RV *Investigator* Voyage Plan

VOYAGE #:	**IN2023_V06**		
Version Number:	Final		
Voyage title:	Understanding Eddy Interactions and Their Impacts in the East Australian Current System		
Mobilisation:	Sydney, White Bay, 6 October 2023		
Pre-medical clearance period:	Sydney, White Bay, 7-8 October 2023		
Depart:	Sydney, White Bay, 9 October 2023		
Return:	Sydney, 2 November 2023		
Demobilisation (science):	Sydney, 2 November 2023		
Demobilisation (MNF):	Hobart, 5 November 2023		
Voyage Delivery Coordinator:	Margot Hind	Contact details:	Margot.hind@csiro.au
Voyage Manager:	Linda Gaskell	Contact details:	Linda.gaskell@csiro.au
Chief Scientist:	Dr Moninya Roughan		
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Voyage objectives

This study focuses on mesoscale eddies, the weather systems of the ocean, that move heat, salinity, and other tracers around. They impact the ocean, ecosystems, and climate. We don't know a lot about how these eddies interact with each other or how they affect the environment. This study aims to learn more about eddy-eddy interactions and their impact on the atmosphere, ocean, and marine life in the East Australian Current System. We will use satellite and in-situ measurements to help improve forecasts and predictions of eddy interactions, which will benefit the Royal Australian Navy and the coastal populations.

The shipboard methods are mostly well-established; however, the innovation lies in the combination of the full suite of physical, atmospheric, and biogeochemical observations to resolve eddy-eddy interactions. Specifically, we will:

- Shipboard ADCPs (75 kHz and 150 kHz) to get velocity profiles to 800m
- Measure deep scattering layers from 0 to 800 m detected from the ADCP (and EK60 if it does not interfere).
- Deploy 20 drifters (10 donated by NOAA's Global Surface Drifter Program, and 10 from BoM) in triplets
- Deploy 3 near surface CARTHE drifters for very near surface currents.
- Deploy 4 Argo floats (BoM sponsored) 2 in cyclones (cold core eddy) and 2 in anticyclones (warm core eddy)
- Deploy 1 BGC-Argo float in the centre of a cyclone (cold core eddy)
- Deploy 40 Radio Sondes for atmospheric properties above eddies and fronts

Underway Atmospheric Observations- continuous

- C-band Doppler radar data to characterize the precipitation (rain, hail, ice)
- ODM optical disdrometer provides 1-minute time series of rainfall
- Underway meteorological sensors (wind, air temperature, humidity, pressure, rain, long and shortwave radiation)
- Turbulent air-sea momentum, heat and potentially carbon fluxes [3-D sonic anemometers and high frequency air temperature, humidity and CO2 instrument] soon to be deployed by U Mel.
- Radiometric SST measurements (ISAR instrument).

Underway Flow-through near-surface obs (~7m)- continuous

Standard sensors plus our own sensors (*)

- Extracted Chl-a from the flow-through and ~30 HPLC samples
- Active fluorescence using FIRe* (Fluorescence Induction and Relaxation)
- Spectra of particle absorption and attenuation as a proxy for phytoplankton community composition, AC-S *
- Images of near-surface micro-phytoplankton from the flow-through system (using a custom-built Planktonscope*; Pollina et al. 2020)

TRIAXUS towed Body (10-350m)

- We will tow the TRIAXUS extensively to extend our understanding of the fine distribution of physical and biogeochemical tracers across the continental shelf, and frontal lines. In addition to the sensors mentioned in the 'Equipment section' we will add:
    - Nitrate (Satlantic ISUS sensor*)
    - Nitrate calibration samples (~30 from the flow through) when TRIAXUS is near the surface
    - Add Moana (user supplied) temperature sensor to the Triaxus for comparison studies

Vertical CTD and L-ADCP Profiles (0-2000m)

- We will conduct ~100 deep CTD casts with L-ADCP to determine eddy-eddy depth structure.
- 4 x 150-200km lines with casts every 5-10km. Using profiling sensors and water samples from Niskin bottles (depths = 0,10,25,50,75,100, 125, 150,175, 200,250,300,400,500,750,1000,1500,2000).
- Primary productivity in surface, DCM (when present) and selected stations depth-integrated determined by 13C incubations, utilizing the Isotope Lab and deck board incubators and water samples from Niskin bottles from ~ 25 CTD casts to determine spatial and temporal variability.
- Phytoplankton count and identification samples will be collected at primary productivity stations for comparison and community composition profile.

Contingency plan for dealing with equipment downtime

- TRIAXUS lines will be maximum of 12 hrs each, and no more than 50hrs (4 x 12 hr lines) in one block.
- We will conduct a line of deep CTD profiles at the start and end of each Triaxus block to allow for TRIAXUS checking and overhaul.
- We will conduct Shallow CTDs, XBTs, Rapdicast CTDs and ADCP lines during down time.
- Test CSIRO XBT auto launcher (2 x 4 hrs)

User Supplied Equipment

- Derived Chl-a (measured fluorometrically) from the flow-through system and ~30 HPLC samples
- Active fluorescence using a FIRe* (Fluorescence Induction and Relaxation).
- Spectra of Absorption and Attenuation for near-surface particles (as a proxy for phytoplankton community composition) measured by an AC-S or AC-9* installed on the flow-through system
- Images of near-surface micro-phytoplankton from the flow-through system (using a custom-built Planktonscope*; Pollina et al. 2020)
- Flow rate should be around 1-2 L/min.
- Instant primary productivity (measured fluorometrically) using LABStaff (Chelsea Technologies) during TRIAXUS for granular spatial and temporal assessment.
- Microtops atmospheric measurements (from foredeck)

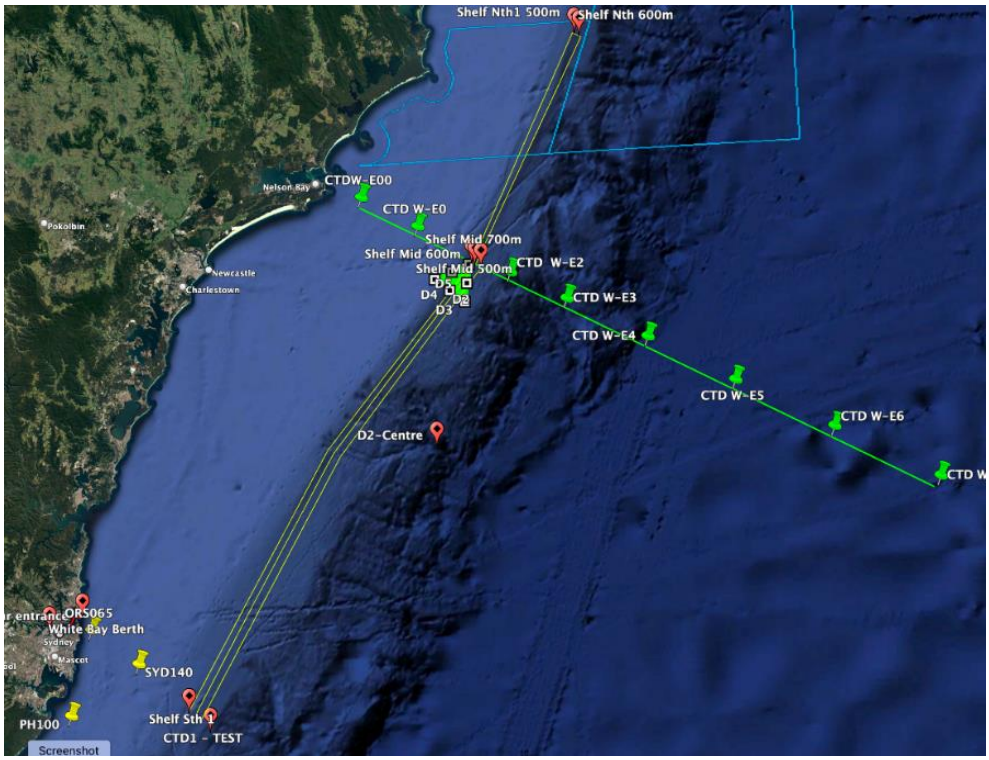
- Radiosondes (40) “What influences can EAC eddies have on environments conducive to thunderstorm occurrence”
- Opportunistic sampling for blue bottles if present at the surface while stationary using a bucket.

Media Activities

ORGANISATION	ACTIVITIES	TIMING	RESPONSIBLE PERSON
UNSW	Pre-voyage media engagement through article (The Conversation or Cosmos Magazine) describing ship capabilities and voyage aims.	Pre-departure	Shane Keating, Moninya Roughan
UNSW	Media engagement via personal Twitter (X), LinkedIn and Instagram accounts including regular story updates, interviews and explainer videos.	Opportunistically throughout voyage and post-voyage	Bella Charlesworth, Moninya Roughan, Shane Keating
UNSW	Informal interviews with scientists on board to discuss science being undertaken	Throughout voyage	Bella Charlesworth
UNSW	Point of contact with media outlets to schedule media interviews with team.	Throughout voyage	UNSW Media Office / Bella
UNSW	Compilation of range of stories and blogs to be released.	Throughout and post-voyage.	Bella Charlesworth

Activity plan for first 24-48 hours of voyage

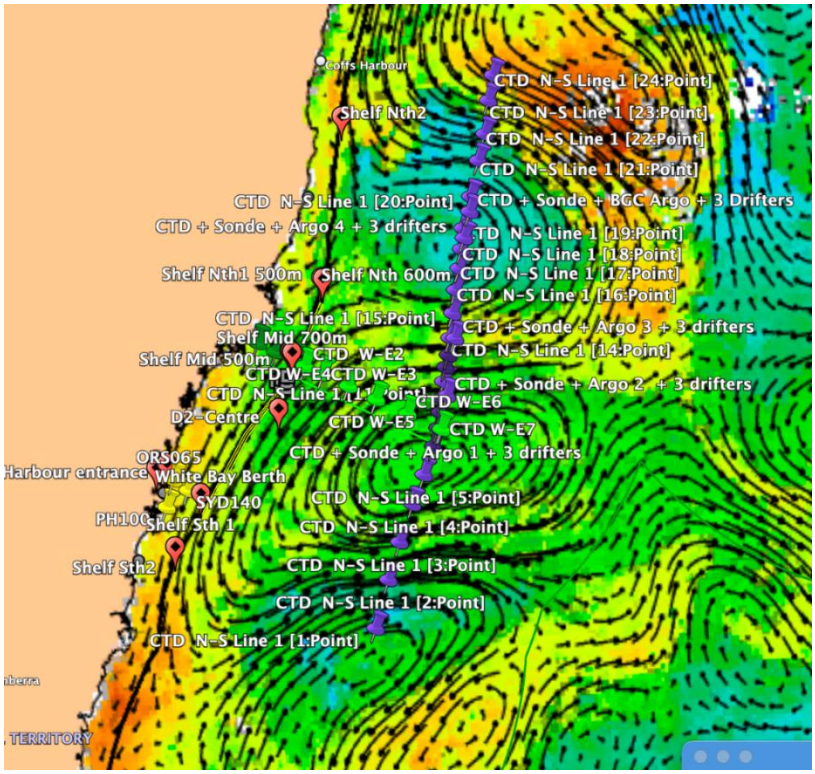
Depart White Bay, Sydney, head to CTD1 – Test at the 1000m isobath, then deploy Triaxus for 12 hrs (under way ADCP and nuts), head north along 500m isobath. Retrieve Triaxus for checking, deploy 6 drifters, in 6nm x 6 nm triangle, conduct CTD cast to 500m, then redeploy Triaxus for 3 x 12 hrs. The below images show the proposed track for first 72 hours, and triangle of drifter deployment.



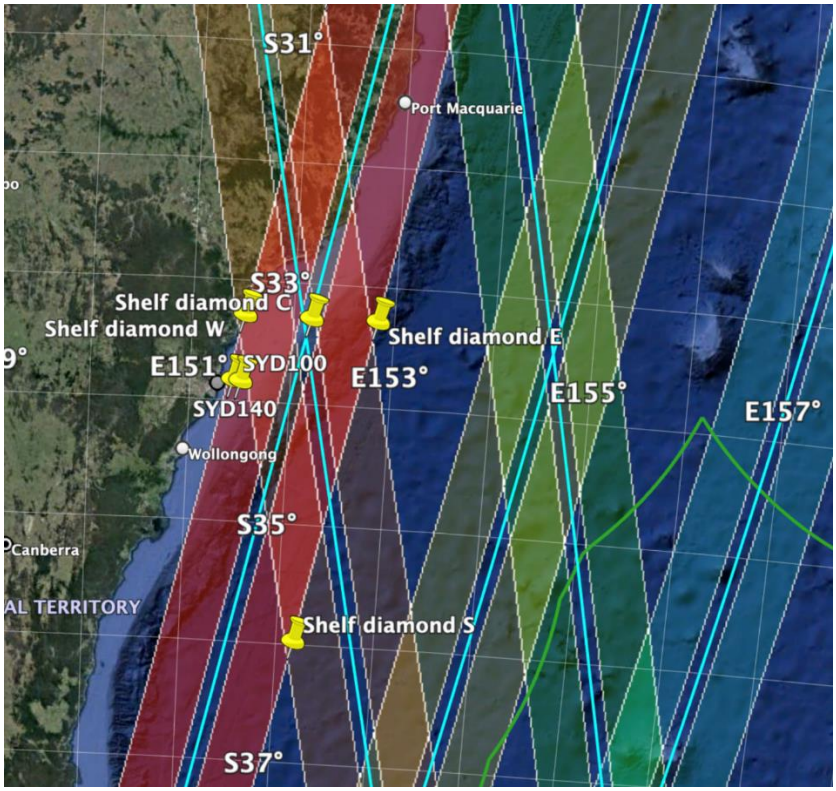
Waypoints for first 72 hours

WP Name	Date /Time	Station Arrival Time	Activity on station [text]	Distance Between current wp and next wp i.e. dist to next Station [nm]
White Bay Berth	Monday, 9 October 2023	09:00	Transit	5.80
Entrance to Syd Harb		09:34	Transit	3.69
ORS065		09:56	Transit	9.38
SYD 140		10:53	Transit	15.17
CTD 1		12:24	Test CTD (> 1000m)	4.58
Shelf Sth 500		13:51	Reposition, deploy Triaxus Tx1	48.15
Shelf Diamond C 500m		20:52	Towing Tx1	37.54
Shelf Mid 500m	Tuesday, 10 October 2023	01:34	Retrieve Tx1, check Tx	0.00
Shelf Mid 500m		02:34	Deploy Triaxus Tx2	40.59
Shelf Nth 500m		07:38	Towing Tx2	0.89
Shelf Nth 600m		07:45	Towing Tx2	40.63
Shelf Mid 600m		12:50	Retrieve Tx2, reposition	0.62
Shelf Mid 500m		13:54	Deploy 6 drifters (6 nm triangle), CTD2 to 500m,	0.62
Shelf Mid 600m		17:59	Deploy Triaxus Tx3	37.59
Shelf Diamond C 600m		23:11	Towing Tx3	47.81
Shelf Sth 600	Wednesday, 11 October 2023	05:10	Retrieve Tx3, reposition	1.11
Shelf Sth 700		06:18	Deploy Triaxus Tx4	48.22
Shelf Diamond C 700m		12:19	Towing Tx4	37.34
Shelf Mid 700m		17:00	Towing Tx4	8.48
Shelf Nth 700m		18:03	Retrieve Tx4	0.00

Voyage track example



SWOT Path



Time estimates until 22nd Oct (additional waypoints dependent on Eddy structure)

Date /Time	Station Arrival Time [Local]	Lat Dec Degrees	Lon Dec Degrees	WP Name	Water Depth [m] at WP	Activity on station
Monday, 9 October 2023	9:00	-33.861583	151.188783	White Bay Berth	20	Transit
	9:34	-33.833333	151.3	Entrance to Syd Harb	20	Transit
	9:56	-33.893633	151.314667	ORS	65	Transit
	10:53	-33.994	151.459	SYD 140	140	Transit
	12:24	-34.167368	151.680985	CTD 1	1000	Test CTD (> 1000m)
	13:58	-34.109383	151.621083	Shelf Sth 500	500	Reposition, deploy Triaxus Tx1
	20:59	-33.432904	152.139376	Shelf Diamond C 500m	500	Towing Tx1
Tuesday, 10 October 2023	1:41	-32.962979	152.632192	Shelf Mid 500m	500	Retrieve Tx1, check Tx
	2:41	-32.962979	152.632192	Shelf Mid 500m	500	Deploy Triaxus Tx2
	7:45	-32.363982	153.004429	Shelf Nth 500m	500	Towing Tx2
	7:52	-32.37174	153.019283	Shelf Nth 600m	600	Towing Tx2
	12:57	-32.969304	152.641892	Shelf Mid 600m	600	Retrieve Tx2, check, reposition
	14:01	-32.962979	152.632192	Shelf Mid 500m	500	Deploy 6 NOAA + 3 Carthe drifters (6 nm triangle),
	16:31	-32.962979	152.632192	Shelf Mid 500m	600	CTD2 to 500m,
	17:36	-32.969304	152.641892	Shelf Mid 600m	600	Deploy Triaxus Tx3
	22:48	-33.444619	152.154812	Shelf Diamond C 600m	600	Towing Tx3
Wednesday, 11 October 2023	4:46	-34.118297	151.644002	Shelf Sth 600	700	Retrieve Tx3, Check reposition
	5:55	-34.128746	151.662349	Shelf Sth 700	700	Deploy Triaxus Tx4
	11:56	-33.44944	152.177739	Shelf Diamond C 700m	700	Towing Tx4
	16:36	-32.976495	152.660396	Shelf Mid 700m	700	Towing Tx4
	17:27	-32.858783	152.7533	Shelf Nth 700m	700	Retrieve Tx4, Relocate to start of CTD Line. Reterminate Triaxus
	19:19	-32.959819	152.632868	CTD W-E1	500	CTD - full depth
	20:46	-32.881298	152.456969	CTD W-E0	150	CTD - full depth
	22:14	-32.793518	152.284167	CTD W-E00	110	CTD - full depth
	22:41	-32.793518	152.284167	CTD W-E00	110	CTD - full depth
Thursday, 12 October 2023	0:09	-32.881298	152.456969	CTD W-E0	150	CTD - full depth
	1:36	-32.959819	152.632868	CTD W-E1	500	CTD - full depth
	2:43	-33.019338	152.742009	CTD W-E2	1500	CTD - full depth
	5:13	-33.098759	152.916396	CTD W-E3	3000	CTD - to 2000m Rapid cast CTD between

Date /Time	Station Arrival Time [Local]	Lat Dec Degrees	Lon Dec Degrees	WP Name	Water Depth [m] at WP	Activity on station
Thursday, 12 October 2023	8:39	-33.213398	153.166472	CTD W-E4	5000	CTD - to 2000m Rapid cast CTD between
	12:13	-33.342435	153.438088	CTD W-E5	4600	CTD - to 2000m Rapid cast CTD between
	15:58	-33.480648	153.747359	CTD W-E6	4600	CTD - to 2000m Rapid cast CTD between
	19:52	-33.62934	154.081629	CTD W-E7	4600	CTD - to 2000m Rapid cast CTD between
	21:52	-33.62934	154.081629	CTD W-E7	4600	Sonde plus Argo (eddy core)
	22:52	-33.62934	154.081629	CTD W-E7	4600	3 drifters in 3nm x 3nm triangle (eddy core)
Friday, 13 October 2023	3:04	-34.112657	153.814665	CTD N-S Line 1 [4:Point]	4600	CTD - to 2000m
	7:04	-33.869337	153.950536	CTD N-S Line 1 [5:Point]	4600	CTD - to 2000m Rapid cast CTD between
	10:58	-33.635417	154.064417	CTD N-S Line 1 [6:Point]	4600	CTD - to 2000m Rapid cast CTD between
	14:10	-33.483361	154.119267	CTD N-S Line 1 [7:Point]	4600	CTD - to 2000m Rapid cast CTD between
	17:11	-33.35052	154.153877	CTD N-S Line 1 [8:Point]	4600	CTD - to 2000m Rapid cast CTD between
	19:13	-33.34691	154.148198	CTD N-S Line 1 [9:Point]	4600	CTD - to 2000m Sonde plus Argo (warm eddy core)
	23:05	-33.233761	154.176722	CTD N-S Line 1 [10:Point]	4600	CTD - to 2000m Rapid cast CTD between
Saturday, 14 October 2023	2:10	-33.092096	154.206725	CTD N-S Line 1 [11:Point]	4600	CTD - to 2000m Rapid cast CTD between
	5:06	-32.969859	154.236081	CTD N-S Line 1 [12:Point]	4600	CTD - to 2000m Rapid cast CTD between
	7:54	-32.868667	154.2689	CTD N-S Line 1 [13:Point]	4600	CTD - to 2000m Sonde plus Argo (warm eddy core)
	11:59	-32.725531	154.295496	CTD N-S Line 1 [14:Point]	4600	CTD - to 2000m Rapid cast CTD between
	15:34	-32.51693	154.338193	CTD N-S Line 1 [15:Point]	4600	CTD - to 2000m Rapid cast CTD between
	19:04	-32.321261	154.380105	CTD N-S Line 1 [16:Point]	4600	CTD - to 2000m Rapid cast CTD between

Date /Time	Station Arrival Time [Local]	Lat Dec Degrees	Lon Dec Degrees	WP Name	Water Depth [m] at WP	Activity on station
Saturday, 14 October 2023	22:28	-32.138881	154.427887	CTD N-S Line 1 [17:Point]	4600	CTD - to 2000m Rapid cast CTD between
Sunday, 15 October 2023	1:42	-31.976888	154.462563	CTD N-S Line 1 [18:Point]	4600	CTD - to 2000m Sonde plus Argo (cyclonic eddy core)
	6:03	-31.7993	154.4907	CTD N-S Line 1 [19:Point]	4600	CTD - to 2000m Sonde plus BGC Argo (cyclonic eddy core)
	11:08	-31.531884	154.585362	CTD N-S Line 1 [20:Point]	4600	CTD - to 2000m Rapid cast CTD between
	15:31	-31.227255	154.68419	CTD N-S Line 1 [21:Point]	4600	CTD - to 2000m Rapid cast CTD between
	19:18	-31.000	154.76293	CTD N-S Line 1 [22:Point]	4600	CTD - to 2000m Rapid cast CTD between
Monday, 16 October 2023	0:16	-31.247986	154.401793	Tx Slope Line Nth	4600	Deploy Tx 5, Sondes across fronts (3?)
	8:22	-32.16278	154.123248	Tx Slope Line Mid 1	4600	Retrieve Tx5, check Tx Deploy Tx6, Sondes across fronts (3?)
	22:32	-33.881353	153.693146	Tx Slope Line Mid 2	4600	Retrieve Tx6, check Tx Deploy Tx7, Sondes across fronts (3?)
Tuesday, 17 October 2023	12:43	-32.16278	154.123248	Tx Slope Line Mid 1	4600	Retrieve Tx7, check Tx Deploy Tx8, Sondes across fronts (3?)
Wednesday, 18 October 2023	2:54	-33.881353	153.693146	Tx Slope Line Mid 2	4600	Retrieve Tx8, Reterminate Tx Sondes across fronts (3?)
	5:47	-34.112657	153.814665	CTD N-S Line 1 [4:Point]	4600	CTD - to 2000m Rapid cast CTD between
	9:24	-33.869337	153.950536	CTD N-S Line 1 [5:Point]	4600	CTD - to 2000m Rapid cast CTD between
	12:55	-33.635417	154.064417	CTD N-S Line 1 [6:Point]	4600	CTD - to 2000m Rapid cast CTD between
	15:52	-33.483361	154.119267	CTD N-S Line 1 [7:Point]	4600	CTD - to 2000m Rapid cast CTD between
	18:41	-33.35052	154.153877	CTD N-S Line 1 [8:Point]	4600	CTD - to 2000m Rapid cast CTD between
	20:43	-33.34691	154.148198	CTD N-S Line 1 [9:Point]	4600	CTD - to 2000m Rapid cast CTD between
	23:25	-33.233761	154.176722	CTD N-S Line 1 [10:Point]	4600	CTD - to 2000m Rapid cast CTD between

Date /Time	Station Arrival Time [Local]	Lat Dec Degrees	Lon Dec Degrees	WP Name	Water Depth [m] at WP	Activity on station
Thursday, 19 October 2023	2:17	-33.092096	154.206725	CTD N-S Line 1 [11:Point]	4600	CTD - to 2000m Rapid cast CTD between
	5:02	-32.969859	154.236081	CTD N-S Line 1 [12:Point]	4600	CTD - to 2000m Rapid cast CTD between
	7:39	-32.868667	154.2689	CTD N-S Line 1 [13:Point]	4600	CTD - to 2000m Rapid cast CTD between
	10:32	-32.725531	154.295496	CTD N-S Line 1 [14:Point]	4600	CTD - to 2000m Rapid cast CTD between
	13:48	-32.51693	154.338193	CTD N-S Line 1 [15:Point]	4600	CTD - to 2000m Rapid cast CTD between
	16:59	-32.321261	154.380105	CTD N-S Line 1 [16:Point]	4600	CTD - to 2000m Rapid cast CTD between
	20:07	-32.138881	154.427887	CTD N-S Line 1 [17:Point]	4600	CTD - to 2000m Rapid cast CTD between
	23:06	-31.976888	154.462563	CTD N-S Line 1 [18:Point]	4600	CTD - to 2000m Rapid cast CTD between
Friday, 20 October 2023	2:11	-31.7993	154.4907	CTD N-S Line 1 [19:Point]	4600	CTD - to 2000m Rapid cast CTD between
	5:51	-31.531884	154.585362	CTD N-S Line 1 [20:Point]	4600	CTD - to 2000m Rapid cast CTD between
	9:48	-31.247986	154.401793	Tx Slope Line Nth	4600	Deploy Tx 5, Sondes across fronts (3?)
	17:54	-32.16278	154.123248	Tx Slope Line Mid 1	4600	Retrieve Tx5, check Tx Deploy Tx6, Sondes across fronts (3?)
Saturday, 21 October 2023	8:04	-33.881353	153.693146	Tx Slope Line Mid 2	4600	Retrieve Tx6, check Tx Deploy Tx7, Sondes across fronts (3?)
Saturday, 21 October 2023	22:15	-32.16278	154.123248	Tx Slope Line Mid 1	4600	Retrieve Tx7, check Tx Deploy Tx8, Sondes across fronts (3?)
Sunday, 22 October 2023	12:26	-33.881353	153.693146	Tx Slope Line Mid 2	4600	Retrieve Tx8, Re-terminate Tx Sondes across fronts (3?)

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 hydrochemists:

- 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 note any special requests – such as special sampling that is intended to be performed by the science party (e.g. sampling for dissolved gases, radioisotopes, etc.); or any user-supplied instrumentation to be fitted to the CTD frame; etc.

CTD Sampling Plan

Conduct ~100 deep CTD casts with L-ADCP to determine full water-column structure to 2000 m collecting measurements with profiling sensors and taking water samples from Niskin bottles (depths = 0,10,25,50,75,100, 125, 150,175, 200, 250, 300, 400, 500, 750, 1000, 1500, 2000).

We will also sample:

- Chlorophyll pigment – Niskin
- HPLC, POC, DIC, Alkalinity (with each BGC Argo float deployment) – Niskin
- Combined chlorophyll fluorescence and backscatter sensor, FLBB (Trull) instead of the MNF fluorometer - where channels permit.
- Primary Productivity on same deployments as HPLC and BGC Argo deployments for surface and DCM (if present) and water column for Argo BCG stations.

	Please select
Fundamentals:	
Which CTD rosette to be used for this voyage (24 or 36 Niskin bottles):	36
Likely total number of casts:	~10 per 24 hours
Likely maximum depth of deepest cast:	2000m
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):	X
PAR Sensor (Biospherical QCP-2300):	X
Transmissometer (Wetlabs C-Star 25cm):	X
Fluorometer – Chlorophyll-a (Chelsea Aquatracka III – 430/685nm):	X

	Please select
Fluorometer – CDOM (Wetlabs FLCDOM – 370/460nm)	
Nephelometer (Seapoint Turbidity Meter)	X
ECO-Triplet (Chlorophyll-a, CDOM & backscatter – maximum depth 2000m)	X
Hydrochemistry Analysis CTD	
Salinity	X
Dissolved Oxygen	X
Nutrients: Nitrate	X
Nutrients: Phosphate	X
Nutrients: Silicate	X
Nutrients: Nitrite	X
Nutrients: Ammonia	X
Hydrochemistry Analysis of approved AA100 (underway during Triaxus lines):	
Salinity	
Dissolved Oxygen	
Nutrients: Nitrate	
Nutrients: Phosphate	
Nutrients: Silicate	X
Nutrients: Nitrite	X
Nutrients: Ammonia	

- Amandine Schaeffer and Shane Keating lead the blue team and the CTD console. The entire blue team (~ 10 people) are available to assist with the CTD.
- Peter Strutton and Christina Schallenberg lead the green team, they have a water budget
- Bottle stops are generally fixed but dependent on local conditions (depths = 0,10,25,50,75,100, 125, 150,175, 200,250,300,400,500,750,1000,1500,2000), but this may vary based on the downcast and the data (e.g. DCM).
- We aim to be doing casts to 2000m every 10nm through an eddy. We have budgeted 2 hrs for a 2000m cast and estimate travel at 8 knots between stations. Some of the CTD casts will be along a line that extends from the shelf (depth =100m) to the deep water (max CTD cast depth of 2000m in water depth of 4000m). As we pass the shelf and shelf break, close approaches to the bottom are desirable, (5m would be ideal).
- HPLC, POC, DIC, Alkalinity (with each BGC Argo float deployment).

Signature

Your name	Moninya Roughan
Title	Chief Scientist
Signature	
Date:	21 September 2023