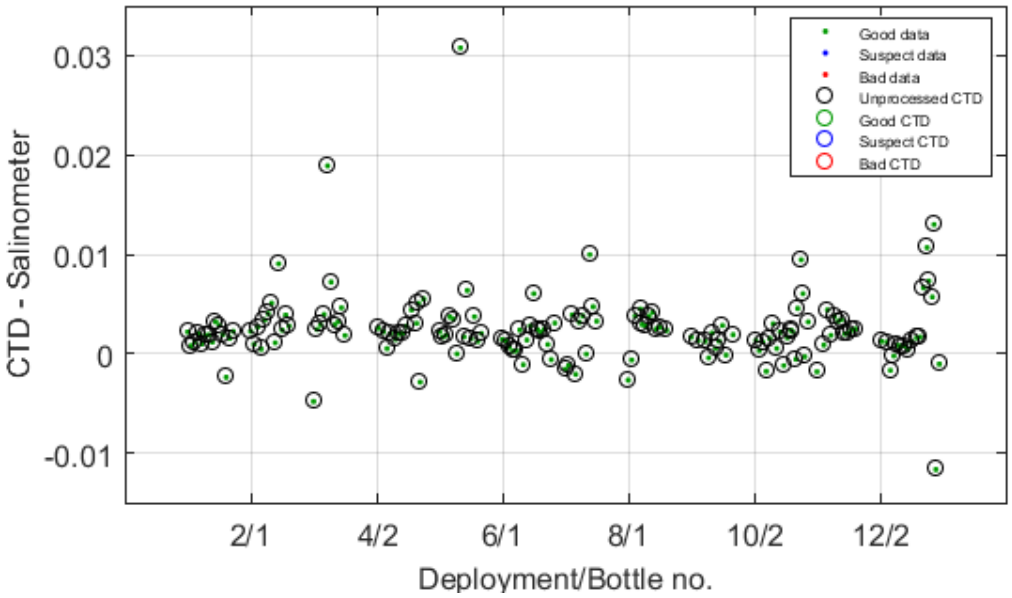
The output from the data logger software is imported into HyPro and collated with the CTD deployment meta-data.

4.3 CTD Salinity vs Bottle Salinity Plot

The difference between the unprocessed (uncorrected) CTD values and the measured bottle salinities is generally less than 0.01 PSU.

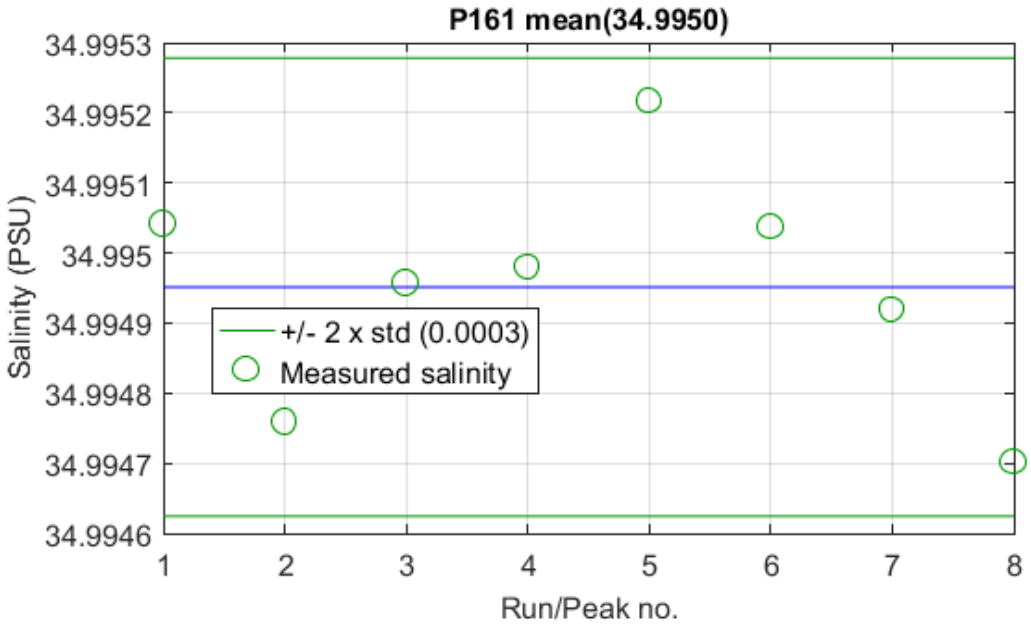
The unprocessed CTD values are adjusted (corrected) by DAP using the bottle results. The corrected values are not reported in the hydrology set. Please contact the DataLibrarians@csiro.au for corrected CTD data.

Note: dots = bottle samples, circles = CTD instrument (unprocessed)



5.4 OSIL Salinity Standard PSU across the Voyage

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



5.5 Missing or Suspect Salinity Data

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

HyPro classified the quality of data as good, no suspect or bad data to report.

5 Dissolved Oxygen Data Processing

5.1 Dissolved Oxygen Parameter Summary

Details	
HyPro Version	5.7
Instrument	Automated Photometric Oxygen system (SIO)
Software	SCRIPPS
CSIRO Hydrochem. Method	Sampling: WI_DO_001 Assay: SOP005
Accuracy	± 0.5 µM
Analyst(s)	Stephen Tibben & Merinda McMahon
Lab Temperature (±1°C)	Variable, 20.19– 23.18°C, Average 21.35°C
Sample Container type	Pre-numbered 140 mL glass iodine determination flasks with glass stopper. 18 flasks per light-proof container.
Sample Storage	Samples stored in the hydrochemistry lab until analysis. All samples were analysed within ~48 hrs
Comments	None.

5.2 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).

Method synopsis: The sample is collected in an iodine determination flask of known volume. 1mL of manganese (II) chloride solution followed by 1mL of alkaline iodide solution is added to the sample, the flask stoppered and inverted a minimum ten times. The dissolved oxygen oxidizes an equivalent amount of Mn (II) to Mn (IV) which precipitates. Just before titration, the sample is acidified, oxidizing the Mn (IV) back to the divalent state liberating iodine twice the original dissolved oxygen content of the sample. The tri-iodine is auto-titrated with a standardised thiosulphate solution using a Metrohm 665 Dosimat fitted with a 1ml 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.

Before each batch of sample assays, the thiosulphate solution is standardised by using it to titrate a 10ml aliquot of potassium iodate primary standard. A blank correction is also determined from the difference between two consecutive titres for 1ml aliquots of the same potassium iodate solution.

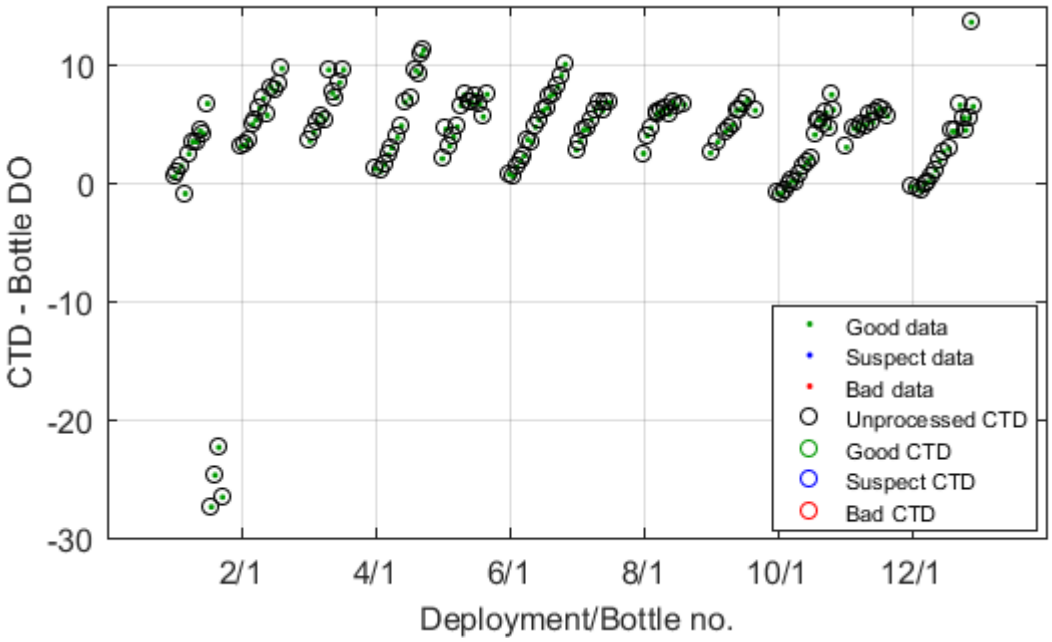
The output from the SIO instrument software is imported into HyPro and collated with the CTD deployment meta-data.

5.3 CTD Dissolved Oxygen vs Bottle Dissolved Oxygen Plot

The CTD values in this plot are unprocessed raw data.

The unprocessed CTD values are adjusted (corrected) by DAP using the bottle results. The corrected values are not reported in the hydrology set. Please contact the DataLibrarians@csiro.au for corrected CTD data.

Note: dots = bottle samples, circles = CTD instrument (unprocessed)



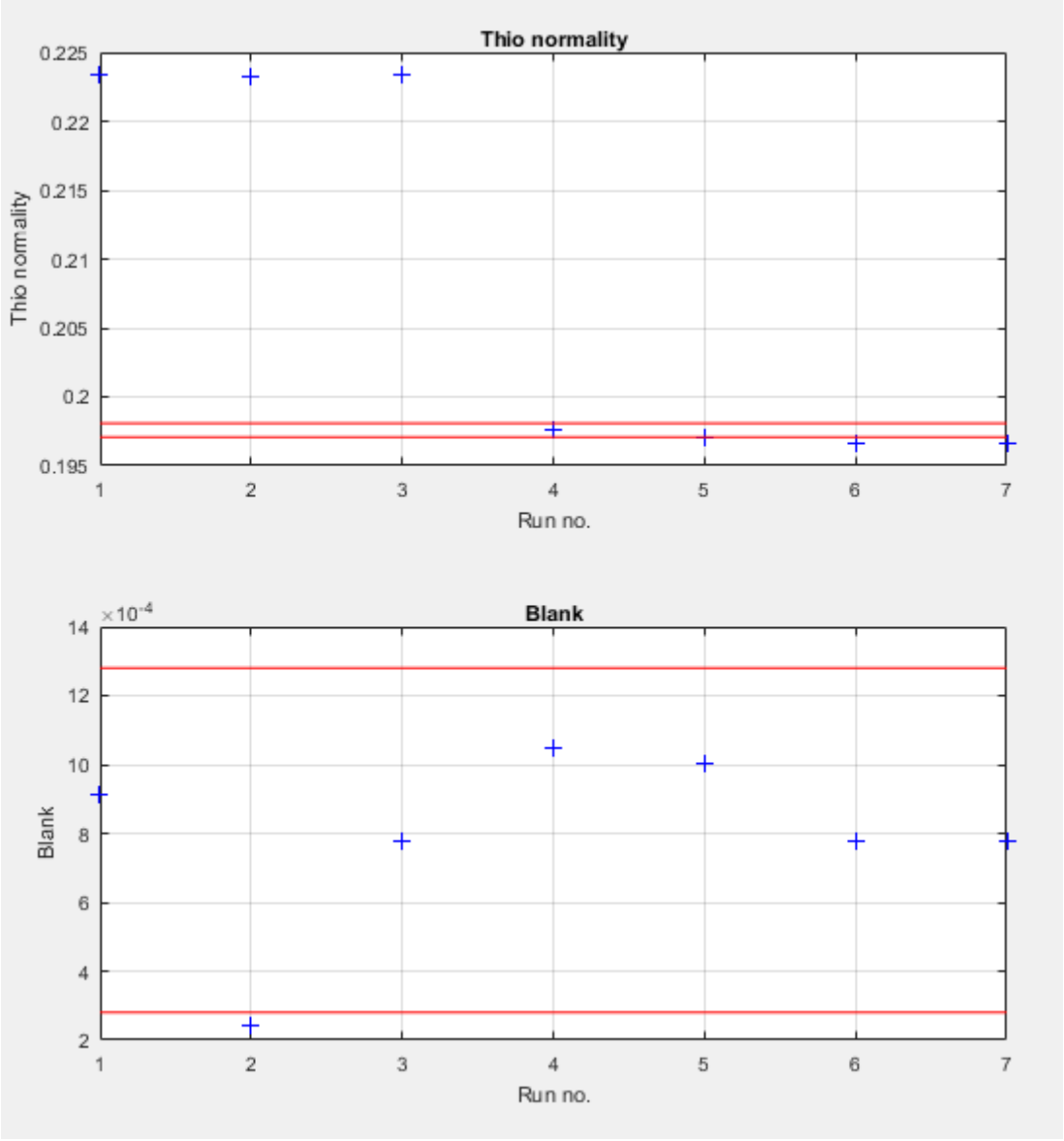
Also note that the large offsets in deployment 1 were due to sensor failure, not bad bottle samples.

5.4 Dissolved Oxygen Instrument titrant: thiosulphate normality and blank correction.

The normality of the thiosulphate titrant (0.2N) varied less than 0.0005 N for all dissolved oxygen sample titrations. The blank correction is less than 0.00012 ml.

Red lines indicate ± 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. The large difference between Run 3 and Run 4 corresponds to a change in thiosulfate.

For reference, titre volumes for dissolved oxygen bottle samples lay in the range 0.46 to 0.80 ml.



5.5 Missing or Suspect Dissolved Oxygen Data.

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.

There was no missing or suspect data for dissolved oxygen.

6 Nutrient Data Processing

6.1 Nutrient Assay Parameter Summary

Details					
CSIRO Software	HyPro 5.7				
Instrument	Seal AA3HR				
Instrument Software	Seal AACE 6.10				
CSIRO Hydrochem. Method, sampling	WI_Nut_001				
CSIRO Hydrochem. Method, nutrient	SOP001	SOP002	SOP003	SOP003	SOP004
Nutrient	Silicate	Phosphate	Nitrate + Nitrite	Nitrite	Ammonium
Concentration range	140 µM	3.0 µM	42 µM	1.4 µM	2.0 µM
Method Detection Limit (MDL)	0.2 µM[1]	0.02 µM	0.02 µM	0.02 µM	0.02 µM
Matrix Corrections	none	none	none	none	none
Analysts	Christine Rees, Stephen Tibben & Merinda McMahon				
Lab Temperature (±1°C)	Variable, 20.19– 23.18°C, Average 21.35°C				
Reference Material	KANSO, RMNS lot CJ				
Sampling Container type	CTD: 50ml HDPE with screw cap lids.				
Sample Storage	< 2 hrs at room temperature				
Pre-processing of Samples	CTD None.				
Comments	RMNS lots CD, CC, & CB were also analysed sporadically throughout the voyage.				

6.2 Nutrient Methods

Please cite the following paper when using Hydrochemistry data for silicate, phosphate, nitrate+nitrite (NOx) and nitrite analysis:

Rees, C., L. Pender, K. Sherrin, C. Schwanger, P. Hughes, S. Tibben, A. Marouchos, and M. Rayner. 2018. Methods for reproducible shipboard SFA nutrient measurement using RMNS and automated data processing. Limnol. Oceanogr: Methods Doi:10.1002/lom3.10294

Nutrient samples are assayed on a Seal AA3HR segmented flow auto-analyser fitted with 1cm flow-cells for colorimetric measurements and a JASCO FP2020 fluorescence instrument as the ammonium detector.

Silicate (SOP001): 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 660nm.

Phosphate (SOP002): 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 molybdate. It is then reduced by ascorbic acid and its absorbance is measured at 880nm.

Nitrate (SOP003): colourimetric, Cu-Cd reduction – naphthylenediamine 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 (SOP003): colourimetric, naphthylenediamine method. As per nitrate method without the copper cadmium reduction column and buffer.

Ammonium (SOP004): fluorescence, 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 460nm after excitation at 370nm.

SOP methods can be obtained from the CSIRO Oceans and Atmosphere Hydrochemistry Group.

6.3 HyPro Processing Parameters

All instrument parameters and reagent batches and operation events are logged for each analysis run. This information is available on request.

Result Details	Silicate	Phosphate	Nitrate + Nitrite (NOx)	Nitrite	Ammonia
Data Reported as	µmol l^{-1}	µmol l^{-1}	µmol l^{-1}	µmol l^{-1}	µmol l^{-1}
Calibration Curve degree	Linear	Linear	Quadratic	Quadratic	Quadratic
# of points in Calibration	7	6	7	6	6
Forced through zero?	N	N	N	N	N
Matrix correction	N	N	N	N	N
Blank correction	N	N	N	N	N
Peak window defined by	HyPro	HyPro	HyPro	HyPro	HyPro
Carryover correction (HyPro)	Y	Y	Y	Y	Y
Baseline drift correction (HyPro)	Y	Y	Y	Y	Y
Sensitivity drift correction (HyPro)	Y	Y	Y	Y	Y
Data Adj for RMNS variance.	N	N	N	N	N
Medium of Standards	LNSW (bulk on deck of Investigator) collected on 28/9/2016. Sub-lot passed through a 10 micron filter on the 15/10/2018 and stored in 20 L carboys in the clean dry laboratory at 22°C.				
Medium of Baseline	18.2 Ω water. Dispensed from Milli Q				
Proportion of samples in duplicate.	<10%. CTD: Niskin fired at the greatest depth sampled in duplicate. Single samples collected for remaining depths.				
Comments	The reported data is not corrected to the RMNS. Per deployment RMNS data tabulated in appendix 7.3.				

6.4 HyPro Data Processing Summary

After a run, the raw absorbance/ fluorescence data is exported from the instrument and processed by HyPro. For each analyte, HyPro re-creates the peak traces, defines the region on the peak's plateau (peak window) used to determine the peak heights, constructs the calibration curve, applies corrections for carry-over, baseline and sensitive drifts then, derives the nutrient concentrations for each sample. The corrections are quantified using dedicated solutions included in every run.

HyPro uses criteria to identify suspect calibration points, noisy peaks, method detection limits that are above the nominal limit and, duplicate sample results that do not match.

With suspect calibration points, their contribution to the curve is given less weighting dependent on their distance from the final curve. 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).
- Within 0.02uM for phosphate, nitrite and ammonium.

HyPro classifies the quality of data as good, suspect or bad and flags accordingly. The flagged nutrient calibration data is in appendix 7.2.

Missing or suspect nutrient data is tabulated in section 6.9, the flags are also in the final hydrology data set. The Flag key is in Appendix 7.4.

6.5 Accuracy - Reference Material for Nutrient in Seawater (RMNS)

Japanese KANSO certified RMNS lot CJ was assayed in triplicate in each run to monitor accuracy. Lots CC, CD & CB were also analysed sporadically throughout the voyage. The certified values are in table 1.

For in2018_v06, the majority of RMNS results are within 1% of their certified mean and within 0.02µM for nitrite. Plots of RMNS values for all runs are below.

The assayed RMNS values per Analysis run and CTD deployments are listed in appendix 7.3

The GO-SHIP criteria (Hyde *et al*., 2010), appendix 7.5 specifies using 1-3 % of full scale (depending on the nutrient) as acceptable limits of accuracy.

Table 1: RMNS concentrations with expanded uncertainty (µmol L^{-1}) at 21°C

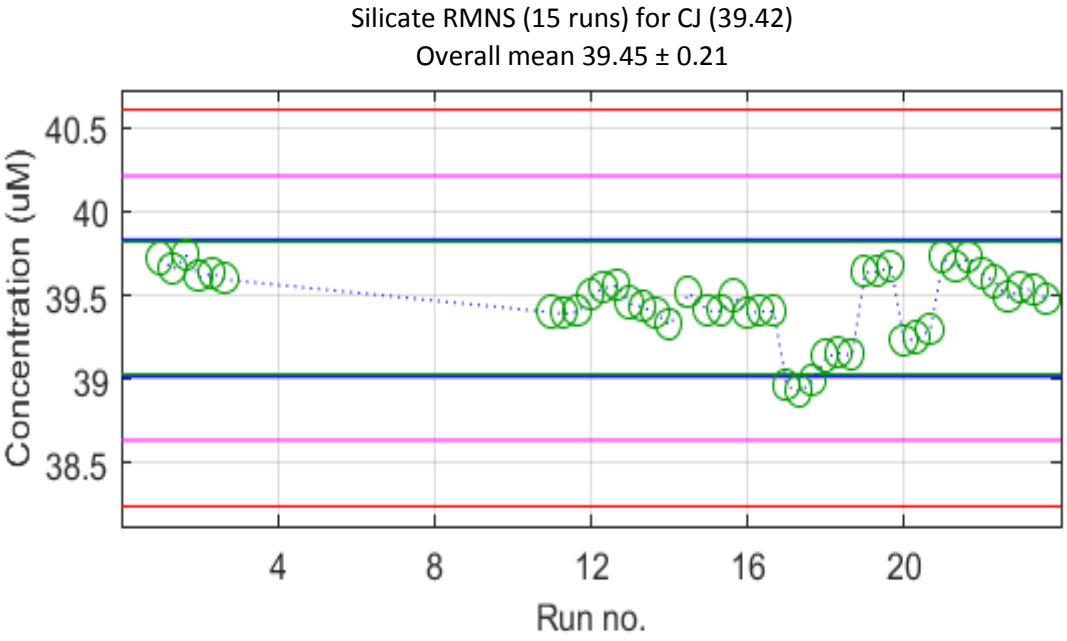
RMNS	NO_3	NO_2	NO_3+ NO_2 (NO_X)	PO_4	SiO_4
Lot CD	5.629 ± 0.051	0.018 ± 0.004	5.647 ± 0.055	0.457 ± 0.008	14.264 ± 0.10
Lot CC	31.621 ± 0.246	0.119 ± 0.006	31.740 ± 0.252	2.130 ± 0.019	88.228 ± 0.492
Lot CB	36.649 ± 0.276	0.119 ± 0.006	36.768 ± 0.282	2.580 ± 0.022	111.821 ± 0.635
Lot CJ	16.588 ± 0.205	0.032 ± 0.007	16.620 ± 0.212	1.219 ± 0.020	39.424 ± 0.410

KANSO publishes the RMNS nutrient values in µ mol kg^{-1}. These are converted to µ mol l^{-1} at 21°C. RMNS does not have a certified value for ammonium (NH_4). NO_x is derived by adding the NO_3 and NO_2 values.

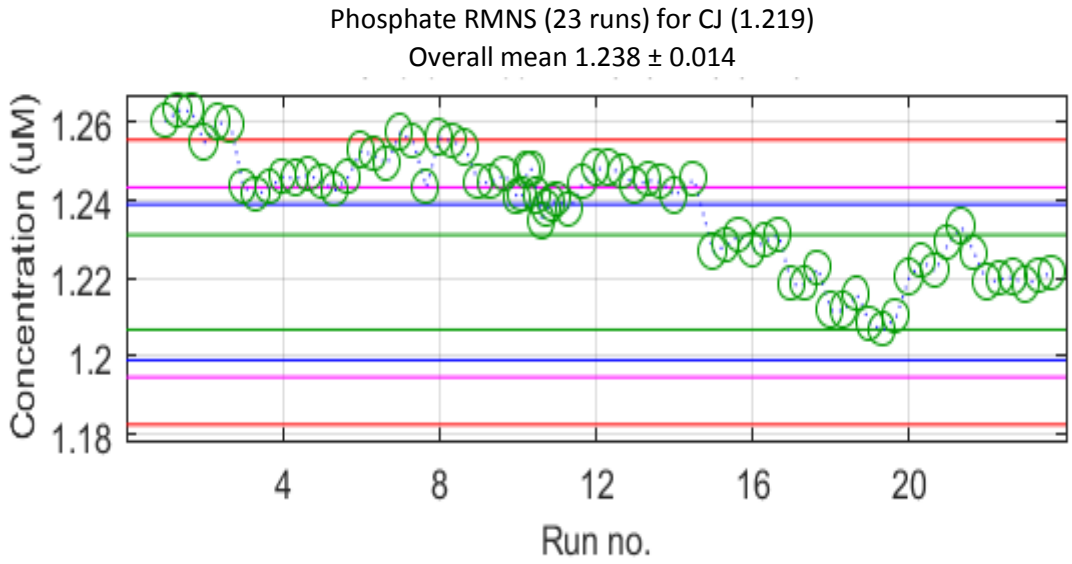
Plot key. The green pink and red lines are the 1%, 2% and 3% contours from the RMNS certified mean value. Exception: nitrite, the contours are at 0.02 µM increments from the certified value. The blue line is the expanded uncertainty of the certified value.

Please note: there is only RMNS values for phosphate runs 4 to 10 as these were experiments conducted only for phosphate and not part of the voyage samples.

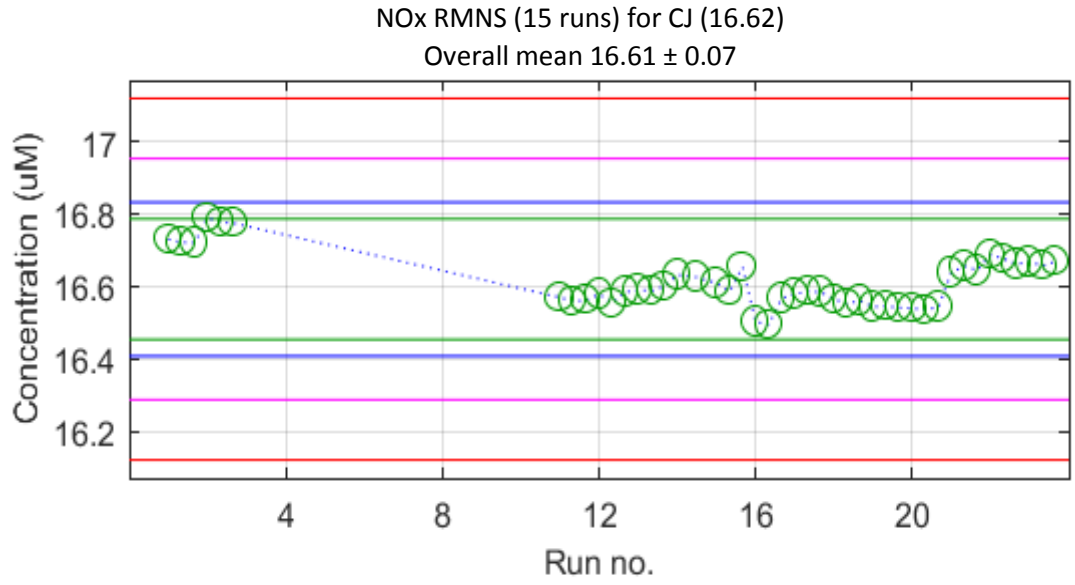
6.5.1 Silicate RMNS Plot



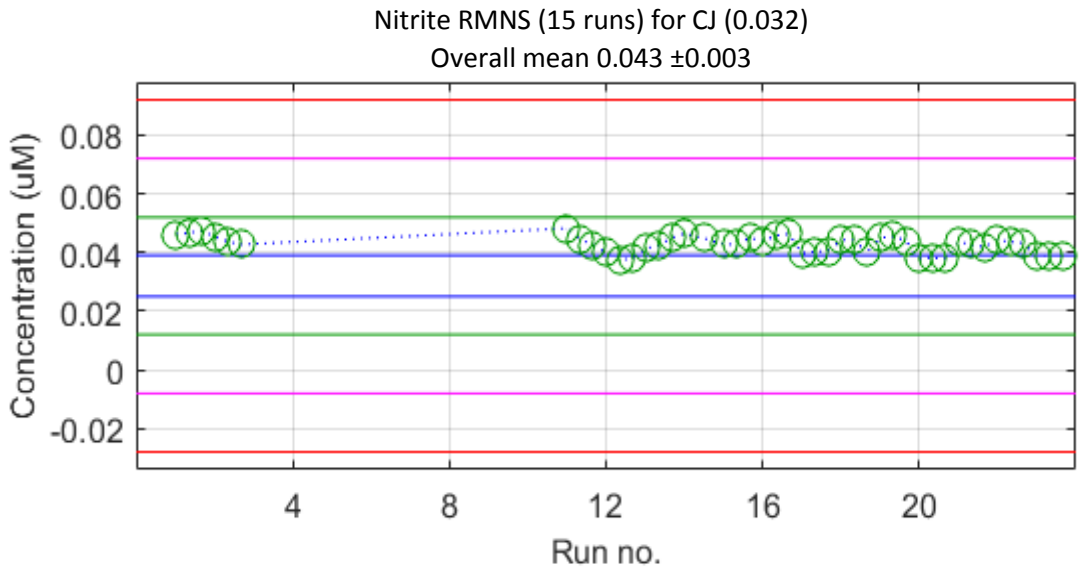
6.5.2 Phosphate RMNS Plot



6.5.3 Nitrate + Nitrite (NOx) RMNS Plot



6.5.4 Nitrite RMNS Plot



6.6 Analytical Precision

6.6.1 Nutrient Measurement Uncertainty

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

Calculated Measurement Uncertainty @ 1 µmol L^{-1}				
Silicate	Phosphate	Nitrate + Nitrite (NOx)	Nitrite	Ammonia
±0.017	±0.024	±0.019	±0.14	±0.30¥

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

¥The ammonia MU precision does not include data for the RMNS.

6.6.2 Nutrient Method Detection Limit

For in2018_v06, the measured detection limits for each run are much lower than the nominal detection limits, indicating high analytical precision at lower concentrations.

MDL	Silicate	Phosphate	Nitrate + Nitrite (NOx)	Nitrite	Ammonia
Nominal MDL*	0.20	0.02	0.02	0.02	0.02
Standard Dev. Min	0.01	0.001	0.004	0.00	0.002
Standard Dev. Max	0.22	0.042	0.019	0.005	0.004
Standard Dev. Mean	**0.06**	**0.006**	**0.009**	**0.003**	**0.003**
Standard Dev. Median	0.04	0.004	0.007	0.003	0.003
Precision of MDL (stdev)	0.05	0.008	0.004	0.001	0.001

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

6.6.3 Reference Material for Nutrients in Seawater

Precision values are calculated from intra-analysis measurements, multiple measurements are taken at a time, typically 3-4.

RMNS CJ	Silicate	Phosphate	Nitrate + Nitrite (NOx)	Nitrite	Ammonia
Published RMNS CJ (µmol l^{-1})	39.42	1.219	16.62	0.032	-
w/std deviation	±0.41	±0.21	±0.21	±0.007	-
Minimum	38.96	1.208	16.52	0.038	0.80
Maximum	39.71	1.262	16.78	0.047	1.17
Mean	39.45	1.238	16.61	0.043	0.92
Median	39.44	1.243	16.59	0.043	0.94
Precision (Stdev)	0.21	0.014	0.07	0.003	0.09

RMNS CD	Silicate	Phosphate	Nitrate + Nitrite (NOx)	Nitrite	Ammonia
Published RMNS CD (µmol l^{-1}) w/std deviation	14.26 ± 0.009	0.46 ± 0.001	5.65 ± 0.004	0.018 ± 0.001	- -
Minimum	14.27	0.445	5.51	0.031	1.55
Maximum	14.63	0.483	5.64	0.037	2.11
Mean	14.42	0.466	5.52	0.034	1.79
Median	14.39	0.467	5.51	0.033	1.76
Precision (Stdev)	0.16	0.013	0.07	0.003	0.24

RMNS CC	Silicate	Phosphate	Nitrate + Nitrite (NOx)	Nitrite	Ammonia
Published RMNS CC (µmol l^{-1}) w/std deviation	88.23 ±0.49	2.130 ±0.019	31.74 ±0.25	0.119 ±0.006	- -
Minimum	87.85	2.105	31.81	0.134	1.69
Maximum	88.84	2.197	32.18	0.135	1.94
Mean	88.50	2.163	31.81	0.135	1.80
Median	88.82	2.186	32.00	0.135	1.78
Precision (Stdev)	0.56	0.050	0.22	0.001	0.13

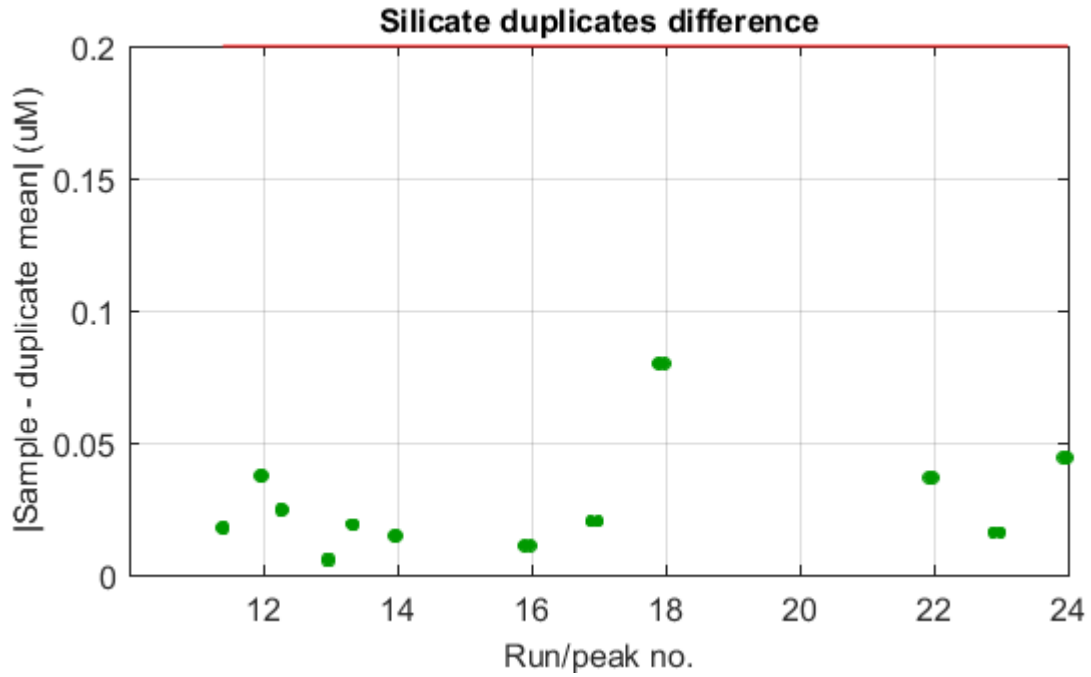
6.7 Sampling Precision

Sampling precision is monitored by assaying duplicate samples collected from the greatest depth for each CTD deployment. The sampling precision is good if the difference between the duplicate concentrations is less than the MDL value. The exception is nitrate+nitrite, which uses 0.06 µM as the MDL boundary.

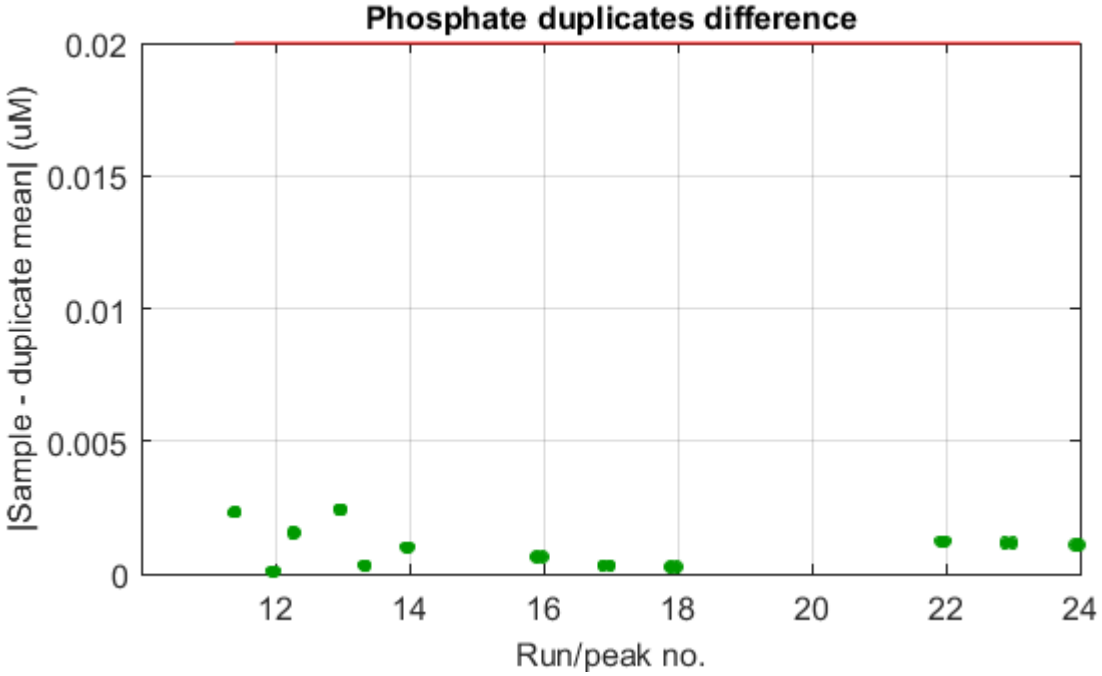
Plots of the difference between the duplicate and their mean for the CTD deployments are below. The red line is the boundary below which sampling precision is deemed good.

For in2018_v06, the sampling precision is good.

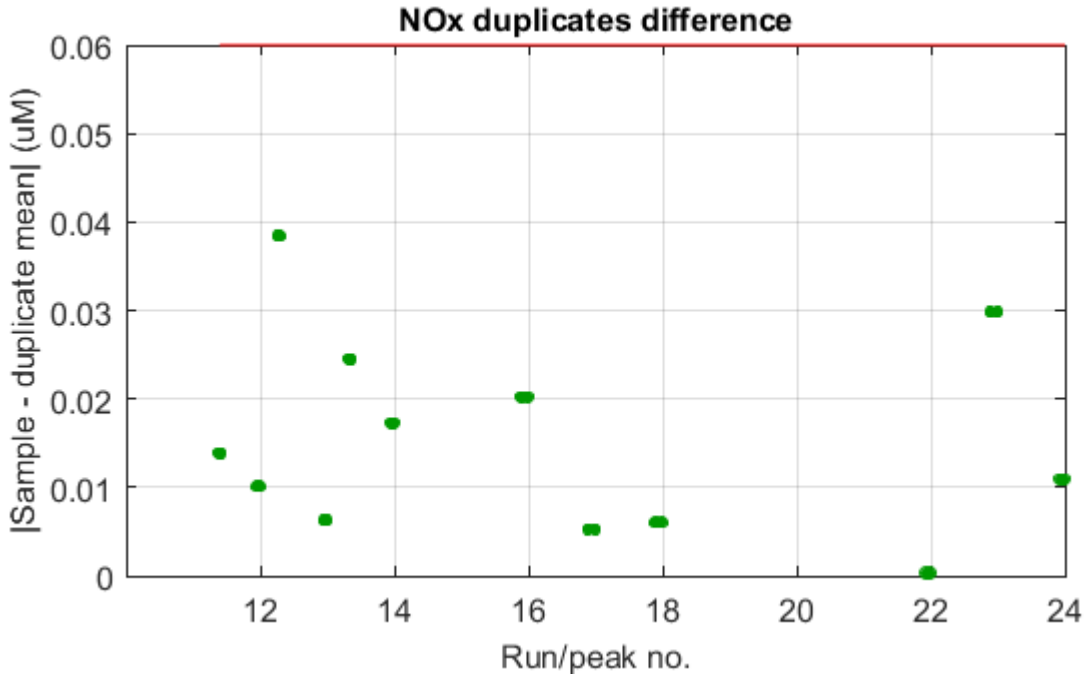
6.7.1 Silicate Duplicates Plot



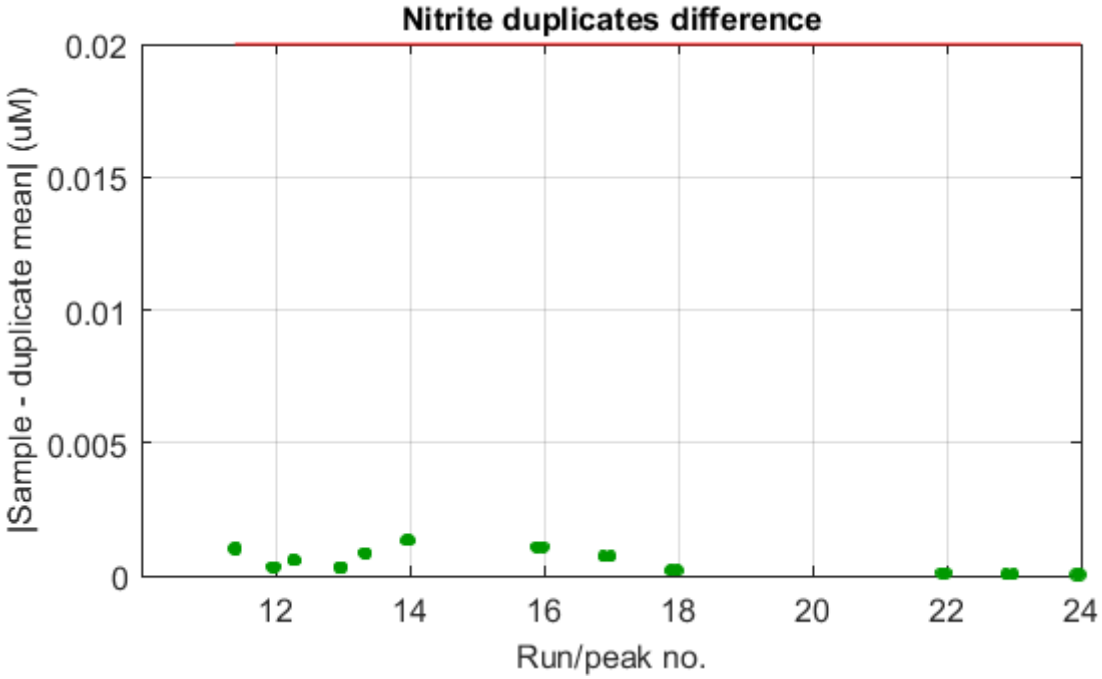
6.7.2 Phosphate Duplicates Plot



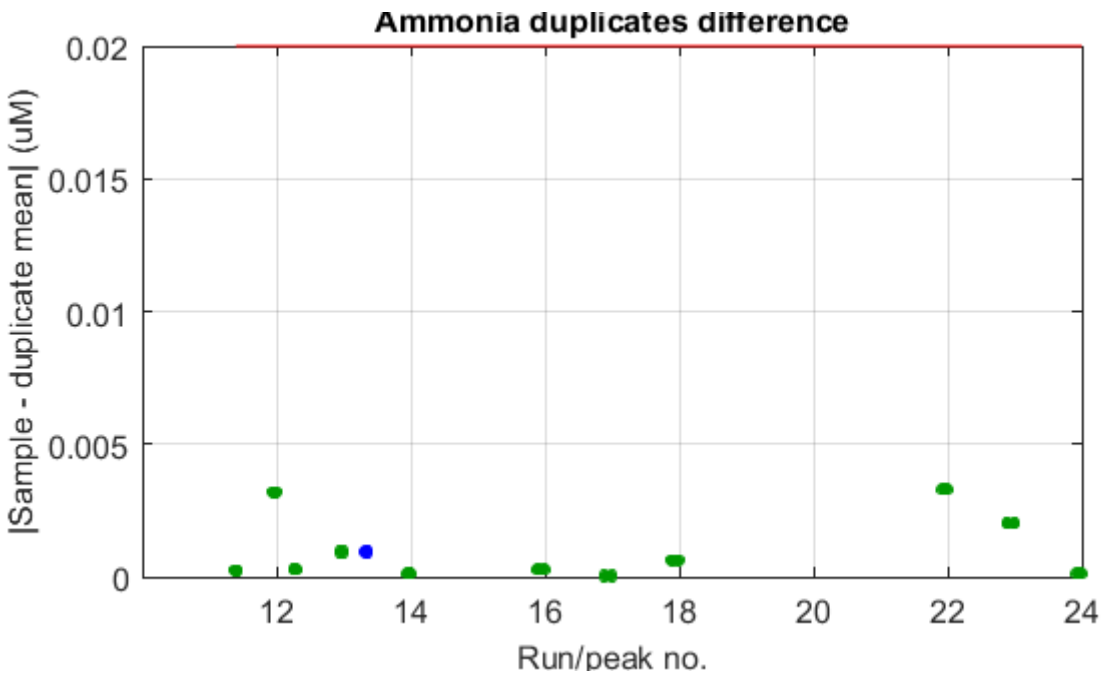
6.7.3 Nitrate + Nitrite (NOx) Duplicates Plot



6.7.4 Nitrite Duplicates Plot

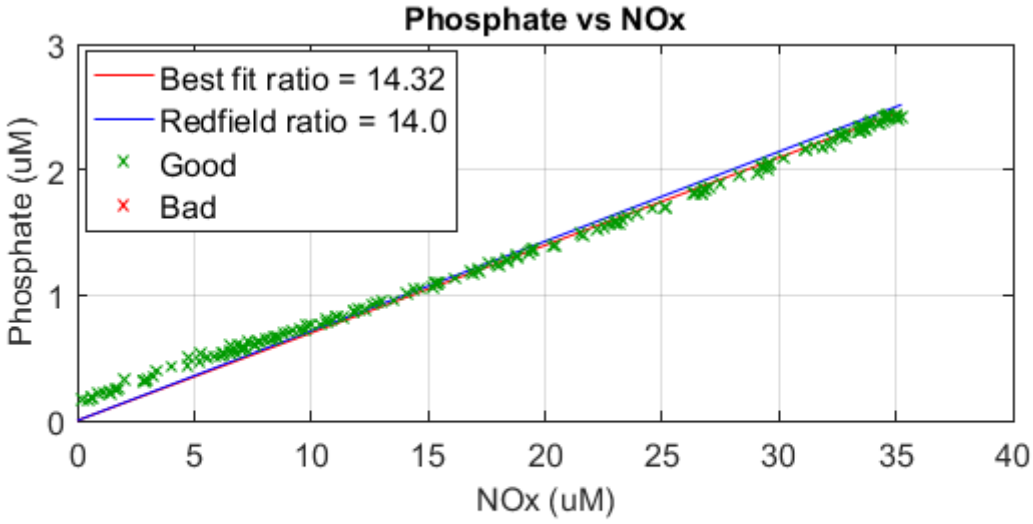


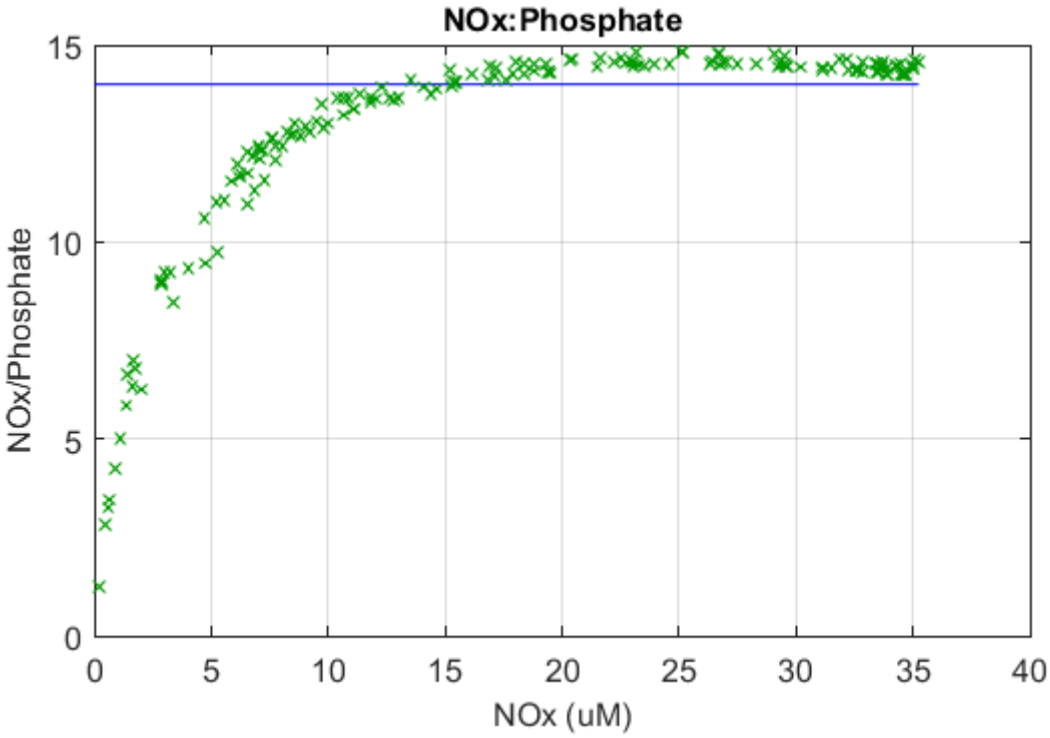
6.7.5 Ammonia Duplicates Plot



6.8 Redfield Ratio Plot (14.0) for CTD Deployments.

Plots consist of phosphate versus NOx for all CTD deployments. Best fit ratio = 14.32





6.9 Missing or Suspect Nutrient Data.

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 to the .csv files. Flag Key in Appendix 7.4.

CTD	RP	Run	Flag	Reason for Flag or Action
5	1, 3, 11	13	133	Uncharacteristic and high values for Ammonia samples, suggesting contamination.
12	4, 8	23	133	Uncharacteristic and high values for Ammonia samples, suggesting contamination.

6.10 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_v06_hyd_voyagereport.docx for this data.

Nutrient samples were placed on the XY3 auto sampler at the average room temperature of 21.35°C. Refer to “in2018_v06_hyd_voyagereport.docx” for room temperature graphs.

The laboratory temperature was measured and recorded on the nutrient run sheets at the start each analysis run. The temperature varied between 20.19 and 23.18°C over the course of the voyage.

7 Appendix

7.1 Salinity: Reference Material Used

Osil IAPSO Standard Seawater	
Batch	P161
Use by date	03/05/2020
K_{15}	0.99987
PSU	35.995

7.2 Nutrients: Flagged Calibration and Quality Control Data

HyPro classifies the quality of data as good, suspect or bad and flags accordingly.

CTD	Peak	Run	Analysis	Reason for Flag or Action
1 & 2	Cal 1	Nut011	NH4	Both points bad, not used in calibration curve.
3 & 4	Cal 4	Nut012	NH4	Both points suspect, less weighting in calibration curve. <70% of calibration peaks are within calibration limits. Cal 2 & 3 suspect less weighting in calibration curve.
5 & 6	Cal 2	Nut013	PO4	1st point suspect, less weighting in calibration curve.
5 & 6	Cal 3	Nut013	NH4	Both points suspect, less weighting in calibration curve.
8	Cal 1 & 6	Nut016	NOx	Ca1 1 & Cal 6 2nd point suspect, less weighting in calibration curve.
9	Cal 1 & 4	Nut017	NH4	Both points are suspect, less weighting in the calibration.

7.3 Nutrients: RMNS results for each Analysis Run & CTD Deployment.

7.3.1 RMNS Lot CJ Results

Analysis Run	CTD #	Silicate	Phosphate	Nitrite	NOx (NO2 + NO3)
CJ certified	-	*39.424*	*1.219*	*0.0320*	*16.621*
1	-	39.703	1.262	0.047	16.724
2	-	39.610	1.258	0.044	16.780
3	-	-	1.243	-	-
4	-	-	1.246	-	-
5	-	-	1.244	-	-
6	-	-	1.251	-	-
7	-	-	1.252	-	-
8	-	-	1.255	-	-
9	-	-	1.245	-	-
10	-	-	1.241	-	-
11	1 & 2	39.396	1.241	0.045	16.564
12	3 & 4	39.533	1.248	0.038	16.572
13	5 & 6	39.424	1.244	0.043	16.593
14	-	39.417	1.243	0.046	16.629
15	7	39.435	1.229	0.043	16.616
16	8	39.399	1.229	0.045	16.521
17	9	38.958	1.220	0.040	16.583
18	-	39.142	1.213	0.043	16.559
19	-	39.648	1.208	0.045	16.544
20	-	39.253	1.222	0.038	16.540
21	10	39.704	1.229	0.043	16.646
22	11	39.563	1.220	0.044	16.675
23	12	39.514	1.220	0.039	16.665

The submitted nutrient results do NOT have RMNS corrections applied.

How to use the RMNS for 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

7.4 Flag Key for Hydrology Data Set

Flag	Description
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.

7.5 GO-SHIP Specifications

7.5.1 Salinity

Accuracy of 0.001 is possible with Autosal™ salinometers and concomitant attention to methodology. 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. A precision of approximately 0.0002 PSS-78 is possible following the methods of Kawano with great care and experience. Air temperature stability of ± 1°C is very important and should be recorded[2].

7.5.2 Dissolved Oxygen

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.

7.5.3 SiO2

Approximately 1-3% accuracy[1], 0.2% precision[3], full scale.

7.5.4 PO4

Approximately 1-2% accuracy[1], 0.4% precision[3], full scale.

7.5.5 NO3

Approximately 1% accuracy[1], 0.2% precision[3], full scale.

7.5.6 Notes

[1] If no absolute standards are available then accuracy should be taken to mean the reproducibility presently obtainable in the better laboratories.

[2] 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 batch is recommended. The bottles should also be used in an interleaving fashion as a consistency check within a batch and between batches.

[3] 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.

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