RV *Investigator* Voyage Plan

Voyage #:	**IN2019_V03**		
Voyage title:	A coupled bio-physical, ecosystem-scale, examination of Australia's International Indian Ocean Expedition line		
Mobilisation:	Fremantle, Monday, 13 May 2019		
Depart:	Fremantle, 15:00 AWST Tuesday, 14 May 2019		
Return:	Fremantle, 08:00 AWST Friday, 14 June 2019		
Demobilisation:	Fremantle, Friday, 14 June 2019		
Voyage Manager:	Hugh Barker	Contact details:	Hugh.barker@csiro.au
Chief Scientist:	Lynnath Beckley		
Affiliation:	Murdoch University	Contact details:	L.Beckley@murdoch.edu.au
Principal Investigators:	David Antoine (Curtin University), Peter Thompson (CSIRO), Helen Phillips (University of Tasmania), Michael Landry (Scripps, San Diego), Andrew Jeffs (University of Auckland), Martin Ostrowski (Macquarie University), Justin Seymour (University of Technology Sydney), Pilar Olivar (CSIC, Barcelona), Raleigh Hood (University of Maryland) and Anya Waite (Dalhousie, Halifax).		
Project name:	As above		
Affiliations:	As indicated above	Contact details:	David Antoine: david.antoine@curtin.edu.au

Scientific objectives

This multi-disciplinary voyage will study the coupling of physical, biogeochemical and ecological processes in the pelagic ecosystem of the SE Indian Ocean along the 110°E line at stations originally occupied by Australia during the first International Indian Ocean Expedition in 1962/63. This voyage is part of Australia's contribution to the second International Indian Ocean Expedition (2015-2020).

The objectives of this voyage are:

1) Quantification of multi-decadal, ecosystem-scale change from the 1960s benchmark in the physical, chemical and biological properties of the water column along 110°E;
2) Characterization of the physical and biological sources of nitrogen to the region and their impacts on regional biogeochemistry and ecology;
3) Determination of trophic relationships between nitrogen-fuelled primary production and zooplankton, including the larvae of mesopelagic fishes;
4) Relating field information on phytoplankton community composition, primary production and carbon export to bio-optical quantities derivable from satellite ocean colour radiometry.

These objectives and the aspects to be examined on the voyage relative to the principal investigators are summarised in Table 1.

Table 1: Scientific objectives, specific aspects to be examined and responsible principal investigators for the 110°E voyage IN2019_V03.

Scientific objective	Aspects to be examined	Principal Investigators
1) Quantification of change	Physical oceanography Chemical oceanography Biological - phytoplankton Biological - zooplankton	Phillips Thompson Antoine Beckley
2) Nitrogen and microbes	Nitrogen uptake Bacteria & DMSP Microbiological communities	Waite Seymour Ostrowski
3) Trophic relationships	Micro-zooplankton grazing Zooplankton Fish larvae	Landry, Hood Landry, Beckley, Jeffs, Olivar Beckley, Olivar, Jeffs
4) Primary production and bio-optics	Primary production Pigments Bio-optical properties Radiometry	Antoine Antoine Antoine Antoine

Voyage objectives

The voyage will take place in the SE Indian Ocean along 110°E between 39°30'S and 11°30'S and, to meet the scientific objectives, a wide range of activities will be conducted. Essentially, on station activities can be classified into CTD deployments with associated water sampling, zooplankton sampling with a range of nets and profiling for optical properties and radiometry (Table 2). Several laboratory and on-deck incubation activities will be conducted and deployment of a Continuous Plankton Recorder, micro-zooplankton profiler, Vertical Microstructure Profiler VMP200, ARGO floats, surface drifters and sonobuoys will also take place. The Triaxus with instrumentation will be towed on the return leg back to Fremantle.

CTD sampling and the vertical hauls with an Indian Ocean Standard Net (IOSN) are the priority tasks at all stations. After this, in the day time, the optical properties work will be a priority and, at night, plankton sampling with the various nets is the priority.

Table 2: Activities that are required to be conducted from the vessel to meet the scientific objectives of voyage IN2019_V03 together with the names of responsible on-board investigators.

Objective	Voyage activity	Specific objective	Investigators on board
1, 2, 3, 4	CTD deployments (to seafloor or 500m) at all stations 35 bottle rosette Associated water sampling (notional depths 0, 25, 50, 75, Chl maximum, O_2 minimum, 100, 125, 150, 200, 250, 300, 400, 500, 1000, 2000, 3000, 4000m, 5000m and just above seafloor). We want to match the 1960's depth for comparison	Measurement of temp, salinity, oxygen, fluorescence etc Nutrients (NOx, P, Si, NH_4, DIC, TA)	Phillips, Benthuysen Thompson & McDonald
		Nitrogen uptake incubations	Raes (for Waite)
		DMSP quantification, filtering for microbial gene expression	O'Brien (for Seymour)
		Microbial communities & genomics,	Focardi & Ranjit (for Ostrowski)
		Pigments, POC, phytoplankton community structure	Antoine & Thompson
		Primary production (photosynthetron with ^{14}C)	Robinson (for Antoine)
		Underwater Video Profiler (particle sizes and particle identification >500μm)	Antoine
		Sorting flow cytometry (particles)	Vine (for Antoine)
		Rates of phytoplankton growth and micro-zooplankton grazing	Landry, Hood & Davies
1	Vertical hauls (200 – 0m) with Indian Ocean Standard Net (all stations - day & night)	Zooplankton biomass comparison	Beckley
3	EZ net (500 – 0m) stratified zooplankton sampling (all stations – day & night)	Zooplankton & fish larvae vertical distribution, samples for isotopes & gut analyses	Beckley, Jeffs & Olivar
3	Surface (neuston) net (all stations – night)	Mesopelagic fish & phyllosoma trophic studies, isotopes & gut analyses	Jeffs, Beckley & Olivar
3	Oblique 200μm net (200-0m) plankton tows (all stations – day & night)	Zooplankton size fractionation	Landry, Davies & Hood
3	Heron 100μm net (100-0m) vertical hauls (all stations - day)	Prey availability for mesopelagic fish larvae	Davies, Olivar & Beckley
4	Vertical profiles (0-150m) of inherent optical properties IOP (all stations – day and evening if time available)	Absorption, attenuation and backscatter in water column	Antoine, Slivkoff, Klonowski

Objective	Voyage activity	Specific objective	Investigators on board
4	Vertical profiles (0-120m) with free-fall radiometer C-OPS & HyperPro (all stations - day)	Radiance, irradiance, U/W light profile	Antoine, Slivkoff, Klonowski, Kovach
4	DALEC above water radiometry (all stations- day)	Reflectance etc	Antoine, Slivkoff, Klonowski
4	Floating Radiance camera (RADCAM) (all stations day)	Underwater radiance distribution just below the sea surface	Antoine, Slivkoff, Klonowski
1	Triaxus deployment (post 110°E line on return transit to Fremantle)	Sections across areas of interest such as fronts of the Eastern Gyral Current (~16°S) & South Indian Counter Current (~22- 28°S)	Phillips, Beckley, Benthuysen, Thompson, Slivkoff, Klonowski, Antoine
1	Continuous Plankton Recorder (between stations on 110°E line)	Zoogeography of SE Indian Ocean meso-zooplankton (IMOS)	Davies, Beckley, McDonald
2	Vertical Microstructure Profiler (0-300m) (all stations day)	Direct estimates of ocean mixing	Phillips & Benthuysen
3	Micro-zooplankton diversity sampling with towed sampler (all stations day)	Metagenomics	Jeffs
1, 3	Vertical haul (20-0m) phytoplankton 20 µm net (all stations - day)	Phytoplankton identification	Davies, Vine & Beckley
	ARGO float deployment (site-specific)	IMOS & JAMSTEC	Beckley & Phillips
	Surface drifter deployments (site-specific)	BoM & NOAA Surface Drifters	Beckley & Phillips
	Underway sonobuoy deployment (between stations)	Acoustic identification of whale migration paths to complement observations	C. Jenner & M. Jenner

When we were preparing this voyage plan it became apparent that the in-water optics deployments (PI Antoine; objective 4) would take much longer than originally expected. This would result in a considerable reduction of time available to transit between stations so much so that we would not be able to maintain the two stations per day that were done in the original 1960's 110°E voyages. We subsequently prepared a revised voyage plan and each of the 20 stations on the 110°E line is now occupied for around 16 hours instead of 4 hours.

For this voyage, on each station we now plan to complete a morning deep CTD (water for Thompson, Antoine, Ostrowski and Seymour teams) and vertical zooplankton haul with the Indian Ocean Standard Net. This will be followed by the optics measurements in the early afternoon and, in the evening, an EZ net tow, assorted plankton and neuston tows and a shallow CTD to obtain water for experiments and incubations (Raes and Landry). As there will be some time available in the afternoon after the optics measurements, we plan to conduct additional day-time EZ net and plankton tows, vertical microstructure profiling and other sampling that would benefit from day/night comparisons. The final temporal arrangement of these late afternoon activities will be subject to time availability, sea conditions and might change to maximize efficiency. However, the evening surface neuston tows must start promptly at 18:00.

This revised plan has no difference from the original voyage proposal with respect to distance travelled by the ship. If we encounter bad weather along the 110°E line, we could wait until it clears using the two-day contingency period. However, if bad weather occurs at the southern-most stations along the 110°E line, the long-term marine weather forecast would have to be considered, as it may be wiser to proceed northwards and skip a station.

Operational Risk Management

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

Media Activities

There will be some specific science communication activities on the voyage.

1) Primarily, this will entail a short article with an appropriate photograph (prepared by M. Jenner, Beckley and all PIs) being disseminated each day to WAMSI and the International Indian Ocean Expedition Joint Project Offices in Perth and India (INCOIS in Hyderabad) for upload onto their respective websites. In addition, the institutional media contact for each Principal Investigator will receive this daily article for dissemination as they see fit.
2) Ben Arthur (CSIRO) has arranged a live crossing via WebEx at 13:00 AWST on 23rd May 2019 for contribution to a post-graduate course in plankton sampling techniques at IMAS (Beckley & Davies) and another one to Murdoch on 31st May at 12:30 AWST (Beckley).
3) Media activity associated with World Oceans Day on 8th June 2019 is also planned (Jenner, Beckley, Benthuysen and post-graduate students tbc)

Overall activity plan including details for first 24 hours of voyage

The overall voyage plan is to steam from Fremantle to 39°30'S 110°E and then proceed north to about 11°30'S along the 110°E line sampling at 90 nautical mile intervals. After completion of the line we will head towards NW Cape and then Fremantle towing the Triaxus with possible deployment of the DALEC during the days if conditions are suitable (Figure 1). The planned daily sampling activity from the vessel at each station on the 110°E line is given in Table 3.

For the first 24 hours, it is envisaged that we will leave Fremantle mid-afternoon on Tuesday 14th May, steam overnight and then, after appropriate toolboxes have been conducted (both watches) and training for the various equipment completed, occupy a full station with all equipment that will be used on the 110°E line (CTD, Indian Ocean Standard Net vertical haul, optics deployments, EZ net tow, other nets, Vertical Mixing Profiler etc). We plan to start underway deployment of sonobuoys for whale acoustics once we have passed Rottnest Island.

Table 3: Planned daily activity at and around each station along the 110°E line (speeds are indicative). ***Bold text*** *indicates that, to ensure fair access to all PIs, timing is not negotiable with these deployments; # indicates that we would prefer this to be done simultaneously with the morning CTD deployment but have scheduled a late afternoon slot to ensure it gets done; * indicates that the vessel can steam back towards the station or to the next station during this tow.*

Time Slot	Steam/station	Activity	Lead Investigators
06:00 - 06:30	Steam 11 kts	Deploy DALEC on port forward boom	Slivkoff, Klonowski & Antoine
06:30 - 06:45	Steam 11 kts	Retrieve CPR	Davies & McDonald
07:00 -10:30	**On station**	**Deep CTD with UVP (to near seafloor)**	**Phillips, Thompson & Antoine**
10:30 - 10:45	On station	IOSN vertical plankton haul (200m)	Beckley
10:45 - 13:45	On station & manoeuvring	IOP, C-OPS, HyperPRO & RADCAM optics measurements	Slivkoff, Klonowski, Antoine & Kovach
13:45 - 14:05	**Steam 2 kts**	**Oblique plankton (200µm) tow (200 m)**	**Landry, Davies & Hood**
14:05 - 15:35	Steam 2 kts	*EZ net (500 – 0m) tow	Beckley, Jeffs & Olivar
15:35 - 15:55	Steam 6 kts	*Towed micro-zooplankton sampler	Jeffs

Time Slot	Steam/station	Activity	Lead Investigators
15:55 - 16:15	On station	Heron net (100µm) vertical drop (100m)	Davies, Olivar & Beckley
16:15 - 16:30	On station	#Phytoplankton (20µm) vertical haul (20m)	Davies, Vine & Beckley
16:30 -17:30	On station	VMP measurements Extra IOP measurements if time allows	Phillips & Benthuysen Antoine
17:30 - 18:00	On station	Retract DALEC on port forward boom	Slivkoff, Klonowski & Antoine
18:00 - 19:40	**Steam 2 kts**	***Repeated surface net neuston tows**	**Jeffs, Beckley & Olivar**
19:40 - 20:00	Steam 2 kts	Oblique plankton (200µm) haul (200 m)	Landry, Davies & Hood
20:00 - 21:00	**On station**	**Shallow CTD with UVP (500m)**	**Benthuysen, Landry, Raes & Antoine**
21:00 - 21:15	On station	IOSN vertical plankton haul (200 m)	Beckley
21:15 - 22:45	Steam 2 knts	*EZ net (200 – 0m) tow (deeper if calm)	Beckley, Jeffs & Olivar
22:45 - 07:00	**Steam 11 knts**	**Deploy CPR & steam for next station**	**Davies**

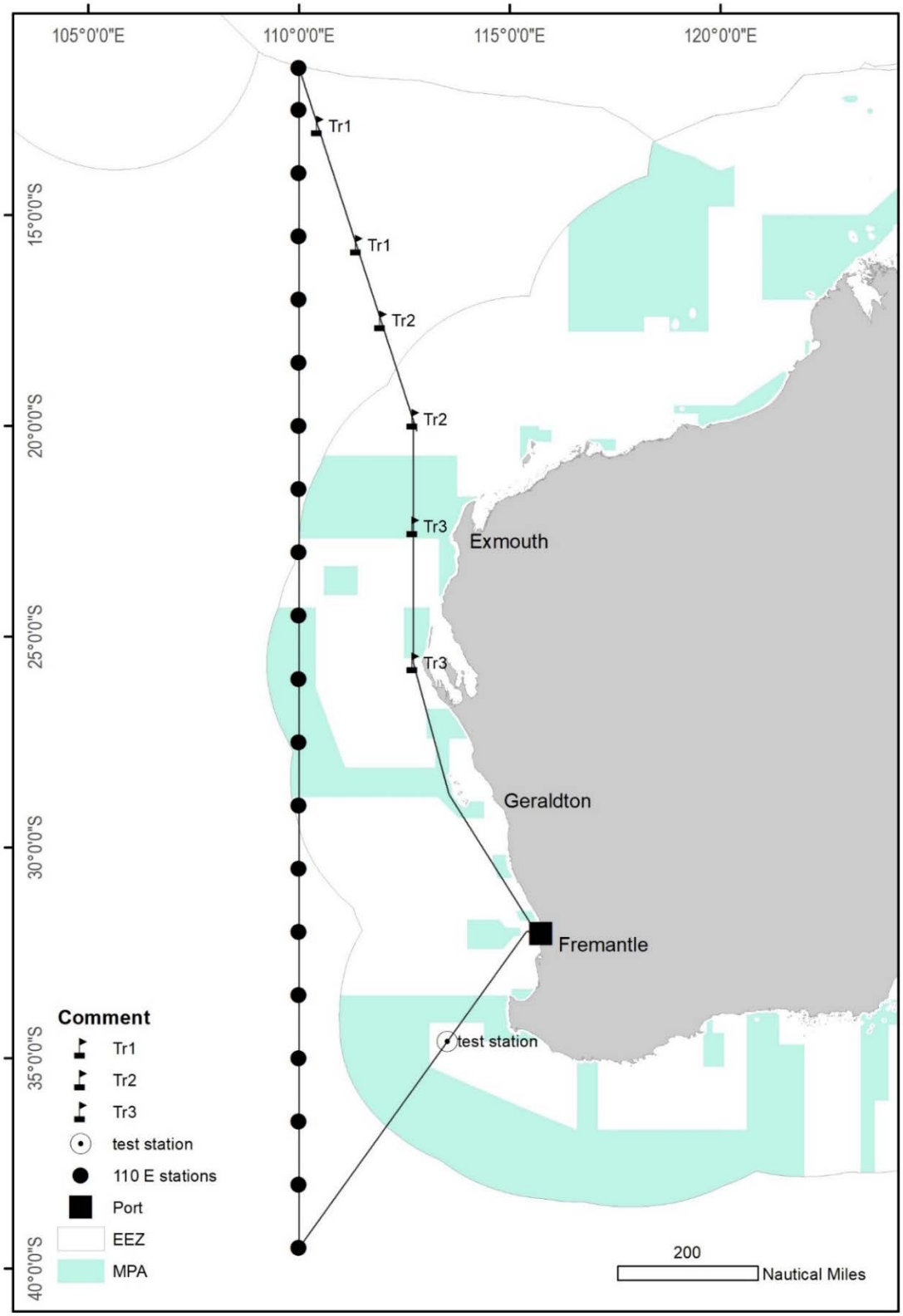
Time of sunrise (Perth): 14 May 06:56; 14 June: 07:14

Time of sunset (Perth): 14 May 17:28; 14 June 17:18

Moon phase: First quarter 12 May; Full moon 19 May; Third quarter 27 May; New moon 3 June; First quarter 10 June

Voyage track example

Figure 1: Intended voyage track for IN2019_V03 indicating test station, 20 stations and Triaxus tow sections.



Waypoints and stations

*Table 4: Location of stations along the 110°E line for voyage IN2019_V03. All calculated at 11 knots except for those marked * which demarcates Triaxus towing at 8 knots.*

	Decimal Latitude S	Decimal Longitude E	Distance (nm)	Total Distance (nm)	Steaming time (hrs)	Total Steam (hrs)
Fremantle port	32° 02.8	115° 44.7				
Cape Vlamingh	31°58.6	115° 25.1	20.2	20.2	2.0	2.0
TBC Training station	~34° 36.0	~113° 30.0	~190	~210.2	~17.0	~19.0
110°E line Stn. 1	39° 30.0	110° 00.0	349.2	539.2	32.5	51.5
110°E line Stn. 2	38° 00.0	110° 00.0	89.8	628.1	8.2	59.7
110°E line Stn. 3	36° 30.0	110° 00.0	89.9	717.9	8.2	67.9
110°E line Stn. 4	35° 00.0	110° 00.0	89.8	807.8	8.2	76.1
110°E line Stn. 5	33° 30.0	110° 00.0	89.8	897.5	8.2	84.3
110°E line Stn. 6	32° 00.0	110° 00.0	89.8	987.5	8.2	92.5
110°E line Stn. 7	30° 30.0	110° 00.0	89.8	1077.3	8.2	100.6
110°E line Stn. 8	29° 00.0	110° 00.0	89.8	1167.1	8.2	108.8
110°E line Stn. 9	27° 30.0	110° 00.0	89.7	1256.8	8.2	117.0
110°E line Stn. 10	26° 00.0	110° 00.0	89.7	1346.6	8.2	125.2
110°E line Stn. 11	24° 30.0	110° 00.0	89.7	1436.3	8.2	133.4
110°E line Stn. 12	23° 00.0	110° 00.0	89.7	1526.0	8.2	141.5
110°E line Stn. 13	21° 30.0	110° 00.0	89.7	1615.7	8.2	149.7
110°E line Stn. 14	20° 00.0	110° 00.0	89.7	1705.3	8.2	157.9
110°E line Stn. 15	18° 30.0	110° 00.0	89.6	1795.0	8.2	166.1
110°E line Stn. 16	17° 00.0	110° 00.0	89.6	1884.6	8.2	174.3
110°E line Stn. 17	15° 30.0	110° 00.0	89.6	1974.3	8.2	182.5
110°E line Stn. 18	14° 00.0	110° 00.0	89.6	2063.9	8.2	190.6
110°E line Stn. 19	12° 30.0	110° 00.0	89.6	2153.5	8.2	198.8
110°E line Stn. 20	11° 30.0	110° 00.0	53.2	2206.7	5.5	204.3
Triaxus 1 Start	12° 52.74	110° 26.7	82.8	2289.6	7.5	211.8
Triaxus 1 End	15° 42.48	111° 22.7	177.5	2467.1	22.2*	234.0
Triaxus 2 Start	17° 30.00	111° 57.0	112.0	2579.1	10.2	244.2
Triaxus 2 End	19° 50.46	112° 42.5	146.3	2725.4	18.4*	262.6
Triaxus 3 Start	22° 23.34	112° 42.5	152.5	2877.9	13.9	276.5
Triaxus 3 End	25° 36.00	112° 42.5	192.0	3069.9	24.0*	300.5
Hartog WP	25°37.6	112°42.5	1.4	3071.4	0.1	301.5
Abrolhos WP	28°44.3	113°33.5	191.6	3263.0	17.4	318.9
FWY BCN WP	31°56.7	115°35.3	219.1	3482.1	19.9	338.8
Fremantle	32° 02.8	115° 44.7	11.6	3493.6	1.0	339.8

Time estimates

The following time estimates for each station and transit between stations are based on a steaming speed of 11 knots. The length of Triaxus lines will vary depending on latest remote sensing information and speed attained with 300m deep undulating profile. The exact location of the launch of drifters is subject to refinement by BoM and NOAA.

*Table 5: Time estimates for daily schedule for IN2019_V03. # indicates Triaxus line length is subject to speed attained with 300m deep undulating profile. *indicates exact location of the launch of drifters is subject to refinement by BoM and NOAA.*

Date	Time	Activity
14 May	15:00	Depart Fremantle
15 May	~10:00	Start training station with all equipment after toolbox meetings. Both watches to undertake training with CTD and equipment related to their watch (~8 - 12 hours). Continue steaming towards 110°E line.
16 May		Continue steaming towards 110°E; ~5 miles before station deploy JAMSTEC APEX float.
17 May	07:00	Start 110°E line Station 1 (39°30'S) *Launch BoM drifter @ end of Station
17 May	22:45	Steam 90 miles
18 May	07:00	Start 110°E Station 2 (38°S)
18 May	22:45	Steam 90 miles
19 May	07:00	Start 110°E Station 3 (36°30'S)
19 May	22:45	Steam 90 miles
20 May	07:00	Start 110°E line Station 4 (35°S)
20 May	22:45	Steam 90 miles
21 May	07:00	Start 110°E Station 5 (33°30'S)
21 May	22:45	Steam 90 miles
22 May	07:00	Start 110°E Station 6 (32°S)
22 May	22:45	Steam 90 miles
23 May	07:00	Start 110°E Station 7 (30°30'S)
23 May	22:45	Steam 90 miles
24 May	07:00	Start 110°E Station 8 (29°S) *Launch NOAA drifter @ 29°S
24 May	22:45	Steam 90 miles
25 May	07:00	Start 110°E line Station 9 (27°30'S) *Launch NOAA drifter @ 27°30'S
25 May	22:45	Steam 90 miles
26 May	07:00	Start 110°E Station 10 (26°S) *Launch NOAA drifter @ 26°30'S
26 May	22:45	Steam 90 miles *Launch BoM drifter @ 25°S
27 May	07:00	Start 110°E Station 11 (24°30'S)

Date	Time	Activity
27 May	22:45	Steam 90 miles *Launch BoM drifter @ 22°30'S
28 May	07:00	Start 110°E Station 12 (23°S)
28 May	22:45	Steam 90 miles
29 May	07:00	Start 110°E Station 13 (21°30'S) *Launch NOAA drifter @ 21°30'S
29 May	22:45	Steam 90 miles
30 May	07:00	Start 110°E line Station 14 (20°S) *Launch BoM drifter & Argo float @ 20°S
30 May	22:45	Steam 90 miles
31 May	07:00	Start 110°E Station 15 (18°30'S) *Launch NOAA drifter @ 18°30'S
31 May	22:45	Steam 90 miles *Launch BoM drifter @ 17°30'S
1 June	07:00	Start 110°E Station 16 (17°S)
1 June	22:45	Steam 90 miles
2 June	07:00	Start 110°E Station 17 (15°30'S)
2 June	22:45	Steam 90 miles *Launch BoM drifter @ 15°00'S
3 June	07:00	Start 110°E Station 18 (14°S) *Launch NOAA drifter @ 14°S
3 June	22:45	Steam 90 miles
4 June	07:00	Start 110°E Station 19 (12°30'S) *Launch NOAA drifter @ 12°30'S
4 June	22:45	Steam 60 miles; ~5 miles before final station deploy JAMSTEC APEX float
5 June	07:00	Start 110°E Station 20 (11°30'S) Note: Must be south of Indonesian EEZ *Launch NOAA drifter @ 11°30'S
5 June	22:45	Steam 83 miles along line to start Triaxus Leg 1
6 June	06:10	Steam 178 miles at 8 knots with Triaxus (Leg 1) # Deploy DALEC at daybreak and retract at sunset (tbc)
7 June	04:20	End Triaxus Leg 1 and steam 112 miles along line to start Triaxus Leg 2
7 June	14:30	Steam 146 miles at 8 knots with Triaxus (Leg 2) # Deploy DALEC in daylight and retract at sunset (tbc)
8 June	08:30	End Triaxus Leg 2 and steam 152 miles to start of Triaxus Leg 3
9 June	22:30	Steam 192 miles at 8 knots with Triaxus (Leg 3) # Deploy DALEC at daybreak and retract at sunset (tbc)
10 June	22:30	End Triaxus Leg 3 and steam to Abrolhos WP
11 June	16:00	Steam to Fremantle
12 June	13:00	Arrive Fremantle / contingency period
13 June		Contingency period (total = 45 hours)
14 June	08:00	Ship docks - demobilisation

Piggy-back project

Ryan Crossing – Coastal Moorings and Biogeochemical Service Team, CSIRO

If time permits, the MNF will conduct a short multi-beam transect over a site where two WA IMOS coastal moorings have failed to surface. Waypoints are:

1. Two Rocks 500m; 31° 46.454'S, 114° 58.081'E
2. Two Rocks 500m; 31° 45.914'S, 114° 57.607'E

Permits

- No foreign clearances required – intend to finish 110°E line at ~11°30'S just south of Indonesian EEZ.
- All 110°E line stations are outside EEZ except stations at 24°30'S 110°E, 26°S 110°E & 27°30'S 110°E which are inside western extent of the Abrolhos Marine Park.
- Training station on 15 May in EEZ will be outside SW Corner Marine Park waters.
- Commonwealth Marine Parks permits (Beckley PA2018-00065F obtained for SW and NW Marine parks)
- Commonwealth Dept Environment permit for sampling for genetics in EEZ (Beckley AU-COM2019-446)
- Commonwealth AFMA permit for phytoplankton, zooplankton & fish larvae in EEZ (Beckley 1004152 obtained)
- Quarantine & import requirements: Samples in 10% formalin, 4% formaldehyde, 1% Lugols, 2% glutaraldehyde (2%) or 70% ethanol do not require permit but need to be properly documented by PIs. For other material (especially frozen material) Ostrowski, Raes, Seymour, Jeffs & Beckley will use institutional permits. Permits for Landry & Antoine in progress.
- Murdoch University Animal Ethics permit for catching zooplankton & larval fishes - Beckley R2885/16 #315 (Pelagic ecology of SE Indian Ocean) obtained
- Permit for laser (Jeffs). Federal & MNF approvals confirmed and H&S training completed.
- Permits for using radioactive sources ^{14}C; ^{15}N

Signature

Your name	Lynnath Beckley
Title	Chief Scientist
Signature	
Date:	29/04/2019

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.

(i) Standard laboratories and facilities

Name	Essential	Desirable	Notes/Comments
Aerosol Sampling Lab			
Air Chemistry Lab	X		Gas chromatograph in air chemistry laboratory - air, helium and hydrogen cylinders (size G). Hydrogen to be connected through to stowage on foredeck, as for IN2015_V03. Ensure sufficient holders for gas cylinders in air chemistry laboratory. Plan for loading of cylinders
Preservation Lab	X		
Constant Temperature Lab	X		Used intermittently for laser evaluation of zooplankton (Jeffs)
Underway Seawater Analysis Laboratory	X		
GP Wet Lab (Dirty)	X		Mainly zooplankton work – Beckley, Jeffs & Landry
GP Wet Lab (Clean)	X		Mainly filtering for phytoplankton/microbes/ genetics – Antoine, Raes, Landry, Focardi & O'Brien
GP Dry Lab (Clean)	X		Cytometry, EIMS-NCP, microscope slide making – Focardi, Landry & Robinson
Sheltered Science Area	X		Triaxus, optics & nets – Slivkoff, Klonowski, Beckley, Landry, Jeffs & Davies,
Observation deck 07 level	X		Whales - Jenners
Walk in Freezer	X		
Blast Freezer	X		
Ultra-Low Temperature Freezer (-80^{0}C)	X		Will be in high demand during voyage. Critical that it is fully operational
Walk in Cool Room	X		
Salt water ice machine	X		Needed for keeping zooplankton samples cold while sorting

(ii) Specialised laboratory and facilities

(May require additional support)

Name	Essential	Desirable	Notes/Comments
Modular Radiation Laboratory	X		Radiation container for ^{14}C and ^{15}N. Radiation container with through flow water connected
Modular Trace Metal Laboratory (TMR1-blue)			
Modular Trace Metal Laboratory (TMR2-white)			
Modular Hazchem Locker	X		HazChem container for ethanol and formaldehyde
Deck incubators	X		Nitrogen uptake - Raes
Stabilised Platform Container			
Clothing container			The use of this container will be identified by MNF

(iii) Standard laboratory and sampling equipment

Name	Essential	Desirable	Notes/Comments
CTD - Seabird 911 with 35 Bottle Rosette	X		
CTD -Seabird 911 with 24 Bottle Rosette	X		Backup for 35 bottle rosette
Total number of Casts:			42 (20 CTDs >4000 m and 20 CTDs to 500 m plus 2 training CTDs)
Maximum depth:			5700 m
Analyses required for each deployment: (indicate which are required and the number of samples per deployment)			In addition to CTDs, Martin Ostrowski's team will be taking nutrient samples from the flow through system as we steam out to the 110°E line and on the way back. He estimates that there will be about 40 extra nutrient samples for analysis.
Salinity	X		
Dissolved oxygen	X		
Nutrients:			Note: analytical throughput based on 2 hydrochemists / 24hours: - Nutrients, dissolved oxygen, salinity. Sampling ratio 1:1:1 equates to 48:48:48 - Nutrients, dissolved oxygen, salinity. Sampling ratio 2:1:1 equates to 72:36:36

Name	Essential	Desirable	Notes/Comments
			- Nutrients only collection from every depth 160 maximum analytical output
Nitrate	X		
Phosphate	X		
Silicate	X		
Nitrite	X		
Ammonia (special request after discussion with hydrochemistry)	X		Peter Thompson has discussed with hydro-chemists
Lowered ADCP	X		Phillips & Benthuysen
MNF Auxiliary Instrumentation for CTD Rosette (please indicate which you require. Note 6 auxiliary sensor channels are generally available:			UVP will occupy one analog channel for Antoine (see below) Note: UVP needs dip to 20 m depth and back to surface before starting cast (Antoine)
Dissolved oxygen sensor	X		
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 111 – 430/685nm	X		
Flurometer – CDOM (Wetlabs)			This analog port will be used for the UVP5. The CDOM fluorometer will not be used (Antoine).
Nephelometer (Seapoint Turbidity Meter)		X	If there are any channels still available
ECO-Triplet (2,000m max depth, chlorophyll, CDOM & backscatter)			
Sonardyne USBL System			
Milli -Q System	X		Situated in the Clean Wet lab. Hydrochemistry to provide filters.
Laboratory Incubators	X		
Heavy Duty Electronic Balance (80kg)			

Name	Essential	Desirable	Notes/Comments
Medium Duty Electronic Balance (15kg/5g resolution)			
Light Duty Electronic Balance (3kg/1g resolution)	X		
Surface Net (mouth area 1m^2) 1,000 micron mesh	X		Deploy forward starboard boom for surface net Depressor weight to be supplied by MNF Spare hard cod ends will be supplied Flow meter and spares are supplied
Bongo Net (500 micron mesh only, not instrumented) ring diameter 485mm, 0.018m^2	X		Backup. Depressor weight to be supplied by MNF Spare hard cod ends will be supplied Flow meter and spares are supplied
Smith Mac grab			
Dissecting Microscopes	X		Two should be sufficient – check *light sources* with bulbs are included

(iv) Specialised laboratory and sampling equipment

Name	Essential	Desirable	Notes/Comments *(These items may require additional MNF support staff)*
TRIAXUS – Underway Profiling CTD	X		Notes: Triaxus is a pilotable towed vehicle capable of carrying a variety of instrumentation. Constant depth towing or undulating profiles (e.g. cyclic depth pattern from 10m to 200m) are possible. Towing speed depends on the tow profile, instrumentation payload and prevailing conditions. Typically, undulations from the surface to 200m are possible at 8 kt, with slower speeds for deeper profiles and faster for constant-depth towing. Maximum achievable depth typically 300m Usual instrumentation: SBE9plus (pressure sensor and communication hub) and dual pumped temperature/conductivity/dissolved oxygen circuits. Usual auxiliary instrumentation includes an ECO-Triplet (Chl, CDOM, backscatter), transmissometer, PAR sensor, and Laser Optical Plankton Counter.

Name	Essential	Desirable	Notes/Comments *(These items may require additional MNF support staff)*
Desired towing profile:			Undulating from surface to 300 m depth (The Eastern Gyral Current is 200-300m deep so if we tow to 300m (as in IN2018_V05) then we can cover the full vertical extent of the flow)
Additional instrumentation: (Please supply, make and model and datasheets. Also a contact person for discussion on integration.	X		1. SUNA nitrate sensor to be added (Phillips & Thompson). Tom Trull has indicated that SUNA will be used on IN2019_V02 and left on board for us. 2. In situ Optics SC3/SC6 precision optical backscattering sensor (self-logging) (Antoine)
Continuous Plankton Recorder (CPR)	X		Daily for 8-hour steam between stations 39° 30'S to 11°30'S. Assistance required in deployment & retrieval
Deep towed camera			
Piston Coring System			
Gravity Coring System			
Multi Corer			
Kasten Corer			
XBT System		X	
Trace Metal Rosette and Bottles			
Sherman epibenthic sled			
Trace-metal in-situ pumps (x4)			See *"Non-MNF owned equipment"* section below for additional 2 units
Rock Dredges			
EZ Net (maximum of 10 nets for depth stratified sampling. Mouth area of $1m^2$ Indicate mesh size required:	X		EZ net support staff required Check that *soft cod-ends* are supplied and there are spare calibrated flow meters Anticipate using eight nets per tow but need full complement of ten nets in case of malfunction or opportunistic sampling at specific features such as Deep Scattering Layer Request 10m/minute retrieval for deeper strata and 5m/minute for shallower strata.
335 micron			
500 micron	X		

Name	Essential	Desirable	Notes/Comments *(These items may require additional MNF support staff)*
1,000 micron			
Rock saw (requires a trained science personnel)			
Portable pot hauler	X		Pot hauler and basket for VMP line to be gathered into after each deployment (Phillips). A small block will be required for attaching to the A-frame through which to run the 6mm deployment line. Pot hauler will also be used for the Heron net (Davies).
Beam Trawl			
Trawl doors (pelagic or demersal)			
MIDOC (multiple opening/closing codend system for pelagic trawl			
Stern Ramp (tick to have the ramp exposed, or leave blank for deck covers installed			
Trawl monitoring instrumentation (ITI) (2,000m depth limit)			
Trawl nets: Mid water research trawl Wing end spread usually 21m Average headline height 8.97m Mouth area (on average) 188.37m^2 Mesh size 200mm in mouth area grading to 10mm in cod end.			
Radiosonde Receiver System			

(v) Equipment and sampling gear requiring external support

(May require additional support from applicants)

Name	Essential	Desirable	**Please give this careful consideration, as there is no guarantee that these resources will be available unless specifically requested. Liaise with Voyage Operations Manager as required. Additional staff may be required for these activities.**
Seismic compressors			
Seismic acquisition system			

(vi) Underway systems

Atmospheric 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		When on station, can GSM please optimize the output to record mesopelagic fish shoals (day & night)
Sub-Bottom Profiler SBP120	X		
Scientific Echo Sounders EK60 (6 bands, 18kHz-333kHz)	X		
Gravity Meter			
Trace metal clean seawater supply	X		Will be used by Ostrowski team for samples for microbes & nutrients whilst underway – see below

Atmospheric Underway Sensors

Name	Essential	Desirable	Notes/Comments
Nephelometer			
MAAP (multi angle absorption photometer)			

Name	Essential	Desirable	Notes/Comments
SMPS (scanning mobility particle sizer)			
Radon detector			
Ozone detector			
CPC (Condensation Particle Counter)			
Picarro spectrometer (analysis of CO_2/CH_4/H_2O)			
Aerodyne spectrometer (analysis of N_2O/CO/H_2O)			
CCN (Cloud Condensation Nuclei)			
Polarimetric Weather Radar			

Underway Seawater Instrumentation

Name	Essential	Desirable	Notes/Comments
Thermosalinograph	X		
Fluorometer	X		
Optode	X		
pCO2	X		

Seawater systems

Name	Essential	Desirable	Notes/Comments
Trace metal	X		Ostrowski team to use for regular sampling of microbes & nutrients when underway
Scientific clean	X		Antoine will be using for underway measurements with WET Labs AC-S spectrophotometer in General purpose wet laboratory (clean) *He needs this water supply to be cleaned (bleached) before the voyage.*
Raw	X		Hoses needed near coring winch and on aft deck for rinsing nets with raw seawater

Non MNF owned equipment which may be accessed

Name	Essential	Desirable	Please give this careful consideration, as there is no guarantee that these resources will be available unless specifically requested. Liaise with Voyage Operations Manager as required.
D & N Francis winch	X		
Box Corer			
University of Tasmania (UTAS) in-situ pumps (x2)			
EM2040			

Special Requests – MNF Scientific Equipment and Facilities

- No regular video conferencing / data communication requirements needed but a WebEX link with IMAS has been planned by Ben Arthur for 23rd May and 31st May with Murdoch. There is a possibility that we may arrange a link-up for World Oceans Day on 8th June 2019.
- Internet access for remotely sensed sea-surface temperature, salinity and sea surface height data (e.g., IMOS Ocean Currents, BoM Ocean Maps) will be required during voyage.
- Seawater hose for rinsing nets near coring winch (assorted nets) and on aft deck (200 µm net & EZ net).
- Freshwater hose for rinsing optical equipment near coring winch and on aft deck.

Appendix B

User equipment and facilities to be provided by the Chief Scientist

List the equipment that will be brought on board under the Lead Principal Investigator/Principal Investigator responsible for the item.

The Voyage Operations Manager will advise if a RV *Investigator* Application form will be required for your nominated equipment. A deck layout will be developed from the information provided here and in the RVI Voyage Specific Equipment Installation Form.

Owner	**Item name**	**Supporting information (weight, dimensions, location on board)**	Please give this careful consideration, as there is no guarantee that these resources will be available unless specifically requested. Liaise with Voyage Operations Manager as required. Do you require any equipment to be fitted to the vessel? What services (e.g. electricity, water) are required to support the equipment? Are there any special procedures to be followed with the new equipment, radiation work, lasers, small boat work or diving? Do you need to test any equipment or procedures before sailing or under controlled conditions? These activities will require separate approvals.	**RV *Investigator* Equipment Application form required?** ***MNF use only (Y/N)***
Beckley	Indian Ocean Standard Net $1m^2$ with 20 kg weight (vertical haul 200m to surface)	50kg 1.2 x 1.2 X 0.4m Sheltered science area & deck workshop	Seawater hose near coring winch for washing net	

	Olympus dissecting microscope with camera system & computer screen	30 kg 0.9 x 0.5 X 0.4m General purpose wet laboratory - dirty	Electrical power	
	Olympus CH40RF200 compound microscope	5 kg 0.6 X 0.3 X 0.4 m General purpose dry laboratory - clean	Electrical power	
	Heron plankton net 100µm mesh with weight & Dyneema 6mm rope	25 kg 0.4 X 0.4 X 0.2 m Sheltered science area and deck workshop	Free-fall to 105m depth with rope retrieved using pot-hauler. Seawater hose near coring winch for washing net	
	Spare 1m^2 surface 1000 µm net with dismantled frame	20kg 1.0 X 0.5 X 0.5m General purpose wet laboratory - dirty	Nil	
	SVP drifters (BoM) X 6	25 kg each 0.72 X 0.71 X 0.65 m General purpose wet laboratory - dirty	Can be stacked	
	ARGO float (IMOS)	26 kg 1 X 0.26 x 0.25 m Forward science storage area (main deck level)	To be deployed at 20°S	
	Deep water APEX float (JAMSTEC) X 2	50 kg 1 X 0.26 x 0.25 m but packed in large wooden boxes Storage location Sheltered Science Area.		
	230L pressurised Liquid Nitrogen cylinder with transfer hose & phase separator	350kg Cylinder = 0.7 x 0.75 x 1.55 m	Certified to EN12079:2006 – Offshore Containers and Associated Lifting Sets for loading and unloading (cage 470kg, 1.05x1.05x2.05m).	

Antoine	UTS container	Weight: TBC 6.06 X 2.44 X 2.90 m Level 2 deck, behind the hazardous chemical storage TBC		
	DALEC radiometer	5 kg 0.2 X 0.2 X 0.2m Location: on the port foredeck boom (close to the bow)	Cable will run from the instrument to the Air Chemistry lab (connected by SIT). Power (220V) for the control laptop required in lab.	
	C-OPS in water profiling radiometer for underwater light profile	5kg 0.55 X 0.35 X 0.15 m Location: SSA, manually deployed from the stern	Power (220V) for the deck unit and control laptop. Extension cord to run out to aft deck during measurements.	
	Reference radiometer for C-OPS	3 kg Cylinder diameter 0.1 X 0.35m length The reference radiometer will be on a pole attached on top of one of the rear deck cranes, to be as far as possible from the ship's superstructure to avoid shading or reflection of sun light.	Crane to be lowered prior to use of the C-OPS to record a "dark measurement" before returning to its highest deployable position while the C-OPS is being used. After completion of C-OPS profile, the crane needs to be lowered again to enable the protective cap to be placed over the instrument. Powered by cable from deck unit/laptop.	
	Radiance camera	3 kg Cylindrical: diameter 0.1m, height 0.15m, plus horizontal plastic arms for flotation, 1.5m each. Location: SSA Manually deployed from the stern; floats at surface (does not profile)	Power (220V) for the control laptop.	
	Wet Labs AC-S inherent optical properties IOP package	50kg Aluminium frame hosting various optical instruments 1.5m X 0.5m x 1.5m		

		Stored in the SSA. Deployed using the coring winch		
	Hydroptics Underwater Video Profiler UVP5 – attached to CTD	30 kg Overall dimensions LWH: 0.33 X 0.376 X 1.153 m (but see drawings) Will be installed inside the 36-bottle rosette frame	Power (220V) for the deck unit and control laptop, which should be installed either in the Electronics workshop close to the CTD room or in the Operations room. Rinse to 20 m before deployment	Received
	Photosynthetron for P vs E curves & ^{14}C primary production	180 kg 2 x 0.3 x 0.5 m Radiation container	Electricity	
	Filtration manifolds (12 slots) & vacuum pump	30 kg LWH: 1.5 x 0.8 x 0.8m General purpose Wet Lab (clean)	Need a sink close to the filtration gear for evacuation of filtered water. Power (220V) for the peristaltic pump	
	WET Labs AC-S spectrophotometer (underway measurements)	25kg LWH: 1.5 x 1.0 x 1.0m General purpose Wet Lab (clean)	Need a sink for evacuation of water after it has been through the instrument. Power (220V) for the control laptop	Received
	SAtlantic HyperPRO in-water profiling radiometer for underwater light profile	5kg 1 X 0.5 X 0.1 m Location: SSA Manually deployed from the stern	Power (110V + transformer) for the deck unit and control laptop. Extension cord to run out to aft deck during measurements	
	Reference radiometer for the HyperPRO	1.5 kg Cylinder diameter 0.06 X 0.36m length Same location as the C-OPS deck reference	See the C-OPS instructions above	
	MictoTOPS hand-held sun photometer	3 kg Portable instrument	Used manually. No need for any ship's equipment or crew. The instrument is equipped with a fibre optic that is pointed to the sea for the measurement.	
	Small dewar with liquid nitrogen	One small (<17L) Dewar close to where the filtration set-up is in General Purpose Wet lab - clean.	Samples are flash frozen in small Dewar and later transferred to the -80°C freezers. Dry shippers will be brought on	

			board when the ship returns to Fremantle	
	EI mass spectrometer with Dell Optiplex 7450 computer	10 kg 0.7 X 0.33 X 0.52m General Purpose Dry lab - clean	Sink with seawater supply	
Landry	Flowing seawater deck incubator (aft deck installation to avoid shading)	60 kg 1.5 x 1.0 X 1.2m Aft deck	Raw seawater supply	
	1m circumference 200 µm mesh zooplankton net (and spare)	20 kg 1.2 x 1.2 X 0.4m Sheltered science area and deck workshop	Needs MNF depressor weight	
	Vacuum pump, 110-220 V power converter & manifold for zooplankton size fractionations	30 kg 1.0 x 0.5 X 0.4m General purpose wet laboratory - clean	Electrical power, near sink	
	Vacuum pump, 110-220 V power converter and manifold for slide preparation of preserved samples	20 kg 0.6 x 0.5 X 0.4m General purpose dry laboratory - clean	Electrical power, fume hood	
	Peristaltic pump and 110-220 V power converter for setting up experiments	30 kg 0.9 x 0.5 X 0.4m General purpose wet laboratory - clean & CTD room	Electrical power Pump used for quickly filtering water from CTD Niskin bottles for dilution experiment setup Pump will be removed from the CTD lab when not in use (agreed by M. Landry)	
	110-220 V power converter, tissue grinder, sonicator & centrifuge for zooplankton gut fluorescence analyses	20 kg 0.6 x 0.5 X 0.4m General purpose dry laboratory - clean	Electrical power	
	Vacuum pump, 110-220 V power converter and 8-place	30 kg 1.3 x 0.5 X 0.3m	Electrical power	

	manifold for chlorophyll filtrations, 500ml bottles, 25mm filters	General purpose wet laboratory - clean		
	Turner fluorometer (A10) 110-220 V power converter	13 kg 0.24 X 0.55x 0.34m General purpose dry laboratory - clean	Electrical power	
	Bottles for grazing experiments	30 kg 0.9 x 0.5 X 0.4m General purpose wet laboratory - clean & incubator on aft deck.	Nil	
Thompson	Turner fluorometer (A10)	13 kg 0.24 X 0.55x 0.34m General purpose dry laboratory - clean	Electrical power	
	Vacuum pump	20 kg 0.6 x 0.5 X 0.4m General purpose wet laboratory - clean		
	50L plastic drum	5 kg 0.5m diameter General purpose wet laboratory - dirty	Back-up for Waite filtering	
Raes	Bottles for Nitrogen uptake incubations	Radiation container & deck incubators		
	Dewar of liquid nitrogen	1 X 10 L Sheltered science area	Samples will be transferred from dewar to -80°C freezer	
	Vacuum pump	5 kg 0.3 X 0.2 X 0.2 m Container - level 2 aft deck (Radiation lab)	Electrical power	
	Filtration set up	2 kg 1.2 X 1.2 X 1.2 m		

		Container - level 2 aft deck (Radiation lab)		
	Vacuum pump	5 kg 0.3 X 0.2 X 0.2 m General purpose wet laboratory - clean	Electrical power	
	Filtration set up	2 kg 1.2 X 1.2 X 1.2 m General purpose wet laboratory - clean		
Ostrowski	Soliense fluorometer	40 kg 0.5 x 0.5 x 0.5m General purpose dry laboratory - clean	Electrical power	
	2 X peristaltic pumps	2 X 10 kg 0.5 X 0.5 X 0.5 m General purpose wet laboratory - clean	Electrical power	
	Small dewar for liquid nitrogen	1 X 15L General purpose dry laboratory - clean		
Seymour	Gas chromatograph (Hydrogen, Helium and air cylinders)	40 kg 1.0 x 0.8 x 0.6 m Air chemistry laboratory Cylinders extra	Electricity	
	2 X Peristaltic pumps	2 X 3 kg 0.3 X 0.2 X 0.2 m General purpose wet laboratory - clean	Electricity	
	Vacuum pump	5 kg 0.3 X 0.2 X 0.2 m	Electricity	

		General purpose wet laboratory - clean		
	Small Dewar with liquid nitrogen	1 X 20 L General purpose wet laboratory – dirty	Samples will be transferred from dewar to -80°C freezer	
Phillips	Vertical Microstructure Profiler (VMP200) with neutrally buoyant line	48 kg in total 1. Instrument case containing VMP200 profiler 1.2 x 0.4 x 0.2 m 2. 420 metres of 6mm Dyneema rope in box 1.0 x 1.0 x 1.0 m 3. Box containing brushes 1.2 x 1.2 x 0.2 m Clean Dry lab	Plastic basket to gather line into	
	SUNA nitrate sensor	5 kg Triaxus		
	NOAA drifters X 8	25 kg each 0.72 X 0.71 X 0.65 m General purpose wet laboratory - dirty	Can be stacked	
Jenner	Sonobuoys	3 crates at 700 kg each 1.0 x 1.0 X 1.3 m each Aft Main deck	Cannot be stacked	Received
	VHF receiving aerial X 3	7.5 kg 1.5 X 0.5 X 0.5 m Observation deck 7	Install prior to voyage	Received
	Receiving station	30 kg 0.4 X 0.4 X 0.8 m Observation deck 7	Electricity	Received
Jeffs	Micro-zooplankton sampler	5 kg 1.0 X 0.5 X 0.5 m		

		General purpose wet laboratory - dirty		
	Portable laser	5 kg 1 X 0.5 X 0.5 m Constant temperature laboratory		
	Trios Ramses – spectroradiometer	10 kg (with battery pack and cable) 1 X 0.5 X 0.5 m General purpose dry laboratory - clean	Back-up instrument only to be used if there is C-OPS failure. 8-12 V DC ± 3 %, ≤ 0.85 W Can be operated in autonomous self-logging mode	

Special Requests – User Equipment

- Equipment to be fitted to the vessel:
  - Jenner - VHF receiving aerials – observation deck level 07
  - Antoine – Radiance sensor reference installed on aft deck crane
  - Antoine - Installation of UVP on CTD rosette
  - Antoine – Installation of DALEC on forward port boom
  - Antoine - Wet labs AC-S absorption/ attenuation – underway in line system in general purpose wet laboratory – clean. The *seawater system on vessel needs to be cleaned* prior to voyage IN2019_V03.
  - Landry – securing of small incubation tank for aft deck with seawater flow