RV *Investigator* Voyage Plan

VOYAGE #:	IN2023_V04
Version Number:	FINAL
Voyage title:	International nutrient inter-comparison study in the Southern Ocean: quantifying and identifying the causes of differences in dissolved inorganic nutrient datasets between global seagoing laboratories - Phase 2
Mobilisation:	CSIRO Wharf Hobart, Wednesday 31 May - Friday 02 June, 2023
Pre-medical clearance period:	Saturday 03 June - Sunday 04 June, 2023
Depart:	0900 CSIRO Wharf Hobart, Monday 05 June, 2023
Return:	CSIRO Wharf Hobart, Sunday 18 June, 2023
Demobilisation:	CSIRO Wharf Hobart, Monday 19 June, 2023
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Scientific objectives

Dissolved inorganic nutrients in seawater are vital to the growth of phytoplankton, the foundation of oceanic food web, and are considered as one of the essential variables determining the ocean productivity, and fertility. Regular measurement and quantification of these nutrients allows for better understanding of several oceanic cycles and prediction of marine ecosystem modelling in which high quality and accurate nutrient concentration datasets is required. Even though comparability of nutrient dataset has been refined in the recent decade with the availability of Certified Reference Material (CRM) and GO-SHIP Repeat Hydrography Nutrient Manual (Becker et al., 2020), but the routine analysis still reveals relative error between nutrient datasets up to 10% when compared between different laboratories.

Therefore, this International Nutrient Inter-Comparison voyage (INIV) aims to minimise differences and enhance comparability of nutrients datasets between laboratories through in-depth investigation of knowledge, methodologies, techniques, and instrumentation used in each laboratory. Nutrient analysts and experts from around the world will be gathered on this voyage and measured nutrients in parallel to ensure potential differences in nutrient sample collection, handling, storage, and analysis process can be recognised and examined. The outcomes from this exercise will not only contribute to standardising the world's best practice in oceanic nutrient analysis where accuracy and confidence in nutrient measurement between dataset can be improved but also ultimately promote an effective dynamic ocean monitoring and management system.

Voyage objectives

INIV 2023 is a phase 2 of the international inter-comparison voyage previously conducted by CSIRO in 2017 in which several possible analytical errors were speculated and will be extensively explored in this voyage. The exercise will be carried out on a 15-day voyage along the hydrographic repeat GO-SHIP SR03 transect line in Southern Ocean. GO-SHIP SR03 transect line is selected due to its availability of long-measured historical nutrient data and its proximity to the home port, Hobart Tasmania. As the focus of this voyage is to preserve the nutrient analysis routine from each laboratory; therefore, various participating team will also utilise several laboratory spaces available on *RV Investigator* to organise and install their instrumentations. Containerised hydrochemistry lab will also be set up on this voyage which can be utilised for any additional secondary experiments.

INIV 2023 will mainly exploit the full-depth CTD. Each participant will collect CTD/Niskin water samples and analyse the sample on board daily. Approximately one CTD cast is planned for every 24 hours targeting a similar daily shift schedule. The CTD will cover the full spatial water profile– which can be up to the maximum of 30 depths – where single sample will be collected for each depth. Specific depths will be identified by the science party during the downcast to ensure specific water masses are targeted. Dissolved oxygen and salinity will also be sampled by MNF hydrochemistry team to calibrate CTD sensor. Approximately 11 stations along the SR03 transect line up to 55°S, 141°E and at the Southern Ocean Time Series (SOTS) will be sampled throughout the duration of this voyage. One of the stations will be dedicated as a precision CTD cast where all Niskin bottles are fired at three depths, the upper circumpolar deep water (UCDW), lower circumpolar deep water (LCDW) and the deep chlorophyll max (DCM) which is carried out for reproducibility purpose.

Nutrient measurement results from this voyage will also be compared with available historical data from both SR03 transect line and SOTS. Unified method of calculation for expanded measurement uncertainty will also be proposed abroad with all participants to determine statistical significance of the datasets.

During the voyage, several experimental exercises have been proposed to incorporate in daily operation for all on board participants as followed:

Exercise 1 - Determination of at-sea measurement uncertainty

Participants will analyse three concentrations of certified reference material (CRM) - one low, one medium, and one high of reference material for nutrients in seawater (RMNS) - in each analytical run over the course of the voyage. The CRM results will be used to assess bias and variability and will be combined into a measurement uncertainty for the results obtained on the voyage. The 'top down' approach will be used to calculate the uncertainty across the voyage and participants will be encouraged to continue to update the uncertainty using long term CRM data. The contribution of sampling error will also be considered – see Exercise 4 sampling technique section below. CRM will be provided to all voyage participants.

Exercise 2 – At sea intercomparison of reference materials

The three concentrations of RMNS will also be used for an intercalibration exercise under shipboard conditions. There are numerous ways to achieve this, for example:

- z-score at each concentration, using certified value of RMNS (Brookman & Mann, 2021)
- z-score at each concentration, using consensus value of RMNS
- ζ-score at each concentration, using certified value of RMNS (Brookman & Mann, 2021)
- ζ-score at each concentration, using consensus value of RMNS
- Correlation coefficient between labs (non-normally distributed) (Rebelo et al., 2003)
- Linearity assessment of RMNS results

Exercise 3 – At sea intercomparison of samples collected om the voyage

Samples from full-depth profiles will be collected during the voyage along the SR03 transect and at the Southern Ocean Time Series (SOTS) station. All participants will be required to collect and analyse samples from these deployments. Specific features, such as the deep chlorophyll maximum (DCM) and a conservative water mass like the upper/lower circumpolar deep water (UCDW/LCDW) will be repeatedly targeted. There are numerous ways to compare the data, such as:

- z-score at concentration of a conservative water mass, using consensus values
- ζ-score at concentration of a conservative water mass, using consensus values
- ANOVA followed by Tukey's post hoc analysis at concentration of a conservative water mass, using consensus values
- "Same sample approach" used by Middag et al, 2015 – which comprises a Friedman Repeated Measures of Analysis of Variance on Ranks, followed by a Tukey post hoc analysis
- Correlation coefficient between labs at the concentration of a conservative water mass (normally distributed)
- Correlation coefficient between labs over each entire depth profile (non-normally distributed)

Exercise 4 – Comparison of sampling techniques

On one deployment, bulk replicates will be sampled from a conservative water mass. Each participant will collect multiple samples to assess the contribution of sampling error to their measurement uncertainty. Participants will also contribute replicate samples to the CSIRO team on board to randomise and analyse in a single analytical run to identify any differences in the results due to participant sampling. The aim is to answer the question:

- Is there a significant difference in the results of samples taken by different participants when following GO-SHIP sample collection guidelines? *i.e.* Does sampling contribute significant error when performed as per the GO-SHIP manual? (Becker et al., 2019)

Exercise 5 – Assessing the contribution of in-house calibration standards to data comparability

In addition to the three concentrations of RMNS, each participant will be required to analyses a blank sample containing low-nutrient seawater (LNSW) (or artificial seawater). These results will combine to provide a set of calibrations standards common to all participants and will be used to reprocess the results for the nutrient depth profiles. These reprocessed results will be compared in the same way as in exercise 3.

Exercise 6 – Comparison of voyage data with historical data

The samples analysed from the full depth profiles and the Circumpolar Deep Water (CDW) will be compared with historical data to assess the intra-voyage variability against the inter-voyage variability. The "same sample approach" used by Middag et al, 2015 can be used for comparing the CDW, which the "different sample approach" will be necessary for the rest of the depth profiles.

Voyage Risk Assessment (VRA)

The MNF, in consultation with the science party and other relevant stakeholders, will develop a comprehensive Voyage Risk Assessment (VRA) to ensure voyage risks are identified and appropriately controlled.
This voyage has undergone a comprehensive risk assessment process.

Activity plan for first 24-48 hours of voyage

In the first 24 -48 hours after pre-voyage medical clearance, RVI will depart Hobart home port and transit directly towards Storm Bay – GSM calibration line #2 where outbound backscatter data will be surveyed. Then we will start the transit towards the first sampling site along the GO-SHIP SR03 transect line – station SR03-05. During this transit, participants will analyse samples as part of an at-sea proficiency test. We will also conduct CTD toolbox meeting to familiarise participants with RVI CTD operation. On arrival at station SR03-05, a test cast to ~2800 m will be performed. Then the RVI will transit overnight to the next sampling site, SR03-08. During this transit, science team will commence analyses of nutrient samples from the CTD cast at station SR03-05.

Voyage track example

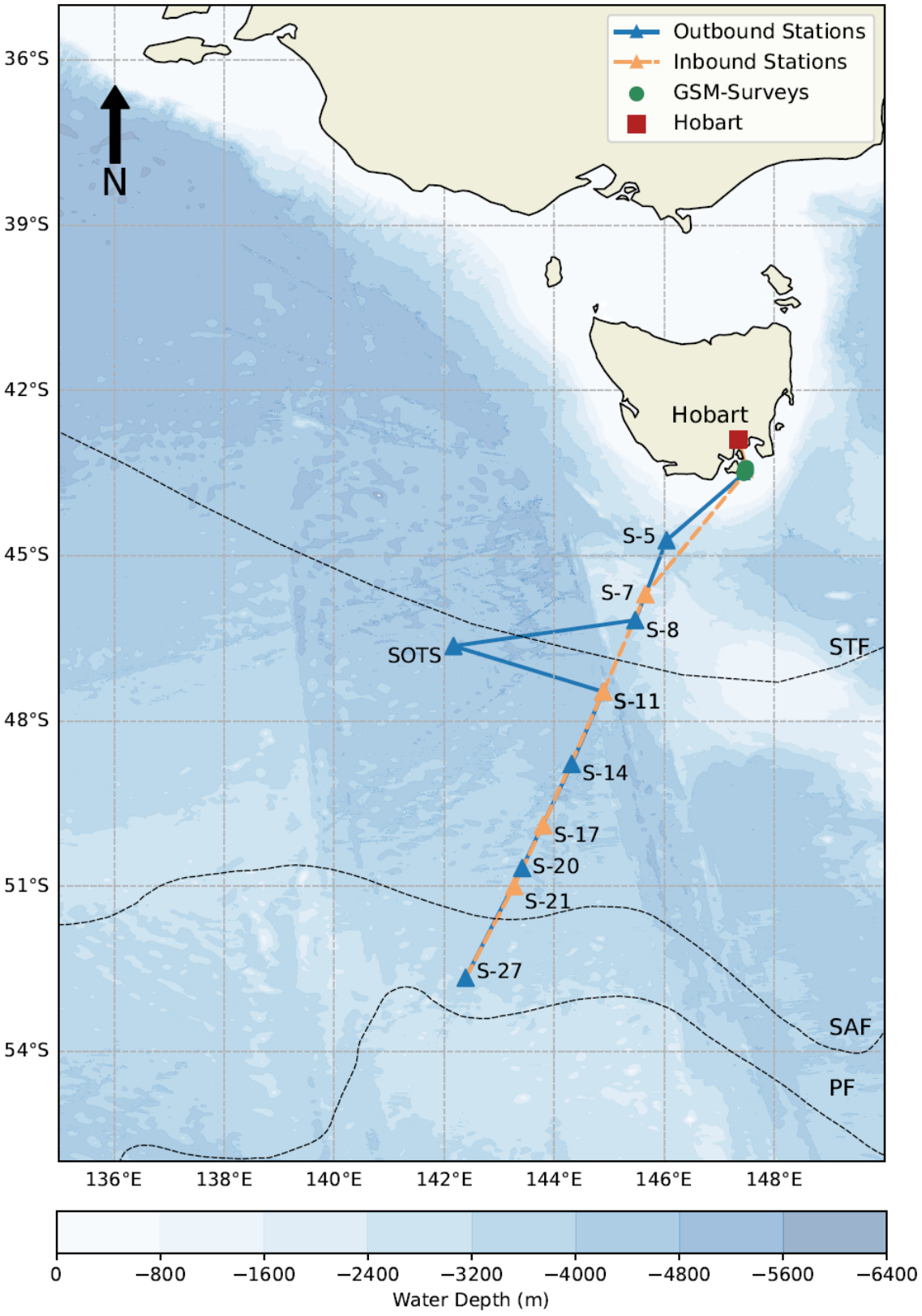


Figure 1. Map of IN2023_V04 planned voyage track. Red colour represents Hobart home port, green colour represents GSM backscattered calibration lines, blue colour represents sampling stations on the outbound route and orange colour represents sampling stations on the inbound route.

Waypoints and stations

Table 1. List of waypoints and stations for IN2023_V04. The transit time is estimated at 10 knots except those marked with asterisk are estimated at 8 knots.

	Location / station	Longitude DDM	Latitude DDM	Distance between (nm)	Total distance (nm)	Transit Time (hrs)	Total Transit Time (hrs)
1	Hobart Port PW04	147° 20.34’E	42° 53.16’S	0	0	0	0
2	GSM cal line #2 start	147° 27.94’E	43° 24.48’S	32	32	3.2	3.2
3	GSM cal line #2 end	147° 26.62’E	43° 30.63’S	6	38	0.8	4.0
4	SR03 station 5	146° 02.52'E	44° 43.19'S	94	132	9.4	13.4
5	SR03 station 8	145° 28.32’E	46° 10.20’S	90	222	9.0	22.4
6	SOTS station	142° 10.08’E	46° 38.40’S	148	370	14.8	37.2
7	SR03 station 11	144° 53.94’E	47° 28.20’S	125	495	12.5	49.7
8	SR03 station 14	144° 19.08’E	48° 46.80’S	82	577	8.2	57.8
9	SR03 station 20	143° 25.02’E	50° 40.20’S	119	696	11.9	69.7
10	SR03 station 27	142° 23.40’E	52° 39.60’S	125	821	12.5	82.2
11	SR03 station 21	143° 16.26’E	51° 00.00’S	105	926	10.5	92.7
12	SR03 station 17	143° 47.88’E	49° 53.40’S	70	995	7.0	99.7
13	SR03 station 11	144° 53.94’E	47° 28.20’S	152	1147	15.2	114.8
14	SR03 station 7	145° 33.59'E	45°56.08'S	111	1258	11.1	125.9
15	GSM cal line #3 end	147° 29.71’E	43° 28.37’S	155	1413	15.5	141.4
16	GSM cal line #3 start	147° 29.66’E	43° 23.82’S	4	1417	0.5	141.9
17	Hobart Port PW04	147° 20.34’E	42° 53.16’S	31	1448	3.1	145. 0

CTD Configuration

	PLEASE SELECT:
Fundamentals:	
Which CTD rosette to be used for this voyage (24 or 36 Niskin bottles):	36
Likely total number of casts:	11
Likely maximum depth of deepest cast:	4650 m
Lowered ADCP required:	Yes
Instrumentation (maximum 6 auxiliary channels in addition to 2x DO):	
2x pumped Temperature, Conductivity, Dissolved Oxygen circuits:	(Standard)
Altimeter (required if operating anywhere near the sea floor):	Yes
PAR Sensor (Biospherical QCP-2300):	Yes
Transmissometer (Wetlabs C-Star 25cm):	
Fluorometer – Chlorophyll-a (Chelsea Aquatracka III – 430/685nm):	Yes
Fluorometer – CDOM (Wetlabs FLCDOM – 370/460nm)	Yes
Nephelometer (Seapoint Turbidity Meter)	
ECO-Triplet (Chlorophyll-a, CDOM & backscatter – maximum depth 2000m)	
Hydrochemistry Analyses:	
Salinity	Yes
Dissolved Oxygen	Yes
Nutrients: Nitrate	Yes

	PLEASE SELECT:
Nutrients: Phosphate	Yes
Nutrients: Silicate	Yes
Nutrients: Nitrite	Yes
Nutrients: Ammonia	Yes

Activity and Time estimates

There will be one CTD deployment per day with the CTD returning on deck during day shift. This means there may be times when the ship is waiting on station for the scheduled deployment. This time buffer is intended to account for poor conditions but can otherwise be utilised for other activities (e.g. GSM). The plan allows for the ship to be stationary and pointing into the wind during CTD sampling for safer and more comfortable working conditions, but this time can be allocated to transiting if deemed necessary. Deployment times are based on estimates of 60 minutes per 1000 m (~30 m/min both directions) and an additional 60 minutes for stopping for 2 minutes at each of the 30 depths. Deployments should take place within 2 nm of nominal locations.

Table 2. Daily activity plan and time estimates on in2023_v04. The following time estimates are based on a steaming speed of 10 knots except for when GSM calibration line survey is conducted where the speed is estimated at 8 knots.
Note #1: MNF Hydrochemistry test CTD as noted above to be included in the Time Estimates table below.
Note #2: MNF GSM calibration lines of Storm Bay (outgoing and incoming) as noted above to be included in the Time Estimates table below.

Day	Date	Time	Activities	Approximate transit / ops time
Monday	5/06/2023	0900	Departure from Hobart Port from PW04 to GSM calibration line #2	3.5 hrs
		1230	GSM calibration line survey #2	15-30 min @8 knots
		1330	Transit to SR03-05 site	9.5 hrs
		2300	Arrive at SR03-05	
Tuesday	6/06/2023	0500	Perform test CTD cast at SR03-05 to ~2800 m	3 hrs
		0800	Sample CTD	

		1000	Transit to SR03-08	9 hrs
		1900	Arrive at SR03-08	
Wednesday	7/06/2023	0400	Perform SR03-08 CTD cast to 2755 m	4 hrs
		0800	Sample CTD	
		1000	Transit to SOTS	15 hrs
Thursday	8/06/2023	0100	Arrive at SOTS	
		0230	Perform SOTS CTD cats to 4650 m	5.5 hrs
		0800	Sample CTD	
		1000	Transit to SR03-11	12.5 hrs
		2230	Arrive at SR03-11	
Friday	9/06/2023	0500	Perform 'sampling comparison' CTD to ~2800m	3 hrs
		0800	Sample CTD	
		1000	Transit to SR03-14	8 hrs
		1800	Arrive at SR03-14	
Saturday	10/06/2023	0230	Perform SR03-14 CTD cast to 4190 m	5.5 hrs
		0800	Sample CTD	
		1000	Transit to SR03-20	12.5 hrs
		2230	Arrive at SR03-20	
Sunday	11/06/2023	0330	Perform SR03-20 CTD cast to 3530 m	4.5 hrs
		0800	Sample CTD	
		1000	Transit to SR03-27	12.5 hrs
		1900	Arrive at SR03-27	
Monday	12/06/2023	0330	Perform SR03-27 CTD cast to 3430 m	4.5 hrs
		0800	Sample CTD	
		1000	Transit to SR03-21	10.5 hrs
		2030	Arrive at SR03-21	
Tuesday	13/06/2023	0300	Perform SR03-21 CTD cast to 3850 m	5 hrs
		0800	Sample CTD	
		1000	Transit to SR03-17	7 hrs
		1700	Arrive at SR03-17	

Wednesday	14/06/2023	0300	Perform SR03-17 CTD cast to 3780 m	5 hrs
		0800	Sample CTD	
		1000	Transit to SR03-11	15 hrs
Thursday	15/06/2023	0100	Arrive at SR03-11	
		0230	Perform SR03-11 CTD cast to 4470 m	5.5 hrs
		0800	Sample CTD	
		1000	Transit to SR03-07	11 hrs
		2100	Arrive at SR03-07	
Friday	16/06/2023	0500	Perform SR03-07 CTD cast to 2160 m	3 hrs
		0800	Sample CTD	
		1000	Transit to GSM calibration line #3	16 hrs
Saturday	17/08/2023	0200	GSM calibration line survey #3	15-30 min @8 knots
		0300	Transit to Hobart Port PW04	4 hrs
		0700	Arrive at Hobart Port PW04, demobilisation	
Sunday	18/08/2023		Bad weather allowance	

Permits

N/A

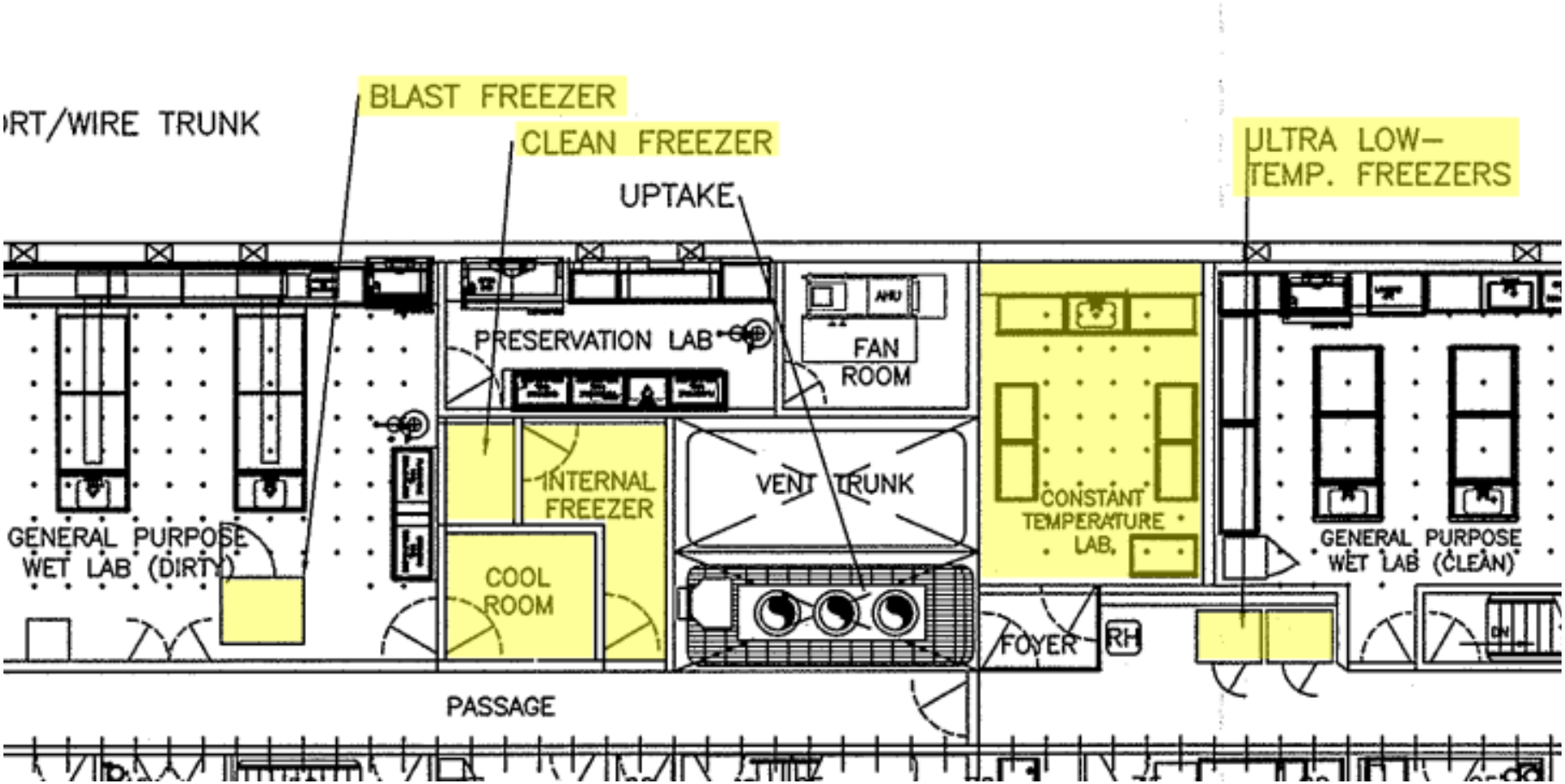
Appendix A

Scientific equipment and facilities provided by the Marine National Facility

Some equipment items on the list may not be available at the time of sailing. Applicants will be notified directly of any changes. Indicate what equipment and facilities you require from the Marine National Facility by placing an **X** in the relevant box.

STANDARD LABORATORIES AND FACILITIES		
NAME	**REQUIRED**	**NOTES/COMMENTS**
Aerosol Sampling Lab		•
Air Chemistry Lab	X	• Designated laboratory space for nutrient analysis for voyage participant
Preservation Lab	X	• Designated laboratory space for nutrient analysis for voyage participant
Constant Temperature Lab (Min temp: ~4°C / Max temp ~35°C)	X	• Designated laboratory space for nutrient analysis for voyage participant
Underway Seawater Analysis Laboratory	X	• General access for underway nutrient collection by hydrochemistry and voyage participants / potential space for voyage participant with small instrument for underway analysis
GP Wet Lab (Dirty)	X	• Designated laboratory space for nutrient analysis for voyage participant
GP Wet Lab (Clean)	X	• Designated laboratory space for nutrient analysis for voyage participant
GP Dry Lab (Clean)	X	• Designated laboratory space for nutrient analysis for voyage participant
Sheltered Science Area	X	• Storage of spare 24 & 36 bottle rosettes
Observation Deck 07 Level		•
Internal Freezer (Dirty Wet lab) (Min temp -25°C / Max temp 0°C) Volume: >20m^3		•
Clean Freezer (Dirty Wet lab) (Min temp -25°C / Max temp 0°C) Volume: >2.5m^3 Co-located within the Internal freezer and separated by a door		•
Blast Freezer (Dirty Wet lab) (Min temp -30°C / Max temp 0°C)		•

STANDARD LABORATORIES AND FACILITIES		
NAME	**REQUIRED**	**NOTES/COMMENTS**
Internal volume >1.5m^3 Capable of reducing the temperature of 150kg of water from +20C to -30C in one hour.		
Cool Room (Dirty Wet lab) (Min temp 0^{o}C / Max temp 10^{o}C)		•
Ultra-Low Temperature Freezers x2 (Main Deck) Min temp -80^{o}C / Max temp -80^{o}C)		•
YODA Freezers (x2) (Clean Dry lab) (Min temp -20^{o}C / Max temp 10^{o}C)		•



MOBILE LABORATORY AND FACILITIES *(MAY REQUIRE ADDITIONAL SUPPORT)*			
NAME	**ESSENTIAL**	**DESIRABLE**	**NOTES/COMMENTS**
Modular Isotope Laboratory			If nominated, additional processes to be completed.
Trace Metal Niskin Sampling Container (TM1-blue - 20ft)			• Used for the determination of trace metal concentrations. It is a clean laboratory containing laminar flow cabinets and is stored on the main deck (if possible).

MOBILE LABORATORY AND FACILITIES *(MAY REQUIRE ADDITIONAL SUPPORT)*			
NAME	**ESSENTIAL**	**DESIRABLE**	**NOTES/COMMENTS**
Trace Metal Seawater Analysis Laboratory (TM2-white - 20ft)			• Used for wet sampling of trace metal clean Niskins and is stored on the main deck (if possible). • Cannot be overstacked
Trace Metal Rosette and Niskin Storage Container			10-foot container
Modular Hazchem Locker			
Stabilised Platform Container			Please indicate what instruments are to be installed in the container Cannot be overstacked
Clothing Container			The use of this container will be identified by MNF

STANDARD SAMPLING EQUIPMENT			
NAME	**ESSENTIAL**	**DESIRABLE**	**NOTES/COMMENTS**
CTD - Seabird 911 with 36 Bottle Rosette	X		
CTD - Seabird 911 with 24 Bottle Rosette	X		
Lowered ADCP	X		
Continuous Plankton Recorder (CPR)			*note: Use of this item must be flagged with the relevant CSIRO Oceans & Atmosphere team responsible for CPR cassette preparation and sample processing. Please discuss your planned CPR use with your VOM, who will assist in liaising with the CPR team.

SPECIALISED SAMPLING EQUIPMENT			
NAME	**ESSENTIAL**	**DESIRABLE**	**NOTES/COMMENTS (THESE ITEMS MAY REQUIRE ADDITIONAL MNF SUPPORT STAFF)**
TRIAXUS – Underway Profiling CTD			Triaxus is a pilotable towed vehicle capable of carrying a variety of instrumentation. Constant depth towing or undulating profiles (e.g. cyclic depth pattern from the surface to 200m) are possible. Towing speed depends on the tow profile, instrumentation payload and prevailing conditions. Typically, undulations from the surface to 200m are possible at 8knt, with slower speeds for deeper profiles and faster for constant-depth towing. Maximum achievable depth typically 300m to a distance of approximately 1.5km from the ship. Triaxus is normally configured with the following sensors as a minimum: • Dual temperature, conductivity and dissolved oxygen (SBE9plus and dual pumped temperature/conductivity/dissolved oxygen circuits) • PAR • Chlorophyll-A, CDROM, optical backscatter (Eco-triplet) • Plankton counter (Laser Optical Plankton Counter) • Transmissometer Contact MNF for further details on other instrumentation and capability.
Desired towing profile:			
Additional instrumentation: (please supply, make and model and datasheets and a contact person for discussion on integration)			
Piston Coring System			
Gravity Coring System			
Multi Corer			

SPECIALISED SAMPLING EQUIPMENT			
NAME	**ESSENTIAL**	**DESIRABLE**	**NOTES/COMMENTS (THESE ITEMS MAY REQUIRE ADDITIONAL MNF SUPPORT STAFF)**
Kasten Corer			
Smith Mac Grab			
Rock Dredges			
Rock Saw			Requires trained science personnel
Seaspy Magnetometer			
Portable Pot Hauler			
Equipment to measure seawater sound velocity/CTD:			
XBT System			2 per day provided
Valeport Rapid SV			
Valeport Rapid CTD			
Valeport SVX2			
Trace Metal Rosette and Bottles			
Trace Metal In-situ Pumps (x6)			• See non-MNF owned section below for additional 2 units. • Science team to organise and pay for battery packs for this system (+ spare). • They can be sourced through a supplier such as 'Batteryworld Hobart' (Graham Cowie, 03 6272 3900) who has made these previously. • The science teams need to calculate how long they will be deployed and bring enough batteries to cover their deployment times. They are rated to 30 Amp hours, which equals to 36,000 litres of sea water being filtered.

SPECIALISED SAMPLING EQUIPMENT			
NAME	**ESSENTIAL**	**DESIRABLE**	**NOTES/COMMENTS (THESE ITEMS MAY REQUIRE ADDITIONAL MNF SUPPORT STAFF)**
Deep Towed Camera			
Drop Camera			
Sherman Epibenthic Sled			Stern ramp must be removed to operate this system.
Brenke Sled			
Hydro-Bios MultiNet (Mammoth) (1m x 1m) *(has replaced the EZ net)*			Please specify 100-micron, 335-micron, or 500-micron mesh Can be used in a vertical or horizontal operations
Surface Net (1m x 1m)			Please specify 335-micron, 500-micron, or 1,000-micron mesh
Bongo Net 485mm diameter			500 micron mesh only
Beam Trawl			
MIDOC			Multiple opening/closing net system with cod ends- suitable for pelagic trawls
Pelagic Trawl System (net, doors)			Contact MNF to discuss net and mesh dimensions
Demersal Trawl System (net, doors)			Contact MNF to discuss net and mesh dimensions
RMT-8 (Rectangular Midwater Trawl) Utilises a single warp so can be deployed on the general-purpose towing wire in self-contained mode. Must be deployed with stern ramp covered.			8m2 mouth area Tow speed ≤2 knots
RMT-16 (Rectangular Midwater Trawl) Utilises a single warp so can be deployed on the general-purpose towing wire in self-contained mode. Must be deployed with stern ramp covered.			16m2 mouth area Tow speed ≤2 knots

SPECIALISED SAMPLING EQUIPMENT			
NAME	**ESSENTIAL**	**DESIRABLE**	**NOTES/COMMENTS (THESE ITEMS MAY REQUIRE ADDITIONAL MNF SUPPORT STAFF)**
Trawl Monitoring Instrumentation (ITI) (2,000m depth limit)			MNF to identify this need, dependent on pelagic or demersal trawling requirement
Stern ramp	**EXPOSED**	**INSTALLED**	MNF to identify this requirement

RESEARCH SUPPORT INFRASTRUCTURE			
NAME	**ESSENTIAL**	**DESIRABLE**	**NOTES/COMMENTS**
Saltwater Ice Machine (Dirty Wet lab)			
Radiosonde Receiver System			
Laboratory Incubators (Clean Dry lab)			
Deck Incubators			Temperature controlled deck incubators
Milli-Q System	X		
Sonardyne USBL System			

SCIENTIFIC / SAMPLE ANALYSIS SYSTEMS				
MICROSCOPES:				**NOTES/COMMENTS**
BRAND / MODEL	**TYPE**	**ESSENTIAL**	**DESIRABLE**	Refer to the "MNF microscopes procedure" for more information
Leica / M80	Dissecting			
Leica / M80	Dissecting			
Leica /MZ6	Dissecting			
Olympus / CH	Compound			
Olympus /CH	Compound			

SCIENTIFIC / SAMPLE ANALYSIS SYSTEMS				
MICROSCOPES:				**NOTES/COMMENTS**
Leica / MTU282	Camera tube			
Adapters for tube / Nikon	Pentax			
Ring Light *2 / MEB121	LED			
Heavy Duty Electronic Balance (80kg)				
Medium Duty Electronic Balance (15kg/5g resolution)				
Light Duty Electronic Balance (3kg/1g resolution)				

Underway systems

ACOUSTIC UNDERWAY SYSTEMS			
NAME	**ESSENTIAL**	**DESIRABLE**	**NOTES/COMMENTS**
75kHz ADCP	X		
150kHz ADCP	X		
Multi Beam Echo Sounder EM122 12kHz (100m to full ocean depth)			
Multi Beam Echo Sounder EM710 70-100kHz (0-1000m approx.)			
Sub-Bottom Profiler SBP120			
Scientific Narrowband Echo Sounders EK60 (6 bands, 18kHz-333kHz)			EK60s will be onboard for use as a backup for EK80s and set in narrowband mode Quantitative measurements from scientific echosounders requires sphere calibration in the watermass of sampling
Scientific Narrowband/Broadband Echo Sounders EK80 (6 bands, 18kHz-333kHz)			EK80s will be used in narrowband mode unless otherwise requested

ACOUSTIC UNDERWAY SYSTEMS			
NAME	**ESSENTIAL**	**DESIRABLE**	**NOTES/COMMENTS**
			Quantitative measurements from scientific echosounders requires sphere calibration in the watermass of sampling
Multibeam Scientific Echo Sounder ME70 (70-100 kHz)			
Omnidirectional Echo Sounder SH90			
Gravity Meter			

ATMOSPHERIC UNDERWAY SENSORS			
NAME	**ESSENTIAL**	**DESIRABLE**	**NOTES/COMMENTS**
Nephelometer			
Multi Angle Absorption Photometer (MAAP)			
Scanning Mobility Particle Sizer (SMPS)			
Radon Detector			
Ozone Detector			
Condensation Particle Counter (CPC)			
Picarro Spectrometer (analysis of CO_2/CH_4/H_2O)			
Aerodyne Spectrometer (analysis of N_2O/CO/H_2O)			
Cloud Condensation Nuclei (CCN)			
Polarimetric Weather Radar			
Filter Aerosol Sampling units (FAS) x 3			Used for collecting physical aerosol samples on filters. FAS includes pumps, filter holders, flow controllers, totalizer, Very Sharp Cut Cyclone (VSCC) PM1 and PM2.5.

ATMOSPHERIC UNDERWAY SENSORS			
NAME	**ESSENTIAL**	**DESIRABLE**	**NOTES/COMMENTS**
			• User to specify how many units are required (maximum 3 supplied by MNF). • User to provide own filters. • User to outline sampling requirements with MNF Seagoing Instrumentation Team (SIT) i.e. ship exhaust sample avoidance etc.

UNDERWAY SEAWATER SYSTEMS AND INSTRUMENTATION			
NAME	**ESSENTIAL**	**DESIRABLE**	**NOTES/COMMENTS**
Thermosalinograph	X		
Fluorometer			
Optode			
pCO2			

SEAWATER SYSTEMS			
NAME	**ESSENTIAL**	**DESIRABLE**	**NOTES/COMMENTS**
Trace metal clean seawater supply			
Scientific clean seawater supplied to laboratories			
Raw seawater available on deck and in laboratories			

EQUIPMENT AND SAMPLING GEAR REQUIRING EXTERNAL SUPPORT (MAY REQUIRE ADDITIONAL SUPPORT FROM APPLICANTS)			
NAME	**ESSENTIAL**	**DESIRABLE**	**PLEASE GIVE THIS CAREFUL CONSIDERATION, AS THERE IS NO GUARANTEE THAT THESE RESOURCES WILL BE AVAILABLE UNLESS SPECIFICALLY REQUESTED. LIAISE WITH YOUR VOYAGE OPERATIONS MANAGER AS REQUIRED. ADDITIONAL STAFF MAY BE REQUIRED FOR THESE ACTIVITIES.**
Seismic Compressors			• Additional crew and seismic acquisition personnel will be required to be onboard to support this system. Number of personnel TBD by the MNF. • The science party is to provide an onboard seismic data processing resource.
Seismic Acquisition System			• Additional crew and seismic acquisition personnel will be required to be onboard to support this system. Number of personnel TBD by the MNF. • The science party is to provide an onboard seismic data processing resource.

NON-MNF OWNED EQUIPMENT WHICH MAY BE ACCESSED			
NAME	**ESSENTIAL**	**DESIRABLE**	**PLEASE GIVE THIS CAREFUL CONSIDERATION, AS THERE IS NO GUARANTEE THAT THESE RESOURCES WILL BE AVAILABLE UNLESS SPECIFICALLY REQUESTED. LIAISE WITH YOUR VOYAGE OPERATIONS MANAGER AS REQUIRED. ADDITIONAL STAFF MAY BE REQUIRED FOR THESE ACTIVITIES.**
D & N Francis winch			15mm electro-optical cable
Box Corer			
UTAS In-Situ Pumps (x2)			
EM2040			Shallow water multibeam echosounder system