RV *Investigator* Voyage Plan

Voyage #:	**IN2019_V06**		
Voyage title:	**Tropical observations of atmospheric convection, biogenic emissions, ocean mixing, and processes generating intraseasonal SST variability**		
Mobilisation:	Darwin, 18 & 19 October 2019		
Depart Leg 1:	Darwin, 20:00, 19 October 2019		
Return Leg 1:	Darwin, 08:00, 11 November 2019		
Port period:	Darwin, 11 November 2019		
Depart Leg 2:	Darwin, 20:00, 11 November 2019		
Return Leg 2:	Darwin, 17 December 2019		
Demobilisation	Darwin, 17 December 2019		
Voyage Manager (Leg 1):	Hugh Barker	**Contact details:**	Hugh.barker@csiro.au
Voyage Manager (Leg 2):	Don McKenzie	**Contact details:**	Don.mckenzie@csiro.au
Chief Scientist:	Dr Alain Protat		
Affiliation:	Australian Bureau of Meteorology (BoM)	**Contact details:**	alain.protat@bom.gov.au
Principal Investigators:	Matthew Wheeler, Charmaine Franklin, Eric Schulz, BoM Susan Wijffels, Ruhi Humphries, CSIRO Todd Lane, Robyn Schofield, Jason Monty, Alex Johnson, University of Melbourne Christian Jakob, Monash University Robin Robertson, Xiamen University Malaysia Zhiyu Liu, Xiamen University Fadli Syamsudin, BPPT, Indonesia Urip Haryoko, BMKG, Indonesia Po-Hsiung Lin, National Taiwan University, Taiwan Damien Callahan, Deakin university Zoran Ristovski, Queensland University of Technology Mei Zheng, Peking University		

Scientific objectives

The objective of this proposal is to improve the parameterization of tropical moist convection in the atmosphere and vertical mixing driven by internal tides in the ocean, which are still major road blocks for producing accurate daily to seasonal weather forecasts and climate predictions. Our associated observational aims are to:

- Over a period of >30 days, in order to sample different phases of the Madden-Julian and/or other monsoon oscillations, extensively characterize the 3D mesoscale atmospheric dynamics of a target coastal location in Northern Australia that has a large diurnal cycle of precipitation.
- Characterize in detail the diurnal through monthly evolution of the upper ocean and near surface structure at the target site to advance our understanding of atmosphere – upper ocean coupling.
- Construct detailed datasets of clouds, air-sea fluxes and atmospheric turbulence and make all datasets available to the international Years of Maritime Continent (YMC) science community, to expedite progress in improving parameterizations of convection, clouds, and the boundary layer.

Voyage objectives

The voyage is broken up into several legs with stations at two locations: on the edge of Australia's **Northwest Shelf**, and just to the north of the Bureau's operational radar at **Warruwi** (Northern Territory). In-between these locations we assume a cruising speed of 11nm/hr. Some observation platforms such as the weather radar, surface meteorology, atmospheric chemistry, and underway shipboard ADCP, will continue to operate and collect valuable scientific measurements during the entire voyage. The opportunity will also be made to deploy 2 fast profiling ALAMO floats.

We plan to launch a total of approx. 350 Vaisala RS41-SGP (or on some occasions RS41-SG) sondes. Launch times will be:

- Leg 1 – 45 minutes before 00 UTC and 12 UTC; Leg 2 – 45 minutes before 00 UTC, 03 UTC, 06 UTC, 09 UTC, 12 UTC, 15 UTC, 18 UTC and 21 UTC.

- There is also the possibility of intensive observational periods on Leg 2 with launches every hour for up to 10 hours.

Transmission frequencies will be 401.3MHz, 401.7MHz, 402.3MHz, and 402.7MHz, trying each one in turn to avoid interference with the operational Darwin airport radiosonde launches.

<u>Northwest Shelf edge (22 days) – Leg 1</u>

The primary intent at the Northwest Shelf station (121.5°E, 14.0°S) will be to study the merging Indonesian Throughflow (ITF) water into the Indian Ocean, ocean internal waves, ocean vertical mixing, wind mixing, water mass transformation, and processes contributing to SST variability. Two 72- hour yo-yos, with alternate hourly CTD/LADCP and microstructure VMP operations will be performed, one during spring tide and one during neap tide, to determine the wind and tidal mixing and the internal waves on a temporal basis. The VMP casts and CTD/LADCP casts will alternate, so there is an hourly measurement, but each occurs every 2 hours. To illuminate the spatial dependence of these processes, two transects with microstructure VMP casts will be executed across the continental shelf. Additionally, a Wire-walker will be deployed and recovered to provide a time series of upper ocean changes during this period to provide a time series upper ocean heat budget estimates.

To investigate the upper ocean heat budget on a wider spatial scale down to 200-300 m, two 72-hour Triaxus tows will be performed in a butterfly pattern around the Wire-walker. A 24-bottle CTD Rosette with a LADCP will be deployed during the Yo-yos to 1000 m and to full depth at the corners of a box surrounding the region to provide information on the full water column. Water samples will be taken during the 4 CTDs, the one CTD cast per day for the Yo-yos, and additional samples at a maximum of 2 days for algal cultures. This brings the total of number of casts that are sampled to ~35. No water will be collected during the remainder of the Yo-yo. Additional water samples will be taken with the CTD to provide water for algal cultures. The samples will be taken to provide estimates of nutrients, oxygen, salinity, and for algal and microbial analysis Students will help MNF analyse these samples to produce results in a timely manner.

The shipboard ADCP will be run continuously for estimates of the flow field and vertical mixing following the method of Fischer (2011). This method requires 1 min averages of the shipboard ADCP data and we would like to receive this data during the voyage. A microstructure vertical profiler (e.g. VMP-500, VMP-200, and MSS-90) will be used to obtain full-depth profiles of ocean turbulence for 2 transects over the shelf and to 1000 m during the Yo-yos. Design of the tows and sampling will be based on the high-resolution modelling of Robertson. Some smaller simulations focussing on the shelf edge will be performed on-board. In addition, we will mount 3 internally recording RBR Argo CTDs to the rosette to help test these for use in the global Argo program. Finally, in order to provide background information on the atmospheric state, one to two radiosondes will be launched every day (at fixed times to be determined).

Warruwi station (35 days) – Leg 2

At the Warruwi station (near 133.6°E, 11.2°S) the primary intent is to make near continuous measurements of the oceanic and atmospheric environment throughout the diurnal cycle as atmospheric moist convection develops, or does not develop, in the range of the Investigator weather radar. Measurements on days where convection does not occur are equally important for the improvement of model parameterizations. The offshore propagation of organized convective systems is of particular interest. We will sample their 3D mesoscale dynamics through dual-Doppler measurements with the Investigator radar and the Bureau of Meteorology's operational radar at Warruwi. This will require the radars being about 50-70km apart. 3-hourly radiosondes will be launched (approximately 7-8 per day) and will be made available for assimilation into operational model analyses and used to determine diurnal wave characteristics for detailed comparison to the high-resolution model simulations. Balloons will be inflated in the science sheltered area in a user-supplied tarp and released from the back deck. In order to capture the offshore variability of the atmospheric conditions associated with night-time offshore propagation of coastally-induced convection for selected case studies, we will sail back-and-forth transects between the Warruwi station and about 150km offshore while launching additional radiosondes when coastally-induced convection develops. Our observational target is to do one back and forth trip, so about 16h, and do that for 3 cases. We would launch three radiosondes on each leg (so 1 every 1.5 hours). Ocean observations while at Warruwi will consist mainly of microstructure profiles, along with at least 2 CTD/LADCP operations per day (< 30 min in the shallow water, with 5-10 min of that in the water). We also would also like to deploy a Wire-walker at the beginning of the time at Warruwi somewhere near the middle of the operations and retrieve it at the end.

Air-sea fluxes from both the bulk and eddy-covariance methods will be continuously derived from the surface meteorology and sonic anemometer measurements that will operate at all times. The bulk fluxes will be computed using the COARE algorithm. For eddy-covariance fluxes, measurements will be made with a Campbell Scientific CSAT3 Sonic anemometer (with high response thermocouple option) and a fast response humidity sensor. The CSAT3 is capable of measuring all 3 fluctuating velocity components at 20 Hz and spatial resolution of ~10cm (Hutchins et al. 2012).

Comprehensive atmospheric chemistry and aerosol measurements will be conducted continuously throughout the voyage using the RV Investigator aerosol laboratory, air chemistry laboratory, and AIRBOX (a containerized laboratory which houses various additional atmospheric monitoring instruments). PI Schofield will coordinate with the AIRBOX consortium to conduct atmospheric biogenic air measurements, aerosol composition, aerosol profile and oxidative capacity measurements to understand the emissions and processing of sulphur and halocarbons from the ocean in this region.

Fresh and snap frozen ocean samples will be stored for bacterial and microalgae identification and halocarbon production analysis ashore.

It is anticipated 72-hour time series (spring and neap tide) VMP-200 deployments to <50m will be conducted, with the aim to perform a time series of profiles through a storm event.

It is projected to conduct twice daily CTD/LADCP casts in < 50 m of water and perform a time series of profiles during events. Events could be storms, high winds, rain squalls, convective events, night time convection, crossing a front, an eddy coming by. These cannot be predicted far in advance, however, it is likely several of them will occur during a 30 day time period. The profiles will be either CTD/LADCP without taking water samples or microstructure VMP (VMP is more likely since they will provide more information (velocity shear) and higher resolution (< 1m)). The profiles will be performed over a period of ½ to 3 days, depending on the lifetime of the event. It is likely profiles will be repeated at 10, 15 or 30 minute intervals with the ship maintaining station.

A CTD/LADCP cast will take approximately 5 minutes in the water after the oxygen sensors have stabilised. If seas are calm, we will consider leaving the CTD in the water at a safe depth (usually 5m) to stabilise the oxygen sensors.

Operational Risk Management

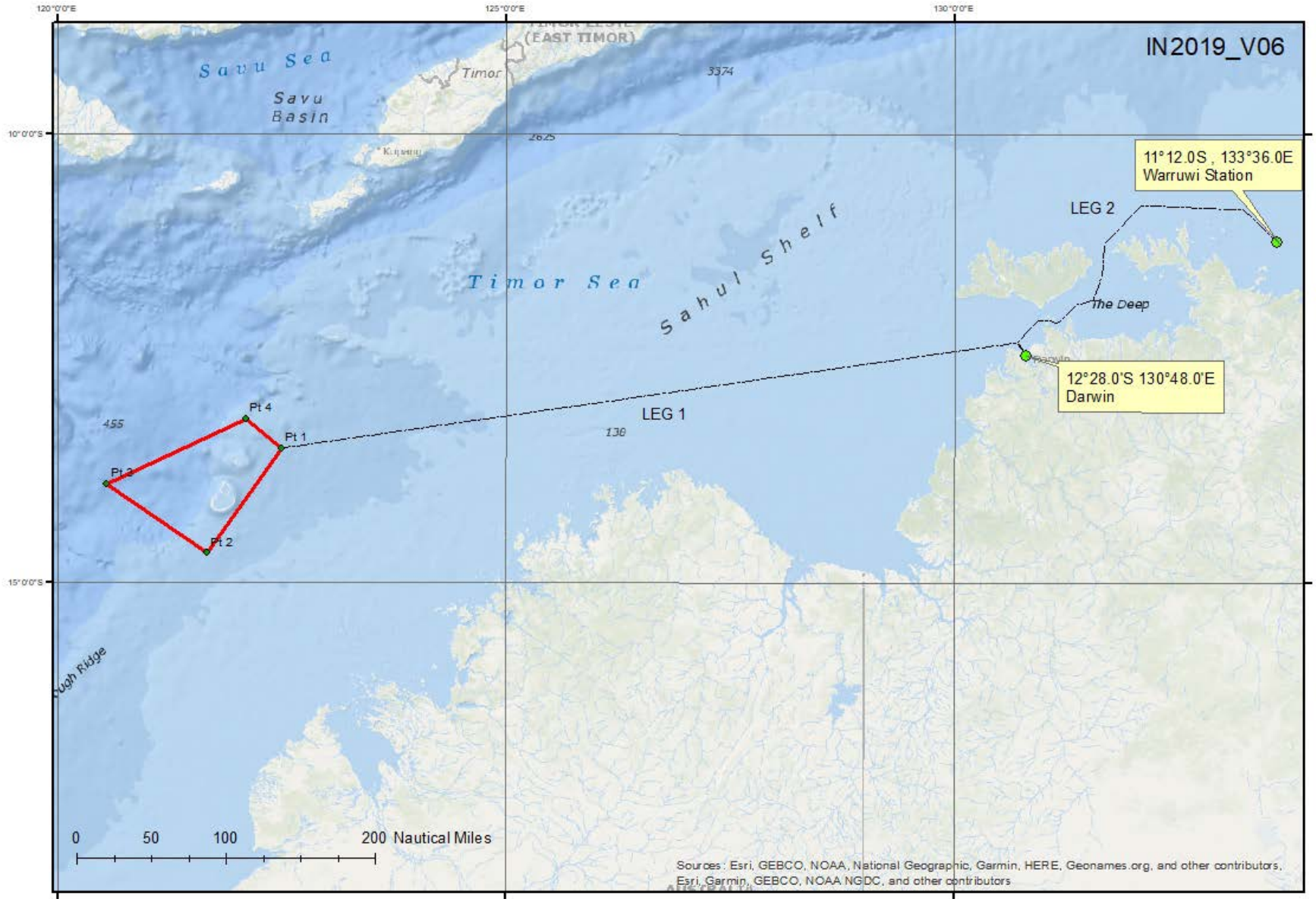
Although ideally, we would like to do pre-cruise test of two of the microstructure profilers, VMP-500 and MSS-90, to ensure their functioning during the cruise, there does not seem to be time. The team operating these instruments is experienced deploying them at hourly intervals for a Yo-yo over multiple tidal cycles. They will use their own winch. Consequently, it is not felt that a pre-cruise test is necessary. No other potentially high-risk work has been identified outside standard operations. To be discussed with MNF. The VMP-250 has already been used on RV *Investigator* but does not reach deep enough for the Yo-yo casts.

Media Activities

Summary of the planned media activities for the voyage to ensure all voyage participants are aware of what may occur in this space. It should document activities for the sponsoring agency/participants and those to be undertaken for the MNF. If a media plan has been developed then this can be referenced and appended to the Voyage Plan.

Organisation	Activities	Timing	Responsible person
All PIs	To be discussed	Opportunistically	All PIs

Voyage track – Legs 1 and 2



Waypoints and stations – Legs 1 and 2

	Decimal Latitude	Decimal Longitude	Distance (nm)	Total Distance (nm)	Steaming time (hrs)	Total Steam (hrs)
LEG 1						
Darwin port	12°28' S	130°48' E				
NW Shelf station	13° 30.0'S	122° 30.0'E	490.1	490.1	44.6	44.6
	14° 40.2'S	121° 40.2'E	85.0	575.1	7.7	52.3
	13° 53.8'S	120° 33.0'E	80.0	655.1	7.3	59.6
	13° 10.2'S	122° 06.0'E	100.5	755.5	9.1	68.7
Darwin port	12°28' S	130°48' E	511.7	1267.2	46.5	115.2
LEG 2						
Darwin port	12°28' S	130°48' E				
Warruwi station	11°12' S	133°36' E	181.3	181.3	23.5	23.5
Darwin port	12°28' S	130°48' E	181.3	362.6	23.5	47.0

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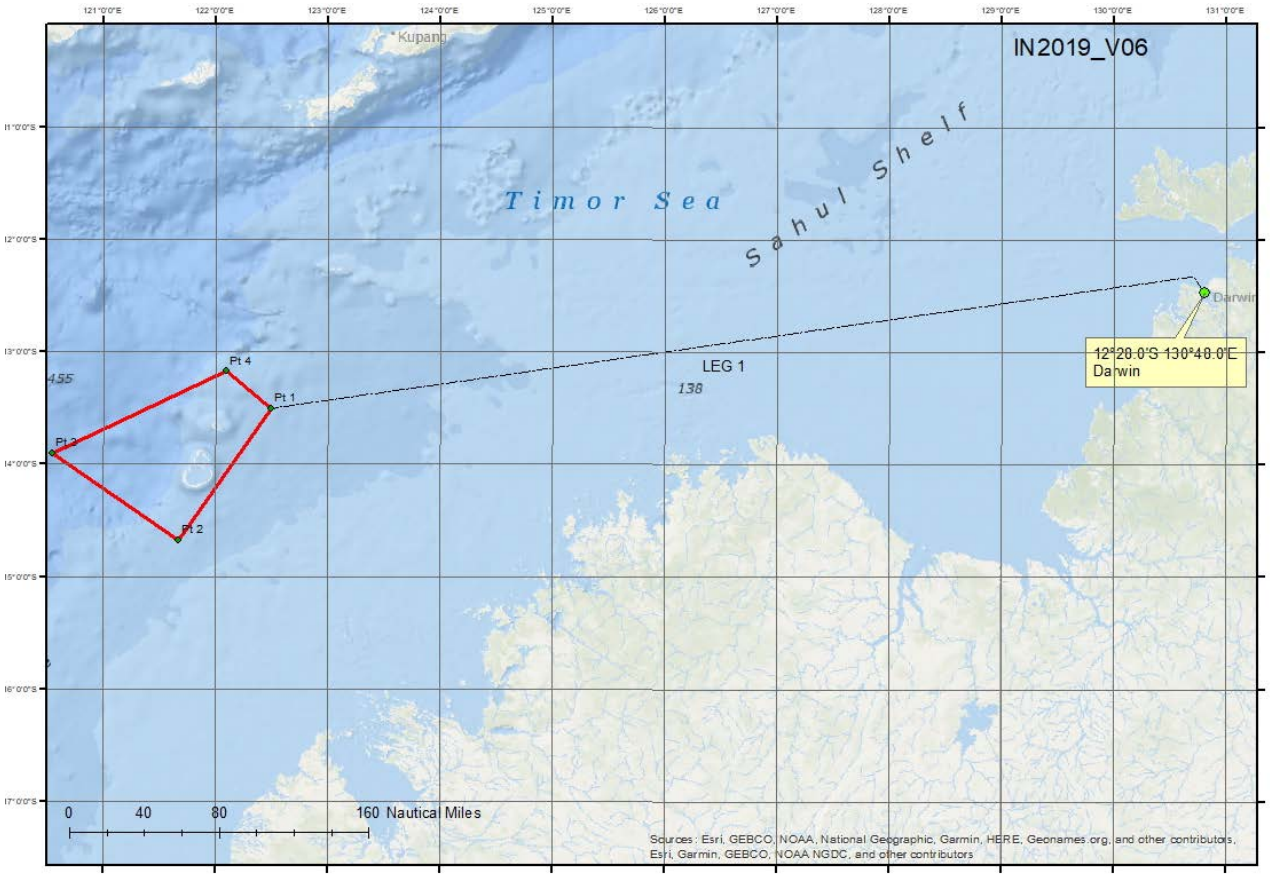
Voyage track – Leg 1



Waypoints and stations, time estimates

	Decimal Latitude	Decimal Longitude	Distance (nm)	Total Distance (nm)	Steaming time (hrs)	Total Steam (hrs)
LEG 1						
Darwin port	12°28' S	130°48' E				
NW Shelf station	13° 30.0'S	122° 30.0'E	490.1	490.1	44.6	44.6
	14° 40.2'S	121° 40.2'E	85.0	575.1	7.7	52.3
	13° 53.8'S	120° 33.0'E	80.0	655.1	7.3	59.6
	13° 10.2'S	122° 06.0'E	100.5	755.5	9.1	68.7
Darwin port	12°28' S	130°48' E	511.7	1267.2	46.5	115.2

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Waypoints and stations, time estimates (cont'd)

ACTIVITY	Number	Longitude	Latitude	Depth/hours	Start date HR:MIN	End date HR:MIN	Activity time (hrs)	Distance (nm)	Sum Distance (nm)	Steaming (hrs)	Sum Steaming (hrs)
Steam to work site		130.85	-12.463	-3	2019 10 19 21 0	2019 10 20 0 0	3	14.859	14.859	1.3508	1.3508
		130.66	-12.298	0	2019 10 20 1 21	2019 10 20 1 21	0	482.48	497.34	43.862	45.212
CTD	1	122.5	-13.5	402	2019 10 21 21 12	2019 10 21 22 30	1.3013	30.617	527.95	2.7834	47.996
CTD	2	122.1	-13.17	993	2019 10 22 1 17	2019 10 22 3 0	1.7117	99.954	627.91	9.0867	57.082
CTD	3	120.55	-13.88	2501	2019 10 22 12 5	2019 10 22 14 41	2.5922	80.548	708.46	7.3226	64.405
CTD	4	121.67	-14.67	375	2019 10 22 22 0	2019 10 22 23 17	1.2788	0	708.46	0	64.405
Deploy Wire walker		121.67	-14.67	-8	2019 10 22 23 17	2019 10 23 7 17	8	0	708.46	0	64.405
Triaxus butterflys around Wire Walker	TRIAXUS 1	121.67	-14.67	-76	2019 10 23 7 17	2019 10 26 11 17	76	71.118	779.57	6.4652	70.87
VMP Section 1	v	121.04	-13.655	-1	2019 10 26 17 45	2019 10 26 18 45	1	5.308	784.88	0.48254	71.353
	v	121.11	-13.709	-1	2019 10 26 19 14	2019 10 26 20 14	1	5.3072	790.19	0.48247	71.835
	v	121.18	-13.763	-1	2019 10 26 20 43	2019 10 26 21 43	1	5.3064	795.49	0.4824	72.318
	v	121.26	-13.817	-1	2019 10 26 22 12	2019 10 26 23 12	1	5.3057	800.8	0.48233	72.8
	v	121.33	-13.871	-1	2019 10 26 23 41	2019 10 27 0 41	1	5.3049	806.11	0.48226	73.282
	v	121.4	-13.926	-1	2019 10 27 1 9	2019 10 27 2 9	1	5.3041	811.41	0.48219	73.764
	v	121.47	-13.98	-1	2019 10 27 2 38	2019 10 27 3 38	1	5.3033	816.71	0.48212	74.247
	v	121.54	-14.034	-1	2019 10 27 4 7	2019 10 27 5 7	1	5.3026	822.02	0.48205	74.729
	v	121.62	-14.088	-1	2019 10 27 5 36	2019 10 27 6 36	1	5.3018	827.32	0.48198	75.211
	v	121.69	-14.142	-1	2019 10 27 7 5	2019 10 27 8 5	1	5.301	832.62	0.48191	75.693
	v	121.76	-14.196	-1	2019 10 27 8 34	2019 10 27 9 34	1	5.3002	837.92	0.48184	76.174
	v	121.83	-14.25	-1	2019 10 27 10 3	2019 10 27 11 3	1	5.2994	843.22	0.48176	76.656
VMP Section 1	v	121.9	-14.305	-1	2019 10 27 11 32	2019 10 27 12 32	1	29.734	872.95	2.703	79.359
Spring Tide Series: alternating 1000 CTD/VMP	TS 1	121.5	-14	-96	2019 10 27 15 14	2019 10 31 15 14	96	0	872.95	0	79.359
Triaxus butterflys around Wire Walker	TRIAXUS 2	121.5	-14	-76	2019 10 31 15 14	2019 11 3 19 14	76	0	872.95	0	79.359
Retrieve/redeploy Wire Walker (if needed)		121.5	-14	-4	2019 11 3 19 14	2019 11 3 23 14	4	33.911	906.86	3.0829	82.442
VMP Section 2	v	121.04	-13.655	-1	2019 11 4 2 19	2019 11 4 3 19	1	5.308	912.17	0.48254	82.925
	v	121.11	-13.709	-1	2019 11 4 3 48	2019 11 4 4 48	1	5.3072	917.48	0.48247	83.407
	v	121.18	-13.763	-1	2019 11 4 5 17	2019 11 4 6 17	1	5.3064	922.78	0.4824	83.889
	v	121.26	-13.817	-1	2019 11 4 6 46	2019 11 4 7 46	1	5.3057	928.09	0.48233	84.372
	v	121.33	-13.871	-1	2019 11 4 8 15	2019 11 4 9 15	1	5.3049	933.39	0.48226	84.854
	v	121.4	-13.926	-1	2019 11 4 9 44	2019 11 4 10 44	1	5.3041	938.7	0.48219	85.336
	v	121.47	-13.98	-1	2019 11 4 11 13	2019 11 4 12 13	1	5.3033	944	0.48212	85.818
	v	121.54	-14.034	-1	2019 11 4 12 42	2019 11 4 13 42	1	5.3026	949.3	0.48205	86.3
	v	121.62	-14.088	-1	2019 11 4 14 11	2019 11 4 15 11	1	5.3018	954.61	0.48198	86.782
	v	121.69	-14.142	-1	2019 11 4 15 39	2019 11 4 16 39	1	5.301	959.91	0.48191	87.264
	v	121.76	-14.196	-1	2019 11 4 17 8	2019 11 4 18 8	1	5.3002	965.21	0.48184	87.746
	v	121.83	-14.25	-1	2019 11 4 18 37	2019 11 4 19 37	1	5.2994	970.51	0.48176	88.228
VMP Section 2	v	121.9	-14.305	-1	2019 11 4 20 6	2019 11 4 21 6	1	29.734	1000.2	2.703	90.931
Neap Tide Series: alternating 1000 CTD/VMP	TS 2	121.5	-14	-84	2019 11 4 23 48	2019 11 8 11 48	84	41.397	1041.6	3.7634	94.694
Steam to and retrieve wirewalker		121.67	-14.67	-8	2019 11 8 15 34	2019 11 8 23 34	8	543.31	1585	49.392	144.09
Waypoint off Darwin		130.66	-12.298	0	2019 11 11 0 58	2019 11 11 0 58	0	14.859	1599.8	1.3508	145.44
Arrive outside Darwin	0	130.85	-12.463	-3	2019 11 11 2 19	2019 11 11 5 19	3	0	1599.8	0	145.44

1. CTD test station proposed soon after departure. To be discussed once on board.
2. Based on 11 knots average speed. Shallow CTDs around the Wire walker will be undertaken whilst inspections and retermination of the Triaxus occur.

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Activity plan including details for first 24 hours of voyage

The first 24h of the voyage will consist of one test CTD and steaming in the Northwest shelf station (120.3°E, 13.7°S).

See the table above for estimated times/steaming information. Note that Triaxus steam time is not currently included in the listed distance/steam time totals.

LOCATION	ACTIVITY
Offshore of Scott Reef in an internal wave tidal beam	Collect 4 full depth CTDs at corners around tidal beam with Niskins and hydrochem analysis. CTD 1 will also act as our test station. CTD 4 is near our time series site. After two of the CTDs, ALAMO floats will be deployed as we leave the station.
At CTD 3 or 4 (or between) in daylight	Deploy Wire-walker (~4 hours daylight, likely much less) Deploy ALAMO float (10 minutes as we come off station)
Middle of CTD box	72 hours for a series of Triaxus tows around wire walker – butterfly pattern, running atmospheric sensors for fluxes and sADCP/TSG. Triaxus termination will be checked as needed. If retermination is required, shallow CTDs/VMP profiles around the wirewalker will be carried out or possibly the new rapid CTD system.
VMP section into shelf slope	Perform around 13 1000m depth VMP casts roughly 10km apart along a section towards Scott Reef. When complete steam back to Time Series site
Time series 1 (TS1)	SPRING TIDE: Over 96 hours perform alternating CTD and VMP profiles to 1000m. Niskin samples might be done once per day. Estimate about 40 CTDs will be completed, 4 with samples. Deploy ALAMO float (10 minutes as we come off station) Steam to Wire-walker location, retrieve and redeploy if too close to EEZ boundary
Wire walker location	72 hours for a series of Triaxus tow around wire walker – butterfly pattern, running atmospheric sensors for fluxes and sADCP/TSG. Triaxus termination will be checked as needed. If re-termination is required, shallow CTDs/VMP profiles around the wire walker will be carried out or possibly the new rapid CTD system.
Wire walker	Possibly retrieve Wire-walker, depending on where it has drifted to. If remaining in region, leave in place. Steam to VMP section start
VMP section into shelf slope	Perform around 13 1000m VMP casts roughly 10km apart along a section towards Scott Reef. When complete steam back to Time series site
Time series 2 (TS2)	NEAP TIDE: Over 84 hours perform alternating CTD and VMP profiles to 1000m. Niskin samples might be done once per day. Estimate about 35-40 CTDs will be completed, 4 with samples. Steam to Wire-walker.
Wire walker	Final retrieval of Wire walker
Time Series site	Head back to Darwin

IN2019_V06 - LEG 1

CTD Configuration	Please select:
Fundamentals:	
• Which CTD rosette to be used for this voyage (24 Niskin bottles or 36):	24
• Likely total number of casts:	~95, but only ~35 will take Niskin samples
• Likely maximum depth of deepest cast:	3500m
• Lowered ADCP required:	Yes: 2 x downward looking 300 kHz
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):	Yes
• PAR Sensor (Biospherical QCP-2300):	Yes
• Transmissometer (Wetlabs C-Star 25cm):	Yes
• Fluorometer – Chlorophyll-a (Chelsea Aquatracka III – 430/685nm):	Yes
• Fluorometer – CDOM (Wetlabs FLCDOM – 370/460nm)	No
• Nephelometer (Seapoint Turbidity Meter)	Yes
• ECO-Triplet (Chlorophyll-a, CDOM & backscatter – maximum depth 2000m)	No
Hydrochemistry Analyses:	
• Salinity	Yes
• Dissolved Oxygen	Yes
• Nutrients: Nitrate	Yes
• Nutrients: Phosphate	Yes
• Nutrients: Silicate	Yes
• Nutrients: Nitrite	Yes
• Nutrients: Ammonia (special request after discussion with hydrochemistry)	No

IN2019_V06 - LEG 1

Time estimates

The following time estimates are based on a steaming speed of 11 knots. See *Waypoints and Stations table* for Leg 1 activity time estimates.

Date	Time	Activity
21/10/2019	09:00	Departure from Darwin port and sail to NW Shelf
23/10/2019	10:50	Arrival at CTD 1, commence intensive surveys (see table above)
08/11/2019	15:22	Departure from NW Shelf and sail back to Darwin port
11/11/2019	08:00	Arrival at Darwin port, demobilisation and personnel swap
11/11/2019	20:00 (TBC)	Departure from Darwin port and transit to Warruwi station

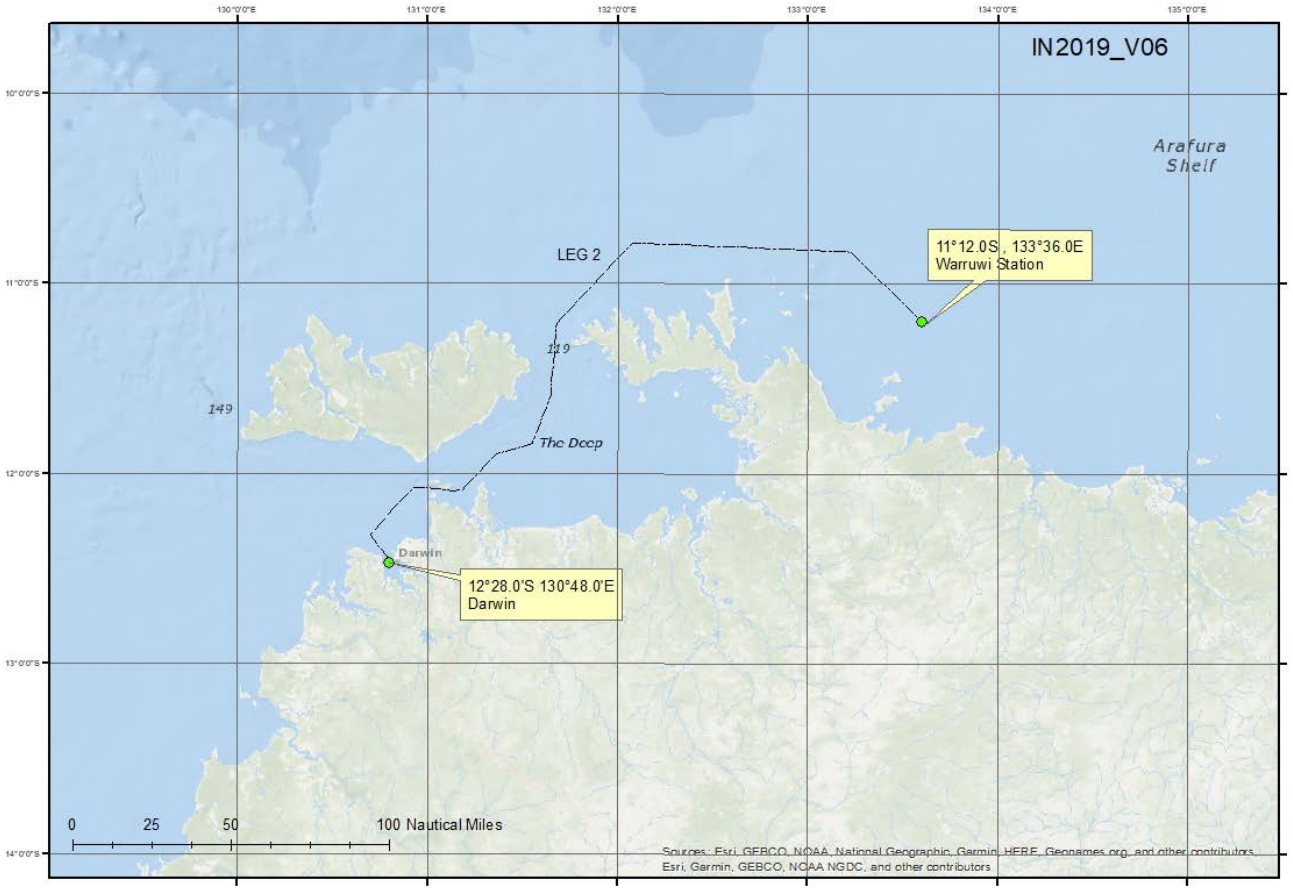
Piggy-back projects

RBR Argo CTD testing during Leg 1 – RBR Canada will supply 2 CTDs with suitable mounts to go on the CTD rosette in Niskin positions. These were developed for a previous Investigator voyage but did not clear customs in time for use. These CTDs are undergoing evaluation for use in the global Argo project and this activity is part of that evaluation. This activity will not require any ship time.

Permits

None needed to operate in these Australian waters, though we should check how close we can work to Scott Reef, which is a marine sanctuary.

Voyage track – Leg 2



Waypoints and stations, time estimates

Departure from Darwin to Warruwi station @ 11.5kts weather permitting (equates to 23h30m steaming).

	Decimal Latitude	Decimal Longitude	Distance (nm)	Total Distance (nm)	Steaming time (hrs)	Total Steam (hrs)
LEG 2						
Darwin port	12°28' S	130°48' E				
Warruwi station	11°12' S	133°36' E	181.3	181.3	23.5	23.5
Darwin port	12°28' S	130°48' E	181.3	362.6	23.5	47.0

Activity plan including details for first 24 hours of voyage

LOCATION	ACTIVITY
Darwin port	• Mobilisation / change in science personnel and crew • Transit to Warruwi station

CTD Configuration	Please select:
Fundamentals:	
• Which CTD rosette to be used for this voyage (24 Niskin bottles or 36):	24
• Likely total number of casts:	2 daily 50m casts ~ 5 bottles.
• Likely maximum depth of deepest cast:	50 m
• Lowered ADCP required:	Yes: 2 x 300 kHz units
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):	Yes
• PAR Sensor (Biospherical QCP-2300):	Yes
• Transmissometer (Wetlabs C-Star 25cm):	Yes
• Fluorometer – Chlorophyll-a (Chelsea Aquatracka III – 430/685nm):	Yes
• Fluorometer – CDOM (Wetlabs FLCDOM – 370/460nm)	No
• Nephelometer (Seapoint Turbidity Meter)	No
• ECO-Triplet (Chlorophyll-a, CDOM & backscatter – maximum depth 2000m)	Yes
Hydrochemistry Analyses:	2 CTDs per day sampled on work site
• Salinity	Yes
• Dissolved Oxygen	Yes
• Nutrients: Nitrate	Yes
• Nutrients: Phosphate	Yes
• Nutrients: Silicate	Yes
• Nutrients: Nitrite	Yes
• Nutrients: Ammonia (special request after discussion with hydrochemistry)	No

Time estimates

Date	Time	Activity
11/11/2019	0800	Arrival at Darwin port and demobilisation of oceanographic equipment.
	0800-2000	• Change in personnel (science and MNF support staff) • Mobilisation of Leg 2 science equipment
12/11/2019	TBD	Arrival at Warruwi station and start of atmospheric work
12/11-15/12/2019	TBD	• Continuation of atmospheric work • Perform series of 72h 50m VMP casts for each storm event when the ship is on station.
16/12/2019	0830	Departure from Warruwi station and sail back to Darwin port *(11.5kts weather permitting, 23h30m steaming)*
17/12/2019	0800	Alongside Darwin port
17/12/2019	0800-1700	Demobilisation

Signature

Your name	Alain Protat
Title	Chief Scientist
Signature	
Date:	11 October 2019

LEG 1

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	X		
Air Chemistry Lab	X		
Preservation Lab			
Constant Temperature Lab			• Please indicate the required setpoint temperature
Underway Seawater Analysis Laboratory	X		
GP Wet Lab (Dirty)	X		
GP Wet Lab (Clean)	X		
GP Dry Lab (Clean)			
Sheltered Science Area	X		
Observation deck 07 level			
Walk in Freezer			
Blast Freezer	X		
Ultra-Low Temperature Freezer (-80^{0}C) X2	X		
Walk in Cool Room	X		
Salt water ice machine			

(ii) Specialised laboratory and facilities *(may require additional support)*

Name	Essential	Desirable	Notes/Comments
Modular Radiation Laboratory			
Modular Trace Metal Laboratory (TM1-blue)			
Modular Trace Metal Laboratory (TM2-white)			• Cannot be overstacked
Trace metal rosette and bottles			• 10 foot container
Modular Hazchem Locker			
Deck incubators			
Stabilised Platform Container	X		
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 36 Bottle Rosette			
CTD - Seabird 911 with 24 Bottle Rosette	X		
Lowered ADCP	X		
Sonardyne USBL System			
Milli-Q System	X		
Laboratory Incubators	X		
Heavy Duty Electronic Balance (80kg)			
Medium Duty Electronic Balance (15kg/5g resolution)			
Light Duty Electronic Balance (3kg/1g resolution)			
Surface Net (mouth area 1m^2)			• Please specify 335 micron, 500 micron, or 1,000 micron mesh
Bongo Net (not instrumented) ring diameter 485mm 0.018m^2			• 500 micron mesh only
Smith Mac grab			

(iii) Standard laboratory and sampling equipment

Name	Essential	Desirable	Notes/Comments
Dissecting Microscopes (x4)	X		• 1 required

(iv) Specialised laboratory and sampling equipment

Name	Essential	Desirable	Notes/Comments (These items may require additional MNF support staff)
TRIAXUS – Underway Profiling CTD	X		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 8knt, 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.
Desired towing profile:			7 knots for 300m profiling.
Additional instrumentation: (Please supply, make and model and datasheets. Also a contact person for discussion on integration.			
Continuous Plankton Recorder (CPR)			
Deep towed camera			
Piston Coring System			
Gravity Coring System			
Multi Corer			
Kasten Corer			
XBT System		X	• 2 per day provided

(iv) Specialised laboratory and sampling equipment

Name	Essential	Desirable	Notes/Comments (These items may require additional MNF support staff)
Trace Metal Rosette and bottles			
Sherman epibenthic sled			
Trace- metal in-situ pumps (x6)			• See non-MNF owned section below for additional 2 units
Rock Dredges			
EZ Net (maximum of 10 nets for depth stratified sampling. Mouth area of 1m^2)			• Please specify 335 micron, 500 micron, or 1,000 micron mesh
Rock saw			• Requires trained science personnel
Portable pot hauler	X		• Leg 2 only
Beam Trawl			
Pelagic trawl system (net, doors)			• Contact MNF to discuss net and mesh dimensions
Demersal trawl system (net, doors)			• Contact MNF to discuss net and mesh dimensions
MIDOC (multiple opening/closing codend system for pelagic trawl)			
Stern Ramp (please select exposed *OR* installed)	Ramp Exposed	Deck covers installed	
		X	
Trawl monitoring instrumentation (ITI) (2,000m depth limit)			
Radiosonde Receiver System	X		• We will bring the balloons and sondes but we need the MNF 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 your Voyage Operations Manager as required. Additional staff may be required for these activities.
Seismic compressors			
Seismic acquisition system			

(vi) Underway systems

Acoustic Underway Systems

Name	Essential	Desirable	Notes/Comments
75kHz ADCP	X		
150kHz ADCP	X		
Multi Beam echo sounder EM122 12kHz (100m to full ocean depth)	X		
Multi Beam echo sounder EM710 70-100kHz (0-1000m approx.)			
Sub-Bottom Profiler SBP120			
Scientific Echo Sounders EK60 (6 bands, 18kHz-333kHz)			
Multibeam Scientific Echo Sounder ME70 (70-100 kHz)			
Omnidirectional Echo Sounder SH90			
Gravity Meter			

Atmospheric Underway Sensors

Name	Essential	Desirable	Notes/Comments
Nephelometer	X		
Multi Angle Absorption Photometer (MAAP)	X		
Scanning Mobility Particle Sizer (SMPS)	X		
Radon detector	X		
Ozone detector	X		
Condensation Particle Counter (CPC)	X		
Picarro spectrometer (analysis of CO_2/CH_4/H_2O)	X		
Aerodyne spectrometer (analysis of N_2O/CO/H_2O)	X		
Cloud Condensation Nuclei (CCN)	X		
Polarimetric Weather Radar	X		
ISAR	X		• To be calibrated prior to being installed on IN2019_V04 *(Nicole Morgan)*
SBE38	X		

Underway Seawater Systems and Instrumentation

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

Seawater systems

Name	Essential	Desirable	Notes/Comments
Trace metal clean seawater supply			
Scientific clean seawater supplied to laboratories	X		

Seawater systems

Name	Essential	Desirable	Notes/Comments
Raw seawater available on deck and in laboratories.			

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. Additional staff may be required for these activities.
D & N Francis winch			• 13mm electro-optical cable
Box Corer			
UTAS In-Situ Pumps (x2)			
EM2040			• Shallow water multibeam echosounder system

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Special Requests – MNF Scientific Equipment and Facilities

- Internet access for all PIs to communicate with other international components of the international YMC project.
- The videoconferencing room on Level 02 (occasionally) to organise met briefings with the BoM Head Office.
- We need to send the radiosonde data to the GTS.
- Yo-Yo: we would like to explore options for keeping a more precise location during these CTDs. They are only shallow so we can tolerate some wire angle.
- LADCP recharging and data download: this might limit our Yo-Yo CTD time, and thus we are interspersing the VMP casts. If the latter fails, a spare battery pack would be terrific to have, so that we could swap it out.
- Triaxus: 7 knots for 300m profiling. Likely to be butterfly or boxes around the Wire-walker with 1 hour lengths (7nm). We would like to see if we can get close to the surface if conditions allow, trying different flight paths with SITS to slowing down on surface approach.

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Appendix B

User equipment and facilities and special requests

Already on board

Owner	Contact Details	Item Name	Weight	Dimensions	Location on Vessel
Bureau of Meteorology	**Alain Protat** 0435 256 261 alain.protat@bom.gov.au	BASTA - 95 GHz cloud radar	~60 kg	(LxWxH) 120x70x100cm	Stabilised Platform container
Bureau of Meteorology	**Alain Protat** 0435 256 261 alain.protat@bom.gov.au	RMAN Lidar	~110 kg	(LxWxH) 80x65x115cm	Stabilised Platform container
University of Melbourne / Queensland University of Technology	**Robyn Schofield** 0422333676 robyn.schofield@unimelb.edu.au **Zoran Ristovski** 0466 207 776 z.ristovski@qut.edu.au	AIRBOX	9 tonnes	High 20" shipping container. With aerosol mast and supports ~2m mounted on the roof	Level 02, port foredeck container space.
University of Melbourne - AIRBOX	**Robyn Schofield** robyn.schofield@unimelb.edu.au 0422333676 **Alessandro Toffoli** alessandro.toffoli@unimelb.edu.au	Sea-state cameras	5kg	LxWxH 30x15x15cm	Deck 05 railing
University of Melbourne - AIRBOX	**Robyn Schofield** robyn.schofield@unimelb.edu.au 0422333676 **Jason Monty** montyjp@unimelb.edu.au **Eric Schulz** E.Schulz@bom.gov.au	Eddy Flux package	10kg	LxWxH 70x15x40cm	On the main aerosol mast

Owner	Contact Details	Item Name	Weight	Dimensions	Location on Vessel
University of Melbourne - AIRBOX	**Robyn Schofield** robyn.schofield@unimelb.edu.au 0422333676 **Robert Ryan** rgryan@student.unimelb.edu.au	MAXDOAS	Optics 5kg (railing) 10kg Spectrometer (3 RU) + laptop	Optics LxWxH 30x20x20 cm Spectrometer 3 RU	Deck 5 railing for optics, 10m fibre optic cable run inside to spectrometer and laptop
University of Melbourne - AIRBOX	**Robyn Schofield** robyn.schofield@unimelb.edu.au 0422333676	miniMPL	instrument 20kg / housing 180 kg	Enclosure: 64 x 64 x 77 cm Scanning unit on top: 35 x 52 x 20 cm	Housing requires crane lift to deck 5. Location on deck 5 against railing, and secured to the deck (as housing has wheels best that a wooden boxing to prevent movement combined with 4 secure points)
University of Melbourne - AIRBOX	**Robyn Schofield** robyn.schofield@unimelb.edu.au 0422333676	u-Dirac	30kg	instrument:50x50x20 columns:LxWxH 10x25x120cm	Aerosol Laboratory - port bench
Macquarie University - University of Melbourne - AIRBOX	**Robyn Schofield** robyn.schofield@unimelb.edu.au 0422333676	Tekran	15kg	Instrument:3RU + laptop	Aerosol Laboratory - port bench
University of Melbourne - AIRBOX	**Robyn Schofield** robyn.schofield@unimelb.edu.au 0422333676	Spectronus	60kg	1000x450x900 (mm L x W X H)	Within the Airbox
Bureau of Meteorology	**Alain Protat** 0435 256 261 alain.protat@bom.gov.au	OceanRAIN disdrometer			Main mast, second highest platform preferred *(has been integrated previously)*
Queensland University of Technology AIRBOX	**Zoran Ristovski** 0466 207 776 z.ristovski@qut.edu.au	NAIS – Neutral Cluster and Air Ion Spectrometer	60 kg	W - 305 mm L - 580 mm H - 810 mm	AIRBOX - on the port-side forward container mounts
Queensland University of Technology AIRBOX	**Zoran Ristovski** 0466 207 776 z.ristovski@qut.edu.au	VHTDMA – Volatility Hygroscopicity Tandem Differential Mobility Analyser	150 kg	1.2 x 0.6 x 1.25 m	AIRBOX - on the port-side forward container mounts
Queensland University of Technology AIRBOX	**Branka Miljevic** 0466 207 776 b.miljevic@qut.edu.au	AMS: Aerosol Mass Spectrometer	180 kg	W - 104cm L - 61cm H - 135cm	AIRBOX - on the port-side forward container mounts
Queensland University of Technology AIRBOX	**Branka Miljevic** 0466 207 776 b.miljevic@qut.edu.au	CIMS	145 kg	59.1 x 42.1 x 82.6 (cm) Scroll pump: 44 x 34 x 34 (cm)	AIRBOX - on the port-side forward container mounts

Owner	Contact Details	Item Name	Weight	Dimensions	Location on Vessel
Wijffels	swijffels@whoi.edu	2 ALAMO profiling floats	2x20kg	150cmx25cmx25xm	wet lab in cardboard boxes until deployed
Xiamen University	Robin Robertson robin.robertson@xmu.edu.my	VMP-200	48kg		To be stored in the Clean Dry lab in between deployments
Many PIs	**Alain Protat** 0435 256 261 alain.protat@bom.gov.au	Radiosondes (balloons) x 300-350.	very light	Balloons are packed 40 to a box and will be carried on board (9 boxes, approx archive box size)	Balloons will be stored in the Dirty Wet lab and will be filled on main deck using the Vaisala Ballon Launcher (see below)
Many PIs	**Alain Protat** 0435 256 261 alain.protat@bom.gov.au	Balloon launcher	48kg	Assembled dimensions: 1510mm(w) x 1270mm(h)	Located near the helium manifolds on main deck
Wijffels/RBR Global	swijffels@whoi.edu	DelMar/RBR Wirewalker - profiler and cable and anchor	200kg	160x60x17cm	cable/anchor on aft deck but profiler in wetlab
Wijffels/RBR Global	swijffels@whoi.edu	DelMar/RBR Wirewalker - float	Incl in above 200kg	90x74cm	Stored on aft deck when not in use
Xiamen University	**Zhiyu Liu** zyliu@xmu.edu.cn	Rockland Scientific VMP-500 https://rocklandscientific.com/products/profilers/vmp-500/	22kg (VMP)	35x35x200cm (VMP)	The VMP can be stored in the Sheltered Science Area when not in use.
Xiamen University	**Zhiyu Liu** zyliu@xmu.edu.cn	Winch to deploy VMP500	100kg	80x100x120cm (winch)	Back deck
Xiamen University	**Zhiyu Liu** zyliu@xmu.edu.cn	MSS-90L microstructure probe (only to be used as a back-up for the VMP-500) https://www.sea-sun-tech.com/marine-tech/offshore/mss-microstructure-probe/mss-90-profiler-microstructure-probe.html	15kg(MSS)	20×20×125cm (MSS-90 is slightly smaller than VMP-500)	The MSS can be stored in the Sheltered Science Area when not in use.
Xiamen University	**Zhiyu Liu** zyliu@xmu.edu.cn	Winch to deploy MSS-90L (only to be used as a back-up for the VMP-500 winch)	50Kg	401x60x80cm (winch)	Back deck
Wijffels/RBR Global	swijffels@whoi.edu	3 RBR Argo test CTDS	3x10kg	50cmx10cm diameter	wet lab until mounted on CTD rosette

Owner	Contact Details	Item Name	Weight	Dimensions	Location on Vessel
Callahan, Deakin Uni	damien.callahan@deakin.edu.au	Inverted microscope	5 kg	50cmx50cmx50cm	Dirty Wet lab
Callahan, Deakin Uni	damien.callahan@deakin.edu.au	Filtering equipment (side arm flask, funnel)	2 kg	30cmx30cmx30cm	Underway seawater lab/general purpose wet lab
Bureau of Meteorology	**Alain Protat** 0435 256 261 alain.protat@bom.gov.au	Micro-rain radar	~20 kg	(LxWxH) 50x50x100cm	Deck 05
CSIRO	**Ruhi Humphries** ruhi.humphries@csiro.au	Aerodynamic Particle Sizer (APS)	10 kg	W - 30 cm L - 38 cm H - 18 cm	Aerosol laboratory
CSIRO	**Erin Dunne** Erin.Dunne@csiro.au	Proton Transfer Reaction Mass Spectrometer (PTRMS)	200 kg	W - 88cm L - 56cm H - 95cm	Air Chemistry Lab
CSIRO	**Erin Dunne** Erin.Dunne@csiro.au	PTRMS Aux rack	50 kg	W - 560cm L - 460cm H - 113cm	Air Chemistry Lab
CSIRO	**Erin Dunne** Erin.Dunne@csiro.au	PTRMS spares and consumables (2 boxes)	60kg	2 boxes (50cm x 50cm x 1m),	Air Chemistry Lab
CSIRO	**Erin Dunne** Erin.Dunne@csiro.au	PTRMS calibration gases (compressed gas N2 with trace VOCs)	20kg	3 gas cylinders - diam 175mm x 397mm(h)	Air Chemistry Lab
Many PIs	**Alain Protat** 0435 256 261 alain.protat@bom.gov.au	Helium manifolds (1 x 16 pack of Size G gas cylinders) for balloon filling	2T	Max. Height: 2141 MM (including frame). Width: 1045 MM x Depth: 1045 MM	Main deck - balloon launcher to be located nearby
Many PIs	**Alain Protat** 0435 256 261 alain.protat@bom.gov.au	Helium manifolds (2 x 16 pack of Size G gas cylinders) for balloon filling	4.1T	Each manifold: Max. Height: 2141 MM (including frame). Width: 1045 MM x Depth: 1045 MM	Main deck - balloon launcher to be located nearby