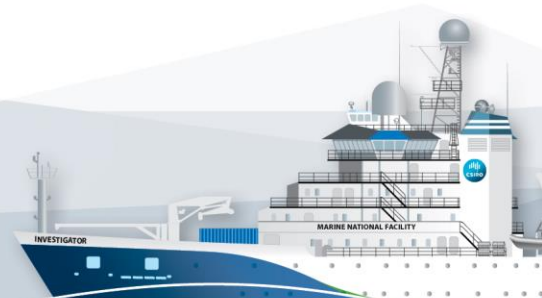


RV INVESTIGATOR

HYDROCHEMISTRY DATA PROCESSING REPORT

Voyage:	IN2023_V01
Chief Scientist:	Alix Post
Voyage title:	Canyons: Antarctic Bottom Water Production in the past: Records from marine sediments, Cape Darnley, East Antarctica
Report compiled by:	Peter Hughes & Alicia Camac



Contents

1	Executive Summary	4
2	Itinerary	5
3	Key personnel list	5
4	Summary.....	6
4.1	Sample Type and Number Assayed.....	6
4.1.1	CTD Samples (Conductivity, Temperature, Density).....	6
4.1.2	TSG Samples (Thermosalinograph).....	6
4.1.3	UWY (Underway)	6
4.2	Data Processing Overview	7
5	Salinity	8
5.1	Salinity Measurement Parameters	8
5.2	Salinity Method.....	8
5.3	CTD Salinity vs Bottle Salinity Plot	8
6	Dissolved Oxygen.....	9
6.1	Dissolved Oxygen Measurement Parameters.....	9
6.2	Dissolved Oxygen Method	9
6.3	CTD Dissolved Oxygen vs Bottle Dissolved Oxygen Plot	10
6.4	Dissolved Oxygen Instrument titrant: thiosulphate normality and blank correction.....	10
7	Nutrients.....	11
7.1	Nutrient Measurement Parameters	11
7.2	Nutrient Methods	11
7.3	HyPro Processing Summary for Nutrients	12
7.4	Accuracy - Reference Material for Nutrient in Seawater (RMNS)	13
7.5	Reference material nutrients seawater (RMNS) plots.....	14
7.5.1	Figure 6: Silicate RMNS Plot ($\mu\text{mol L}^{-1}$).....	14
7.5.2	Figure 7: Phosphate RMNS Plot ($\mu\text{mol L}^{-1}$).....	15
7.5.3	Figure 8: Nitrite RMNS Plot ($\mu\text{mol L}^{-1}$).....	15
7.5.4	Figure 9: Nitrate + Nitrite (NOx) RMNS Plot ($\mu\text{mol L}^{-1}$)	16
7.6	Estimated Measurement Uncertainty	16
7.7	Precision.....	16
7.8	Redfield Ratio Plot for CTD Deployments	17
7.9	Temperature & Humidity Change over Nutrient Analyses	17
8	Appendix.....	18
8.1	Salinity: Reference Material Used.....	18

8.2	Nutrients: Reference Material Used	18
8.2.1	RMNS certified concentrations \pm expanded uncertainty (U) at 21°C.	18
8.2.2	RMNS Lot CP Results per CTD Deployment	18
8.2.3	RMNS Lot CG Results per CTD Deployment.....	18
8.3	Missing or Suspect Salinity Data	19
8.4	Missing or Suspect Dissolved Oxygen Data	19
8.5	Missing or Suspect Nutrient Data.	19
8.6	Data Quality Flag Key	19
9	References	20

1 Executive Summary

This voyage has two main scientific objectives (1) to understand past changes in Antarctic Bottom Water (AABW) and (2) to develop an improved bathymetry model to support oceanographic modelling of AABW pathways. To this end, the science party will recover long sediment cores from the shelf and slope off Cape Darnley to provide palaeoceanographic records over multiple glacial-interglacial cycles. The core's sedimentological, geochemical, and biological proxies will provide evidence of the nature and timing of past changes in AABW formation, and associated variations in meltwater input, and the extent of the Cape Darnley polynya. The science party will also investigate the presence and distribution of hydrocorals associated with AABW, and, if present, analyse their carbonate skeletons to understand past water mass variability over recent centuries, complementing the sediment core records.

After 4 days in the survey area, the vessel returned to Australia for medical reasons thus the initial scientific objectives were not completed.

Water column and underway samples collected during the voyage were analysed in the ship's hydrochemistry laboratory for dissolved oxygen (DO), salinity and, nutrients (silicate, phosphate, nitrate + nitrite (NO_x), nitrite and ammonium).

Overall, the quality of IN2023_V01 hydrology data is good. The measured nutrient reference materials (RMNS) were within 2% of their values. The bottle salinities and dissolved oxygen results were mostly within 0.004 PSU and 12 µmol L⁻¹ respectively of the unprocessed CTD measurements.

CTD deployment versus measured RMNS values are listed in Appendix 8.2

Missing and suspect hydrology data are listed in Appendix 8.3 on.

Please cite the following manuscript when reporting or publishing data for silicate, phosphate, nitrate+nitrite (NO_x) and nitrite:

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, 17(1): pp. 25-41.

doi:10.1002/lom3.10294

If publishing ammonium data, please cite the following:

Rees, C., Janssens, J., Sherrin, K., Hughes, P., Tibben, S., McMahon, M., McDonald, J., Camac, A., Schwanger, C. and Marouchos, A., (2021) "Method for Reproducible Shipboard Segmented Flow Analysis Ammonium Measurement Using an In-House Reference Material for Quality Control."

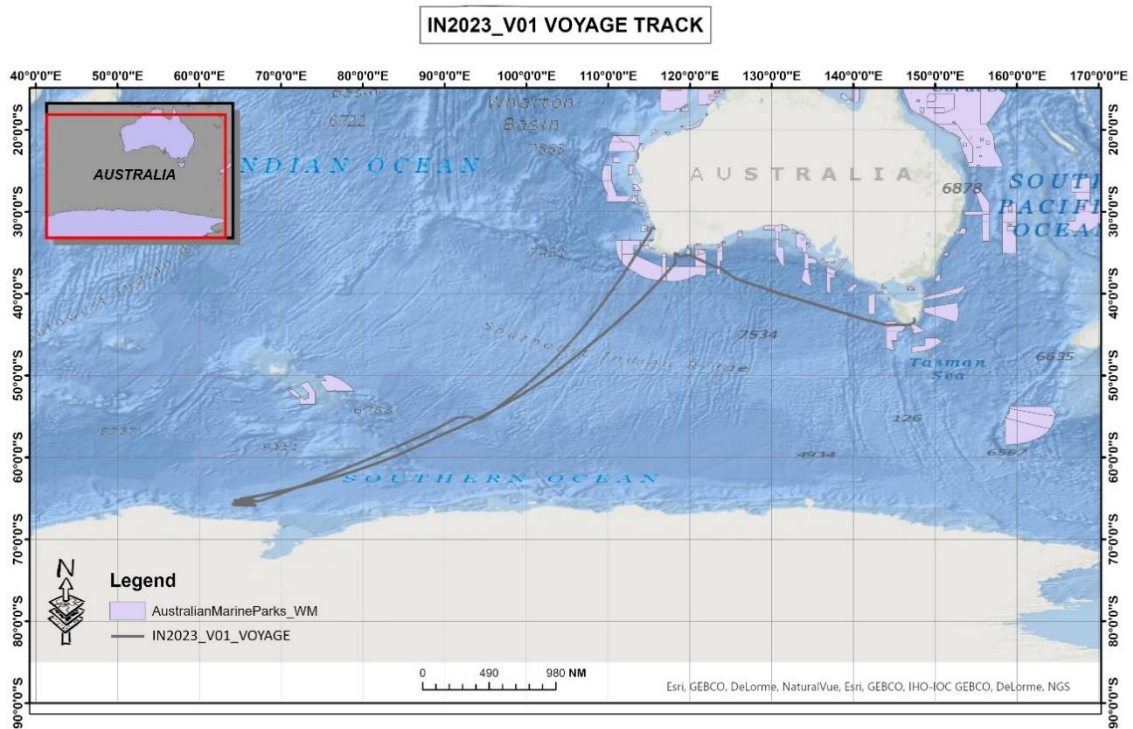
Frontiers in Marine Science, 8.

doi:10.3389/fmars.2021.581901

Final hydrology data, analytical methods, related log sheets and processing notes can be obtained from the CSIRO data centre. Please contact NCMI_DataLibrarians@csiro.au

2 Itinerary

Henderson (W.A.) to Hobart, January 25th, 2023 – March 2nd, 2023.



3 Key personnel list

Table 1: Key Personnel list

Name	Role	Organisation
Alix Post	Chief Scientist	Geoscience Australia
Claire Grubb	Voyage Manager	CSIRO
Alicia Camac	Hydrochemist	CSIRO
Dawn Herweynen	Hydrochemist (Trainee)	CSIRO
Peter Hughes	Hydrochemist	CSIRO

4 Summary

4.1 Sample Type and Number Assayed

Table 2: **Sample Type and Number Assayed**

Analysis	Samples Assayed	Type
Salinity	94	CTD
	17	TSG
Dissolved Oxygen	107	CTD
Nutrients	107	CTD
	45	UWY

4.1.1 CTD Samples (Conductivity, Temperature, Density)

- Taken from the 12L Ocean Test Equipment bottles on the 36-bottle rosette that is deployed at depth for water collection.
- 7 CTD deployments in total, 6 deployments sampled by:
 - Hydrochemistry team: Alicia/ Peter & Dawn, with help from.
 - Science party: Sienna/ Matt & Molly

4.1.2 TSG Samples (Thermosalinograph)

- Taken from the underway instrument clean seawater line supplying the pCO₂ instrument in the underway laboratory.
- TSG samples collected by the hydrochemistry team. Results and elog emailed to Vito Dirita (CSIRO) during the transit back to port.

4.1.3 UWY (Underway)

- Taken from the same sampling point as per the TSG samples.
- Triplicate nutrient samples were collected in 10mL tubes by the science party. Samples stored frozen (- 18 °C) in the Hydrochemistry lab until analysis. 37 samples assayed in duplicate during the voyage. The remainder assayed at CSIRO Hobart post voyage. Results to Taryn Noble (UTAS) and Layla Creach (UTAS).

4.2 Data Processing Overview

All hydrochemistry data is processed using CSIRO's program HyPro as per the schematic below (fig.2).

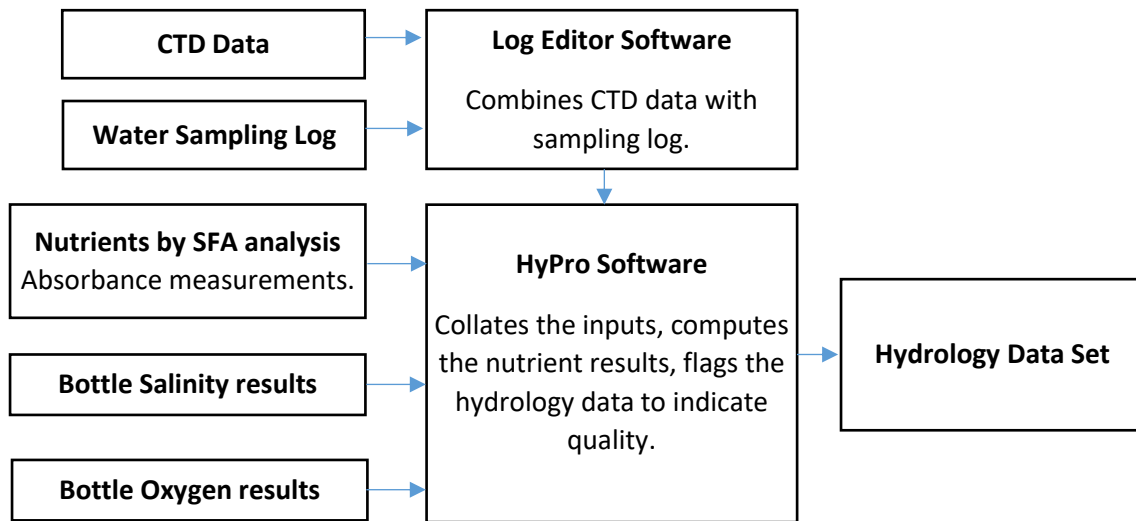


Figure 2: Hydrology Data Processing Schematic.

5 Salinity

5.1 Salinity Measurement Parameters

Table 3: Salinity Measurement Parameters

Details	
Processing Software	CSIRO HyPro 5.7
Instrument	Guildline Autosal Laboratory Salinometer 8400(B) – SN 72151 Bath temperature 24.0°C
Instrument Software	Ocean Scientific International Ltd (OSIL) Data Logger ver 1.2
Hydrochemistry Methods.	Sampling: WI_Sal_002 Measurement: SOP006
Accuracy	± 0.001 practical salinity units
Reference Material	OSIL IAPSO - Batch P164, use by 23/03/2023, $K_{15} = 0.99985$
Sample Container	200 ml volume OSIL bottles made of type II glass (clear) with disposable plastic insert and plastic screw cap.
Sample Storage	Stored in salinometer lab > 8 hrs before measurement.
Lab Temperature	Mean 21.3°C SD 0.7
Samplers	Hydrochemistry and Science Party
Analysts	Hydrochemistry: Peter, Alicia, Dawn.
Comments	Good agreement between bottle results and unprocessed CTD data. Deployment7 depth 4198 dbar niskin not sampled due to operator error.

5.2 Salinity Method

Salinity samples were measured on a Guildline Autosal 8400B instrument operated in accordance with its technical manual. The measured value is recorded with an OSIL data logger.

The Autosal is calibrated with standard seawater (OSIL, IAPSO) of known K_{15} ratio. The frequency of calibration is at least once per shift or for every 36 samples measured.

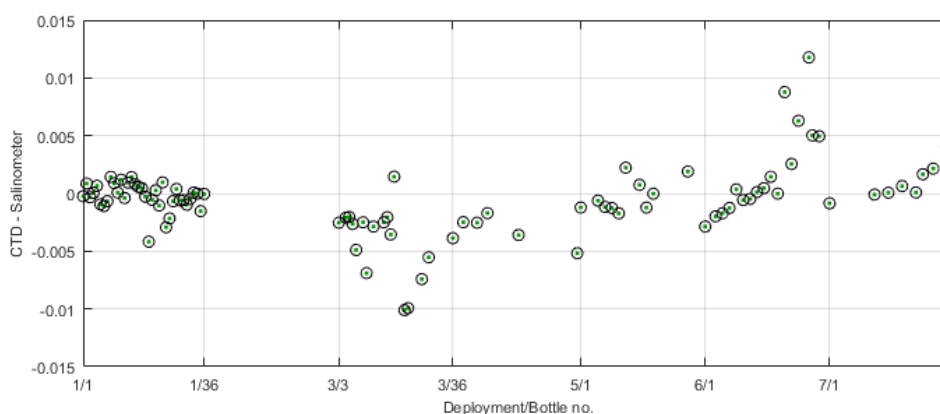
Method: The sample is collected in a 200ml OSIL bottle. The bottle is rinsed three times with the sample, then filled from the bottom, via a polytetrafluoroethylene (PTFE) straw, till overflowing. The bottle is removed from the straw and the sample is decanted to allow a headspace of approximately 25cm³. A dry 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. The OSIL data logger records the measurements and calculates the practical salinity.

5.3 CTD Salinity vs Bottle Salinity Plot

For IN2023_V01, the difference between the unprocessed CTD salinity and the measured bottle salinity is generally less than 0.004 PSU. Deployment 3 RP 32 salinity is not included in this plot as the CTD result is suspect. (Bottle = 33.934, CTD = 33.886, PSU).

Missing and suspect salinity data are listed in Appendix 8.4.

Figure 3: CTD Salinity - Bottle Salinity vs CTD deployment plot.



Legend Salinity Samples: bottle = dot, CTD (unprocessed) = circle.

6 Dissolved Oxygen

6.1 Dissolved Oxygen Measurement Parameters

Table 4: Dissolved oxygen measurement parameters.

Details	
Processing Software	CSIRO HyPro 5.7
Instrument	Scripps Automated Photometric Oxygen System (SIO)
Instrument Software	LVO2 ver 2.36 Scripps Institution of Oceanography (SIO)
Hydrochemistry Methods.	Sampling: WI_DO_001 Assay: SOP005
Accuracy	$\pm 0.5 \mu\text{mol L}^{-1}$
Reference Material	None. Titrant standardisation: In-house potassium iodate standard solution.
Sample Container	140 mL glass iodine determination flasks with glass stopper.
Sample Storage	Stored in hydrochemistry lab until analysis.
Lab Temperature	Mean 19.4°C SD 0.6
Samplers	Hydrochemistry and Science Party
Analysts	Hydrochemistry: Peter, Dawn.
Comments	Good agreement between bottle samples and unprocessed CTD results. Two samples flagged suspect/ bad. Deployment7 depth 4198 dbar niskin not sampled due to operator error.

6.2 Dissolved Oxygen Method

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

Method: The sample is collected in an iodine determination flask of known volume. 1mL of manganese (II) chloride solution followed by 1 mL of alkaline iodide solution is added to the sample, the flask

stopped, inverted a minimum of 15 times and stored in the lab until titration. To titrate, the sample is acidified, and the liberating iodine is titrated immediately with a standardised thiosulphate solution. The endpoint is determined by measuring the UV transmittance at 365 nm.

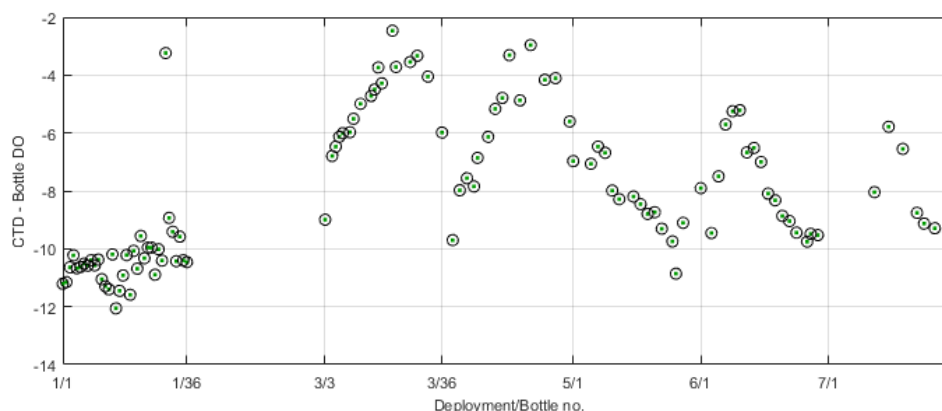
The thiosulphate solution is standardised with a 10ml aliquot of potassium iodate primary standard made in-house. A blank correction is also determined from the difference between two titres of consecutive additions of 1 mL aliquots of potassium iodate to the same blank sample. The standardisation is done at least once per 12-hour shift when samples are being assayed.

6.3 CTD Dissolved Oxygen vs Bottle Dissolved Oxygen Plot

For IN2023_V01, the difference between the unprocessed CTD dissolved oxygen and the measured bottle dissolved oxygen is generally less than $12 \mu\text{mol L}^{-1}$. Deployment 7 RP 1 dissolved oxygen is not included in this plot as the bottle result is suspect (Bottle = 118, CTD = 204, $\mu\text{mol L}^{-1}$).

Missing and suspect dissolved oxygen data are listed in Appendix 8.5.

Figure 4. CTD Dissolved Oxygen - Bottle Dissolved Oxygen vs Deployment Plot.



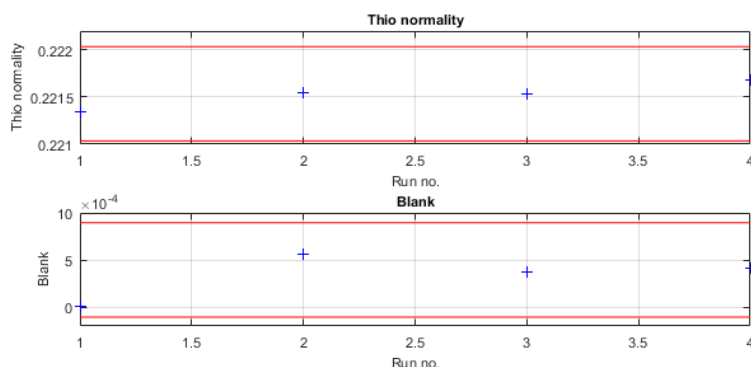
Legend Dissolved Oxygen Samples: bottle = dot, CTD (unprocessed) = circle.

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

The difference in thiosulphate concentration complies with our QC parameter of less than 0.0005N between standardisations.

The blank correction (in mL) is subtracted from the thiosulphate titre used in the calculation of the thiosulphate normality.

Figure 5. Thiosulphate standardisation and blank correction plots.



7 Nutrients

7.1 Nutrient Measurement Parameters

Table 5: Nutrient measurement parameters. All instrument parameters, reagent batches and instrument events are logged for each analysis run. This information is available on request.

Details					
Processing Software	CSIRO HyPro 5.7				
Instrument	Seal AA3HR segmented flow analyser.				
Instrument Software	AACE 7.10				
Hydrochemistry. Methods					
• Sampling	WI_Nut_001				
• Assay	SOP001	SOP002	SOP003	SOP004	SOP005
	Silicate	Phosphate	NOx *	Nitrite	Ammonia
• Top range, $\mu\text{mol L}^{-1}$	140	3.0	42	1.4	2.0
• Reporting limit, $\mu\text{mol L}^{-1}$	0.2	0.02	0.02	0.02	0.02
Reference Material	KANSO RMNS lot CG, CP				
Sample Container	50 mL HDPE with screw cap lids. Reused after acid wash with 1M HCl				
Sample Storage	Samples assayed within 4 hrs at room temperature, or 24 hrs refrigerated (4°C)				
Sample preparation	Assayed neat. No filtration.				
Lab Temperature (°C)	Mean 19.4°C SD 0.6				
Samplers	Hydrochemistry and Science Team				
Analysts	Hydrochemistry: Alicia, Peter, Dawn				
Comments	Data Good. RMNS results within 2% of their reference values. Deployment7 depth 4198 dbar niskin not sampled due to operator error.				

* NOx = nitrate + nitrite

7.2 Nutrient Methods

Nutrient samples are assayed on a Seal AA3HR segmented flow auto-analyser coupled with a JASCO FP2020 fluorescence instrument for the measurement of ammonia.

Silicate (SOP001). Based on Armstrong et al. (1967). Acidified ammonium molybdate is added to a seawater sample to produce silicomolybdic acid which is reduced to a blue silicomolybdenum complex following the addition of stannous chloride. The sample is passed through a 10mm flowcell and absorbance measured at 660nm.

Ortho-phosphate (SOP002). Based on Murphy and Riley (1962) with modifications from the NIOZ-SGNOS¹ Practical Workshop 2012. Acidified ammonium molybdate is added to a seawater sample to produce phosphomolybdic acid which is then reduced to a blue phosphomolybdenum complex

following the addition of ascorbic acid. The sample is passed through a 10mm flowcell and absorbance measured at 820nm.

Nitrate (SOP003). Based on Armstrong et.al (1967). A pH buffered seawater sample is passed through a cadmium column where nitrate is reduced to nitrite. Nitrite is then diazotized with sulphanilamide and coupled with N-(1-naphthyl)-ethylenediamine to form a red dye. The sample is passed through a 10mm flowcell and absorbance measured at 540nm.

Nitrite (SOP003). As per nitrate method without the buffer nor cadmium column.

Ammonium (SOP004). Based on K  rouel and Aminot (1997). The sample is combined with a working reagent made up of ortho-phthalaldehyde (OPA), sodium sulphite and borate buffer. Fluorescence proportional to the ammonium concentration is measured at 460nm following excitation at 370nm.

7.3 HyPro Processing Summary for Nutrients

The raw absorbance/ fluorescence data is exported from the instrument and processed by HyPro. With this, HyPro re-creates the peak traces, defines the region on the peak's plateau to determine their peak heights, fits the calibration curve, applies corrections for carry-over, baseline and sensitivity drifts then, derives the nutrient concentrations for each sample. The corrections are quantified by measuring dedicated solutions included in every analysis run.

In addition, HyPro applies quality control criteria identifying suspect absorbance peak shapes, calibration outliers, RMNS outliers and duplicate results that do not match, then, flags the data accordingly. For calibration curve fitting, the data points are outliers if they are offset from the fitted curve more than:

- $\pm 0.5\%$ of the concentration of the top standard for silicate and nitrate+nitrite (as per WOCE¹).
- $0.02\mu\text{mol}^{-1}$ for phosphate, nitrite and ammonium.

¹ World Ocean Circulation Experiment

Table 6: HyPro Processing Parameters. All instrument parameters and reagent batches and operation events are logged for each analysis run. This information is available on request.

HyPro Processing Settings					
Absorbance Peak heights	Determined by HyPro				
Absorbance Corrections	Carry-Over, Baseline Drift, Sensitivity Drift				
Calibration Curve	Silicate	Phosphate	Nitrate + Nitrite	Nitrite	Ammonia
• Fit	Linear	Linear	Linear	Linear	Quadratic
• Number of points	7	6	7	6	6
• Forced through zero	No				
RMNS Corrections	Nutrient concentrations are not adjusted to correct for the measured RMNS bias. Per CTD deployment RMNS results tabulated in appendix 8.2.				
Reporting Units	$\mu\text{mol L}^{-1}$				
Medium of Standards	Low nutrient seawater (LNSW, 1000L stored on deck of Investigator) collected Jun 2021. Filtered (-5um) Oct 2022 then stored in 20 L carboys in the ship's clean dry laboratory at 22°C.				
Medium of Baseline	18.2 Ω water. Dispensed from the Milli Q IQ 7010.				
Duplicate samples.	CTD: Niskin fired at the greatest depth sampled in duplicate. Single samples collected for remaining depths.				
Comments	Data Quality: Good. RMNS results within 2% of their reference values. Deployment7 depth 4198 dbar niskin not sampled due to operator error.				

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

Japanese KANSO certified RMNS lot assayed in triplicate in each run to monitor accuracy. The certified values are in Table 7.

For IN2023_V01, the certified reference material results for NO_x and silicate are within 2%, phosphate is within 3% and nitrite within 0.06 $\mu\text{mol L}^{-1}$ of their certified mean concentration. The GO-SHIP criteria (Becker *et al.*, 2019) specifies using 1-3 % of full scale (depending on the nutrient) as acceptable limits of accuracy. The assayed RMNS values per CTD deployments are listed in the appendix 8.3.

Table 7: RMNS certified concentrations \pm expanded uncertainty (U) at 21°C. Units: $\mu\text{mol L}^{-1}$

RMNS	Silicate (Si(OH) ₄) ($\mu\text{mol L}^{-1}$)	Phosphate (PO ₄) ($\mu\text{mol L}^{-1}$)	Nitrite (NO ₂) ($\mu\text{mol L}^{-1}$)	Nitrate (NO ₃) ($\mu\text{mol L}^{-1}$)	NO ₃ + NO ₂ (NO _x) ($\mu\text{mol L}^{-1}$)
Lot CP	62.6 \pm 0.3	1.795 \pm 0.018	0.32 \pm 0.07	25.4 \pm 0.31	25.72 \pm 0.38
Lot CG	57.7 \pm 0.5	1.740 \pm 0.02	0.061 \pm 0.03	24.27 \pm 0.21	24.33 \pm 0.24

KANSO publishes the RMNS nutrient values in $\mu\text{mol kg}^{-1}$. These are converted to $\mu\text{mol L}^{-1}$ at 21°C. The RMNS is not certified for ammonium. NO_x is derived by summing the NO₃ and NO₂ values.

Table 8: RMNS CP statistics for of this voyage. **BQC** = in-house CSIRO reference seawater.

Units: $\mu\text{mol L}^{-1}$

RMNS CP	Silicate (Si(OH)_4)	Phosphate (PO_4)	Nitrite (NO_2)	$\text{NO}_3 + \text{NO}_2$ (NO_x)	Ammonia (NH_4) (BQC)
Minimum	62.4	1.78	0.320	25.39	1.09
Maximum	63.6	1.84	0.337	26.10	1.15
Mean	62.7	1.81	0.327	25.72	1.12
Median	62.8	1.81	0.327	25.76	1.12
Repeatability	0.08	0.016	0.004	0.06	0.02

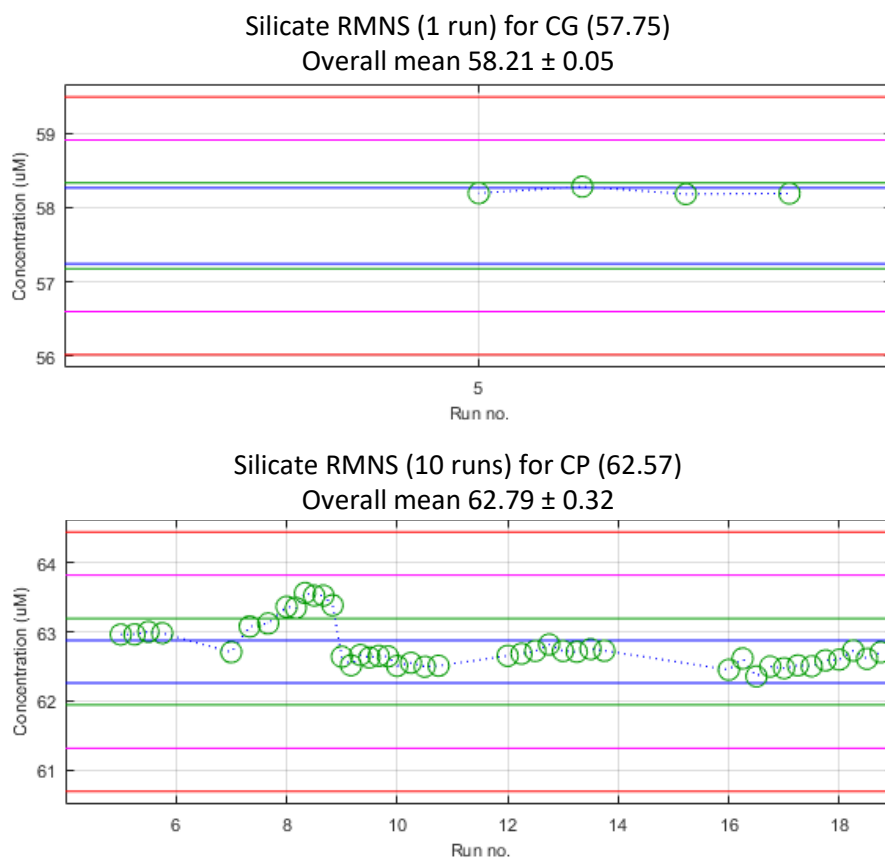
7.5 Reference material nutrients seawater (RMNS) plots

An RMNS sample is measured in all nutrient analysis runs for quality control (QC). Their results for each run are plotted below.

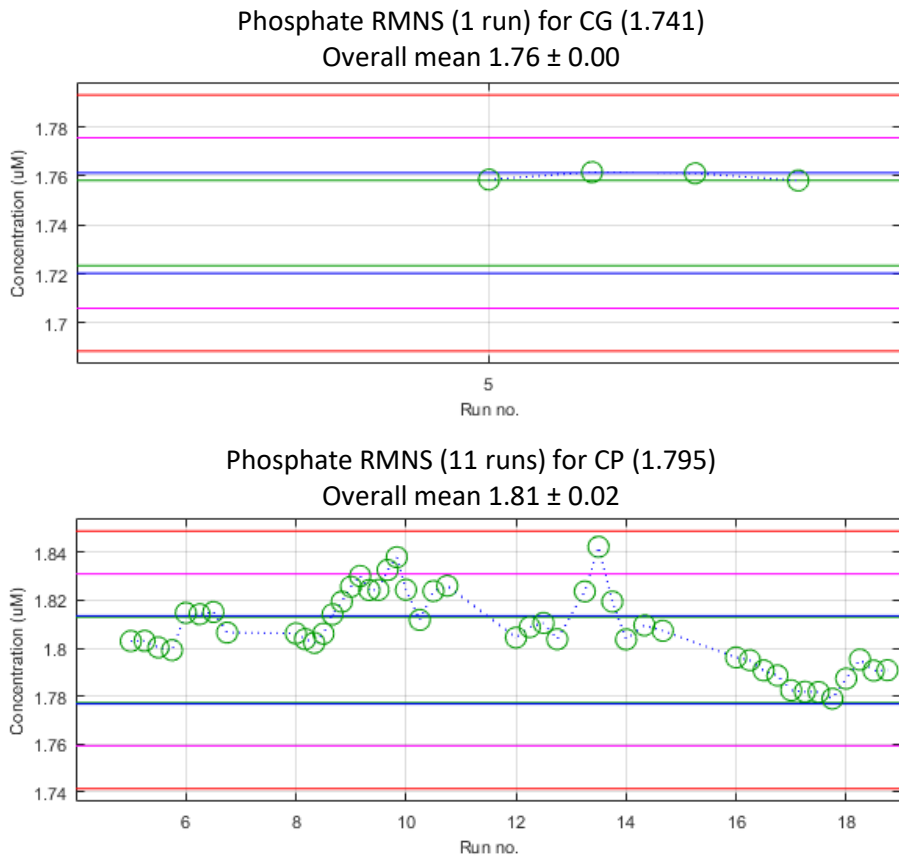
Contours as a percentage from the RMNS certified value.

- 1 %
- 2 %
- 3 %
- RMNS expanded uncertainty

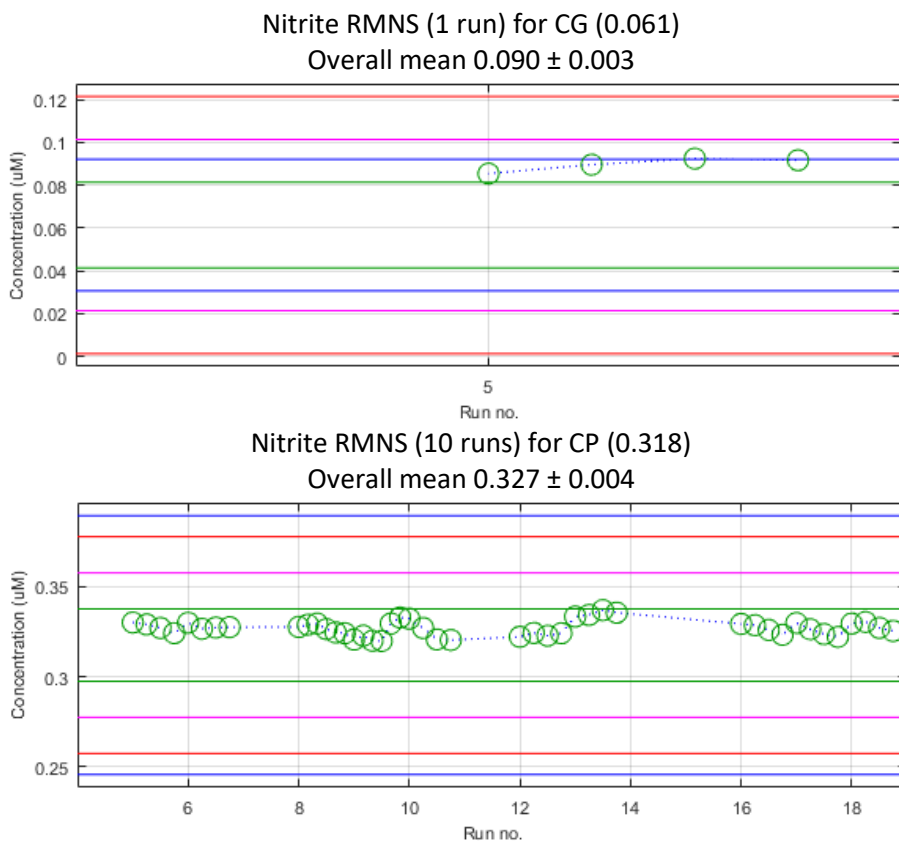
7.5.1 Figure 6: Silicate RMNS Plot ($\mu\text{mol L}^{-1}$)



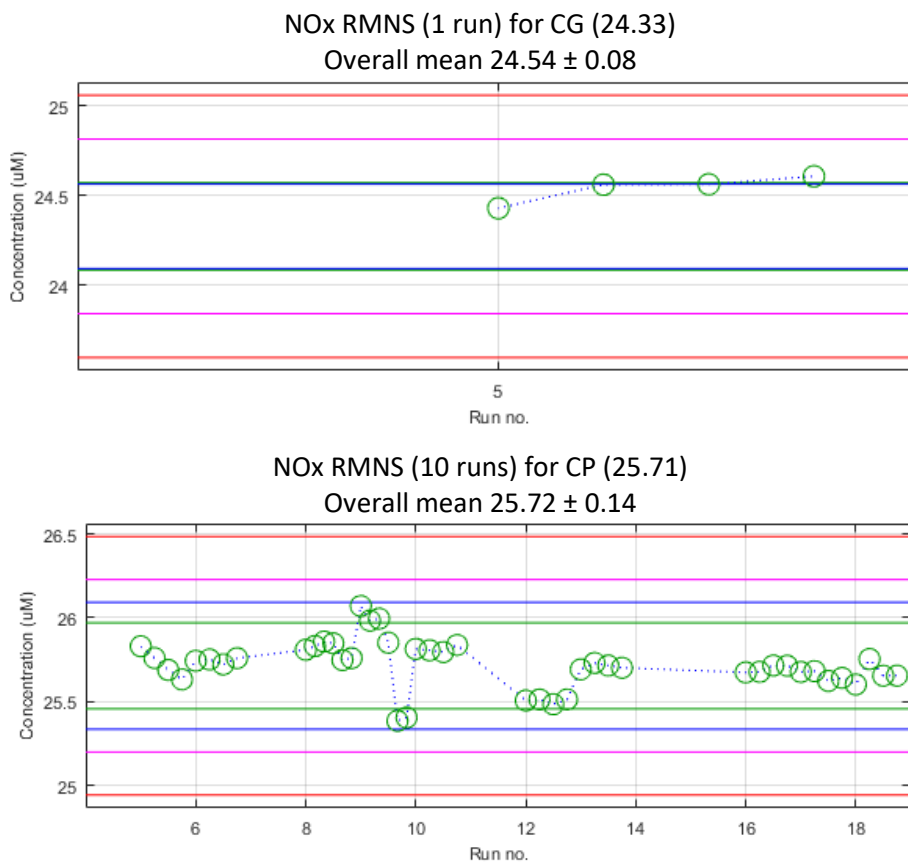
7.5.2 Figure 7: Phosphate RMNS Plot ($\mu\text{mol L}^{-1}$)



7.5.3 Figure 8: Nitrite RMNS Plot ($\mu\text{mol L}^{-1}$)



7.5.4 Figure 9: Nitrate + Nitrite (NOx) RMNS Plot ($\mu\text{mol L}^{-1}$)



7.6 Estimated 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).

Table 9: CSIRO Hydrochemistry nutrient analysis uncertainty values. Units: $\mu\text{mol L}^{-1}$

Calculated Measurement Uncertainty @ $1 \mu\text{mol L}^{-1}$				
Silicate	Phosphate	Nitrite	Nitrate + Nitrite (NOx)	Ammonia
± 0.017	± 0.024	± 0.14	± 0.019	$\pm 0.30^{\text{‡}}$

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.

7.7 Precision

The overall precision for this voyage is GOOD.

Initial overall precision is determined with the first CTD deployment where all bottles are fired at 1000 dBar depth and sampled for hydrochemistry (see Table 10). Note, there were multiple samplers from the science party for the test CTD thus potential for slight variations in the data due to their inexperience.

For nutrients, the precision is good if the difference from the mean of duplicate measurements is less than the nominal method detection limit. The exception: NO_x (nitrate+nitrite) which uses the limit 0.06 μmol L⁻¹. Duplicate samples that exceed this limit are flagged 69 (suspect).

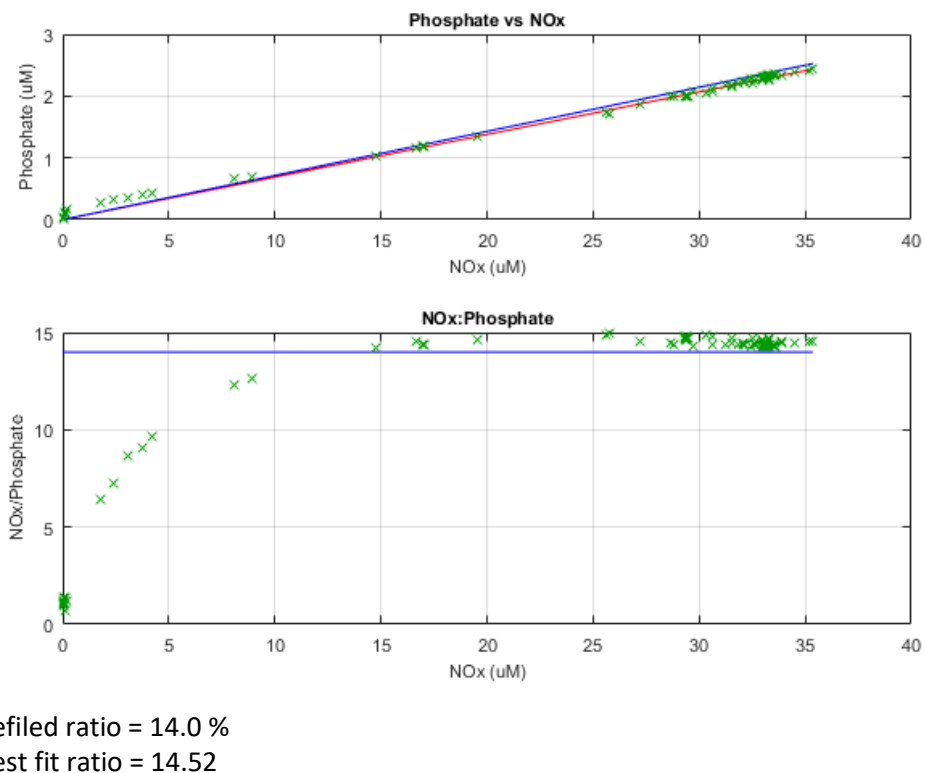
Table 10: CTD deployment 1. 36 bottles at 1000 dbar. Units: μmol L⁻¹

	Salinity (PSU)	Dissolved Oxygen	Silicate (Si(OH) ₄)	Phosphate (PO ₄)	Nitrite (NO ₂)	NO ₃ + NO ₂ (NO _x)
Minimum	34.3164	222.2	23.7	1.99	0.009	29.30
Maximum	34.3212	225.0	23.8	2.01	0.018	29.42
Mean	34.3173	223.5	23.75	2.00	0.014	26.35
SD	0.0010	0.5	0.05	0.005	0.003	0.03

7.8 Redfield Ratio Plot for CTD Deployments.

For IN2023_V01, the best fit Redfield ratio = 14.52

Figure 10. Redfield ratio plots.



7.9 Temperature & Humidity Change over Nutrient Analyses

The ambient conditions in the hydrochemistry laboratory and within the AA3HR instrument were measured and logged as follows:

- (1) Above the AA3HR instrument, temperature only. Mean 19.4°C SD 0.6
- (2) On the deck of the nitrate & nitrite AA3HR chemistry module, temperature and humidity. Data on request.
- (3) On the outboard bulkhead, Temperature, humidity and pressure. Data on request.

8 Appendix

8.1 Salinity: Reference Material Used

OSIL IAPSO Standard Seawater	
Batch:	P164
Use by date:	23/03/2023
K ₁₅ :	0.99985
PSU:	34.994

8.2 Nutrients: Reference Material Used

8.2.1 RMNS certified concentrations ± expanded uncertainty (U) at 21°C.

RMNS	Silicate (Si(OH) ₄) (μmol L ⁻¹)	Phosphate (PO ₄) (μmol L ⁻¹)	Nitrite (NO ₂) (μmol L ⁻¹)	Nitrate (NO ₃) (μmol L ⁻¹)	NO ₃ + NO ₂ (NO _x) (μmol L ⁻¹)
Lot CP	62.6 ± 0.3	1.795 ± 0.018	0.32 ± 0.07	25.4 ± 0.31	25.72 ± 0.38
Lot CG	57.7 ± 0.5	1.740 ± 0.02	0.061 ± 0.03	24.27 ± 0.21	24.33 ± 0.24

8.2.2 RMNS Lot CP Results per CTD Deployment

CTD Deployment	Silicate (Si(OH) ₄) (μmol L ⁻¹)	Phosphate (PO ₄) (μmol L ⁻¹)	NO _x (NO ₂ + NO ₃) (μmol L ⁻¹)	Nitrite (NO ₂) (μmol L ⁻¹)
1	62.9	1.81	25.73	0.328
3	62.6	1.82	25.82	0.325
4	62.7	1.81	25.51	0.323
5	62.6	1.79	25.71	0.327
6	62.5	1.78	25.71	0.325
7	62.7	1.79	25.68	0.328

8.2.3 RMNS Lot CG Results per CTD Deployment

CTD Deployment	Silicate (Si(OH) ₄) (μmol L ⁻¹)	Phosphate (PO ₄) (μmol L ⁻¹)	NO _x (NO ₂ + NO ₃) (μmol L ⁻¹)	Nitrite (NO ₂) (μmol L ⁻¹)
5	58.2	1.76	24.50	0.090

The published nutrient results do NOT have RMNS corrections applied.

8.3 Missing or Suspect Salinity Data

CTD	RP	Flag	Reason for Flag
3	14	141	No Result. Sample not collected from niskin (depth = 601 dBar). Niskin Leaking.
4	13,15,17,22,25,29,32	141	No Result. Sample not collected from niskin. Reason unknown.
7	9	141	No Result. Sample not collected from niskin (depth = 4198 dBar). Operator error.

8.4 Missing or Suspect Dissolved Oxygen Data

CTD	RP	Flag	Reason for Flag
3	14	141	No Result. Sample not collected from niskin (depth = 601 dBar). Niskin Leaking.
6	4	133	Result not reported. Instrument error. Sample titrated, endpoint not well defined.
7	1	69	Result suspect. Outlier on depth profile when compared with the CTD dissolved oxygen results. Cause unknown.
7	9	141	No Result. Sample not collected from niskin (depth = 4198 dBar). Operator error.

8.5 Missing or Suspect Nutrient Data.

Not listed, data flagged 63 (below detection limit).

CTD	RP	Analyte	Flag	Reason for Flag
3	14	All	141	No Result. Sample not collected from niskin (depth = 601 dBar). Niskin Leaking.
7	9	All	141	No Results. Sample not collected from niskin (depth = 4198 dBar). Operator error.

8.6 Data Quality Flag Key

Flag	Description
0	Data is GOOD
63	Nutrients only Data below nominal detection limit.
69	Data is SUSPECT Duplicate data is outside of set limits (software). Data point is an outlier on the depth profile plot (operator). Tagged by software or operator
133	Data is BAD Set by operator. Not reported in final data set.
141	NO Data Used in netcdf results file only.

9 References

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