RV *Investigator* Voyage Plan

Voyage #:	IN2019_T03
Voyage title:	**ORCA: Using the Investigator radar as a moving reference for the Australian operational radar network.**
Mobilisation:	0800, Darwin, 22/12/2019
Depart:	0800, Darwin, 23/12/2019
Return:	0800, Henderson, 02/01/2020
Demobilisation:	0800, Henderson, 02/01/2020
Voyage Manager:	Matt Boyd
Chief Scientist:	Dr Alain Protat
Affiliation:	Australian Bureau of Meteorology (BoM)
Project name:	**Microplastic in the food chain: impact on the microbial and planktonic organisms.**
Principal Investigators:	Dr Sophie Leterme
Affiliation:	Flinders University
Project name:	**Spatial and temporal variability in the distribution and abundance of seabirds**
Principal Investigators:	Dr Eric Woehler
Affiliation:	Birdlife Australia

Primary Project Scientific objective

Optimizing Radar Calibration and Attenuation Corrections (ORCA)

The aim of the *Optimizing Radar Calibration and Attenuation corrections* (ORCA) project is to use the Investigator C-band Doppler dual-polarization weather radar (SEAPOL) and OceanRAIN ODM470 disdrometer as moving references to (i) evaluate (and if needed improve) the calibration of selected coastal radars from the Bureau of Meteorology operational weather radar network and investigate some aspects of these calibration techniques further, and (ii) characterize the regional variability of the so-called self-consistency dual-polarization calibration relationship using disdrometer observations for use in future operational calibration techniques. Our second main aim is to develop C-band attenuation corrections for SEAPOL using unattenuated collocated S-band ground-based radar measurements from the operational radar network collected during the transit voyages.

Voyage objectives

Recently, the Bureau has developed the SCAR (Satellite and Clutter Absolute Radar calibration) framework to monitor calibration of the operational radars (Louf et al. 2018). This approach is based on a combination of two (three) techniques for single (dual) polarization radars. The first technique, the Relative Calibration Adjustment (RCA), assumes that "ground clutter" radar echoes (buildings, topographic structures, trees, etc …) within 10km range have constant reflectivity. This technique tracks changes in calibration to better than 0.2 dB but does not provide a reference (baseline) value. The second technique (Warren et al. 2017) statistically compares collocated ground radar and spaceborne radar from the NASA Global Precipitation Measurement (GPM) mission. This technique provides an absolute calibration with an accuracy of about 1.5 dB. SCAR uses the RCA technique to detect stable periods of calibration and averages all GPM estimates of the absolute calibration, improving the accuracy to better than 1 dB. SCAR is now used semi-operationally at the Bureau but has never been evaluated against a single reference. Transit voyages along the coast with SEAPOL offer a unique opportunity to do this.

The voyage objectives are to collect Investigator C-band Doppler dual-polarization weather radar (SEAPOL), Ocean RAIN, ODM470 disdrometer, and micro rain radar (MRR-2) observations of precipitation collocated with as many radars from the BoM operational radar network located along the coast from Darwin to Fremantle.

When no precipitation is present, we will make use of the SEAPOL radar data in clear air to better understand the sources of variability of ground clutter produced by land along the coast. One uncertainty in the RCA technique is that changes in ground clutter reflectivity statistics can be due to calibration changes or changes in the tilt angle of the radar beam, although this is rare and would indicate a malfunctioning of the radar. This effect has not been quantified in the literature. To study this we will request to stay on stations by periods of 10 minutes along the transit voyage and change the first tilt angle of the volumetric scan by 0.1 degree from 0.5 degree to 1.0 degree in order to measure changes in ground clutter reflectivity due to a change in tilt angle.

Methods

In terms of method at sea, we will carefully look in real time at the 5 days forecast to optimize collocation of ground radar, ship radar, and the big unknown: precipitation. It is understood that there are only 30 hours of flexibility assigned to our project for the transit voyage, so we will factor that in in our communications with the voyage manager and the master. We will only request to adjust ship speed when there is precipitation expected within the common sampling volume of the radars and when we want to collect ground clutter measurements at different tilt angles (offshore rom operational radars).

Supplementary projects

1. Microplastics in the food chain: impact on the microbial and planktonic organisms.

Principal Investigator: Dr Leterme

Scientific and Voyage Objectives

Microplastics consist of pieces of plastic smaller than 5 mm, such as the microbeads found in domestic and personal care products. Plastic pollution of oceanic ecosystems can be observed anywhere on the planet, but microplastics create a global biological and chemical hazard due to their propensity to be ingested by marine life that is later consumed by humans. Small plastics can also adhere onto the surface of micro-organisms that are preyed upon by higher levels of the oceanic food chain such as fish. The aims of the project are (i) to assess the amount of plastics (micro through to pico in size) present in blue waters around Australia and (ii) to identify their impact on microorganisms at the base of the oceanic food chain.

Eight hours of ship time have been allocated for the microplastics project. Sampling sites will overlap with the ORCA radar observation sites. CTD deployments will be undertaken whilst ship is at rest with EZ-Net deployments to be undertaken once Radar and CTD operations have been complete at each site.

At least three stations will be selected aiming for the regions of (Broome, Carnarvon, and Geraldton) and in tandem with ORCA project requirements. Each sampling period will take about 2.5 hours (1.5 hours for the EZ net tow (activated twice at 3 depths) at a speed of 2 knots, and 1 hour for the CTD deployment/recovery).

1.a. Sampling for enumeration and microscopy:

1. CTD will inform of the depth of the Deep Chlorophyll Maximum (DCM)
2. 2 Niskin bottles will be triggered at each of 3 depths: subsurface (S), DCM and 20 m above the bottom (B-20) (or at the maximum depth the Niskin bottles can be triggered).

3. EZ net tows (335µm) will be undertaken at stations already planned along the route of the ship. Two nets will be triggered at the surface, at the DCM and 20 m above the bottom (or at the maximum depth the net can be triggered).

Water from the Niskin bottles will be collected, passed through a 1 µm filter (to collect all fractions of microplastics) and kept in a petri dish until analysis for assessing the abundance of small plastics.

After each net tow, the contents of the cod end from one net at each depth will be washed through a 35 µm sieve. Microplastics will be transferred to a jar and kept until analysis for assessing the abundance of microplastic and compare the collection method to the Niskin bottle sampling. Planktonic organisms will be transferred into a container filled with 95% ethanol within 15 min of the end of the tow.

These samples will be used to:

1. Count the microplastics present in the samples under a fluorescent microscope;
2. Identify the organisms that are attached onto the microplastics under Scanning Electron Microscopy (SEM);
3. Assess if microplastics are attached to zooplankton organisms under SEM;
4. Collate the data into our data set that will be used to develop an oceanographic model of plastic (micro – pico in size) distribution and movement in Australian waters.

1.b. Sampling for sequencing of communities associated to microplastics:

Samples will be collected from the second nets triggered at each depth during the EZ-Net tow from 1a above. The samples will be used to identify the bacteria and phytoplankton attached on the microplastic surface, but also to identify the community composition of zooplankton.

The content of the cod end will be washed through a 35 µm sieve and transferred to petri dishes filled with sterile seawater for separating microplastics from zooplankton organisms:

1. Under a laminar flow, the zooplankton will be separated from the microplastics particles with sterile tweezers and placed into Eppendorf tubes containing 50 µl of Lysis buffer. The microplastics will be left in the petri dish and frozen at −20 °C until analysis. Those samples will be later sequenced for 16S (bacteria) and 18S (phytoplankton) rRNA genes.

2. The Lysis buffer will digest the exoskeleton of the zooplankton and allow for the zooplankton associated microplastics (i.e. either ingested by or attached to those organisms) to be released in the buffer. At the same time, the DNA of those zooplankton organisms will be eluted in the buffer. Samples will be kept frozen at −20 °C until analysis.

In order to understand which fraction of the ocean microbial communities are associated to microplastics, 5 L of water will be collected in triplicates using Niskin bottles triggered at the same depth as the EZ nets. The water will be concentrated into 1 L using tangential flow filtration and filtered through 0.22 and 0.45 µm Sterivex filters for 16S and 18S, sequencing, respectively.

Sample Summary:

Section	Niskin bottles	EZ nets
1.a. **Sampling for enumeration and microscopy**	6 Niskin bottles; 2 Niskin bottles triggered at 3 depths (S, DCM, B-20)	3 nets in total; 1 net triggered at 3 depths (S, DCM, B-20)
1.b. Sampling for sequencing of communities associated to microplastics	9 Niskin bottles; 3 Niskin bottles triggered at 3 depths (S, DCM, B-20)	3 nets in total; 1 net triggered at 3 depths (S, DCM, B-20)

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:	3
• Likely maximum depth of deepest cast:	500m
• Lowered ADCP required:	
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):	
• PAR Sensor (Biospherical QCP-2300):	YES
• Transmissometer (Wetlabs C-Star 25cm):	
• Fluorometer – Chlorophyll-a (Chelsea Aquatracka III – 430/685nm):	YES
• Fluorometer – CDOM (Wetlabs FLCDOM – 370/460nm)	YES
• Nephelometer (Seapoint Turbidity Meter)	YES
• ECO-Triplet (Chlorophyll-a, CDOM & backscatter – maximum depth 2000m)	

2. Spatial and temporal variability in the distribution and abundance of seabirds.

Principal Investigator: Dr Eric Woehler

Scientific and Voyage Objectives

The project will collect data to quantify the variability in the distribution and abundance of seabirds in the marine environment around Australia. The project will examine the relationships between physical oceanographic features and their use as seabird feeding areas. The study also seeks to identify species assemblages, or associations, in the species of seabirds observed that are persistent over time. The project will use standard survey methods to ensure compatibility with existing data sets for the same species in other areas (e.g. Southern Ocean and south-eastern Australia).

Observations of marine mammals will be shared with researchers to facilitate greater understanding of the role of oceanographic processes in the spatial and temporal distribution of marine mammals at sea around Australia. The project will also provide a context to current research efforts tracking seabirds and marine mammals, which are often constrained to a relatively low number of instrumented individuals relative to the population as a whole.

Seabird at sea data will be collected by three seabird observers according to the method described by the BIOMASS Working Party on Bird Ecology. This method has been used by Australian Antarctic Division (AAD) personnel since 1980/81 and reflects the standard protocol for obtaining seabird at sea data. Observations will be made continuously while the vessel is underway during daylight hours from the specifically designed monkey bridge on board Investigator.

Briefly, all seabirds within a 300m forward quadrant will be recorded, with details of their ages (where identifiable) and behaviours (such as feeding, sitting on water, etc). By using standard methods, the data collected on these voyages will be able to be integrated with other data sets collected adjacent with, or in overlapping areas (e.g. Australian Antarctic Division surveys 1980/81 onwards). Observations of marine mammals are also included (in the absence of dedicated marine mammal observers) using standard protocols. Observation of marine debris are also recorded.

Data will be entered in real time on laptops connected to the ships oceanographic and GPS system to automatically record abiotic and biotic data along-side seabird observational records. Standardised methods of data collection ensure continuity and compatibility with extant data for the same species elsewhere and with similar studies of other species.

3. Supplementary Cloud Radar, Lidar and Aerosol Measurements

Principal Investigator: Dr Protat/Dr Schofield

The Stabilised Platform Container housing the BOM 95 GHz cloud radar (BASTA) and Cloud and aerosol mini-Raman lidar (RMAN), and the University of Melbourne AIRBOX containerised facility will remain on board from the previous voyage (IN2019_V06).

Scientific and Voyage Objectives

The stabilized platform container with the cloud radar and lidar from BOM is to complement the weather radar observations that will be collected during the ORCA project. The cloud radar observations combined with the disdrometer and micro rain radar will be used to validate the calibration of the CSIRO weather radar (which will in turn be used as the single reference for the calibration of operational radars along the coast), derive statistical relationships between rainfall and radar observables at different frequencies, and derive self-consistent dual-polarization curves at different locations along the Australian coast, which will be used operationally to refine the operational BOM calibration procedures. Such combined use of cloud radar, disdrometer, and micro rain radar had been demonstrated during IN2018_V01 (Klepp et al. 2018; Protat et al. 2019).

We will also collect all baseline aerosol measurements available from RV Investigator to allow for investigations of how (if at all) aerosol loading and properties impact statistical relationships between radar observables and rainfall rate. While several of the instruments will have to be demobilized after IN2019_V06 in Darwin, the miniMPL, MAXDOAS, Spectronus, Tekran and uDirac instruments will continue to run with an operator, which will allow measurements of aerosol, boundary layer height, boundary layer oxidants and halocarbons to be made continuously until the AIRBOX facility is decommissioned in Fremantle. Together with the previous voyages, these measurements will provide a unique 2.5 months long dataset over the north Australian maritime environment to complement the precipitation and aerosol measurements.

References:

Klepp, C., S. Michel, A. Protat, J. Burdanowitz, N. Albern, A. Dahl, M. Kähnert, V. Louf, S. Bakan, and S. A. Buehler, 2018: OceanRAIN, a new in-situ shipboard global ocean surface-reference dataset of all water cycle components. Nature – Scientific Data, DOI: 10.1038/sdata.2018.122.

Protat, A., C. Klepp, V. Louf, W. Petersen, S. P. Alexander, A. Barros, and G. G. Mace, 2019: Why is Satellite Precipitation Going South of 40°S and North of 40°N? Part 1: The Latitudinal Variability of Drop Size Distribution Properties. J. Geophys. Res. Atmos., submitted May 2019.

Demobilisation of SPC and AIRBOX

As demobilisation time is not allotted within the intervening port period between the IN2019_T03 and IN2020_V01 port period, decommissioning of the AIRBOX, SPC and associated components is to commence approximately 48 to 72 hours prior to arrival in port sufficiently to allow a quick transfer of the equipment within containers by crane on the morning of arrival at BAE Henderson. This will include the safe disconnection and derigging of all external mounted equipment and storage within the containerised facilities whilst underway.

Other Projects

1. Engagement and Outreach: CSIRO Educator on Board (EOB)

CSIRO Educator on Board is a professional development program for Australian STEM (science, technology, engineering and mathematics) school teachers which aims to support teacher professional development and provide students with a window on the real word application of STEM. Educator on Board puts teachers on voyages to assist with scientific operations and share their on-board experience with students across Australia through live ship-to-shore video broadcasts. Teachers will also develop curriculum-linked resources based on the ship and underway science to create a pool of lessons to share in schools across Australia.

Two berths have been allocated for the EOB program on IN2019_T03.

2. Engagement and Outreach: MNF Indigenous Time at Sea Scholarship (ITSS)

CSIRO and the Marine National Facility (MNF) are striving to increase access to STEM (science, technology, engineering and mathematics) education for Aboriginal and Torres Strait Islander students. In a new initiative, university students will be given the opportunity to join research voyages on RV Investigator through an Indigenous Time at Sea Scholarship (ITSS).

The ITSS Program offers Aboriginal and Torres Strait Islander university students the opportunity to participate in research voyages on Australia's blue-water research vessel (RV) Investigator. The Program offers students a unique opportunity to gain experience on a state-of-the-art marine research vessel, supporting Australia's atmospheric, oceanographic, biological and geoscience research from the tropical north to the Antarctic ice-edge.

The ITSS program brings students on board RV Investigator to work alongside scientists and technicians to assist with research and gain valuable at-sea research experience. The Program will support two students on identified voyages, who will work together, as well as with on-board and on-shore mentors. Students will also be provided with ongoing support, mentoring and the potential for employment opportunities to continue their engagement with CSIRO.

Two berths have been allocated for the ITSS program on IN2019_T03.

3.Continuous Plankton Recorder (CPR)

The CPR will be towed where possible over the longer transit stretches to collect phytoplankton and zooplankton data from the West Coast. This is a poorly sampled region of Australia and the data will be a valuable resource and addition to the IMOS plankton databases. The more northern CPR sampling will occur in a similar region to the measurements of atmospheric halocarbons and DMS taken on V06. Establishing the plankton community composition from the CPR samples will increase the understanding of which plankton species are associated with high atmospheric concentrations. The data will be made publicly available through the AODN as part of the IMOS AusCPR survey.

Planned CPR deployments are:

Leg	Distance (nm)	Cassette #
Darwin to Broome	667	1 and 2
Broome to Port Headland	238	2
Dampier to Carnarvon	377	3
Carnarvon to Serpentine	518	4

Overall activity plan including details for first 24 hours of voyage

First 48hour plan

Sunday 22nd December: 1400 Science Participants to meet and board ship.

1430 Sea Going Inductions (ASP)

1600 Voyage Management Team Meeting

Monday 23rd December:0800 Depart Fort Hill Wharf

0900 Emergency Drill

Voyage Briefing Presentation

The default activity plan will involve transiting directly for the first 24 hours from Darwin to Fremantle by the shortest route. Any alteration to the initial straight transit from Darwin to Fremantle will be decided before leaving port, as this decision is weather dependent. If there is weather on departure day, we will request to leave port, station about 10-20km off the Darwin coast to collect radar observations for about 3 hours, which will count as one of the stops allocated to the ORCA project.

Voyage track example

Voyage Track. Blue markers are conventional radars and yellow markers are Doppler radars from the Bureau operational radar network.

Waypoints, stations and time estimates

Stations

Station	Decimal Latitude	Decimal Longitude	Distance (nm)	Total Distance (nm)	Steaming time (hrs)	Total Steam (hrs)
DARWIN	-12.4771	130.8447	0	0	0	0
*BROOME	-17.9488	121.8407	667	717	60.6	65.1
PORT HEADLAND	-19.8306	118.4757	238	955	21.6	86.7
DAMPIER	-20.31	116.6788	108	1063	9.8	96.5
LEARMONTH	-21.7777	113.8254	199	1262	18.1	114.6
*CARNARVON	-24.6542	113.3383	178	1440	16.2	130.8
*GERALDTON	-28.8606	114.5376	406	1846	36.9	167.7
SERPENTINE	-32.4081	115.5344	112	1958	10.2	177.9
FREMANTLE	-32.024	115.684	43	2000	3.9	181.7
*****HENDERSON***	*-32.204*	*115.745*	12	2012	1.1	182.8

* Sites selected for the microplastics project.

**24hours allocated to Fremantle to Henderson for bunkering from 0800 Jan1 to 0800 Jan2.

Steam hours calculated at average 11 knots. 216 hours (9 days) total available for passage and science with 34 hours allocated for science.

Detailed waypoints

Location	Latitude	Longitude	Approx. Distance (nm)	Cum. Distance (Nm)
DARWIN	-12.4771	130.8447		
	-12.4772	130.8236		
	-12.4082	130.7667		
	-12.3461	130.7137		
	-12.3294	130.6921		
	-12.2578	130.4813		
	-13.0434	125.9299		

Location	Latitude	Longitude	Approx. Distance (nm)	Cum. Distance (Nm)
	-15.6673	122.1894		
	-16.7121	121.5825		
	-17.4812	121.7736		
BROOME	-17.9488	121.8407	667	717
	-18.6282	121.2608		
	-19.3673	120.5114		
	-19.4171	118.998		
PORT HEADLAND	-19.8306	118.4757	238	955
	-20.0082	118.0126		
	-20.1338	116.8935		
DAMPIER	-20.31	116.6788	108	1063
	-20.2761	116.504		
	-20.4092	116.2075		
	-20.7423	115.9406		
	-21	115.6011		
	-21.1029	115.5399		
	-21.1529	115.5689		
	-21.2036	115.4795		
	-21.2468	115.301		
	-21.1365	115.1264		
	-21.399	114.7208		
	-21.6391	114.1937		
LEARMONTH	-21.7777	113.8254	199	1262
	-22.6374	113.4776		
	-24.077	113.1966		
CARNARVON	-24.6542	113.3383	178	1440
	-24.675	113.002		
	-25.4636	112.7134		
	-28.3453	113.9903		
GERALDTON	-28.8606	114.5376		
	-30.6607	114.7983		
	-31.7363	115.2115		
SERPENTINE	-32.4081	115.5344	517	1957
	-31.987	115.398		
	-31.9575	115.6353		
FREMANTLE	-32.024	115.684	43	2000
	-32.061	*115.688*		
	-32.202	*115.718*		
HENDERSON	*-32.204*	*115.745*	*12*	*2012*

Approximate Total distance: 2062 nm / 3818km

Time estimates

NB: Time estimates below are all subject to change depending on the presence of significant weather when arriving near each radar site. We will ask permission to stay for longer when this happens. Normal passage distance is 1805nm, modified radar passage defined in voyage plan is therefore ~207nm additional passage distance. This needs to be considered when allocating time between passage, radar and microplastics project: ~**26 hours allocated for radar observations, 8 hours for microplastics project.**

We will make sure that the total 30 hours allocated to the ORCA project won't be exceeded. The time estimates below assume 3.5 hours stops at each radar site and 2.5 hours stops at each of the three microplastics sites.

Date	Time	Activity
22/12 (D0)	T0	Leaving Port and steaming to Broome site (option to stay off the Darwin coast for a few hours if there is weather within the Berrimah radar coverage)
+0.2 days	T0+4.5	
+0.3 days	T0+6.5h	
+2.7 days	T0+65.1	Arriving at Broome site for radar comparisons and microplastics operations
+3 days	T0+71.1h	Leaving Broome site and steaming to Port Hedland site
+3.9 days	T0+92.7h	Arriving at Port Hedland site for radar comparisons
+4 days	T0+96.2h	Leaving Port Hedland site and steaming to Dampier site
+4.4 days	T0+106h	Arriving at Dampier site for radar comparisons
+4.6 days	T0+109.5h	Leaving Dampier site and steaming to Learmonth site
+5.3 days	T0+127.6h	Arriving at Learmonth site for radar comparisons
+5.5 days	T0+131.1h	Leaving Learmonth site and steaming to Carnarvon site
+6.1 days	T0+147.3h	Arriving at Carnarvon site for radar comparisons and microplastics operations
+6.4 days	T0+153.3h	Leaving Carnarvon site and steaming to Geraldton site
+7.9 days	T0+190.2h	Arriving at Geraldton site for radar comparisons and microplastics operations
+8.2 days	T0+196.2h	Leaving Geraldton site and steaming to Serpentine site
+8.6 days	T0+206.4h	Arriving at Serpentine site for radar comparisons
+8.7 days	T0+209.9h	Leaving Serpentine site and steaming to Fremantle PBG
+9.0 days	T0+213.8h	Arrival at Fremantle Anchorage for Bunkers

Permits

The voyage transits through Australian Marine Parks and World Heritage Areas including the Kimberley, Gascoyne, Abrolhos and Jurien Marine Parks, and the Ningaloo and Shark Bay World Heritage Areas. A number of smaller Western Australian State legislated Marine Parks also reside along the voyage track. There is a particularly high density of Marine Conservation Areas along the coast between Dampier and Exmouth on the Pilbara Coast.

- The Microplastics project will be completed using the EZ Net Tows and CTD water sampling. Sampling stations are loosely predetermined and may be further resolved whilst underway dependent on the ORCA radar requirements. Applications to permit EZ and CTD sampling in Commonwealth Marine parks have been made for maximum flexibility.

- The Investigator has permits to conduct passive underway hydrochemistry and aerosol sampling and sonar data collection (multibeam etc) in Commonwealth Marine Parks (Permit PA2018-00005-001).

- Permit for Entry to protected Zone (100399) authorizing Investigator to survey I-124 wreck site under the *Underwater Cultural Heritage Act 2018.*

- The ORCA project is reliant on passive meteorological observations and permits are not required for this science.

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	X		
Constant Temperature Lab			• Please indicate the required setpoint temperature
Underway Seawater Analysis Laboratory			
GP Wet Lab (Dirty)	X		
GP Wet Lab (Clean)	X		
GP Dry Lab (Clean)			
Sheltered Science Area			
Observation deck 07 level			
Walk in Freezer	X		
Blast Freezer			
Ultra-Low Temperature Freezer (-80^{0}C) X2	X		
Walk in Cool Room			
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		Will be on the ship for IN2019_V06. Demobilization requested in Fremantle.
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			
Sonardyne USBL System			
Milli-Q System	X		
Laboratory Incubators			
Heavy Duty Electronic Balance (80kg)			
Medium Duty Electronic Balance (15kg/5g resolution)			
Light Duty Electronic Balance (3kg/1g resolution)	X		
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			
Dissecting Microscopes (x4)	3	3	• Please specify number required

(iv) Specialised laboratory and sampling equipment

Name	Essential	Desirable	Notes/Comments *(These items may require additional MNF support staff)*
TRIAXUS – Underway Profiling CTD			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:			
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			• 2 per day provided
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)	X		**335 micron;** 6 nets = 2 triggered at 3 different depths for each cast (3 casts per sampling site)
Rock saw			• Requires trained science personnel
Portable pot hauler			

(iv) Specialised laboratory and sampling equipment

Name	Essential	Desirable	Notes/Comments *(These items may require additional MNF support staff)*
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**	
Trawl monitoring instrumentation (ITI) (2,000m depth limit)			
Radiosonde Receiver System			

(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	Notes/Comments
75kHz ADCP			
150kHz ADCP			
Multi Beam echo sounder EM122 12kHz (100m to full ocean depth)		y	
Multi Beam echo sounder EM710 70-100kHz (0-1000m approx.)		y	
Sub-Bottom Profiler SBP120			

(vi) Underway systems

Acoustic Underway Systems

Name	Essential	Desirable	Notes/Comments
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		

Underway Seawater Systems and Instrumentation

Name	Essential	Desirable	Notes/Comments
Thermosalinograph			
Fluorometer			
Optode			
pCO2			

Seawater systems

Name	Essential	Desirable	Notes/Comments
Trace metal clean seawater supply			
Scientific clean seawater supplied to laboratories	X		
Raw seawater available on deck and in laboratories.	X		

Non MNF Owned Equipment which may be accessed

Name	Essential	Desirable	
D & N Francis winch			• 13mm electro-optical cable
Box Corer			
UTAS In-Situ Pumps (x2)			

Non MNF Owned Equipment which may be accessed

Name	Essential	Desirable	
EM2040			• Shallow water multibeam echosounder system

Special Requests – MNF Scientific Equipment and Facilities

No Special Requests.

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	Weight	Dimensions	Location on Vessel
Bureau of Meteorology	95 GHz cloud radar (BASTA)	~60 kg	(LxWxH) 120x70x100cm	Stabilised Platform container
Bureau of Meteorology	Cloud and aerosol mini-Raman lidar (RMAN)	~110 kg	(LxWxH) 80x65x115cm	Stabilised Platform container
Bureau of Meteorology	Micro-rain radar (MRR-2)	~20 kg	(LxWxH) 50x50x100cm	Deck 05
University of Melbourne / Queensland University of Technology	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	Sea-state cameras	5kg	LxWxH 30x15x15cm	Deck 05 railing
University of Melbourne - AIRBOX	Eddy Flux package	10kg	LxWxH 70x15x40cm	On the main aerosol mast
University of Melbourne - AIRBOX	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	miniMPL	180 kg	Enclosure: 64 x 64 x 77 cm Scanning unit on top: 35 x 52 x 20 cm	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)

Owner	Item name	Weight	Dimensions	Location on Vessel
University of Melbourne - AIRBOX	u-Dirac	30kg	instrument:50x50x20 columns:LxWxH 10x25x120cm	Aerosol Laboratory - port bench
Macquarie University - University of Melbourne - AIRBOX	Tekran	15kg	Instrument:3RU + laptop	Aerosol Laboratory - port bench
University of Melbourne - AIRBOX	Spectronus	60kg	1000x450x900 (mm L x W X H)	Within the Airbox
Flinders University -Elise Tuuri	Millipore- Peristaltic pump	3.6 kg	15H x 20L x 10W	Wet Lab (Clean)