RV *Investigator* Voyage Plan

Voyage #:	**IN2018_T01**		
Voyage title:	Physical and biogeochemical gradients in the East Australian Current		
Mobilisation:	Hobart, Tuesday 03 April, 2018		
Depart:	08:00 Hobart, Friday 06 April, 2018		
Return:	16:00 Brisbane, Saturday 14, April, 2018		
	Hobart, Tuesday 22 May, 2018		
Voyage Manager:	Don McKenzie	**Contact details:**	don.rivergum@outlook.com
Chief Scientist:	Assoc Prof Zanna Chase		
Affiliation:	UTAS	**Contact details:**	zanna.chase@utas.edu.au
Principal Investigators:	Dr Helen Phillips Assoc Prof Patti Virtue Dr Christina Schallenberg		
Affiliation:	IMAS, University of Tasmania	**Contact details:**	zanna.chase@utas.edu.au

Scientific objectives

This voyage has both scientific and educational objectives. This transit voyage will be part of the unit Oceanographic Methods (KSA724/KSA324) that forms part of the Master of Marine and Antarctic Science (KSA724) and Bachelor of Marine and Antarctic Science (KSA324) courses at the University of Tasmania. The primary educational objective of the voyage is to introduce students to research at sea and standard methods in physical, chemical and biological oceanography.

After completing this voyage students should be able to:

- plan a research voyage
- describe how different scientific instruments work
- analyse, interpret and present data from a subset of oceanic instrumentation
- write a scientific report
- understand the working routines onboard a research vessel

The scientific objectives of the voyage focus around the contrasting physical, biological and chemical gradients associated with warm-core and cold-core eddies of the East Australian Current. These areas will be addressed by groups of 3-4 students working on projects with each of the PIs as follows:

Phillips: Dynamics of eddies; Heat and salt budget of cyclonic and anticyclonic eddies

Virtue: Zooplankton communities /microplastic loads in cyclonic and anticyclonic eddies

Chase: Nutrient, oxygen and carbon budgets of cyclonic and anticyclonic eddies

Schallenberg: Contrasting the phytoplankton communities in cyclonic and anticyclonic eddies in the East Australian Current (EAC). See detailed description in the Appendix.

Voyage objectives

<u>Sampling plan</u>

We plan to focus sampling efforts on eddies during the transit between Hobart and Brisbane. Ideally, we will sample one cyclonic and one anti-cyclonic eddy intensively. Intensive sampling will consist of:

a. A Triaxus transect across the diameter of the eddy, with a CTD station at the start of the transect
b. High-density CTD transects through the eddy, back over the Triaxus path to the eddy centre, for a total of 5 CTDs per eddy. Each CTD will be to a depth of 1000m. We will sample for chlorophyll, oxygen and nutrients from the CTD
c. Plankton (Bongo and neuston) net at every CTD station
d. Secchi disk deployed at every second CTD station
e. Occasional bucket sampling for microplastics

We also plan to occupy a ‘reference’ station consisting of CTD and plankton net located outside an eddy, but close to the chosen eddies. In total, including the test station, we expect to occupy 12 CTD stations

If time permits, we will sample an additional eddy that we encounter during the transit, on an opportunistic basis. Such opportunistic sampling would consist of one of the following, depending on time (from most time-intensive to least):

a. A CTD transect through the eddy
b. A Triaxus transect through the eddy
c. Surface sampling through the eddy, with a CTD at the centre

<u>Measurement plan</u>

Water samples will be collected with the 36 bottle rosette. Temperature and salinity will be measured by the CTD and calibrated with salinity samples taken from the CTD. Students will be trained in the analysis of salinity bottle samples. The same is true for oxygen bottle samples that will be taken to calibrate the CTD oxygen sensor.

Size-fractionated water samples will be filtered for chlorophyll and will be analysed on board using a bench-top fluorometer and reagents supplied by UTAS. We request the MNF nutrient analysis capability and will take water samples for nutrients (nitrate, nitrite, ammonia, phosphate and silicic acid).

Secchi disk will be deployed by hand to measure light attenuation

Plankton net samples will be viewed under the microscope at sea to identify major groups. We will estimate biomass by measuring wet weight and volume at sea. A small number of samples may be preserved in formalin and returned to IMAS for further study.

Underway samples and measurements

Water filters (30micron) will be taken from the clean surface seawater line every 2 hours (50L), for microplastic analysis. Filters will be viewed under compound microscope. Fibres will be counted and photographed.

Size-fractionated water samples for chlorophyll analyses will also be taken at hourly intervals from the underway line while transiting through eddies with the Triaxus in the water.

In addition to the routine underway data stream supplied by the ship's systems (i.e. temperature, salinity, fluorescence, pCO2), an ac-9 and FIRe instrument will be plugged into the underway water supply. These instruments will already be in use on the voyage preceding IN2018_T01, so will remain in place and thus should be ready to go.

Sensors on Triaxus

In addition to CTD sensors, we will also use the <u>Laser Optical Plankton Counter (LOPC)</u> to determine the size distribution and abundance of zooplankton and the <u>SUNA nitrate sensor</u> (from Tom Trull) to measure nitrate concentrations.

We will need FTP transfer enabled to allow Jason Everrett (UNSW) to download LOPC data to help us interpret and process the data.

<u>Educational plan</u>

- Students will work on research projects in small groups, 3-4 students with an instructor
- There will be 2 shifts, from 2 – 2 with 2 lecturers per shift

- If MNF staff are willing, we would be very interested in involving them in instruction. This worked well on ss2013_t01, where students spent time particularly in the hydrochemistry lab learning about the different instruments and analyses. We would be keen to develop this partnership further, perhaps incorporating a rotating ‘shadowing’ scheme, where students spend time in small groups with the different MNF groups (e.g. geophysics, electronics, hydrochemistry) throughout the voyage. This could potentially be expanded to the crew, if appropriate.
- A lecture each day after lunch when shifts turnover

Operational Risk Management

No potentially high risk work has been identified outside standard operations.

Overall activity plan including details for first 24 hours of voyage

The exact location of stations will depend on eddy locations at departure. We will be able to provide eddy locations, and therefore waypoints, within a week of departure. Peter Strutton (IMAS) will provide ground support in the form of satellite altimetry, SST and chlorophyll files to help us track the eddies while at sea (see figure S1). We will provide exact CTD waypoints 24 hours in advance. The plan is to set a course for the centre of the eddy, and then monitor the underway surface velocities on the ADCP to determine when we enter the eddy and when we reach the eddy centre. The target eddies will be at least one day steam away from Hobart. CTD stations will be at the start of the Triaxus tow, at the end, and then at 3 stations back along the Triaxus tow, ending at the centre of the eddy. We will then transit to the next eddy.

CTD stations will be adjusted if necessary to avoid sampling in CMRs.

First 24 hours will consist of familiarising the students with the operation of the ship, and giving them time to gain sea legs. We will conduct a test station roughly 9 hours after departure preferably in the vicinity of the Maria Island time-series site, where we will deploy the CTD, secchi disk and the plankton net.

Voyage track example

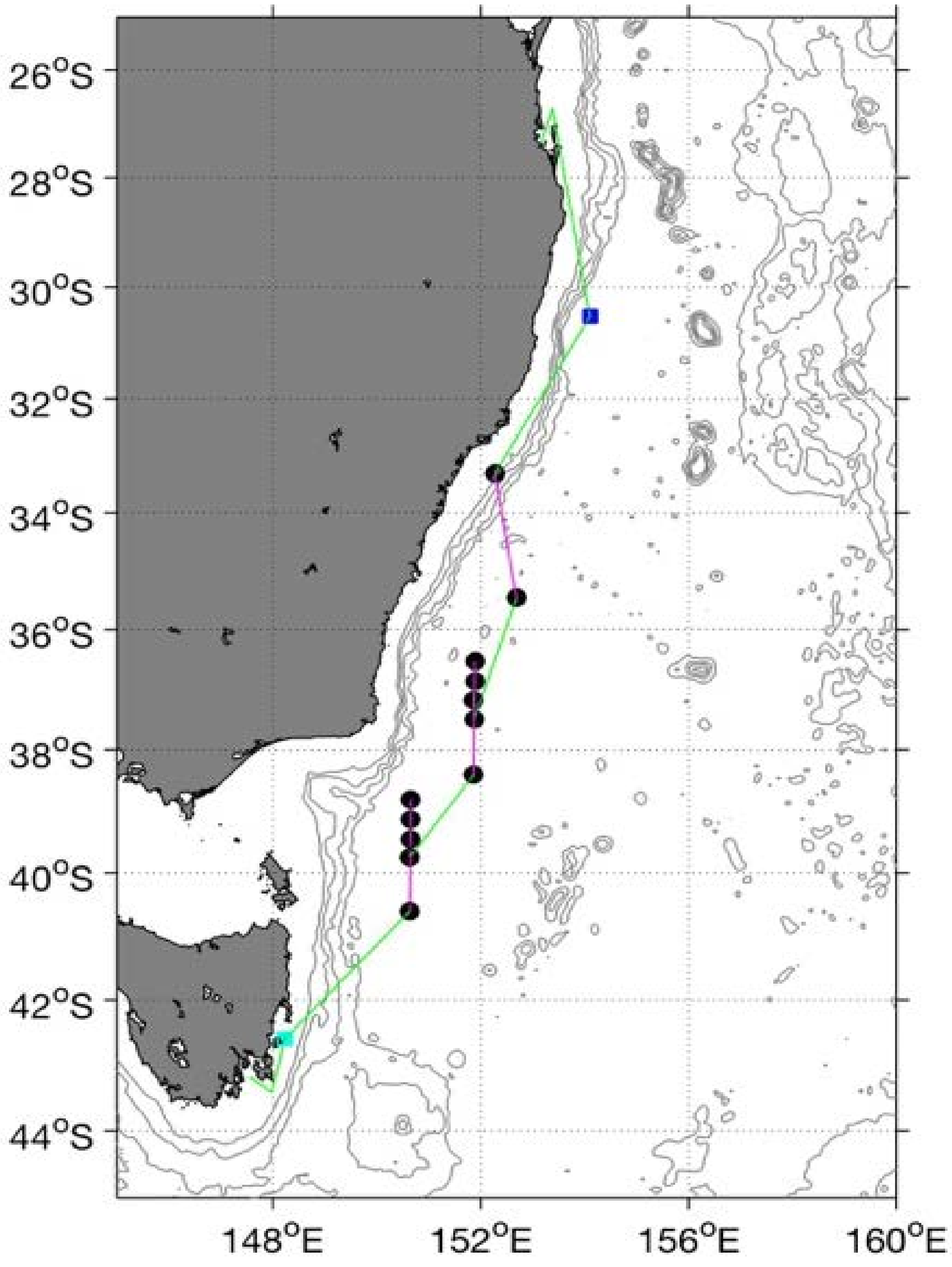


Figure 1: An indicative voyage track (green) based on satellite altimetry from February 2018, showing a test station at Maria Island, Triaxus tows in magenta, eddy CTD stations in black over the magenta and a control station in blue.

Waypoints and stations

The waypoints given below related to eddies are indicative only, based on the February 2018 eddy field. Actual waypoints will be determined based on data available prior to sailing, and adjusted in real time. Time estimates are based on 10 knots steaming, 8 knots towing Triaxus, and 3 hours per station. I have also included 6 hours to navigate Moreton Bay into Brisbane.

	Decimal Longitude	Decimal Latitude	Distance (nm)	Total Distance (nm)	Steaming time (hrs)	Total Steam (hrs)
Hobart	147.56	-43.19				
waypoint	147.98	-43.42	23	23	2.3	2.3
MI- test	148.23	-42.60	90	113	9.0	11.3
Triaxus eddy 1 start	150.64	-40.61	161	274	16.1	27.4
Triaxus eddy 1 end	150.65	-38.81	107	382	13.4	40.9
eddy 1 stn 2	150.65	-39.14	20	402	2.0	42.9
eddy 1 stn 3	150.65	-39.45	19	420	1.9	44.7
eddy 1 stn 4	150.64	-39.75	18	438	1.8	46.5
Triaxus eddy 2 start	151.87	-38.41	99	537	9.9	56.4
Triaxus eddy 2 end	151.89	-36.53	113	649	14.1	70.4
eddy 2 stn 2	151.89	-36.86	19	669	1.9	72.4
eddy 2 stn 3	151.87	-37.19	20	689	2.0	74.4
eddy 2 stn 4	151.87	-37.49	18	707	1.8	76.2
Triaxus eddy 3 start	152.69	-35.46	128	835	12.8	89.0
Triaxus eddy 3 end	152.27	-33.31	130	965	16.3	105.3
control stn 2	154.10	-30.53	191	1156	19.1	124.4
waypoint	153.38	-26.72	231	1388	23.1	147.5
Brisbane	153.16	-27.38	41	1429	10.1	157.7

Time estimates

The following time estimates are based on a steaming speed of 10 knots, a Triaxus time of 8 knots and 3 hours per station. This comes to a total of 158 hours steaming (including Triaxus tow time) and 43 hours on station. Arrival time in Brisbane is 14/04/18 15:40.

Date	Time (hr)	Activity
5/04/2018	24	Mobilisation
6/04/2018	9	Transit to test station (Maria Island)
	4	Test station CTD, plankton tow
	16.1	Transit to eddy 1 start
	3	Eddy 1 station 1

Date	Time (hr)	Activity
	13.4	Triaxus across eddy 1
	3	Eddy 1 station 2
	2	Transit to eddy 1 station 3
	3	Eddy 1 station 3
	1.9	Transit to eddy 1 station 3
	3	Eddy 1 station 4
	1.8	Transit to eddy 1 station 5
	3	Eddy 1 station 5
	9.9	Transit to eddy 2 start
	3	Eddy 2 station 1
	14.1	Triaxus across eddy 2
	3	Eddy 2 station 2
	1.9	Transit to eddy 2 station 3
	3	Eddy 2 station 3
	2	Transit to eddy 2 station 4
	3	Eddy 2 station 4
	1.8	Transit to eddy 2 station 5
	3	Eddy 2 station 5
	12.8	Transit to eddy 3 start
	3	Eddy 3 station 1 (dependent on time; can drop)
	16.3	Triaxus across eddy 3
	3	Eddy 3 station 2 (dependent on time; can drop)
	19.1	Transit to control station
	3	Control station
	33.2	Transit to Brisbane including 6 hours through Moreton Bay

Piggy-back projects (if applicable)

Title: The experiment on the study of sky radiance and surface roughness effect on ISAR SST measurements

Principal Investigators: Minglun Yang (Ocean University of China) and Helen Beggs (Bureau of Meteorology)

Please see the appendix, Experimental Outline for IN2018_T01 Cruise, for details of the scientific and voyage objectives of this piggy back. As all measurements are underway, it will not affect the time estimates.

Investigator equipment (MNF)

Equipment, facilities and support staff required from MNF are summarised in the tables below. Note that we need a refrigerator to store samples for chlorophyll extractions. If there is no fridge, then we'll need the walk in cool room.

Piggy-Back Project MNF equipment/support requested (Minglun Yang, OUC):

- Minglun Yang will require some form of weight (~ 8 kg) to attach to the thermistor chain.
- Crew assistance may be required when deploying and retrieving the thermistor chain.
- Note that additions have been made to the atmospheric underway sensors list (Meteorological sensors (wind, rain, short and long-wave solar radiation)) and the underway seawater instrumentation (ISAR (Infra-red SST Autonomous Radiometer) and SBE 38 water temperature sensor).

User Equipment

4 Dissecting microscopes- IMAS
Filtration rig- IMAS
Fluorometer- IMAS

Pipettes
Graduated cylinders

ac-9 and FIRe on the underway seawater supply

SUNA on Triaxus

Secchi disk

Piggy-Back Project Equipment (Minglun Yang, OUC):

- KT15 radiometer (class 2 laser) (Figure 2)
- U-shaped metal component to attach the KT15 to the deck railing (Figure 2)
- Associated 220 VAC power adaptor, batteries and data cables
- Laptop used for KT15 and thermometer data logging
- 5 thermometers and rope for thermistor chain (Figure 3)

Figure 2: KT15 radiometer (top left), U-shaped attachment for attaching to railing (top right) and approximate proposed location for KT15 installation on RV Investigator marked with red ellipse (bottom).

Figure 3: Thermometers on rope with metal weight (as deployed on OUC **DongFangHong II**).

Special Requests

Piggy-Back Project Special Requests (Minglun Yang, OUC):

- The KT15 radiometer with rotating disk needs to be attached to the deck railing close to the site that the ISAR radiometer is installed on the Port Bridge Wing Deck (Figure 2), using OUC supplied components. This installation can be performed before the ship sails but will require assistance from MNF electronic support staff.
- The KT15 will be left attached during the voyage but Minglun Yang will need to remove it if it rains and re-install it when weather clears.
- The KT15 will be removed at the end of the voyage.
- Power will need to be supplied to the KT15 from the Bridge equipment room via a power cable. Minglun Yang will supply the 220 VAC power adaptor and power cable.
- Data cable (supplied by OUC) will need to run from the KT15 to an OUC laptop to be located in the Bridge Equipment Room.
- Minglun Yang plans to deploy a thermistor chain (Figure 3) only when the ship is stationary and bring the thermistor chain back on board before the ship starts to move.
- It is essential that the ISAR be operating properly during the voyage for the experiment to be a success. The ISAR should be calibrated by MNF staff both before and as soon as possible after the IN2018_T01 cruise.

MNF DAP - ADCP Calibration

A RDI Workhorse Sentinel 150kHz ADCP will be temporarily mounted in the drop keel, as our standard Ocean Surveyor 150kHz ADCP is currently being repaired at the factory, and a 150kHz ADCP is a critical requirement for in2018_v03. To ensure the temporary ADCP is working and calibrated correctly, some ship time will be required to perform a bottom tracking calibration. Ideally *Investigator* will cruise at about 8kts in water no deeper than 250m along a constant heading for approx. 45 minutes, immediately followed by a reciprocal line using the same parameters. 150kHz ADCP operation will be monitored on shore by University of Hawaii and CSIRO staff in collaboration with support staff on board. Bottom tracking mode should be left on whenever *Investigator* is in water shallower than 500m for the duration of the transit. ADCPs should run freely and not triggered using the K-Sync system.

CSIRO O&A Argo float deployments

Five Seabird Argo floats will be deployed for the Australian Argo program. These deployments contribute to the International Argo program, monitoring the ocean for temperature and salinity. The approximate deployment locations are in the table below. Ideally, the floats can be deployed after a CTD station when leaving the site. The maximum depth should be >2000m when deployed.

Latitude	Longitude	Float number	Comment
-36.86	151.89	0902	After Eddy 2 stn 2
-36.53	151.89	0903	End of triaxis eddy 2 line
-35.46	152.69	0904	Approaching triaxis eddy 3 start
-31.00	153.75	0905	In transit to Control CTD stn 2
-30.53	154.10	0906	After control CTD stn 2

Permits

AFMA

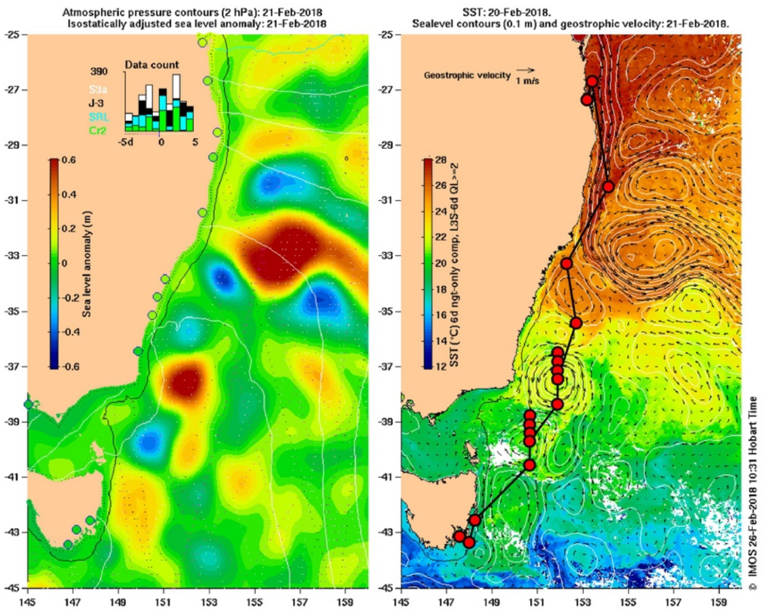
Personnel List

1.	Don McKenzie	Voyage Manager	CSIRO MNF
2.	Nicole Morgan	SIT Support	CSIRO MNF
3.	Will Ponsonby	SIT Support	CSIRO MNF
4.	Stuart Edwards	GSM Support	CSIRO MNF
5.	Matt Boyd	GSM Support	CSIRO MNF
6.	Francis Chui	DAP Support	CSIRO MNF
7.	Ian Hawkes	DAP Support	CSIRO MNF
8.	Kendall Sherrin	Hydrochemist	CSIRO MNF
9.	Mark Rayner	Hydrochemist	CSIRO MNF
10.	Jason Fazey	Mech tech	CSIRO MNF
11.	A/Prof Zanna Chase	Chief scientist	UTAS/IMAS
12.	Dr Helen Phillips	Principal Investigator/alternate chief scientist	UTAS/IMAS
13.	A/Prof Patti Virtue	Principal Investigator	UTAS/IMAS
14.	Dr Christina Schallenberg	Principal Investigator	UTAS/IMAS
15.	Minglun Yang	Piggyback CI	OUC
16.	Xiao Chen	student	UTAS
17.	Jihong Hu	student	UTAS
18.	Xiaoxuan Jiang	student	UTAS
19.	Mitchell Kirley	student	UTAS
20.	Brett Kitchener	student	UTAS
21.	Zhichun Liu	student	UTAS
22.	Zimeng Su	student	UTAS
23.	Ziliang Tian	student	UTAS
24.	Haoran Wang	student	UTAS
25.	Yu Wang	student	UTAS
26.	Hongrui Xie	student	UTAS
27.	Wenyue Xue	student	UTAS
28.	Chengcheng Yang	student	UTAS
29.	Jingwei Zhang	student	UTAS
30.	Jingyuan Zhang	student	UTAS
31.	Shance Zhang	student	UTAS
32.	Weiyan Zhang	student	UTAS
33.	Zelin Zhang	student	UTAS
34.	Ziyan Zhang	student	UTAS
35.	Alexandra Johne	student	UTAS
36.	Phil Butterworth	student	UTAS
37.	Chloe Power	student	UTAS
38.	Matt Corkill	student	UTAS
39.	Georgia Lofts	student	UTAS
40.	Alexandra Parrott	student	UTAS

Signature

Your name	Zanna Chase
Title	Chief Scientist
Signature	
Date:	1 November 2017

List of additional figures and documents



1. Figure S1: Example of Ocean Currents data that will be used to determine the location of eddies at the time of the voyage. This example is from February 2018. All waypoint estimates in this draft are based on this map, for indicative purposes only.

2. The attached pdf, Experimental Outline for IN2018_T01 Cruise contains details of the piggyback project

3. Project description for student sub-project with Dr Christina Schallenberg

Contrasting the phytoplankton communities in cyclonic and anticyclonic eddies in the East Australian Current (EAC)

Mesoscale eddies present a unique physical environment (i.e., upwelling vs downwelling) for resident phytoplankton by modifying the supply of nutrients and light. Accordingly, chl-a concentrations in cyclonic and anticyclonic eddies in the EAC differ significantly (Everett et al. 2012, GRL 39, L16608), and differences in the associated phytoplankton communities are expected. Such differences in phytoplankton composition are not only important for predators such as zooplankton, but they may also affect the accuracy of chl-a retrieval with satellite algorithms. The proposed project thus aims to contrast the different phytoplankton communities from a bio-optical perspective.

From an oceanographer's point of view, eddies present an excellent opportunity to study the drivers behind differences in phytoplankton community composition. Factors such as mixed layer depth, nutrient supply and concentration, and the photosynthetically available radiation at different depths can be examined and evaluated. Students will develop hypotheses for the expected distribution of phytoplankton and chl-a in eddies based on their understanding of the physics and of the basic principles of phytoplankton growth. These hypotheses will relate to the concentration of phytoplankton in upwelling versus downwelling eddies, the vertical distribution of biomass and chl-a in the respective eddies, and the dominant cell sizes. The students will then test their hypotheses with the data, and will further investigate the drivers of the distributions (i.e. light, nutrients) using a number of bio-optical methods that are complimentary to *in situ* chl-a measurements (size-fractionated filtrations):

- Absorbance measurements at 9 wavelengths (which can be used to evaluate the packaging effect, related to underwater light fields and cell size)
- Transmission/turbidity on the CTD
- Active fluorescence (Fv/Fm from underway FIRe, which holds information on phytoplankton physiology)
- Fluorometer on the CTD (for chl-a estimation, with limitations)
- Attenuation coefficients (K_d) measured with 2 different methods: Secchi disk and PAR sensor on the CTD. These estimates of attenuation coefficients can be used as independent estimators of chl-a and compared to in situ observations. The testing/comparisons of different methods yields additional information regarding the validity of assumptions (such as uniform distribution of chl-a and biomass with depth).

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.

(i) Standard laboratories and facilities

Name	Essential	Desirable
Aerosol Sampling Lab		
Air Chemistry Lab		
Preservation Lab		
Constant Temperature Lab	X	
Underway Seawater Analysis Laboratory	X	
GP Wet Lab (dirty)	X	
GP Wet Lab (Clean)	X	
GP Dry Lab (Clean)	X	
Sheltered Science Area	X	
Observation deck 07 level		X
Walk in Freezer		
Clean Freezer	X	
Blast Freezer		
Ultra-Low Temperature Freezer		
Walk in Cool Room		X

(ii) Specialised laboratory and facilities

May require additional support

Name	Essential	Desirable
Modular Radiation Laboratory		
Modular Trace Metal Laboratories		
Modular Hazchem Locker		
Deck incubators		
Stabilised Platform Container		

(iii) Standard laboratory and sampling equipment

Name	Essential	Desirable
CTD - Seabird 911 with 36 Bottle Rosette	X	
CTD -Seabed 911 with 24 Bottle Rosette		
LADCP	X	
Sonardyne USBL System		
Milli -Q System	X	
Laboratory Incubators		
Heavy Duty Electronic Balance		
Medium Duty Electronic Balance	X	
Light Duty Electronic Balance	X	
Surface Net	X	
Bongo Net	X	
Smith Mac grab		
Dissecting Microscopes	X	

(iv) Specialised laboratory and sampling equipment

May require additional support

Name	Essential	Desirable
TRIAXUS – Underway Profiling CTD	X	
Continuous Plankton Recorder (CPR)		X
Deep tow camera		
Piston Coring System		
Gravity Coring System		
Multi Corer		
XBT System	X	
Trace Metal Rosette and Bottles		
Sherman epibenthic sled		
Trace- metal in-situ pumps		
Rock Dredges		
EZ Net		X
Rock saw		
Portable pot hauler		
Beam Trawl		
Trawl doors (pelagic or demersal)		
Stern Ramp		
Trawl monitoring instrumentation (ITI)		
Radiosonde		

(v) Equipment and sampling gear requiring external support

May require additional support from applicants

Name	Essential	Desirable
Seismic compressors		
Seismic acquisition system		

(vi) Underway systems

Acoustic Underway Systems

Name	Essential	Desirable
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 Echo Sounders EK60 (6 bands, 18kHz-333kHz)	X	
Gravity Meter		
Trace metal clean seawater supply	X	

Atmospheric Underway Sensors

Name	Essential	Desirable
Nephelometer		
MAAP (multi angle absorption photometer)		
SMPS (scanning mobility particle sizer)		
Radon detector		
Ozone detector		
Manifold instrumentation (intake temperature and humidity)		
Picarro spectrometer (analysis of CO_2/CH_4/H_2O)		
Aerodyne spectrometer (analysis of N_2O/CO/H_2O)		
Manifold instrumentation (intake temperature and humidity)		
CCN (Cloud Condensation Nuclei)		
Polarimetric Weather Radar		

Underway Seawater Instrumentation

Name	Essential	Desirable
Thermosalinograph	X	
Fluorometer	X	
Optode	X	
PCO2	X	