RV *Investigator* Voyage Plan

Voyage #:	**IN2020_V08**
Version Number:	Final – 2.1
Voyage title:	SOLACE - Southern Ocean Large Areal Carbon Export: quantifying carbon sequestration in subpolar and polar waters
Mobilisation (science):	Hobart, 30/11/2020 – 1/12/2020
Medical clearance period:	Hobart, 2/12/2020 – 4/12/2020
Depart:	Hobart, 0800 5/12/2020 (TBC pending release of COVID-19 test results)
Return:	Hobart, 0800 16/01/2021
Demobilisation:	Hobart, 0900 16/01/2021 – 17/01/2021
Voyage Manager:	Lisa Woodward
Chief Scientist:	Philip Boyd
Affiliation:	UTAS
Principal Investigators:	David Antoine Michael Ellwood Rudy Kloser Pere Masque Tom Trull
Affiliation:	Curtin University ANU CSIRO Edith Cowan CSIRO

Scientific objectives

The aims of the Southern Ocean Large Areal Carbon Export (SOLACE) project are as follows:

First, to improve water column measurement of the downward export flux of carbon of the biological pump using an integrated suite of new technological advances – from particle decomposition to mesopelagic vertical migrations.

Second, to integrate these improved estimates of the functioning of the biological export with bio-optical properties, used as proxies of biogeochemical (BGC) properties, and which can be remotely sensed using satellite sensors. A combination of conventional passive "ocean colour radiometry" and active "CALIOP" LIDAR (that 'sees through clouds' and also senses below the surface) will be validated on SOLACE to provide a comprehensive regional extrapolation of carbon export fluxes.

Third, to cross-link larger scale estimates of the biological pump (termed the BGP – biological gravitational pump - in a Review paper at Nature by Boyd, Claustre, Levy, Siegel and Weber, under revision) with those of PIPs (Particle Injection Pumps, Boyd et al., 2019, Nature) such as the Mixed Layer Pump (Llort et al., 2018) than can be assessed using profiling biological-floats (i.e., BGC-ARGO) as part of the US S. Ocean SOCCOM mission (www.soccom.edu), as well as the individual programmes of France, Australia and others.

Fourth, to link these S. Ocean findings with those of international programmes on this topic, working on N. Hemisphere analogues, via data synthesis and modelling (co-collaborator Dave Siegel, UCSB) to produce large areal maps of carbon export by both the BGP and PIPs. These programmes sit under the JETZON umbrella - http://jetzon.org/ .

Voyage objectives

1) A modular 3.5 day cycle of diverse water column activities from deployment and recovery of surface tethered free floating moorings (RESPIRE, particle sediment traps), to deployment from the ship of CTD, profiling cameras, net tows, ISP's, and water sampling to run lab based experiments. This cycle will be repeated 3 times at the subantarctic site (lower productivity and particle export) and 4 times at the polar site (bloom/bust and higher productivity and particle export). The mooring deployment / recovery is the most weather dependent event. Weather days will be factored in and may result in a modification of the number of cycles or their duration. In order to fully meet the multiple aims of the voyage we will carry out additional sampling (to add to our time series) on 'weather days' that we do not use for bad weather.
2) Land-based satellite oceanography will be linked to shipboard bio-optical and optical sampling for validation (within the 3.5 day cycle of 1) above). It will be further underpinned by the deployment of gliders (from collaborators at CALTEC, USA) – one at each site (recovered post voyage downstream off New Zealand by another vessel). Weather should be of little influence for these deployment activities across the 45 day voyage.
3) Deployment of two state-of-the-art BGC-ARGO profiling floats with miniaturised UVP (Underwater Vision Profiler) on a 5 year mission. The floats telemeter datasets and their output will be modelled by collaborators in Spain. If weather conditions permit we may attempt to retrieve each BGC-ARGO for a data download (using 'Trull' device – see equipment manifest for details).
4) SOLACE sits under the JETZON umbrella - http://jetzon.org/ . The site is currently being developed and we are already (in anticipation of our voyage) contributing to metadata development and modelling initiatives.
5) Conduct aerosol and rain sampling:

   a. ASP to provide advance notice of incineration events and a final record of incineration events for the voyage to both the aerosols and atmospheric teams.
   b. Require access to aerosol sampling lab.
6) Cosmic ray measurements from underway instrument (Dr Grahame Rosolen, CSIRO).
7) Cloud Aerosol Precipitation Radiation Interactions eXperiment (CAPRIX) (Dr Alain Protat, BOM).
8) Completion of noise signature testing (MNF).
   a. This will be completed in Storm Bay immediately following departure and will be structured so as not to impact science equipment testing in Storm Bay and the voyage schedule.
9) To complement the CTD casts and regular BGC Argo floats, underway instrumentation will be running and will require some estimate of the mixed layer depth to support these observations. To give subsurface temperature structure while the ship is in transit, deployment of 12 x XBTs to observe subsurface properties while the ship is in transit between the 2 sites will be undertaken. These deployments are not permitted occur within Australian Marine Parks (AMPs).

Voyage Specific Risk Assessment

This voyage has undergone a comprehensive risk assessment process. The full VSRA is at Appendix C.

Media Activities

The MNF will seek to pursue opportunities that arise during the voyage to promote the science, scientists and ship, via conventional and social media channels, in consultation and/or collaboration with the relevant ship user.

Organisation	Activities	Timing	Responsible person
MNF/UTAS	Webex live cross via iPad for the BHP Science and Engineering Awards finalists' camp.	12th December at 1000-1045 (AEDT)	Onshore host: Ben Arthur (MNF) Onboard host: Svenja Halfter (IMAS)
UTAS	Chief Scientist undertaking interviews with networks to discuss science being undertaken	Pre-departure	Andrew Rhodes (IMAS)
UTAS	Live cross to network and a range of stories and blogs to be released. Note all comms will be low resolution video and / or audio and no bandwidth upgrade is required.	Throughout voyage	Andrew Rhodes (IMAS)

Overall activity plan including details for first 24 hours of voyage

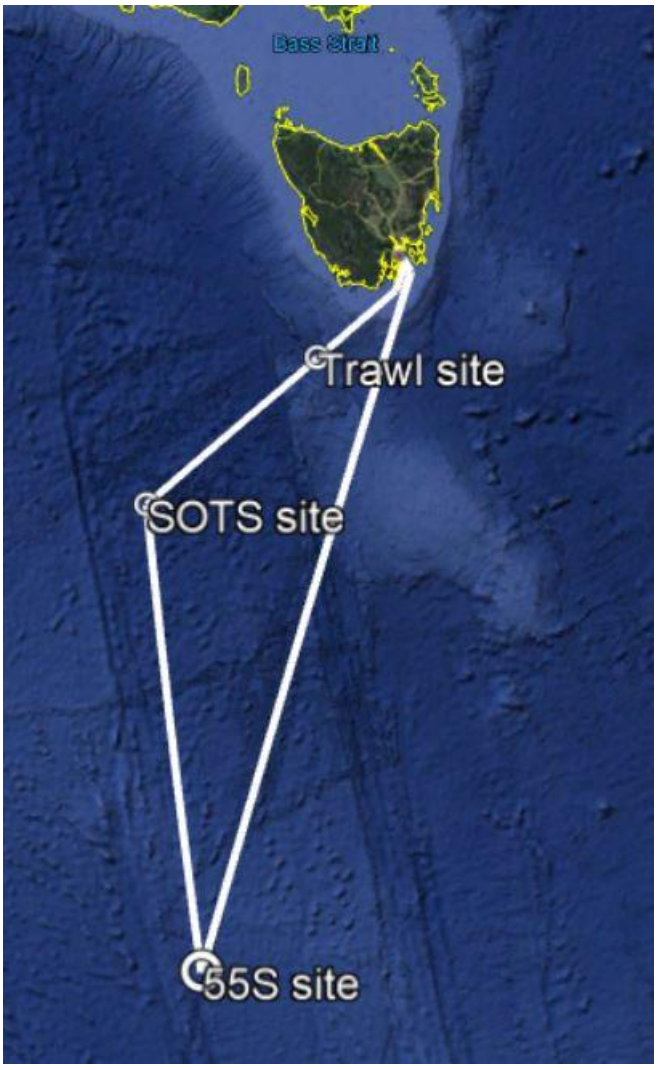
After an equipment testing station in Storm Bay (testing CTD, Triaxus, RESPIRE mooring only (no instruments), RMT net, seaglider and PLAOS), we will set a course for SOTS and stop at the Trawl site (see map below) along the course. Here we will conduct mid water trawls, ZOORESPIRE, PLAOS and a CTD bottle firing test, and then proceed on to the SOTS site. We will not deploy any device – such as CPR – in order to get to our first site promptly.

Preference is to extend the drop keel up to 4m where possible, depending on real-time data quality and navigation constraints, however, extension to 2m will suffice while underway.

Voyage track example

The selection of the southerly site - polar (bloom/bust and higher productivity and particle export) – is still ongoing. PI Antoine is looking at a decade of satellite remote sensing archives – including the 2019/20 phytoplankton growth season to identify a site with the following characteristics:

A high chlorophyll feature (bloom) that is about to peak and decline in late Dec/start of January.
A feature within an eddy feature (to assist with sampling it in a coherent manner).
The bloom decline is the period of high downward particle export we wish to sample – for now I have included the map we submitted in the original proposal with a place marker S site. SOTS – will be our N site.



Waypoints and stations

	Degrees Decimal Minutes Latitude	Degrees Decimal Minutes Longitude	Distance (nm)	Total Distance (nm)	Steaming time (hrs)	Total Steam (hrs)
Hobart	42° 52.2 S	147° 21.0 E				
Storm Bay	43° 19.8 S	147° 21.54 E	27.62	27.62	2.4	2.4
In transit paired day/night trawls (Kloser team)	44° 45.8S	145° 24.4 E	128	155.62	11.6	14.0
Site 1 (SOTS)	47°S	141° E	81	400.62	7.4	36.4
Site 2 (Polar bloom)	55°S	141°E	~480	880.62	43.6	80.1
Hobart	42° 52.2 S	147° 21.0 E	771	1651.62	70.1	150.2

Based on steaming at 11 knots. Note site 2 latitude and longitude (in red) are place-markers; the final position of the site will be made using remote-sensing observations in late 2020.

CTD Configuration

Note: A test CTD will be undertaken prior to your first planned CTD cast. This requirement is a single cast to a minimum of 1000 m, firing half the bottles at the maximum depth of the cast, followed by firing of the remaining bottles near the chlorophyll maximum (requiring one stop on the retrieval). This test CTD is essential to the MNF Hydrochemistry team and supports the training of samplers, testing of Niskin bottles, collection of a tracking standard for the voyage, and ongoing quality and uncertainty calculations. Please allow for this cast in your voyage's Time Estimates (approximately 1 hour).

This 1000 m test cast will be made at the trawl site (44° 45.8S station) en route to SOTS.

MNF Hydrochemistry will use a combination of the following two options during the voyage

- 72 nutrient, 36 dissolved oxygen, 36 salinity analyses per 24 hours; OR
- 160 nutrient analyses (only) per 24 hours.

Nutrient analysis will be needed for:

- TMR: 60 samples (including replicates) per 3.5 day cycle
- Triaxus (underway sea-water for nitrate sensor calibration)
- Deep CTDs (36 oxygen, 36 salinity and 24 nutrients per deep cast – 3 at SOTS site only, none at Southern station).
- Shallow CTDs (0-1000 m, 5 per 3.5 day cycle) 18 salinities, 18 oxygen and 18 nutrients per cast.

	Please select:
Fundamentals:	
• Which CTD rosette to be used for this voyage (24 Niskin bottles or 36):	36
• Likely total number of casts:	40
• Likely maximum depth of deepest cast:	4000

	Please select:
• Lowered ADCP required:	Y
Instrumentation (maximum 6 auxiliary channels in addition to 2x DO):	
• 2x pumped Temperature, Conductivity, Dissolved Oxygen circuits:	(Standard)
• Altimeter (required if operating anywhere near the sea floor):	
• PAR Sensor (Biospherical QCP-2300):	Y
• Transmissometer (Wetlabs C-Star 25cm):	Y
• Fluorometer – Chlorophyll-a (Chelsea Aquatracka III – 430/685nm):	Y
• Fluorometer – CDOM (Wetlabs FLCDOM – 370/460nm)	Y
• Nephelometer (Seapoint Turbidity Meter)	
• ECO-Triplet (Chlorophyll-a, CDOM & backscatter – maximum depth 2000m)	Y
Hydrochemistry Analyses:	
• Salinity	Y
• Dissolved Oxygen	Y
• Nutrients: Nitrate	Y
• Nutrients: Phosphate	Y
• Nutrients: Silicate	Y
• Nutrients: Nitrite	Y
• Nutrients: Ammonia (special request after discussion with hydrochemistry)	Y

Time estimates

The following time estimates are based on a steaming speed of 11 knots.

Please include estimates of time for periods in between all activities noted below.

Note, given the complex series of ~40 events within each of the 3.5 day repeat cycles there may be times when we will have to request to exchange events (for example due to unforeseen technical or mechanical issues). We will keep this to a minimum, but request some flexibility in time-tabling.

Departure is tentatively scheduled for 0800 on 5/12/2020, however, this may be earlier pending results of the COVID-19 test results.

Date	Time	Activity
5/12/2020	0800	Depart Hobart and transit to Storm Bay
	1000	DALEC deployment
	TBC	Noise signature testing in Storm Bay (daylight operations only)
	1030	Storm Bay test station: - CTD dip for sensor calibration (1 hr; day or night) - Triaxus test using terminated unit (3 hr; daylight only)

Date	Time	Activity
		- Glider - RESPIRE mooring only (no instruments) (3 hr, daylight only) - RMT net (3 hr; day or night) - PLAOS (1 hr; day or night) - A-frame and winch hydraulics - GSM calibration lines to monitor backscatter data from the multibeam echosounders (8 knots for ~ 15 mins).
	1400	Depart Storm Bay and transit to trawl site (~44 45.8S, ~145 24.4E), Rudy Kloser requests some flexibility on the exact location.
	1700	DALEC retracted
6/12/2020	0130	Arrive at trawl site – the aim is to target scattering layers at day and night to collect/enumerate animals – so some flexibility on exact location is requested.
6/12/2020	0130	ZOORESPIRE test, 0-200 m night 200-600 m night trawls and a 1000 m PLAOS profile
	0600	DALEC deployment
	0700	1000 m CTD test and bottle firing with 36 bottle rosette (MNF)
	0800	0-200 m day and 200-600 m trawls day and a 1000 m PLAOS profile
	1430	Depart and transit to SOTS site
	1700	DALEC retracted
7/12/2020	0600	DALEC deployment
	0700	Arrive SOTS, 1000 m CTD (36 bottle for all casts)
	1000	Deploy Triaxus
	1700	DALEC retracted
8/12/2020	0400	Recover Triaxus, then deploy BGC-ARGO float and glider #1 (glider to be recovered 'downstream' off New Zealand by a charter vessel).
	0600	Commence repeat cycle (#1) (3.5 days duration)
	0600	DALEC deployment
	0700	CTD 1000 m (36 btl)
	0900	Antoine Optics cast (corer boom 200 m)
	0930	RESPIRE (surface tethered free drifting mooring, 400 m deep) deploy
	1330	CTD 1000 m
	1430	PLAOS
	1600	Mesozoo nets – Day (0-1000 m)

Date	Time	Activity
	1700	PLAOS 1000 m
	1700	DALEC retracted
	1830	ISP 1 (500 m) (Trace Metals/Carbon)
	2200	ZooRESPIRE (deploy on same wire as ISP, 200 m)
9/12/2020	0100	PLAOS 1000 m
	0230	Mesozoo nets night (0-200 m)
	0330	CTD 1000 m (no bottles fired)
	0400	TMR 1 (300 m) (for Primary Production samples)
	0530	TMR onboard TMR 1 (300 m) (for Primary Production samples)
	0600	DALEC deployment
	0600	CTD 1000 m
	0900	Antoine Optics cast (corer boom 200 m)
	0930	Trawls 200 m & 400 m
	1530	TMR 1500 m
	1700	DALEC retracted
	1800	ISP 2 (500 m) (Particles)
	1930	Surface tow TM fish (3-4 knots, coring boom and midships)
	2200	Trawls 200 m & 400 m
10/12/2020	0430	Trawl in board
	0430	CTD (1000 m) no bottles fired
	0600	DALEC deployment
	0600	CTD 1000 m
	0730	Antoine Optics cast
	0800	TM Fish (water collection)
	1115	Recover TM fish
	1130	Mesozoo nets Day
	1230	Mesozoo nets Day
	1400	PLAOS 1000m
	1530	CTD 1000 m
	1700	DALEC retracted
	1700	CTD 4000 m (needed only once at the SOTS site, on other repeat cycles this will be a free time spacer)
	2300	Trawls 1000 m
11/12/2020	0300	Trawl inboard Trawls 1000 m
	0300	CTD 2250 m (needed only twice at the SOTS site, on one other repeat cycles this will be a free time spacer)
	0600	DALEC deployment

Date	Time	Activity
	0700	CTD inboard
	0700	Antoine Optics cast
	0730	RESPIRE mooring recovery
	1230	RESPIRE inboard
	1300	CTD 1000 m
	1400	1000 m Trawl
	1700	DALEC retracted
	1730	Trawl in board
	1800	Free time spacer
	1900	Deploy Triaxus
12/12/2020	0500	Recover Triaxus
	0600	Commence repeat cycle (#2) (3.5 days duration)
13/12/2020	0600	24 h elapsed of repeat cycle 2
14/12/2020	0600	48 h elapsed of repeat cycle 2
15/12/2020	0600	72 h elapsed
15/12/2020	1800	End of repeat cycle 2
16/12/2020	1800	24 h bad weather window
16/12/2020	1800	Deploy Triaxus
17/12/2020	0500	Recover Triaxus
17/12/2020	0600	Commence repeat cycle 3 (3.5 duration)
18/12/2020	0600	24 h elapsed repeat cycle 3
19/12/2020	0600	48 h elapsed repeat cycle 3
20/12/2020	0600	72 h elapsed
20/12/2020	1800	End of repeat cycle 3
21/12/2020	1800	24 h bad weather window
21/12/2020	1800	Depart SOTS in transit to Southern site (Lat and Long will have been confirmed from remote-sensing observations recived during our occupation of SOTS site)
22/12/2020	1800	24 h elapsed of transit to S site
23/12/2020	0600	DALEC deployment
	1400	Arrive at Southern site
	1400	1000 m CTD
23/12/2020	1530	Deploy Triaxus
	1700	DALEC retracted
24/12/2020	0400	Recover Triaxus, then deploy BGC-ARGO float and then deploy glider #2 (recovered by a charter vessel)
	0600	Commence repeat cycle (#1) (3.5 day duration) float
	0600	Deploy SURFER (holey sock drogue with tracker)

Date	Time	Activity
	0600	DALEC deployment
	0700	CTD 1000 m (36 btl)
	0900	Antoine Optics cast
	0930	RESPIRE mooring deploy
	1330	PLAOS 1000 m
	1500	Mesozoo nets Day
	1600	Mesozoo nets Day
	1700	DALEC retracted
	1700	PLAOS 1000 m
	1830	ISP 1 (500 m) TM/C
	2000	1000 m CTD
	2130	Mesozoo nets night
	2230	Trawl 200 m
25/12/2020	0130	ZOORESPIRE
	0300	TMR 1 (PP)
	0330	TMR onboard
	0330	1000 m CTD (no bottles fired)
	0600	DALEC deployment
	06000	CTD 1000 m
	0730	Antoine Optics cast
	0800	Free time spacer
	0930	Trawls 200 m & 400 m
	1530	TMR 1500 m
	1700	DALEC retracted
	1800	ISP 2 (500) (Particles)
	1930	TM fish surface tow)
	2130	PLAOS 1000 m
	2230	Trawls 400 m
26/12/2020	0200	ZooRESPIRE
	0530	ZooRESPIRE Inboard
	0600	DALEC deployment
	0600	CTD 1000 m
	0730	Free time spacer
	0800	Antoine Optics cast
	0830	TM fish (water collection)
	1100	Mesozoo nets Day
	1200	Mesozoo nets Day
	1330	PLAOS 1000m

Date	Time	Activity
	1500	CTD 1000 m
	1700	DALEC retracted
	1700	TM fish
	2130	Mesozoo nets NIGHT
	2230	Trawl 1000 m
27/12/2020	0200	ZooRESPIRE
	0530	ZooRESPIRE inboard
	0600	DALEC deployment
	0600	CTD 1000 m
	0700	Antoine Optics Cast
	0730	RESPIRE mooring recover
	1230	RESPIRE inboard
	1300	Trawls 1000 m
	1700	Trawl inboard
	1700	DALEC retracted
	1630 to 1800	Free time spacer
	1800	Deploy Triaxus
28/12/2020	0400	Recover Triaxus
28/12/2020	0600	Commence repeat cycle (#2) at Southern site
29/12/2020	0600	24 h elapsed of cycle #2
30/12/2020	0600	48 h elapsed of cycle #2
31/12/2020	0600	72 h elapsed
31/12/2020	1800	Completion of repeat cycle (#2)
01/01/2021	1800	Bad Weather day
02/01/2021	1800	Bad Weather day
02/01/2021	1800	Deploy Triaxus
03/01/2021	0400	Recover Triaxus
03/01/2021	0600	Commence repeat cycle (#3) at Southern site
04/01/2021	0600	24 h elapsed of cycle #3
05/01/2021	0600	48 h elapsed of cycle #3
06/01/2021	0600	72 h elapsed
06/01/2021	1800	Completion of repeat cycle #3
07/01/2021	1800	Bad Weather day
07/01/2021	1800	Deploy Triaxus
08/01/2021	0400	Recover Triaxus
08/01/2021	0600	Commence repeat cycle (#4) at Southern site
09/01/2021	0600	24 h elapsed of cycle #4
10/01/2021	0600	48 h elapsed of cycle #4

Date	Time	Activity
11/01/2021	0600	72 h elapsed
11/01/2021	1800	Completion of cycle #4
12/01/2021	1800	Bad Weather day
12/01/2021	1800	Free time spacer (14 h), then Commence transit to Hobart (possible CPR tow for part of the transit)
13/01/2021	0600	DALEC deployment
	1700	DALEC retracted
	1800	24 h of transit elapsed
14/01/2021	0600	DALEC deployment
	1700	DALEC retracted
	1800	48 h of transit elapsed
15/01/2021	0600	DALEC deployment
	1700	DALEC retracted
	1800	72 h of transit elapsed, plus 2 h to allow for Storm Bay survey lines
16/01/2021	0800	Dock in Hobart
	0900	Commence demob

Piggyback Projects

Cosmic ray measurements (Dr Grahame Rosolen, CSIRO)

Objectives

The objective of the project is to collect cosmic ray data at variable locations and look for correlations with space weather events and cosmic ray measurements with a similar detector located in Sydney. The wide range of latitudes covered by the voyage is particularly useful for this research. The data gathered can be used to investigate the susceptibility of sensitive electronic systems to cosmic radiation. The results of the analysis provide useful information for designing robust electronic systems for critical applications.

Project Details

The proposed work is to collect cosmic ray measurement data throughout the voyage. The cosmic ray detector provides a time stamped record of cosmic ray detections and these can be correlated with ship positional data to investigate the variation is cosmic rays flux with latitude and longitude. It will also be possible to compare this data with a log taken over a similar period at a land based cosmic ray detector in Sydney. Another feature of the experiment is the possibility to compare the data taken on the voyage with measurements already undertaken on a flight between Melbourne and Antarctica.

Equipment

The cosmic ray measuring equipment consists of three pieces which are the detector electronics, the powers supply and detector head. All three components are housed in metal boxes and these boxes are attached to the base plate of a standard 19” rack. The rack mounted system is 485 mm wide by 385 mm deep and 90 mm high. The total system weighs about 7 kg.

Cloud Aerosol Precipitation Radiation Interactions eXperiment (CAPRIX) (Dr Alain Protat, BOM)

Objectives:

Cloud microphysical properties produced from the competition between supercooled liquid and ice particles for water vapour in subfreezing cumulus clouds over the Southern Ocean and off the coast of Antarctica have been directly linked to errors in absorbed solar radiation at the sea surface, which have been further linked to uncertainty in predicting global climate sensitivity under CO2 warming and sea surface temperature biases in climate models.

Strikingly, the latest climate simulations using improved knowledge gained on the frequency of occurrence of supercooled liquid water from earlier voyages (IN2015_V02, IN2016_V02, IN2018_V01, IN2018_V02) indicate the existence of two distinct large surface shortwave radiation biases of opposite sign north or south of about 55°S latitude. From the IN2018_V01 observations collected closer to the coast of Antarctica, we have gathered evidence that emissions of aerosol precursors from over Antarctica produce very high concentrations of aerosols and different cloud properties from further north and from when air masses bring pristine air from the open ocean. However, our number of samples remain quite limited to draw statistically significant conclusions. The other major result obtained from past voyages is the potentially important role of ocean productivity (linked to phytoplankton blooms, dimethyl sulphide and resulting atmospheric particles) in the local production of aerosols leading to cloud formation and driving cloud microphysical properties. However, only partial observations were collected during earlier voyages, which did not fully capture the suite of interactions.

Following these conclusions, our proposal here is to collect a suite of aerosol, cloud, surface radiation, surface eddy momentum, heat and moisture fluxes, and precipitation observations in areas characterized by high ocean productivity (a major objective of IN2020_V08 and a likely opportunity during IN2021_V02) and close to the coast of Antarctica in different synoptic situations, including air masses originating from the ocean or from Antarctica (we note that the planned ship track of IN2021_V01 would be ideally suited to collect such observations, as it is south of the polar front for a long period of time). These new datasets will be combined with the existing ones to continue to build a comprehensive understanding of the relationship between ocean productivity, aerosol formation, cloud microphysics and then link to rainfall properties and surface radiation.

Data Collection: Tables 1 and 2 list the proposed instruments and critical measurements that are needed for this project. All instruments will operate continuously under supervision of MNF SIT engineers, who have all been exposed to these instruments in the past and know how to operate them. All instruments have operated on RV Investigator during several voyages since 2016.

Voyage Track:

There will be no requirement from our project to modify in any way the planned voyage tracks of these experiments.

Mobilisation of instruments:

Given current travel restrictions, the mobilisation of our proposed instruments has been discussed. This will be supported by local scientists in Tasmania (Marc Mallet, post-doc, UTAS, and Simon Alexander, AAD, co-PI of this proposal) and Ian McRobert from MNF has indicated that he felt comfortable with the installation of the cloud radar and lidar components in the air chemistry lab, as he has contributed to such installation many times in the past.

Table 1. Principal Investigators and Responsibilities

Name	Project Role	Instrument(s)	Affiliation and Location
Alain Protat	Principal Investigator Radar and Lidar calibration, science analysis	BASTA W-band Cloud Radar RMAN Lidar	BOM, Melbourne
Jay Mace	Co-Investigator MWR data processing, Radar and Lidar Science analysis.	2-channel Microwave radiometer	University of Utah, Salt Lake City, Utah
Simon Alexander	Co-Investigator Lidar data calibration and processing	Micro Rain Radar Parsivel-2 disdrometer CTK-25 Ceilometer	Australian Antarctic Division, Hobart
Ruhi Humphries	Co-Investigator Aerosol Data processing and aerosol-cloud science analysis	Baseline MNF aerosol instrumentation + ToF-ACSM (Time of Flight Aerosol Chemical Speciation Monitor)	CSIRO Climate Science Centre, Oceans & Atmosphere, Aspendale

Table 2. Critical Instrumentation

Instrument	Measurement(s)	Owner	Ship Location	Current Location
OceanPol C-Band Weather Radar	Hydrometeor radar properties	MNF	Monkey Island	Ship
Aerosol and Air Chemistry Lab Instruments	Aerosol Measurements	MNF / CSIRO	Aerosol and Air Chemistry Lab	Ship
BASTA W-Band Doppler Radar	Vertically pointing radar reflectivity and Doppler velocity	Alain Protat	Stabilized platform container (Level 2, forward deck, starboard side)	Ship
RMAN Raman Lidar	Lidar attenuated backcatter	Alain Protat	Stabilized platform container (Level 2, forward deck, starboard side)	Ship
Micro Rain Radar	K Band vertically pointing radar reflectivity	Simon Alexander	Deck 5 Railing	Hobart

OceanRAIN disdrometer	Drop size distribution, rainfall rate	MNF / Alain Protat / Christian Klepp	Main mast	Ship
Sonic anemometer and fast temperature and humidity sensors (for eddy flux calculations)	Eddy surface fluxes	MNF / Jason Monty / Eric Schulz	Main mast	Ship
Parsivel-2 Disdrometer	Drop size distribution, rainfall rate	Simon Alexander	Deck 5 Railing	Hobart
CTK-25 ceilometer	Cloud backscatter	Simon Alexander	Deck 5 Railing	Hobart

Permits

In summary:

AQIS Permit: 0003652063
Valid for: multiple consignments
between 10 February 2020 and 10 February 2022
This permit is issued to: Dr Michael Ellwood (ANU)

Dr Rudy Kloser (CSIRO): Ecological and carbon sequestration role of mesopelagic organisms

- Animal ethics permit for mid-water towing with RMT net trawl, #2020-03
- AFMA permit for mid-water towing with RMT net trawl, #1004748
- Import permit for micronekton samples, #IP0003975507.
- Commonwealth MPA permit for RMT and PLAOS, AU-COM2020-490
- Commonwealth MPA permit for logging acoustic sensors, CMR-17-000471

AQIS Permit: 0003181884
Valid for: multiple consignments
between 30 July 2019 and 30 July 2021 (application filed for new permit – number to be advised).
This permit is issued to: University of Tasmania
301 Sandy Bay Road
HOBART TAS 7005
Australia
Attention: Dr Toby Bolton

Oceanic seawater <5L (free of suspended solids) and phytoplankton and zooplankton can come in to port under BICON conditions.
You can find all BICON conditions on the BICON website:
https://bicon.agriculture.gov.au/BiconWeb4.0/

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		Aerosol sampling (every 36 to 48 h per filter)
Air Chemistry Lab			
Preservation Lab	X		Photographing and preserving biological specimens collected from the trawls
Constant Temperature Lab	X		Ambient surface water temp at SOTS then modify for the polar site when we depart SOTS
Underway Seawater Analysis Laboratory	X		
GP Wet Lab (Dirty)	X		Trawl sample processing and others
GP Wet Lab (Clean)	X		Experimental set-up and sample processing, RESPIRE sampler set-up
GP Dry Lab (Clean)	X		Camera processing and camera lab experiments
Sheltered Science Area	X		Triaxus and compressor for TM fish surface sampling and RESPIRE final set-up
Observation Deck 07 Level			
Walk in Freezer	X		Trawl and other samples
Blast Freezer	X		Trawl and other samples
Ultra-Low Temperature Freezer (-80^{0}C) X2	X		HPLC and other samples
Walk in Cool Room	X		Sample holing for incubations preparations
Salt Water Ice Machine	X		For cooling samples and incubations

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

Name	Essential	Desirable	Notes/Comments
Modular Radiation Laboratory	X		
Modular Trace Metal Laboratory (TM1-blue)	X		Trace metal sampling
Modular Trace Metal Laboratory (TM2-white)	X		• Trace metal processing – Note cannot be overstacked
Trace Metal Rosette and Bottles	X		• 10 foot container
Modular Hazchem Locker	X		Haz chemicals
Deck Incubators	X		Shipboard incubations
Stabilised Platform Container	X		CAPRIX piggyback project
Clothing Container	X		• 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	X		Needed for sampling requirments and to accommodate the UVP5 (David Antoine is voyage contact)
CTD - Seabird 911 with 24 Bottle Rosette	X		
Lowered ADCP	X		
Sonardyne USBL System			
Milli-Q System	X		Require 18.2 Mohm water
Laboratory Incubators	X		Two are required. One incubation experiment per repeat cycle (7 experiments in total).
Heavy Duty Electronic Balance (80kg)	X		
Medium Duty Electronic Balance (15kg/5g resolution)	X		Trawl samples
Light Duty Electronic Balance (3kg/1g resolution)	X		Trawl sampls
Surface Net (mouth area 1m^2)	X		• 335 micron (requested by Svenja Halfter)

(iii) Standard laboratory and sampling equipment

Name	Essential	Desirable	Notes/Comments
Bongo Net (not instrumented) ring diameter 485mm 0.018m^2	X		• 500 micron mesh only. Require hard codend and flowmeter (Svenja)
Smith Mac Grab			
Dissecting Microscopes (x4)	X		• 4 please, (1 for Kloser team with camera adapter)
Compound microscope			

(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:			In a "Bow-tie pattern around central station co-ordinates (at SOTS and at the S site). 10 to 200 m depth.
Additional instrumentation: (Please supply, make and model and datasheets. Also a contact person for discussion on integration)			
Continuous Plankton Recorder (CPR)	X		MAY TOW ON NORTHWARDS TRANSECT TO HOBART
Deep Towed Camera			
Drop Camera			

(iv) Specialised laboratory and sampling equipment

Name	Essential	Desirable	Notes/Comments *(These items may require additional MNF support staff)*
Piston Coring System			
Gravity Coring System			
Multi Corer			
Kasten Corer			
Equipment to measure seawater sound velocity/CTD:			
XBT System	X		• 12 x XBT's to be deployed opportunistically in transit between leaving SOTS site and between 55° site (outside of Marine Parks) – contact on board Tyler Rohr.
Valeport Rapid SV			
Valeport Rapid CTD			
Valeport SVX2			
Seaspy Magnetometer			
Trace Metal Rosette and Bottles	X		Deploy to maximum depth of ~1500m (may look to do a deep cast if time allows)
Sherman Epibenthic Sled			
Brenke Sled			
Trace Metal In-situ Pumps (x6)	X		• See non-MNF owned section below for additional 2 units • Deploy to maximum depth of ~500m • Minimum pump separation depth is 10m
Rock Dredges			
EZ Net (maximum of 10 nets for depth stratified sampling. Mouth area of 1m^2)			•
Rock Saw			
Portable Pot Hauler	X		Required for PLAOS
Beam Trawl			

(iv) Specialised laboratory and sampling equipment

Name	Essential	Desirable	Notes/Comments *(These items may require additional MNF support staff)*
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	**Ramp Exposed**	**Deck covers installed**	Use of RMT16 net means that deck covers can be installed – this will ensure the RESPIRE mooring can be deployed and recovered from the stern as took place in prior *Investigator* voyages
		X	
Trawl Monitoring Instrumentation (ITI) (2,000m depth limit)	X		
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 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		Please discuss calibration and other matters with Rudy Kloser.
150kHz ADCP	X		

(vi) Underway systems

Acoustic Underway Systems

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

Atmospheric Underway Sensors

Name	Essential	Desirable	Notes/Comments
Nephelometer			
Multi Angle Absorption Photometer (MAAP)			
Scanning Mobility Particle Sizer (SMPS)			
Radon Detector			
Ozone Detector			
Condensation Particle Counter (CPC)			
Picarro Spectrometer (analysis of CO_2/CH_4/H_2O)			
Aerodyne Spectrometer (analysis of N_2O/CO/H_2O)			
Cloud Condensation Nuclei (CCN)			
Polarimetric Weather Radar			

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		
Raw seawater available on deck and in laboratories	X		Yes please – essential for sample processing

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)	X		Michael Ellwood will liaise with Andy Bowie
EM2040			• Shallow water multibeam echosounder system – discuss with Rudy Kloser.

Appendix B

User Supplied Equipment

NOTE: User supplied equipment will remain the responsibility of the science party throughout the voyage. The MNF technicians and ship's crew endeavour to assist wherever possible, however the MNF take no responsibility for the pre-deployment checks or repairs and maintenance of this equipment

Owner	Item name	Weigh t	Dimensions	Location on Vessel
David Antoine	DALEC radiometer	5 kg	0.2 x 0.2 x 0.2m	AT the end of the boom on port side, Front deck
Elizabeth Shadwick / CSIRO moorings	POC particle filtration system	5 kg	1 m bench space	Clean Dry lab
Michael Ellwood	sampling and filtration equipment	50 kg	2 m2	Clean Dry lab
Michael Ellwood	trace metal pH/H2O2 systems	20kg	1x2 m2	Clean Dry lab
Lev Bodrossey	eDNA cartridge filtration system	20 kg	1 m bench space	CTD room
Elizabeth Shadwick / CSIRO moorings	FLBB sensor	10 kg	1 m2	CTD room
IMAS/ Boyd	ZOORESPIRE	40 kg	1.3 m long x 0.4 m wide	Deployed off mid ships coring winch to 200 m depth and in CT lab for extended incubations

Owner	Item name	Weigh t	Dimensions	Location on Vessel
Rudy Kloser	PLAOS spares	100 kg	1*0.5*0.5	Dirty Wet lab
AAD	Flo cam	25 kg	1 x 0.6 x 0.6 m	Dry lab
IMAS / Boyd	FRRF active fluorometer (discrete samples)	30 kg	0.6 x 0.6 x 0.8 m	Dry lab
David Antoine	Filtration manifolds & vacuum pump	30 kg	1.5 x 0.8 x 0.8 m	General purpose Wet Lab (clean)
IMAS/UTAS/Boyd /Bressac	6 x Sediment traps (cross with 4 sampling tubes)	30 kg each	See attached mooring diagram	In dirty wet lab and preservation lab (sampling tube containing formaldehyde) and deployed within each 3.5 day cycle for ~3 days
IMAS/UTAS/Boyd /Bressac	5 x RESPIRE PARTICLE INTERCEPTOR	50 kg each	See attached mooring diagram	In dirty wet labs and deployed within each 3.5 day cycle for ~3 days
Elizabeth Shadwick / CSIRO moorings	Bullhorn mooring fairlead	100 kg	1m	Main deck
	Moorings workshop container			Main deck
Elizabeth Shadwick / CSIRO moorings	Video cameras	0.5kg	0.1 m2	Main deck

Owner	Item name	Weigh t	Dimensions	Location on Vessel
Michael Ellwood	Trace metal rosette (ANU)	300 kg	1.5 m3	Main deck
Rudy Kloser	RMT net midwater trawl	1000 kg	~4*0.5*0.5 m tba	Main deck
Elizabeth Shadwick / CSIRO moorings	Mooring winch	1.5 tonne	2x1x1.5 m	Main deck / Sheltered Science Area
David Antoine	Underwater Vision Profiler (UVP) 5	30 kg	LWH: 0.33 X 0.376 X 1.153 m	Mounted on 36 bottle CTD rosette

Owner	Item name	Weigh t	Dimensions	Location on Vessel
David Antoine	Underwater Vision Profiler (UVP) 6		LWH: 0.3 x 0.3 x 0.5 m	Mounted on 36 bottle CTD rosette
CSIRO (Dr Grahame Rosolen)	Cosmic ray instrument	12 kg	48.5x38.5x19 cm	Rack in Aerosol Lab
Elizabeth Shadwick / CSIRO moorings	Hand held and deck mounted pneumatic line throwers (grappling gun)	50 kg	0.5 m	Sheltered Science Area
Michael Ellwood	Trace metal clean fish	40kg	3 m2	Sheltered Science Area

Owner	Item name	Weigh t	Dimensions	Location on Vessel
Rudy Kloser	PLAOS system	500 kg	1*1*3 m	Sheltered Science Area
David Antoine	Inherent Optical Properties (IOP) package	30 kg	0.5 x 0.5 x 1.2 m	Sheltered Science Area
ANU	Spare TMR			Stored in crate on aft deck (sheltered area - forward
IMAS (Hafner)	Additional zoo nets			Stored in wet lab before their deployment
IMAS/UTAS Boyd	2 BGC-ARGO with mini UVP	100 kg each	1.3 m long x 0.6 m wide	Stored in wet lab before their deployment
CALTEC (Thompson)	2 gliders	200 kg	1.8-2.0 m long (configuration dependant) Max diameter: 30 cm	Stored in wet lab before their deployment (recovered by NZ vessel after our voyage)
Michael Ellwood	iron(III/II)	20 kg	1x1 m2	Trace metal container - blue

Owner	Item name	Weigh t	Dimensions	Location on Vessel
Elizabeth Shadwick / CSIRO moorings	Pigment filtration system and FIRE	25 kg	1 m2	Underway Seawater Lab
Elizabeth Shadwick / CSIRO moorings	AC-9 bio-optical instrument	10 kg	1 m2	Underway Seawater Lab
Trull/Strutton/ Boyd	FIRE active fluorometer	30 kg	< 1 m long	Underway wetlab
IMAS /Butterworth	Zoo incubation and remineralisation equipment	15 kg	0.6 x 0.6 x 0.8 m	Wet lab and CT lab
IMAS/Strutton	Fluorometer	4 kg	32.82 cm x 26.52 cm x 21.39 cm	Dry lab
ANU/Ellwood	LIFT fluorometer (discrete samples)	15 kg	1 m bench space	Dry lab (temperature contolled room)
Elizabeth Shadwick (CSIRO)	EIMS O2/Ar system	15kg	0.2 x 0.2 x 0.2m	udnerway lab
Elizabeth Shadwick (CSIRO)	EIMS Spare parts	50 kg total	0.2 x 0.2 x 0.2m (3 plastic boxes, one wooden crate)	Dirty Wet Lab (under bench)
Philip Boyd (IMAS)	SURFER (2 holey sock drogues with lines to attach a small (low freeboard) float with an embedded GPS tracker	30 kg each	0.8 * 0.7 m	Stored in wet lab before their deployment