RV *Investigator* Voyage Plan

VOYAGE #:	**IN2024_V04**		
Version Number:	Final (30.5.2024)		
Voyage title:	Linking East Australian Current dynamics and submarine canyon geomorphology to marine ecosystem hotspots		
Mobilisation:	Sydney, Thursday 6th June		
Boarding:	Sydney, Friday 7th June 2024		
Depart:	Sydney, Friday 7th June 2024 (1900)		
Return:	Brisbane, Wednesday 3rd July 2024 (0800)		
Demobilisation:	Brisbane, Wednesday 3rd July 2024		
Voyage Delivery Coordinator and Voyage Manager:	Margot Hind	**Contact details:**	Margot.hind@csiro.au
Chief Scientist:	Bernadette Sloyan	**Contact details:**	Bernadette.Sloyan@csiro.au
Affiliation:	CSIRO		
Principal Investigators	Chris Chapman, CSIRO Iain Suthers, UNSW Ben Scoulding, CSIRO (not on voyage) Franzis Althaus, CSIRO (not on voyage) Eric Raes, Minderoo Foundation (not on voyage) Alysha Johnson, University of Wollongong Zhi Hang, GA (not on voyage) Scott Nichol, GA (not on voyage) Moninya Roughan, UNSW (not on voyage) Craig Stevens, NIWA (not on voyage)		

Scientific Objectives

The East Australian Current (EAC) influences the climate and marine industries for more than half of Australia's population, from Brisbane to Hobart. The strongest and most coherent part of the EAC lies between 25-32°S of the continental shelf, where it interacts with the shelf break and slope, driving sporadic upwelling of cool, nutrient rich waters. Of particular interest is the role of the EAC in driving sporadic upwelling of colder, nutrient rich waters onto the shelf-region. Upwelling of nutrients is especially important on the narrow east Australian continental shelf, as the region depends on open ocean nutrient fluxes to sustain marine productivity. These canyon systems are largely unexplored, despite their size and potential influence on coastal ecosystems and the strong gradients in vertical relief.

This voyage will survey two shelf-incising canyons that are exposed to the influence of the EAC: Solitary Canyon (~30.1 °S, within the Central Eastern Marine Park) and the Richmond Canyon (~28.4°S). The project will evaluate and compare the hydrography, circulation, and benthic biology of each canyon, surrounding area and relation to the EAC to explain any observed similarities and differences between them. We will survey the adjacent shelf and slope environments, to compare canyon and non-canyon environments, and reveal the role of submarine canyons in setting the shelf conditions.

Our central scientific hypothesis is that cross-shelf flow will be enhanced in certain canyons when compared with surrounding, non-canyon regions, due to the canyons providing a direct conduit to deliver cool, nutrient rich off-shore water to the shelf. We further hypothesise that the position of the EAC with respect to the shelf may control the effectiveness of the exchange between the deep ocean and shelf and that the canyons acts as a conduit for efficient and rapid exchange. This enhanced cross-shelf flow will transport increased concentrations of nutrients sustaining a higher biomass of plankton, megafauna such as whales, benthos such as corals, and fish. This proposed mechanism at specific geographic locations is potentially important for ameliorating the coastal warming and tropicalisation as the EAC changes, and for driving greater fisheries production in the region.

Working with Traditional Owners of the Sea Country in which the voyage will operate, Gumbaynggirr, Bundjalung and Yeagl, we will work together to understand how the canyons and East Australian Current influences the coastal shelf region. The Indigenous Sea Ranger will undertake marine mammal observations during the voyage.

Voyage Objectives

The voyage will undertake oceanographic, geophysical, and biological sampling using the CTD system, water nutrient samples, benthic camera tows, and water sample eDNA analysis and marine mammal observations. These observations will enable investigation of the canyons' physical environment, the rate of turbulent mixing and upwelling of cool, nutrient rich water through the canyon, the benthic communities present within the canyons, and the use of the canyon environment by macrofauna such as whales and sea birds.

Numerous CTD/LADCP canyon cross-sections and 12-hour CTD Yo-Yo stations, sampling temperature, salinity, dissolved oxygen, nutrient, chlorophyll-a, eDNA and, in conjunction with the Lowered Acoustic Doppler Current Profiler (LADCP), ocean currents, will be performed within and adjacent to the target canyons. We will also conduct an areal CTD/LADCP survey, and near-synoptic CTD/LADCP sections across the East Australian Current. The approximate locations of these CTD stations are shown in Figure 1. The canyon CTD/LADCP sections will be used to characterise the oceanographic environment within and adjacent to the target canyons, while the areal CTD/LADCP survey will enable us to characterise the ambient environmental conditions.

As the position of the EAC is likely to strongly influence the flow through the submarine canyon, the EAC sections will enable the characterisation of the boundary current itself, including its strength and exact position.

We will use the 36-bottle rosette with the lowered ADCPs (150 kHz and 300 kHz) attached. We will collect salinity and oxygen samples for calibration of the CTD salinity and oxygen sensors. We will also collect nutrient (silicate, phosphate, and nitrate) observations. Water samples will also be used for the collection of eDNA, which will then be compared with similar sampling on the west Australian coast by scientists from the Minderoo foundation.

Numerous Deep Towed Camera sections will be undertaken across the canyon walls following a pre-determined sampling strategy. These camera tows will allow for the characterisation of the benthic ecology of the canyons and surrounding shelf environment, as well as enable characterisation of the seafloor type (ie. sandy or rocky). During these tows, the acoustic EK80 and EK60 will be employed to estimate the midwater biomass in the canyons and over the surrounding shelf. Put together, the data will enable us to understand the role of submarine canyons in shaping the ecosystems of the east Australian continental shelf.

In conjunction of Geoscience Australia, we will assess the submarine canyons' geomorphology and stability using the Sub-Bottom Profiler. This will provide evidence of past and potential future submarine landslides and associated tsunami risks, as well as providing valuable information on the geological structure of these undersea features and how they have formed. Geoscience Australia have identified priorities for sea-floor mapping, with a particular focus on ancient coastlines. Should time permit, we will perform limited but targeted mapping using the multi-beam, particularly on the continental shelf in the vicinity of the Richmond canyon.

Three indigenous Sea Country rangers will participate in the voyage, providing marine mammal observations and valuable insight into scientific questions to be addressed from the perspective of a Traditional Owner.

The following specific activities will be conducted:

1. CTD/LADCP sections, areal surveys; and surveys across the EAC
2. Collect eDNA for rapid, low cost understanding of ecological communities present in the regions under study
3. Deep towed camera sections to characterise benthic ecology, sea floor composition and geomorphology
4. Assess submarine canyon geomorphology and stability through a series of targeted north/south sub-bottom profiler sections. These sections may be undertaken during transits to CTD or deep towed camera sites
5. Marine Mammal Observations
6. Targeted sea-floor mapping of the continental shelf in under sampled regions as identified by GA (time permitting)

Piggyback Project: Unidentified Shipwreck Survey – Heritage NSW

An investigation of an unidentified shipwreck off the NSW coast will be conducted at the beginning of the voyage during the transit to the study area. This project has been allocated a maximum of six hours on station and is being conducted on behalf of Heritage NSW. Dr Brad Duncan from Heritage NSW is the referring marine archaeologist on the investigation.

The investigation will involve a systematic bathymetric survey of the wreck and surrounding site and, if time and conditions permit, a drop camera inspection of the wreck. The objective of the investigation is to gather data and imagery to assist Heritage NSW in the positive identification of the wreck. This wreck has previously been mapped, recorded and reported by RV *Investigator* in 2021 (during IN2021_V03 Sloyan) but only limited data was collected (from a single pass) at that time due to voyage time constraints.

This investigation is part of an ongoing collaborative project involving project partners Heritage NSW, the Sydney Project and members of the community. There will be an embargo on the release of information, data and outcomes from the shipwreck investigation. Lifting the embargo will be at the discretion of Heritage NSW or one year following completion of the investigation, whichever is sooner.

Activity plan for first 24-48 hours of voyage

7th June

1900: depart Sydney

8th June

1100: Arrive test cast CTD cast to 1000m

ADCP calibrations (6hrs)

Transit to shipwreck site (~7hrs)

9th June

Shipwreck survey (6hrs)

Transit to first site (~7hrs)

On transit prepare for deployment of Deep Camera

~1400: Arrive at Solitary Canyon for first deep camera tow: start tow location at 153 42.60’ E 30 5.22’S and end tow location at 153 43.52’ E 30 6.55’S.

Waypoints and stations – General Working Area

SITE	LAT (DDM)	LONG (DDM)	DISTANCE (NM)
Sydney			
Solitary Canyon Working Area	30° 5.22'S	153° 42.60' E	~280
(CTD, 12hr CTD yo-yo, DTC, Mapping)	30° 20.42S	154° 02.16E	
	29° 58.22S	154° 32.94E	
	29° 53.40S	153° 33.00E	
General Area (CTD)	29° 58.22S	154° 32.40E	
	29° 53.40S	153° 33.00E	
	28° 36.17S	153° 51.84E	
	28° 40.22S	154° 55.26E	
Richmond Canyon Working Area	28° 40.22S	154° 55.26E	
(CTD, 12hr CTD yo-yo, DTC, Mapping)	28° 36.17S	153° 51.84E	
	28° 07.82S	153° 53.76E	
	28° 16.62S	154° 44.16E	
Brisbane			~130

Refer to external file for full way point / station details and order of activities.

Planned Totals

- Number of activities is 126
- Number of Deep Camera Tows is 40
- Number of 12hr Yo-Yo is 10
- Number of CTDs is 76
- Number of CTDs with water samples 53

Voyage track example

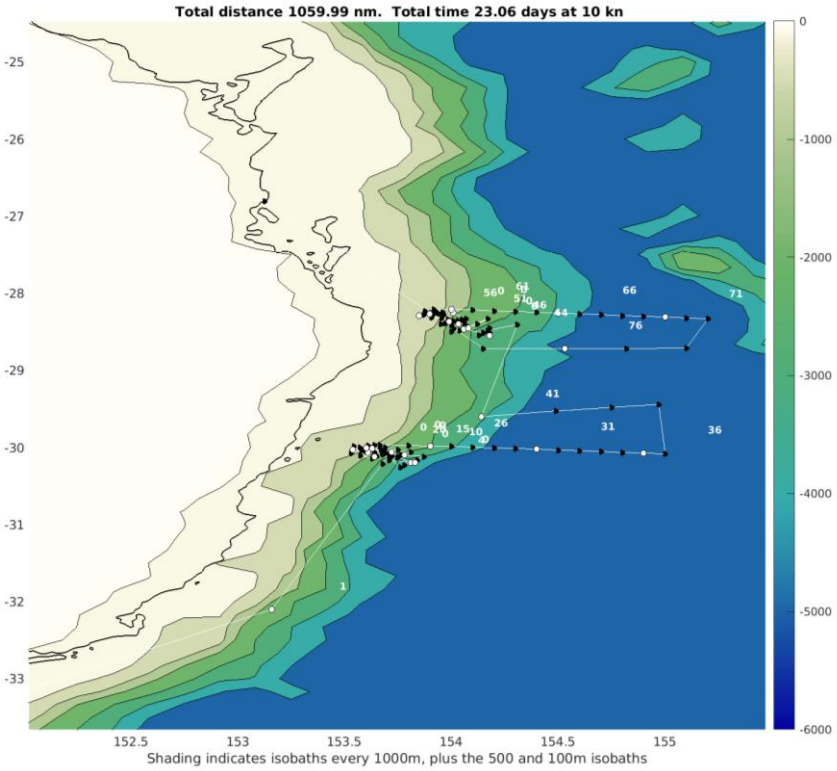

Figure 1 Voyage activities.

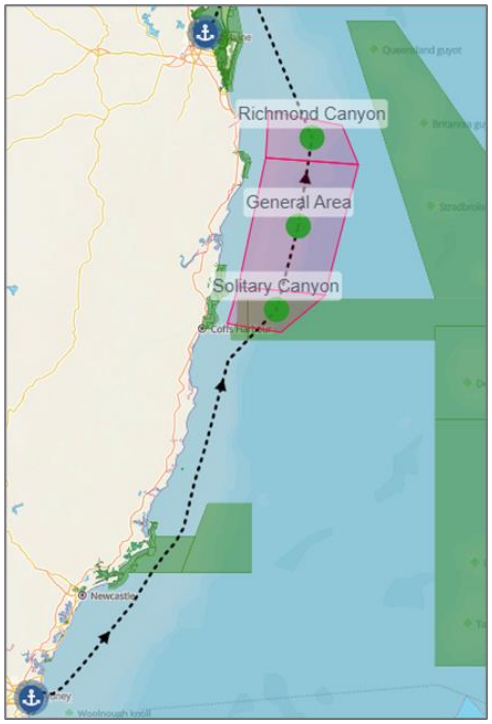

Figure 2 General work areas outlining two priority canyon areas

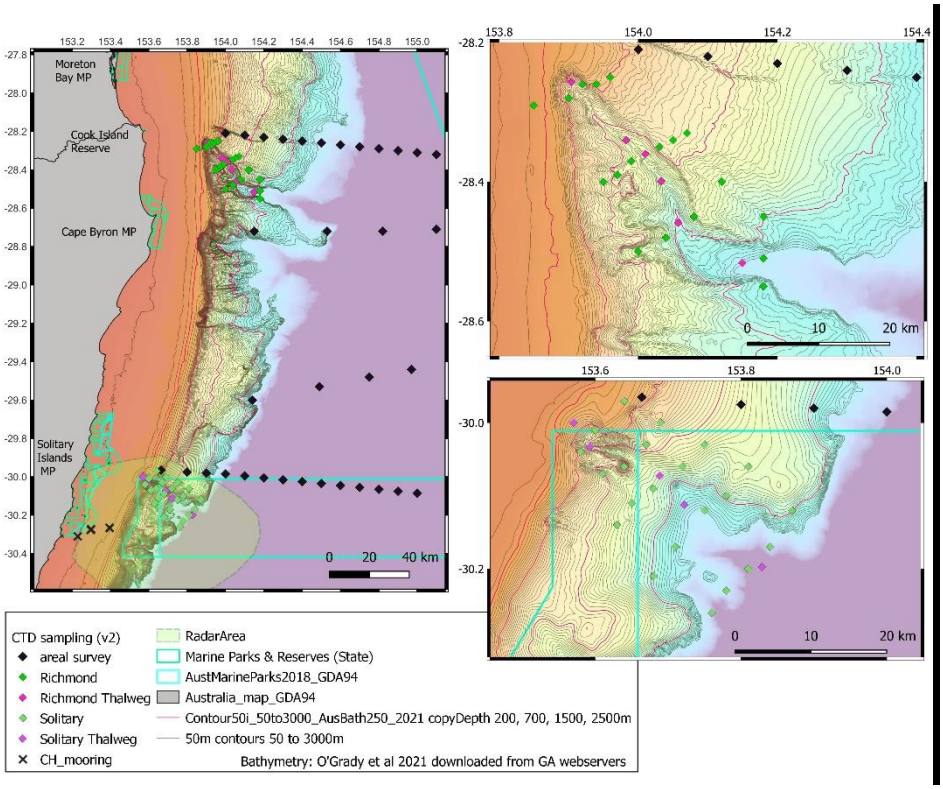

Figure 3. Location of the Solidary Canyon and Richmond Canyon. Left panel, location of both EAC CTD sections (green stars), CTD areal stations (black squares) and CTD 12hr (yo-yo) time series stations (cyan circles). Also shown are the position of IMOS Coffs Harbour mooring locations (X) and sampling region of IMOS Coffs Harbour HF-radar (shaded yellow). Right Upper and Lower panels. High resolution maps of each canyon showing location of yo-yo stations (cyan circles) and cross-canyon CTD locations (pink diamonds). Location of Australian marine parks boundaries are shown by bold cyan lines.

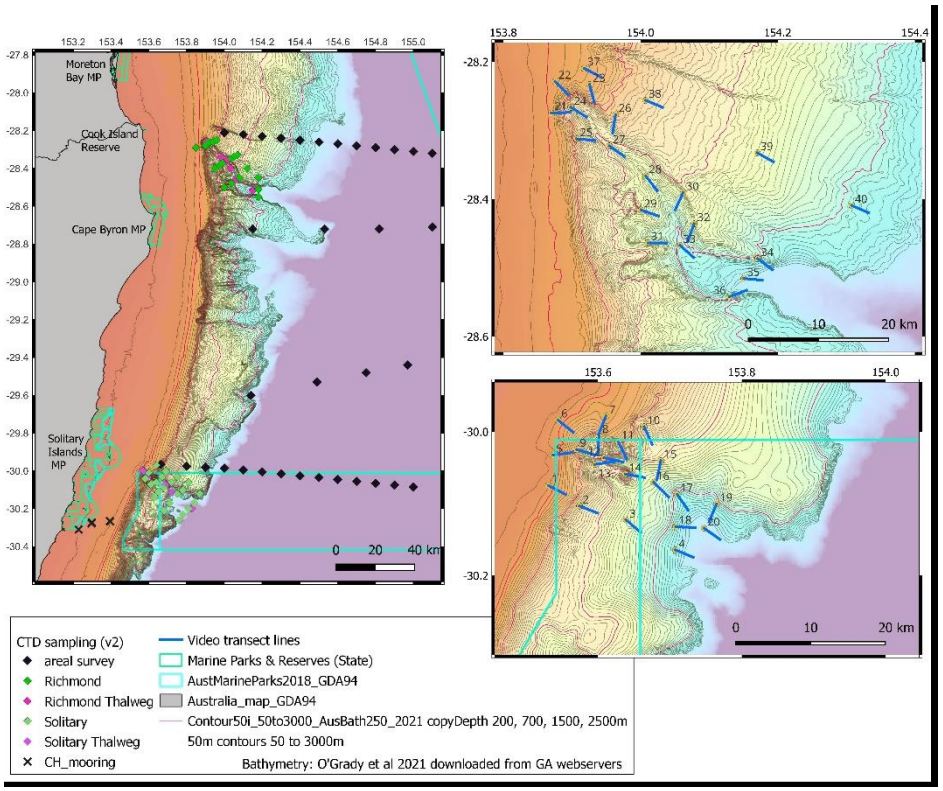

Figure 4 As for Figure 3, but right panels show 3-km long benthic camera tows for each canyon. Camera tows will sample from shallow to deep for each section.

Argo float deployment locations

Core Argo

core float, underway	-33	Along track	EAC
core float, off the Southern Canyon	-31.5	Along track	EAC
core float, off the Southern Canyon	-30.1	155.2	EAC
core float, off the Northern Canyon	-28.6	155.2	EAC

BGC Argo

BGC float, northeasternmost voyage waypoint. Must be after a CTD with water samples	-28.3	155.2	EAC
BGC float, anywhere deeper than 2000 m. Must be after a CTD with water samples	-28.3	154.8	EAC

Time estimates

Regional Timings:

- Arrive first Deep Camera Tow (DCT) (Start Position 153 42.60' E 30 5.22' S End position 153 43.52' E 30 6.55' S) at 14:00 Sunday 9 June
- Work in the Solitary Canyon region until 19-20 June.
- The region between the canyons (General Area) is planned for 8 CTD on the 21 June.
- Work in Richmond Canyon area from 22 June to 1 July
- Transit to pilot station is ~12 hours, we will leave Richmond canyon region at an appropriate time to be ready for pilot to board at ~0400 on 3 July.

Priorities:

Priority work regions are the Solitary and Richmond canyons. All the activities fit into the allocated days. However, if time delays occur, we will reduce the number of CTD in the eastern off-shore region.

Permits

This voyage will work within the following Marine Parks:

- Central Eastern Marine Park in Temperate East marine park region, Solitary Canyon

All planned operations are included in the list of authorised equipment in Parks and MNF Permit PA2020-0041-6 (variation PA2020-0041-12), and permit variation PA2020-00041-12 (VARIATION PA2020-00041-13) for benthic camera tows.

- CSIRO Animal ethics permit required for camera work.

CTD Configuration

The MNF CTD is a Seabird 911 system with a variety of auxiliary sensors, installed on either a 24 or 36 bottle Niskin frame.
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.

- Plan for the following maximum rate of analyses based on 2 Hydro-chemists:
- 48 nutrients, 48 dissolved oxygen, 48 salinity analyses per 24 hours; OR
- 72 nutrient, 36 dissolved oxygen, 36 salinity analyses per 24 hours; OR
- 160 nutrient analyses (only) per 24 hours.

	PLEASE SELECT:
Fundamentals	
Which CTD rosette to be used for this voyage (24 or 36 Niskin bottles):	36
Likely total number of casts:	78
Likely maximum depth of deepest cast:	5000m
Standard CTD Configuration - Instrumentation (maximum 6 auxiliary channels plus 2 x DO) 6000m	
1 x SBE9+ (CTD) 2 x SBE3P Temperature Sensors 2 x SBE4C Conductivity Sensors 2 x SBE5T pumps	Yes
2 x SBE43 Dissolved Oxygen Sensors	Yes
1 x Tritech PA200/500 Altimeter	Yes
1 x Biospherical QCP2300HP PAR Sensor	Yes
1 x Wetlabs C-Star 25cm Transmissometer	NO
1 x Wetlabs ECO FLCDRTD Fluorometer – CDOM (370/460nm)	NO
1 x Wetlabs ECO FLBBRTD Fluorometer – Chlorophyll-a & Backscatter (2 x channels - 470/695nm)	YES
Alternative Instruments (Instruments highlighted in grey can be substituted from standard configuration)	
Seapoint Turbidity Meter – Nephelometer	
Chelsea Aquatracka III (430/685nm) Fluorometer – Chlorophyll-a	

Seabird SUNA – Ultraviolet Nitrate Analyzer (**Serial Connection - 2000m**)	
Standard LADCP Configuration – Instrumentation: 6000m	
1 x Teledyne 300 kHz LADCP (Slave - Up) 1 x Teledyne 150 kHz LADCP (Master - Down) 1 x 48V Deep Sea Battery	Yes
Alternative LADCP Configuration - Instrumentation: 6000m	
1 x Teledyne 300 kHz LADCP (Slave - Up) 1 x Teledyne 300 kHz LADCP (Master - Down) 1 x 48V Deep Sea Battery	Yes/No
Hydrochemistry Analyses	
Salinity	Yes
Dissolved Oxygen	Yes
Nutrients: Nitrate	Yes
Nutrients: Phosphate	Yes
Nutrients: Silicate	Yes
Nutrients: Nitrite	Yes
Nutrients: Ammonia	Yes/No

- We will attach ocean turbulence (micro-rider) to the rosette near the 911+ . The data from this instrument will be recorded internally and downloaded after the rosette is recovered onto the ship.

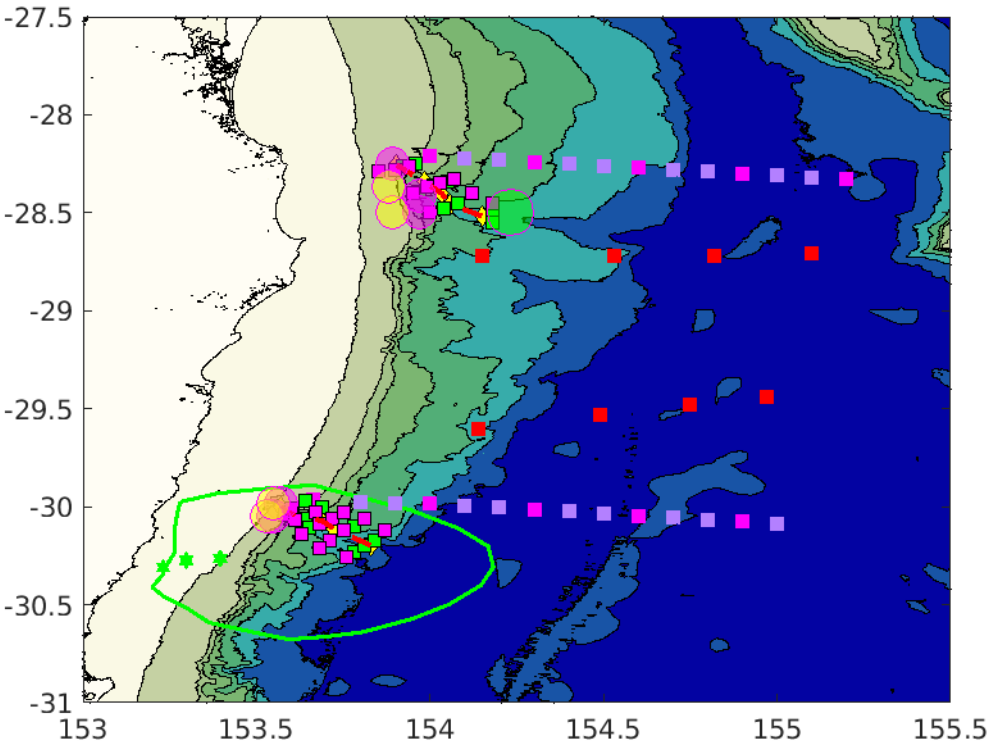

Figure 3. Filled magenta and red squares indicate CTD stations that will include water samples. Water samples will also be taken on the last yo-yo profile (filled yellow squares).

Signature

Your name	Bernadette Sloyan
Title	Chief Scientist
Signature	
Date:	30 May 2024

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		
Preservation Lab		
Constant Temperature Lab (Min temp: ~4°C / Max temp ~35°C)		
Underway Seawater Analysis Laboratory		
GP Wet Lab (Dirty)	X	• Store Argo floats
GP Wet Lab (Clean)	X	
GP Dry Lab (Clean)	X	
Sheltered Science Area	X	• Store DTC & BGC Argo floats
Observation Deck 07 Level		
Internal Freezer (Dirty Wet lab)		
Clean Freezer (Dirty Wet lab)		
Blast Freezer (Dirty Wet lab)		
Cool Room (Dirty Wet lab)		

STANDARD LABORATORIES AND FACILITIES		
NAME	**REQUIRED**	**NOTES/COMMENTS**
Ultra-Low Temperature Freezers x2 (Main Deck) Min temp -80^{o}C / Max temp -80^{o}C)	X	• Store eDNA and chlorophyll samples
YODA Freezers (x2) (Clean Dry lab)		

Deep Towed Camera	X With Open/closing device for underway eDNA mounted		Animal ethics permit process underway. Need to send to Marine Parks for permit approval
Drop Camera	X		Piggyback Shipwreck Survey

Underway systems

ACOUSTIC UNDERWAY SYSTEMS			
NAME	**ESSENTIAL**	**DESIRABLE**	**NOTES/COMMENTS**
75kHz ADCP	X		Included in list of authorised equipment in Parks and MNF Permit variation (PA2020-0041-12)
150kHz ADCP	X		Included in list of authorised equipment in Parks and MNF Permit variation (PA2020-0041-12)

ACOUSTIC UNDERWAY SYSTEMS			
NAME	**ESSENTIAL**	**DESIRABLE**	**NOTES/COMMENTS**
Multi Beam Echo Sounder EM122 12kHz (100m to full ocean depth)	X		Included in list of authorised equipment in Parks and MNF Permit variation (PA2020-0041-12)
Multi Beam Echo Sounder EM710 70-100kHz (0-1000m approx.)	X		Included in list of authorised equipment in Parks and MNF Permit variation (PA2020-0041-12)
Sub-Bottom Profiler SBP120	X		Included in list of authorised equipment in Parks and MNF Permit variation (PA2020-0041-12)
Scientific Narrowband Echo Sounders EK60 (6 bands, 18kHz-333kHz)	X		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)	X		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)			
Omnidirectional Echo Sounder SH90			
Gravity Meter			

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

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

Appendix B

User Supplied Equipment

The table below will include information provided by the Chief Scientist / Principal Investigators in the '*Equipment Manifest-user supplied voyage specific'* document. The Chief Scientist will co-ordinate the completion of this Manifest with all PIs and forward the completed document to the Voyage Operations Manager.

NOTE: User supplied equipment will remain the responsibility of the science party throughout the voyage. The MNF technicians and ship's crew endeavor to assist wherever possible, however the MNF take no responsibility for the pre-deployment checks or repairs and maintenance of this equipment.

This information will also be used for the mobilisation list and deck plan for the voyage.

Owner	Contact details	Item name	Weight	Dimensions	Location on Vessel
CSIRO, Environment	Gabriela.Semolinipilo@csiro.au	Core Argo float			Dirty wet lab
CSIRO, Environment	Christina.Schallenberg@utas.edu.au	BGC-Argo float			Dirty wet lab
JAMSTEC, Japan	Bernadette.Sloyan@csiro.au	Rockland micro-rider	5.5 kg	L: 0.88m D:89 mm	Secured to CTD rosette
CSIRO, Environment	Christina.Schallenberg@utas.edu.au	POC filtration system			Dry clean lab
Mindaroo Foundation	eraes@minderoo.org	eDNA sampling system		4 m2	Dry clean lab
UNSW	a.schaeffer@unsw.edu.au	4 x Carthe drifters	4kg	0.5m2	Dirty wet lab
UNSW	Mroughan@unsw.edu.au	Moana Sensor and Deck box			Dirty wet lab and secured to CTD rosette

Appendix C

Deck Plan