RV *Investigator* Voyage Plan

Voyage #:	IN2023_V01
Version:	**FINAL**
Voyage title:	**Antarctic Bottom Water Production in the past: Records from marine sediments, Cape Darnley, East Antarctica**
Mobilisation:	AMC Henderson, Saturday 21st January – Sunday 22nd January 2023
Medical Clearance Period:	AMC Henderson, Monday 23rd January – Tuesday 24th January 2023
Depart:	Fremantle, Wednesday 25th January 2023
Return:	Hobart, Sunday 12th March 2023
Science Demobilisation:	Hobart, Sunday 12th March 2023
Chief Scientist:	Alix Post
Affiliation:	Geoscience Australia
Principal Investigators:	Helen Bostock (Alternative Chief Scientist), University of Queensland Linda Armbrecht, University of Tasmania Zanna Chase, University of Tasmania Taryn Noble, University of Tasmania Yusuke Yokoyama, University of Tokyo Jodie Smith, Geoscience Australia Kevin Welsh, University of Queensland

Scientific objectives

This study has two main scientific objectives i) to understand past changes in Antarctic Bottom Water (AABW) production using long sediment cores from the continental slope over multiple warm periods during the Pleistocene; ii) develop an improved bathymetry model to support oceanographic modelling of AABW pathways. Sediment core records of previous warmer interglacials will provide an analogue for understanding the impact of any future changes in bottom water production associated with a warming climate. This project will recover long sediment cores from the shelf and slope off Cape Darnley to provide palaeoceanographic records over multiple glacial-interglacial cycles, including previous interglacials when Antarctic air temperatures were 2 to 4.5°C warmer than today. A multi-proxy approach, combining 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.

AABW has previously been associated with unique and diverse benthic ecosystems, including hydrocorals. We will investigate the presence and distribution of hydrocorals, and, if present, analyse their carbonate skeletons to understand past water mass variability over recent centuries, complementing the sediment core records.

Voyage objectives

Multibeam acquisition: Ten days will be allocated to multibeam data acquisition along the upper and mid continental slope. Water depths will range from ~400 m to ~3500 m. We will primarily rely on data collected from the EM122 system, with use of the EM710 at depths less than ~1500 m. Lines will be run E-W, roughly parallel to slope to ensure even coverage by adjacent swath lines. Where possible, survey speeds will be 8-10 kts to maximise resolution and survey time, though in areas with sea ice floes and growlers speeds will be reduced to 5 kts. Multibeam mapping will be interspersed with other activities where possible, allowing mapping to occur during poor weather windows when other operations are not possible. In our planning we have accounted for up to 2 days bad weather. Sub-bottom profile data (SBP120) will be acquired concurrently with the multibeam data.

Kasten cores: Up to 10 kasten cores will be retrieved from key locations on the continental slope at depths mostly <2000 m, but up to 3500 m. Shallower depths will provide better preservation of carbonates for dating and isotopic analysis. Likely core sites will be on the Wild Drift and levees adjacent to the slope canyons. Existing seismic data will be used for preliminary site selection, but multibeam mapping and sub-bottom profiles will be required to determine areas of undisturbed, continuous sedimentation in the upper 50 – 100 m. Preliminary data from the kasten cores will enable further selection of the best locations for piston coring.

Piston cores: Piston cores will be retrieved in 4 to 6 locations, providing records up to 24 m long. Sites will be selected to provide records over past glacial/interglacial cycles, most likely over the last 500,000 years. These records are the primary objective of this voyage, and will be the highest priority.

Multicores: These will be collected at up to 4 sites, providing an undisturbed sediment-water interface for analysis of palaeoproxies.

CTDs: CTDs will be deployed at up to 13 sites within canyons and at each core site to provide conductivity and temperature profiles, and discrete water samples to be selected from key water masses based on the conductivity and temperature profiles at each site.

Trace metal rosette: A trace metal rosette will be used at 4 of the core sites to depths 2000m, for analysis of micronutrient trace metals and Pb and U isotopes in addition to standard nutrient analyses plus ammonia.

Deep tow camera: Still and video imagery will be acquired at up to 6 key locations within shelf-cutting canyons and along the upper slope at depths ranging from ~400 to 2500 m. The priority for analysis is high resolution still imagery, preferably with stereo pairs to allow future work determining size of organisms. The MNF data team will be working with Greybits Engineering to facilitate Squidle+ under water video capture and annotation software.

Modified rock dredge: A rock dredge will be modified to include a mesh bag for collection of biological samples. The rock dredge will be used at up to 4 sites if evidence for hydrocorals is observed during the deep tow camera transects.

Unmanned aerial vehicle (UAV): A UAV will be used at up to 10 locations to acquire aerial images of survey activities for science outreach and engagement, showcasing the science that we are undertaking and the environment where we are working.

Towed Magnetometer: The MNF magnetometer will be towed on the **south transit** commencing from the CTD test site out of Fremantle.

CPR: Deploy AAD CPR on full **transit north** (excl Marine Parks).

Voyage track example

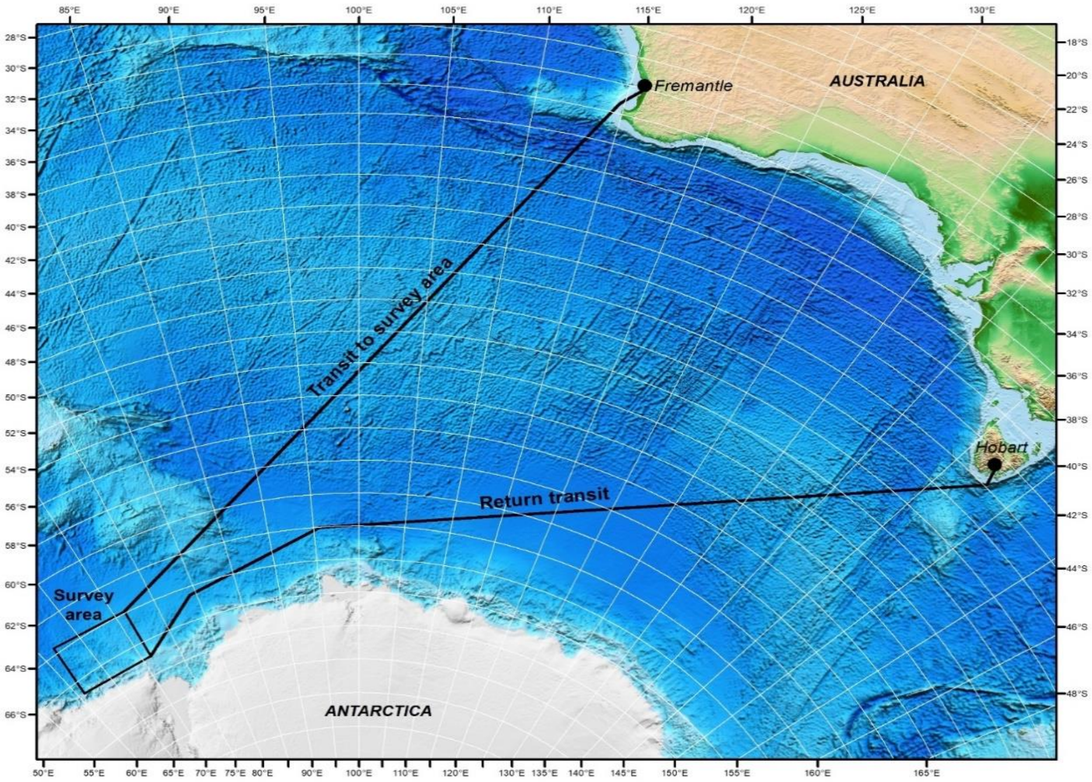


Figure 1. Potential voyage track to the primary survey area.

We provide a figure of the potential voyage track to the operation area (Figure 1). The voyage transit to and from the survey area should be as direct as possible being subject to weather conditions on the day of departure and those forecast for the following ten days. The exact entry point to the survey area (NE or SE corner) will be determined 24 – 36 hours in advance depending on sea ice conditions along the southern boundary.

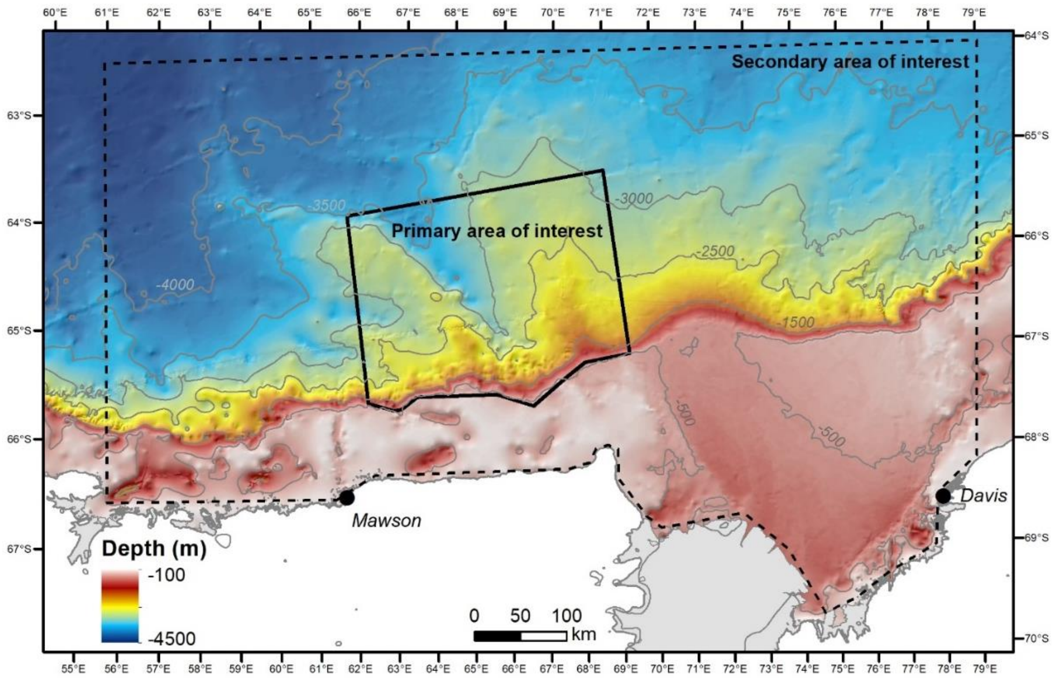


Figure 2. Detailed map of the survey area. A secondary survey area is identified to provide flexibility depending on sea ice. The size of the primary survey area will be maintained within the secondary survey area.

Waypoints and stations

The survey is based around swath mapping of the area. We have not determined detailed way points for the swath surveys as these will need to be worked out with the MNF staff and probably modified depending on conditions at the time (e.g. effective swath width, sea ice extent). **Table 1** lists the way points to the corners of this survey area (defined in **Table 2**). We are assuming entry to the survey area via the NE corner, however, if sea ice conditions allow we will prioritise mapping from the SE corner first. We have calculated transit speeds at 10 knots and survey speeds at 5-8 knots. We assume an operating speed of 5 knots in ice affected waters, and while we will not be entering ice, occasional sea ice floes and growlers are possible so we have assumed a safety-first policy.

RouteName:IN2023_V01

WPName:	Latitude DDM	Longitude DDM	Distance	Total Distance	Transit	Transit Days	Steaming Time	Total Steam Hours	Total Steam Days
Fremantle Harbour	32° 3.233S	115° 44.208E							
Rottnest Island	31° 56.499S	115° 21.600E	13	23.2			1.3	2.3	0.1
Test CTD Site	35° 12.118S	113° 24.699E	218.7	241.9	2592.0	10.8	21.9	24.2	1.0
NE corner	65° 18.6S	67°31.74E	2351	2592.0			256.9	259.2	10.8
Mapping to shelf edge and other operations (estimate) @6.5kts *			1529	4121.0			235.2	494.4	20.6
SE corner	66° 50.700S	70° 28.200E	0	4121.0			0.0	494.4	20.6
Ice Avoidance	61° 32.202S	94° 23.666E	696	4816.9			69.6	564.0	23.5
Pedra Branca Avoi	43° 59.752S	147° 8.320E	2107	6924.0	2877.1	12.0	210.7	774.7	32.3
GSM Cal Start	43° 30.629S	147° 26.619E	32	6956.0			3.2	777.9	32.4
GSM Cal Start	43° 24.478S	147° 27.939E	6	6962.3			0.6	778.6	32.4
PW4	42° 53.170S	147° 20.320E	0	6998.2			0.0	782.1	32.6

*DOES NOT include Station to Station Transits as this will be determined during surveying of area. Voyage plan currently allows 48 hours station to station transits

Table 1: Waypoints to and from primary survey area / other operations. Total voyage estimates

Notes:

- Time estimates can accommodate up to additional 48hrs of station-station transit depending on time/fuel ROB.
- 1 generator in good weather @ 10-10.3 knots
- 2 generators in bad weather @ 8-9 knots
- 1 generator in the bounding box transiting between stations @ 8.5 knots
- 5-6 knots overnight in ice

Site	Lat_DDM	Long_DDM	Lat_DD	Long_DD
NE corner	64° 59.900S	070° 32.900E	-64.998	70.5483
NW corner	64° 54.100S	064° 43.600E	-64.902	64.7267
SW corner	66° 45.400S	064° 02.300E	-66.757	64.0383
SE corner	66° 50.700S	070° 28.200E	-66.845	70.47

Table 2: Survey Area Bounding Box

Time estimates

The following time estimates are based on a steaming speed of 10 knots, and survey speed of average 6.5knots.

Stations will be determined based on interpretation of bathymetry mapping and sub-bottom profiles. Transit time between stations can therefore only be estimated. We have estimated the following time requirements for our operations, based on a survey speed of 5-8 knots depending on sea ice conditions.

Activity	# Deploy	Dist.	Transit		On Station		Cumulative Days	Date
			Hours	Days	Hours	Days		
ETD Fremantle 0800hrs								**25/01/2023 8:00**
Test CTD/TMR Casts		**242**	**24.2**	**1.0**	**5**	**0.2**		**26/01/2023**
Transit to Survey Area		**2351**	**235.1**	**9.8**		**0**	**11.0**	**5/02/2023**
Survey Area Activities								
Multibeam Mapping @ avg 6.5 kts		**1529**	**235.2**	**9.8**				
Kasten Cores	**10**				**37.5**	**1.6**		
Piston Cores	**6**				**54.0**	**2.3**		
Multicores	**4**				**15.0**	**0.6**		
CTDs	**13**				**30.0**	**1.3**		
TMR	**4**				**12.0**	**0.5**		
Deep Towed Camera	**6**				**15.5**	**0.6**		
Rock Dredge	**4**				**9.0**	**0.4**		
Station Transit Times			**96**	**4.0**				
							21.0	
Weather Contingency					**48**	**2.0**	**2.0**	
Depart Survey Area								**28/02/2023**
ETA Hobart		**2877**	**287.7**	**12.0**			**12.0**	**12/03/2023 8:06**
Total DAYS							**47.0**	

Supplementary projects

The evolution of marine life in Antarctica: a novel approach using ancient DNA - Dr. Linda Armbrecht (UTAS)

Characterise past Antarctic marine communities over multiple glacial interglacial cycles using novel ancient DNA techniques and investigate the evolution of key polar marine organisms through time.

This project requires no additional voyage time as the analyses will be undertaken on the cores that are to be collected as part of our key voyage objectives.

Piggyback projects

Trace metal sampling for micronutrient distributions and paleo-proxy development- (Taryn Noble/Zanna Chase – UTAS).

The purpose of this project is to understand the processes controlling the distribution of dissolved trace metals in Antarctic waters and to develop new geochemical proxies for past ice sheet and ocean change. Distinguishing between meltwater input from ice sheet retreat and changes in sea ice and precipitation using traditional tracer approaches such as salinity and oxygen isotopes provides a non-unique solution. However, isotopes of uranium (U) and lead (Pb) derived from chemical weathering at the ice sheet bed have a unique geochemical fingerprint that could be used to identify meltwaters sourced from ice sheet retreat.

Melt waters sourced from ice sheet retreat are also rich in micronutrient trace elements, such as iron and manganese, which are important for phytoplankton growth. The micronutrient distributions along the Antarctic margin are not well documented, and how they might vary in response to climate change is poorly understood. By measuring dissolved iron in addition to dissolved and particulate iron and thorium in the water column (the latter are approved activities), this project will help determine two poorly constrained parameters (i) the solubility of iron in the region, and (ii) the relationship between Th and Fe in the dissolved and particulate phases. These key pieces of information can then be used to develop a sediment-based proxy method to determine how past dissolved Fe inputs changed during glacial to interglacial climate variability. We plan to collect pore waters from multi-core sediments to investigate the sedimentary flux of trace metals to the water column. By measuring trace metals in the water column above, we will be able to quantify the importance of this contribution to the chemical properties of Cape Darnley Bottom Water.

The outcomes of this project will:

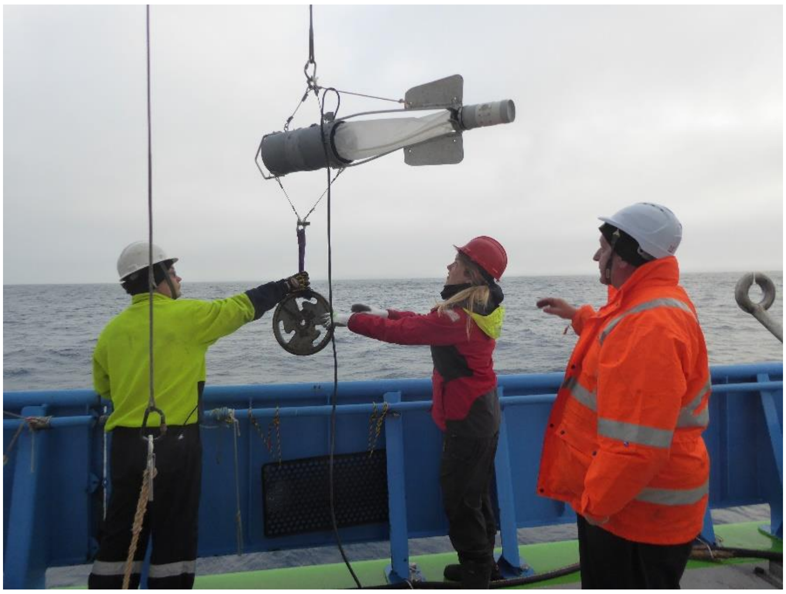
1. Quantification of micronutrient availability on the Antarctic margin.
2. Determination of the end member composition of natural Pb and U isotopes in the study region.
3. Development of Pb and U isotopes to distinguish ocean and cryosphere processes.
4. Validate sediment leaching methods to reconstruct past chemical weathering fluxes associated with meltwater input.

Sampling plan

- 125mL samples for micronutrient trace metal analysis (Cd, Co, Cu, Fe, Ga, Mn, Ni, Pb, Ti and Zn)
- 5-10L samples for Pb isotopes
- 1 L samples for U isotopes

We request 3-4 **trace metal rosett**e deployments where CTD deployments are planned at coring stations along the continental slope: 4@2000 to 3000 m = 4 x 3 hr =12 hours. The TMR can be deployed at night between day-time coring operations and/or set-up periods. Trace metal rosette deployments will require assistance from MNF staff, with support from the science team (Chase/Noble).

Opportunistic sampling utilising the **NiPR** (see pic) over the A-frame . This is a pumped plankton net initially designed for sampling under ice. It is operated at a fixed depth (0-50m) while on station. It is typically deployed for about 10 minutes. It is powered from a 12V car battery.



Deep Ocean camera - Australian Antarctic Division (Andy Carroll-GA)

The Cape Darnley seafloor is mostly uncharacterised for the distribution of benthic biota and habitats. We will utilise a deep ocean camera to extend opportunities to observe the seafloor biota beyond dedicated transects with the MNF deep-towed camera system. The deep ocean camera will be attached to the 36 bottle CTD rosette and operated on all full-depth CTD casts. The CTD will need to be lowered to within 3 to 5 m off the ocean floor, with the camera commencing and lasting a total of 5 minutes before CTD ascent.

Floats: BGC-ARGO (Pete Strutton, UTAS), Core ARGO (Gabriela Semolino-Pilo, Pat McMahon, CSIRO), Deep NINJA (JAMSTEC Steve Rintoul, CSIRO), 2 AAP (Esmee van Wijk, Steve Rintoul, CSIRO)

(10 total):

Kathy Gunn will oversee float deployments on the voyage.

Core Floats

The core floats in the list can be deployed by latitude (i.e., it does not matter at which longitude they are deployed). If possible, the first five floats should be deployed on the southward leg, so that another opportunity is possible on the return leg in case any deployments are missed due to bad weather. If possible, the last float could be deployed on the northward leg (as a slightly different route will be taken in longitude thereby helping to space the floats out).

If the exact latitude is not possible, please deploy as close as practical, and ideally float deployments should be separated by at least 1 degree of latitude, when possible.

Six core ARGO floats will be deployed during the transit:

Hull S/N	Latitude	Longitude	Float Type
11502	-50		MRV Alto
11501	-55		MRV Alto
22AU020	-59		NKE
22AU003	-61		NKE
9753	-63		APEX APF11
9292*	-62		APEX APF11

* Deploy on return leg to Hobart if space in lab to store it. Otherwise, deploy on southward leg.

AAPP Canyon Floats

Two AAPP ice floats will be deployed in the project area to combine with proposed work in the Daly and Wild canyons. Float data will contribute to the science objectives of the voyage.

Daly Canyon:

One APEX APF11 Argo float (Hull No. 9756) will be deployed in the project area towards the head of the Daly Canyon, preferably in the central (deepest) part of the trough. The float deployment can adapt to suit the voyage plan, ideally, we would like the float to go in somewhere along the central deep trough axis in water depths of between 700-1200m preferred (or anywhere between 500-2000m, depending on how far up the canyon the ship is able to proceed). The aim is to measure the deep water outflows in the canyons.

Wild Canyon:

One APEX APF11 Argo float (Hull No. 9755) will be deployed in the project area at the head of the Wild Canyon, preferably in the central (deepest) part of the trough. The float deployment can adapt to suit the voyage plan, ideally, we would like the float to go in somewhere along the central deep trough axis in water depths of between 700-1200m preferred (or anywhere between 500-2000m, depending on how far up the canyon the ship is able to proceed). The aim is to measure the deep water outflows in the canyons.

If a deployment in the canyon is not possible due to ice, weather conditions etc. Then deployment on the slope as close as possible to the canyon outlets would be the next best option (any water depth).

BGC Floats

Two BGC-Argo floats will be deployed at the locations listed in the first table below. For each deployment, a paired CTD is useful. The highest priority for a paired CTD is float P44043-22AU005. CTD casts should be to 2250m or ocean bottom, whichever is deeper, with samples collected in the top 2000m as described in the second table below (from the BGC-Argo protocols document). Each paired CTD will be sampled for DIC, alkalinity, POC, and pigments. Zanna Chase and Veda Surapaneni have been trained on this sampling.

Lon	Lat	Region	Deployment by lat/lon	Float type	Hull S/N
65	-65	1° area	By lat. Northern part of the primary area, with CTD.	NKE BGC	P44043-22AU005
70 (65 also OK)	-63 to -64	1° area	By lat. Must be between 63°S and 64°S	NKE BGC	P53435-21AU001

RosettePosn	Nominal Depth	Oxygen	TCO2	TA	Salinity	Nutrients	POC	Pigments
Water	*needed (L)*	*0.5*	*1.5*	*1.5*	*0.5*	*0.1*	*2*	*4*
24	surface	24			24	24	5	5
23	surface	23	12	12	23	23		
22	20	22			22	22	4	4
21	20	21	11	11	21	21		
20	50	20			20	20	3	3
19	50	19			19	19		
18	80	18			18	18	2	2
17	80	17	10	10	17	17		
16	110	16			16	16	1	1
15	110	15			15	15	-	-
14	150	14	9	9	14	14	-	-
13	150	13			13	13	-	-
12	200	12	8	8	12	12	-	-
11	250	11			11	11	-	-

10	300	10	7	7	10	10	-	-
9	400	9	6	6	9	9	-	-
8	600	8	5	5	8	8	-	-
7	800	7	4	4	7	7	-	-
6	1000	6			6	6	-	-
5	1200	5	3	3	5	5	-	-
4	1400	4			4	4	-	-
3	1600	3	2	2	3	3	-	-
2	1800	2			2	2	-	-
1	2000	1	1	1	1	1	-	-

Comments:

1. Oxygen, salinity and nutrients are included here but they will likely be taken care of by the hydrochemists.
2. Tripping pairs of bottles provides contingency if a bottle leaks, and to cover any need for more than the Niskin volume (12L) at a given depth.
3. Note that the cast should go to at least 2250m deep, to provide sensor data below the depth of the deepest bottle sample collected at 2000m.
4. **Always sample DIC and Alkalinity pairs in duplicate at 2000m (2 DIC and 2 Alk samples total)**

Deep Float

One Japanese deep ARGO NINJA float from JAMSTEC will be deployed in the project area to combine with one of the project CTD, ideally along the northern extent of the survey area.

Natural iron fertilization of oceans around Australia: linking terrestrial dust and bushfires to marine biogeochemistry (Andrew Bowie, UTAS).

This project will facilitate an integrated ship-based atmospheric observational program for trace elements in oceans around Australia. We will sample atmospheric particles containing terrestrial dust, bushfire smoke and anthropogenic emissions that are transported from Australia to its surrounding oceans. We will install an atmospheric sampling system for the clean collection of particles in the ship's aerosol lab. This system consists of vacuum pumps (Thomas Sheboygan 2107CD18), flow meters (DiTGM ML-2500) and filtration systems (Savillex PFA). The manifold is connected to air intake lines fed from the sampling nozzle located ~10 m above sea level on the foremast at the bow of the vessel. Samples will be collected on filters housed in 47 mm filtration holders located within a laminar flow hood (AirClean Systems) to avoid contamination. The system is controlled by automated sector control switch (pump controller) to ensure the system only samples 'clean' air from the forward sector (nominally between 270° port and 90° starboard), avoiding air impacted by the ship's exhaust. The system is capable of running up to 4 flow lines in parallel, to enable replicate sampling or to sample for different parameters using different filters on different lines. Sampled filters will be stored frozen and returned to the shore-based laboratory for further experiments and analyses.

We will also opportunistically collect event-based clean rainwater samples using a polyethylene funnel and collection bottle (when conditions allow) located on deck 5, to quantify the trace metal deposition in the 'bulk' and 'precipitate-only' fractions. Ideally samples would be collected on upper and forward decks, either above the bridge or at the bow when heading into the wind. Rain samples will be acidified on board with a small amount of distilled concentrated acid (1-2uL/mL) and will be stored in the ship's freezer (in the hallway, (non-walk-in) freezer between laboratories). This project has been successfully completed on more than 10 previous RV Investigator voyages.

Organic aerosol characterisation in the Southern Ocean (Holly Winton & Ruhi Humphries, Victoria University of Wellington)

Purpose of project and anticipated outcomes: Organic marine-derived aerosols play an important role in the climate system. In addition, they are one of the main constitutes in Antarctic ice core records. Novel biomarkers of sea ice and phytoplankton have been developed based on the organic composition of Antarctic snow and ice (biogenic sulphur, fatty acid and fluorescent organic matter). However, the present-day sources in the Southern Ocean are not well characterised or quantified. The aim of the project is to collect aerosol samples for biogenic sulphur, fatty acid and fluorescent organic matter characterisation to help validate new ice core proxies of sea ice and primary production. The outcome will be a better characterisation of the sources of organic aerosol over the Southern Ocean and validation of novel ice core proxies.

Description of proposed work, including sample collection parameters and post collection activities: Collection of three sets of co-registered aerosol samples using FAS units for subsequent laboratory analysis of the organic composition. Aerosol filter change over every 3 days will be supported by the onboard science team. Samples to be kept frozen.

Assessment of marine biodiversity in the Southern Ocean using environmental DNA (Leonie Suter, AAD)

Purpose of project and anticipated outcomes: The purpose of this project is to determine the metazoan biodiversity, metazoan bioregions and indicator variables in the Southern Ocean Ecosystem by analysing environmental DNA (eDNA) collected on the CANYON voyage. The samples collected on this voyage will add to a comparable sample set from the TEMPO voyage that RV *Investigator* conducted in January to March 2021 at largely overlapping geographic locations. Having a repeated set of samples will allow us to produce robust results and make reliable recommendations for future eDNA monitoring. Trialling passive eDNA collection (metaprobes) at the sediment coring sites may allow us to compare present-day biodiversity to historic biodiversity determined from ancient DNA analyses from the deep sea sediment. In addition, attaching metaprobes to visual survey equipment may allow direct comparisons of eDNA-based molecular detection of species with visual identification of species.

Outcomes and outputs will include scientific publications, development of an eDNA reference database for the Southern Ocean, establishment of best practice guidelines for eDNA sampling and processing in the Southern Ocean, with the goal of initiating long-term monitoring using eDNA-based methods.

Description of proposed work, including sample collection parameters and post collection activities: We suggest to collect 5 L eDNA samples three times a day during transit (from Fremantle to the survey area and from the survey area to Hobart) from the uncontaminated seawater line. A peristaltic pump will be used to filter these water samples, and the filters – which will be the sample to take home – will be stored in small tubes at -80 ˚C. In addition, we suggest to collect 5 L samples from the CTD casts, ideally at least from the surface and near the sea floor, but potentially from more depths if water is available. Lastly we would like to trial passive eDNA collection by attaching “metaprobes” to equipment deployed to the deep sea, e.g. sediment corers or visual survey equipment. The metaprobes are small perforated plastic balls filled with eDNA-absorbing sponge material. Once collected, the plastic ball can be opened and the sponge stored at -80 ˚C. These samples will be processed in the molecular lab of the Australian Antarctic Division after the voyage, using a set of metabarcoding markers to determine metazoana biodiversity.

Permits

No foreign clearances required (i.e. DFAT).

Environmental Approvals obtained through the AAD include:

- Permit Antarctic Marine Living Resources 21-22, 1 January 2023 – 31 May 2023
- Permit Antarctic Treaty (Environmental Protection), Science, Expiry 31 May 2023
- Permit Antarctic Treaty (Environmental Protection), CSIRO, Expiry 31 May 2025

Quarantine permits will be required to bring samples into Australia from Antarctica, and are the responsibility of each PI.

Quarantine or Import Permit #	Issued to Organisation covering PIs	Valid from;Expiry date	For samples
IP 0007096761	Geoscience Australia Post	1 Dec 2022 to 1 Dec 2024	Sediments, water
IP0005328002	University of Queensland Bostock	22 Jun 2021 to 22 June 2023	Sediments, water
IP0005254494	University of Tasmania Chase, Noble	19 November 2021 to 19 November 2023	Sediments, water, microorganisms

No radioactive source use – no permits required.

No permits or certificates required for Unmanned Aerial Vehicles (UAVs) or notice to mariners for buoys and moorings; unless deployed by MNF staff who require certification.

Transit South crosses the South-west Network : PA2020-00041-2 Permit - South-west Network

Transit North crosses the South-east Network: PA2020-00041-1 Permit - South-east Network

Overall activity plan for mobilisation and transits

Date	Activity
Mobilisation	
18 – 23 January 2023	• Quarantine for seagoing staff and participants • Mobilisation 20 – 22nd January (non-seagoing personnel support) *Note, most MNF equipment will likely be mobilised ahead of this period with the preceding calibration voyage and port-period.
23 – 24 January 2023	• ABF Clearance, Board RVI, Sea Going Inductions, Muster • Final mobilisation activities • Pre-voyage medical clearance
25 January 2023	• Departure

<table>
<tr><th>Date</th><th>Activity</th></tr>
<tr><td colspan="2">Anticipated Activities on south transit</td></tr>
<tr><td colspan="2">• Commencement of gravity meter recording.
• Commencement of swath mapping for general collection purposes.
• A test CTD will be undertaken at 35° 12.118S,113° 24.699E with scientific samples collected (12 depths with DO and Nutrients including Ammonia) simultaneously. A short 500m TMR dip will also be completed at the same site.
• Deploy towed magnetometer for full transit south from test CTD site.
• Deployment of Argo floats. Note: magnetometer will need to be retrieved/re-deployed at an Argo float deployment</td></tr>
<tr><td colspan="2">Anticipated Activities on north transit</td></tr>
<tr><td colspan="2">• AAD CPR tow
• Float deployments if required</td></tr>
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Media Plan

The MNF will seek to pursue opportunities that arise during the voyage to promote the science, scientists and ship, via conventional and social media channels, in consultation and/or collaboration with the relevant ship user.

Organisation	Activities	Timing	Responsible person
All	Blog posts and podcasts will be written and recorded regularly by the science team. Blog posts: ACEAS website	1-2 / week	All. Helen Bostock to do final review with MNF approval.
GA	Incorporation of drone footage into media releases	Throughout voyage	Andrew Carroll
GA, UQ, UTAS (ACEAS), MNF	Facebook (@Canyons_voyage, @Sea2School_au), Twitter (@Canyons_voyage) posts will be released throughout the voyage	Throughout voyage	All, with review by relevant PI and organisation.
GA, UQ, UTAS (ACEAS), MNF	Live scientist at Sea sessions with Australian classrooms via WebEx. Will include ship's tours, and live interviews with scientists, support staff and crew members.	February	All interested members.
GA, UQ, UTAS (ACEAS), MNF	Press release to be coordinated at the start and end of voyage	Immediately before and after voyage	Lead CI and PIs
GA, UQ, UTAS (ACEAS), MNF	Opportunities for media interviews will be sought throughout the voyage.	Throughout voyage	Lead CI and PIs

List of additional figures and documents

Appendix A – MNF equipment

Appendix B – CTD Configuration

IN2023_V01 – User Supplied Equipment Manifest

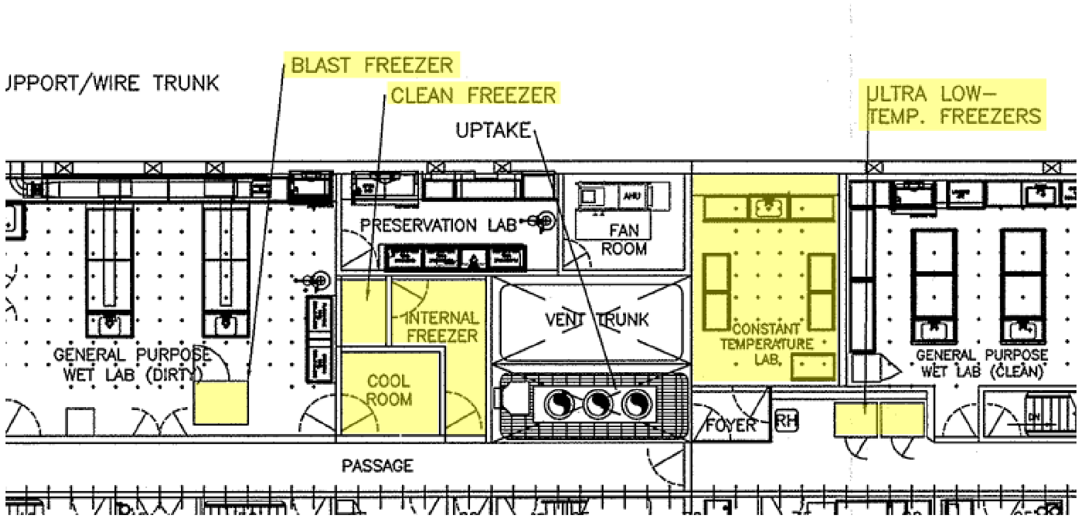
IN2023_V01 – Hazardous Materials Manifest

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	**X**	Two low risk aerosol filtering experiments will be on located in this lab and moitord by the science team.
Air Chemistry Lab		
Preservation Lab	**X**	Preservation of samples colleceted from benthic collection (dredges, cores)
Constant Temperature Lab (Min temp: 2°C / Max temp 35°C)	**X**	Core storage. Side benches to be removed so we can store cores in cage pallets. Back benches will be used for centrifuge equipment. Set temperature 2°C
Underway Seawater Analysis Laboratory	**X**	Filtering of water samples for microplastic and phytoplankton analysis and nutrients and oxygen isotopes
GP Wet Lab (Dirty)	**X**	Photography, logging and sampling of kasten cores, invertebrates and other sediment samples.
GP Wet Lab (Clean)	**X**	Use of microscopes for preliminary analysis of core material and invertebrates
GP Dry Lab (Clean)	**X**	Analysis of piston cores with the magnetic susceptibility loop sensor. Measurement of kasten cores with handheld magnetometer and XRF

Standard laboratories and facilities		
Name	Required	Notes/Comments
Sheltered Science Area	X	Labelling and capping of piston core sections. Transit area for kasten cores.
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) Internal volume >1.5m^3	X	15 ml centrifuge tubes for diatoms. Microplastic samples on filters.

Standard laboratories and facilities		
Name	Required	Notes/Comments
Capable of reducing the temperature of 150kg of water from +20C to -30C in one hour.		-30°C
Cool Room (Dirty Wet lab) (Min temp 0°C / Max temp 10°C)	X	Water storage. Set temperature 2°C
Ultra-Low Temperature Freezers x2 (Main Deck) Min temp -80°C / Max temp -80°C)	X	This is required for BGC Argo filters and sed eDNA samples.
YODA Freezers (x2) (Clean Dry lab) (Min temp -20°C / Max temp 10°C)		

Mobile laboratory and facilities *(may require additional support)*			
Name	Essential	Desirable	Notes/Comments
Modular Isotope Laboratory			
Trace Metal Niskin Sampling Container (TM1-blue) - 20ft container			Niskin racks from this container to be freighted for install in the clean 'bubble'
Trace Metal Seawater Analysis Laboratory (TM2-white) - 20ft container			
Trace Metal Rosette and Niskin Storage Container	X		10-foot container
Modular Hazchem Locker			
Stabilised Platform Container			
Clothing Container	X		

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)			AAD CPR will be utilised on northward transit. Helen Bostock will manage onboard.

Specialised sampling equipment			
Name	Essential	Desirable	Notes/Comments
TRIAXUS – Underway Profiling CTD			
Desired towing profile:			
Additional instrumentation:			
Giant Piston Coring System	X		
Gravity Coring System	X		
Multi Corer	X		
Kasten Corer	X		
Box Corer		X	New larger Box Corer if ready after E01, otherwise SMG will suffice
Smith Mac Grab		X	
Rock Dredges	X		To be modified for biological sampling due to reconfiguration of the back deck.
Rock Saw		X	

Specialised sampling equipment			
Name	Essential	Desirable	Notes/Comments
Seaspy Magnetometer	X		To be deployed on southward transit
Portable Pot Hauler			
Equipment to measure seawater sound velocity/CTD:			
XBT System	X		2 per day provided
Valeport Rapid SV			
Valeport Rapid CTD		X	We would like to trial this on dedicated transects to profile the upper ~200m of the water column. This would be achieved as underway profiles at a transit speed of 6-7 knots.
Valeport SVX2			
Trace Metal Rosette and Bottles	X		
Trace Metal In-situ Pumps (x6)			
Deep Towed Camera	X		
Drop Camera		X	
Sherman Epibenthic Sled			
Brenke Sled			
EZ Net (Multiple net system, 1m x 1m)			
Hydro-Bios MultiNet (1m x 1m)			

Specialised sampling equipment			
Name	Essential	Desirable	Notes/Comments
Surface Net (1m x 1m)			
Bongo Net	X		750mm frame, 500 micron mesh net and 335micron cod end
Beam Trawl			
MIDOC			
Pelagic Trawl System (net, doors)			
Demersal Trawl System (net, doors)			
RMT-8 (Rectangular Midwater Trawl)			
RMT-16 (Rectangular Midwater Trawl)			
Trawl Monitoring Instrumentation (ITI) (2,000m depth limit)			
Stern ramp	INSTALLED		Deck Inserts in covering stern ramp.

Research support infrastructure			
Name	Essential	Desirable	Notes/Comments
Salt Water Ice Machine (Dirty Wet lab)			
Radiosonde Receiver System			
Laboratory Incubators (Clean Dry lab)		X	
Deck Incubators			
Milli-Q System	X		

Research support infrastructure			
Name	Essential	Desirable	Notes/Comments
Sonardyne USBL System	X		

Scientific / sample analysis systems				
Microscopes:				Notes/Comments
BRAND / MODEL	TYPE	Essential	Desirable	
Leica / M80	Dissecting	X		
Leica / M80	Dissecting	X		
Leica /MZ6	Dissecting	X		
Olympus / CH	Compound	X		
Olympus /CH	Compound	X		
Leica / MTU282	Camera tube		X	
Adapters for tube / Nikon	Pentax		X	
Ring Light *2 / MEB121	LED		X	
Heavy Duty Electronic Balance (80kg)		X		
Medium Duty Electronic Balance (15kg/5g resolution)			X	
Light Duty Electronic Balance (3kg/1g resolution)		X		

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)	X		
Multi Beam Echo Sounder EM710 70-100kHz (0-1000m approx.)	X		
Sub-Bottom Profiler SBP120	X		
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 Quantitative measurements from scientific echosounders requires sphere calibration in the watermass of sampling
Multibeam Scientific Echo Sounder ME70 (70-100 kHz)		X	We would like to use this on dedicated transects to determine whether we can detect internal waves and eddies.
Omnidirectional Echo Sounder SH90			
Gravity Meter		X	

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)		X	
Aerodyne Spectrometer (analysis of N_2O/CO/H_2O)			
Cloud Condensation Nuclei (CCN)			
Polarimetric Weather Radar			
Filter Aerosol Sampling units (FAS) x 3	X		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. 3 FAS required 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		

Underway Seawater Systems and Instrumentation			
Name	Essential	Desirable	Notes/Comments
Fluorometer	X		
Optode	X		
pCO2	X		

Seawater systems			
Name	Essential	Desirable	Notes/Comments
Trace metal clean seawater supply	X		
Scientific clean seawater supplied to laboratories	X		
Raw seawater available on deck and in laboratories	X		

Appendix B

CTD Configuration

Note: A test CTD will be undertaken at an appropriate site on transit south to the survey area. The test CTD will be used by the MNF Hydrochemistry team to support the training of samplers, test Niskin bottles, collect a tracking standard for the voyage ongoing quality and uncertainty calculations. Scientific samples will be collected on the test cast also (12 depths with DO and nutrients including ammonia).

The science party may be required to assist with sampling the Niskin bottles, preparing the bottles for deployment and for setting up and logging each deployment of the CTD. Training will be given by the MNF DAP and hydrochemistry teams on board.

Fundamentals:	
Which CTD rosette to be used for this voyage (24 or 36 Niskin bottles):	36
Likely total number of casts:	20
Likely maximum depth of deepest cast:	3500
Lowered ADCP required:	Y
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):	Y
PAR Sensor (Biospherical QCP-2300):	Y
Transmissometer (Wetlabs C-Star 25cm):	Y
Fluorometer – Chlorophyll-a (Chelsea Aquatracka III – 430/685nm):	N
Fluorometer – CDOM (Wetlabs FLCDOM – 370/460nm)	Y
Nephelometer (Seapoint Turbidity Meter)	N
ECO-Triplet (Chlorophyll-a, CDOM & backscatter (full depth version))	Y

Hydrochemistry Analyses (CTD and TMR):	
Salinity	Y
Dissolved Oxygen	Y
Nutrients: Nitrate	Y
Nutrients: Phosphate	Y
Nutrients: Silicate	Y
Nutrients: Nitrite	Y
Nutrients: Ammonia	Y
Analysis of underway samples by hydrochemists (~50 samples): Zanna Chase and Taryn Noble	
Dissolved Oxygen	Y
Nutrients: Nitrate	Y
Nutrients: Phosphate	Y
Nutrients: Silicate	Y
Nutrients: Nitrite	Y
Analysis of multi-core pore waters by hydrochemists (~90 samples): Zanna Chase and Taryn Noble	
Dissolved oxygen	N
Nutrients: Nitrate	Y
Nutrients: Phosphate	Y
Nutrients: Silicate	Y
Nutrients: Nitrite	Y
Nutrients: Ammonia	Y

Additional sampling by science team: Taryn Noble and Helen Bostock	
DIC/Alkalinity (CTD, underway water)	Y
14C (CTD)	Y
U (CTD)	Y
Th/Nd isotopes (CTD)	Y
REE (CTD)	Y
O isotopes (CTD)	Y
Trace metals (pore waters)	Y
d18O diatoms (underway water)	Y
Microplastics	Y
Forams	Y
Micronutrients (Cd, Co, Cu, Fe, Ga, Mn, Ni, Pb, Ti and Zn) (TMR)	Y
Pb isotopes (TMR)	Y
U isotopes (TMR)	Y
BGC Argo CTD samples (2 sites): Zanna Chase	
Paired Total CO2 and Total Alkalinity (12 depths above 2000m depth, approx even spacing)	Y
Oxygen, salinity, and nutrients (12 depths for analysis by hydrochem)	Y
Paired POC and Pigments (5 depths, typically above 150 m). Filtered and frozen by science team	Y
Oxygen, salinity, and nutrients (5 additional depths for analysis by hydrochem)	Y