RV *Investigator* Voyage Plan

Voyage #:	**IN2022_V03**		
Voyage title:	**SOTS: Southern Ocean Time Series automated moorings for climate and carbon cycle studies southwest of Tasmania**		
Mobilisation:	Hobart, 0800hrs Wednesday 27 – Saturday 30 April, 2022		
Pre-voyage medical clearance period:	Hobart, Sunday 01 May – Tuesday 03 May, 2022		
Depart:	Hobart, 0800hrs Tuesday 03 May, 2022		
Return:	Hobart, 0800hrs Sunday 15 May, 2022		
Demobilisation:	Hobart, Monday 16 May, 2022		
Voyage Delivery Coordiator (VDC):	David Flynn	**Contact:**	David.Flynn@csiro.au
Voyage Manager (VM):	Matt Kimber	**Contact:**	Matt.Kimber@csiro.au
Deputy Voyage Manager:	David Flynn	**Contact:**	David.Flynn@csiro.au
Chief Scientist (CS):	Elizabeth Shadwick		
Affiliation:	CSIRO O&A / AAPP	**Contact:**	Elizabeth.Shadwick@csiro.au
Alternative CS:	Eric Schulz		
Affiliation:	Bureau of Meteorology (BoM)	**Contact:**	Eric.Schulz@bom.gov.au
SUPPLEMENTARY PROJECTS			
Principal Investigator:	Dr. Ben Scoulding (Scoulding)		
Project name:	Ecological and carbon sequestration role of mesopelagic organisms in the Southern Ocean	**Contact:**	Ben.Scoulding@csiro.au
Affiliation:	CSIRO		
PIGGYBACK PROJECTS			
Principal Investigator:	Dr. Jay Mace (CAPRIX)		
Project name:	Cloud Aerosol Precipitation Radiation Interactions eXperiment (CAPRIX).	**Contact:**	Jay.Mace@utah.edu
Affiliation:	Uni of Utah		
Principal Investigator:	Dr. Scott Meyerink (Onboard) with Dr. Zanna Chase and Dr. Andy Bowie (Chase)		

Voyage #:	**IN2022_V03**		
Project name:	Quantification of dust deposition to the ocean using thorium isotopes in seawater and aerosol sampling	**Contact:**	Zanna.Chase@utas.edu.au
Affiliation:	University of Tasmania (UTAS)		
Principal Investigator:	Mr. Craig Hanstein		
Project name:	ARGO Float Deployments	**Contact:**	Craig.Hanstein@csiro.au
Affiliation:	CSIRO		

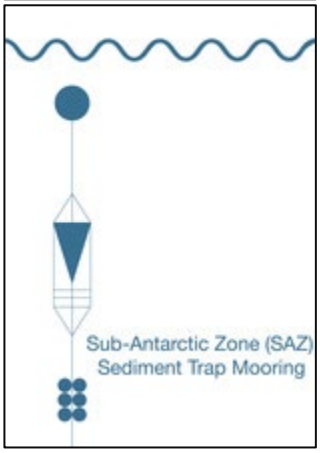
Voyage objectives

Primary Project

#1. SOTS: Southern Ocean Time Series automated moorings for climate and carbon cycle studies southwest of Tasmania.

Principal Investigator: Dr. Elizabeth Shadwick – CSIRO O&A

The Southern Ocean has a predominant role in the movement of heat and carbon dioxide into the ocean interior, moderating Earth's average surface climate. The IMOS - SOTS moorings are designed to remotely and automatically measure these oceanographic processes under extreme conditions, where they are most intense and have been least studied. The atmosphere-ocean exchanges occur on many timescales, from daily insolation cycles to ocean basin decadal oscillations and thus high frequency observations sustained over many years are required. The current context of anthropogenic forcing of rapid climate change adds urgency to the work.



The primary objectives listed below focus on ensuring the long-term dataset is not interrupted (i.e. deploy new moorings, then recover old moorings). The measured parameters include: Sea surface water and air temperature, dissolved oxygen, zooplankton backscatter, CO2 partial pressure and many more.

- The Southern Ocean Flux Station (SOFS) moorings measure meteorological and ocean properties important to air-sea exchanges, ocean stratification, waves, currents, biological productivity and ecosystem structure. Water samples are collected for more detailed nutrient and plankton investigations after recovery.
- Sub-Antarctic Zone sediment trap (SAZ) moorings collect samples to quantify the transfer of carbon and other nutrients to the ocean interior by sinking particles and investigate their ecological controls.

Ancillary work on transit to moorings sites, on station and on return transit, will sample atmospheric and oceanographic conditions using CTD casts, Triaxus towed body, Continuous Plankton Recorder and autonomous profiling Biogeochemical-Argo floats, and potentially casts of a bio-optical sensor package.

Activities List (SOTS)

1. Deploy SOFS-11 meteorology/biogeochemistry mooring
2. Deploy SAZ-24 sediment trap mooring
3. Recover SOFS-10 meteorology/biogeochemistry mooring
4. Recover SAZ-23 sediment trap mooring
5. Do CTDs (2 cast to 4550m, 2 to 600m) at the SOTS site, including collecting samples for nutrients, oxygen, dissolved inorganic carbon, alkalinity, and particulate matter analyses
6. Ship meteorological observations at SOFS buoy for comparisons
7. Tow MacArtney Triaxus on transit to SOTS site
8. Tow CPR on return to Hobart
9. Carry out underway air and water sampling and sensor measurements, including bio-optics and bio-acoustics

Voyage Priorities (SOTS)

Note: The objectives list above are NOT the priority ranking, because the list is designed for efficiency, using past voyage experience, to achieve all goals. In particular, deploying SOFS-11 as the first operation frees up deck space and increases efficiency. This sequence also optimises fatigue management (long day, spooling/rest day, short day, short day, long day), but is subject to change based on the weather conditions and other factors including the fatigue of the team.

The overall priority is successful SOTS moorings deployment, recovery, and collection of calibration/validation samples (SOTS objectives 1 – 5). The next priority is to complete Scoulding objectives, then remaining SOTS objectives. After these, the piggyback project operations are prioritised lower, however careful consideration has been applied during planning and will be applied during voyage management at sea, in order to optimise timing of operations for maximum outcomes across all projects.

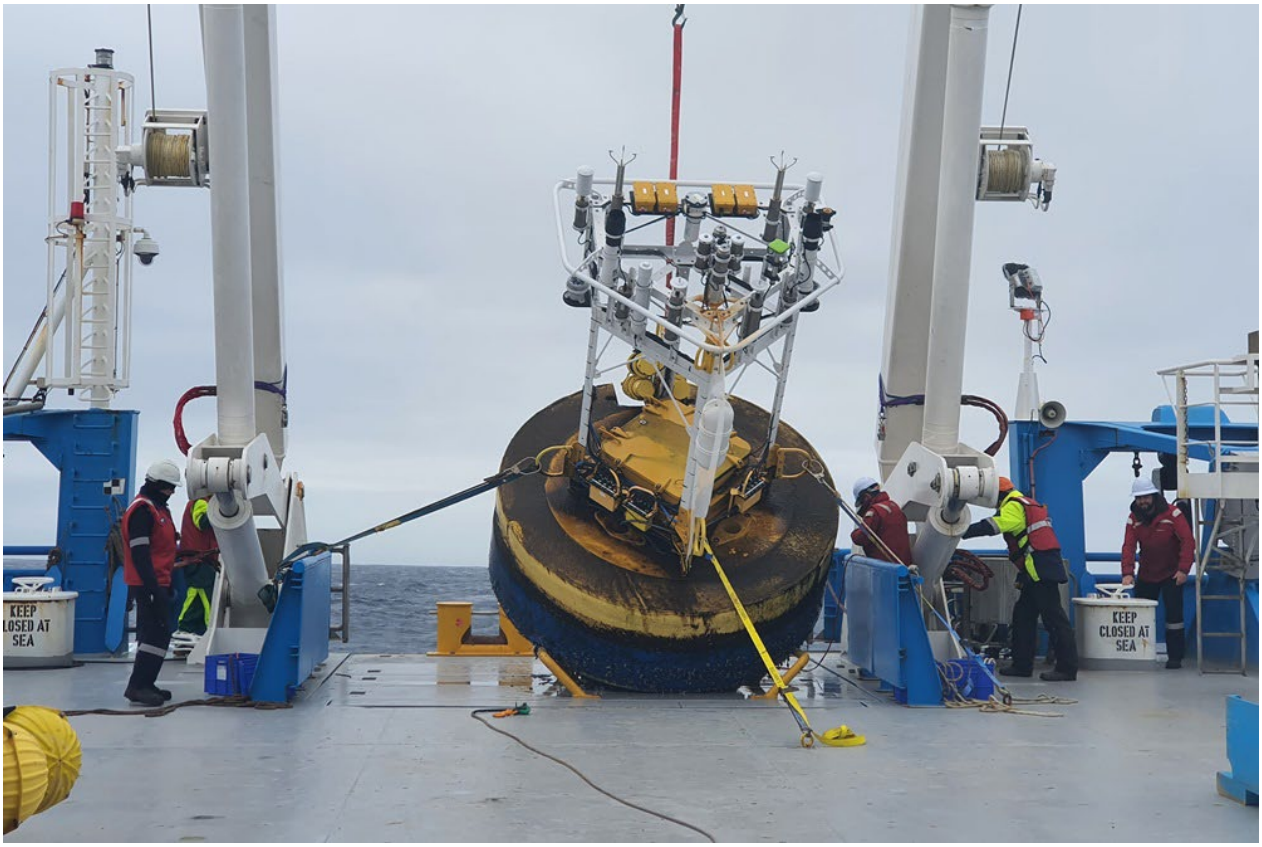


Figure 2. SOFS-8 secure on deck of RV Investigator. Image Adrian Koolhof

Supplementary Projects

#1. Ecological and carbon sequestration role of mesopelagic organisms in the Southern Ocean

Principal Investigator: Dr. Ben Scoulding – CSIRO O&A

The small crustaceans, squids, fishes and gelatinous organisms that make up micronekton are a key biological component of the worlds' oceans many making nightly migrations from mesopelagic 200-1000 m depths to the surface epipelagic 0-200m depths. Understanding their diversity, distribution, biomass and energetic needs are key to further understanding the carbon cycle and linking primary production to top predators. Commonly nets, optic and acoustic samplers are used to determine the taxonomy, size, biomass, trophic linkage and energetics of zooplankton and micronekton. Each of these sampling methods have bias and uncertainty that need to be quantified prior to attributing changes within and between regions. This is particularly true for the gelatinous community that covers a wide range of taxonomic and energetic groups that are difficult to sample with nets. To improve vessel mounted acoustic and net sampling methods of macro-zooplankton and micronekton the profiling Lagrangian acoustic and optical system (PLAOS) was developed. Lagrangian refers to the motion of the PLAOS in space and time as it profiles the water column from 0 to 1000 m at a descent rate of ~0.5 ms^{-1}. The PLAOS is tethered to the vessel but allowed to free fall until it reaches depth when it is hauled back onboard. The PLAOS is the evolution of an instrument first used in 2006 and has been deployed in its current configuration (with periodic system upgrades) as part of SOTS since 2018. The most recent upgrade includes the addition of downward looking stereo cameras and a pair of upward looking echosounders. This voyage offers the opportunity to test these new systems and to collect visually verified acoustic measurements of micronekton. Further it allows for the testing of a new buoyancy engine to enable the system to do repeat profiles. A Rectangular Midwater Trawl net (RMT16) single wire net will be used to capture micronekton for species identification. The RMT will target discrete micronekton layers identified by the ship-based acoustic systems. Development of this methodology and technology will significantly advance our knowledge of micronekton biomass and distribution and provide the necessary structure and function understanding for the development of carbon and ecosystem models of the open ocean linking to the AAPP Biogeochemistry and Ecosystems Projects as well as the MESOPP ecosystem program.

Note: Each PLAOS deployment records ~50-60 GB of data. With ~5 targeted deployements (weather permitting), DAP have prepared onboard storage to store data on science drives.

Voyage Objectives (Scoulding)

1. Repeat PLAOS deployments (5 total, ideal with some day-night comparison).
2. 2-3 Targeted RMT16 net tows at depths down to 1000m (depth determined by echosounder observations).
3. Collect ship-based acoustic data using the ship's echosounders.

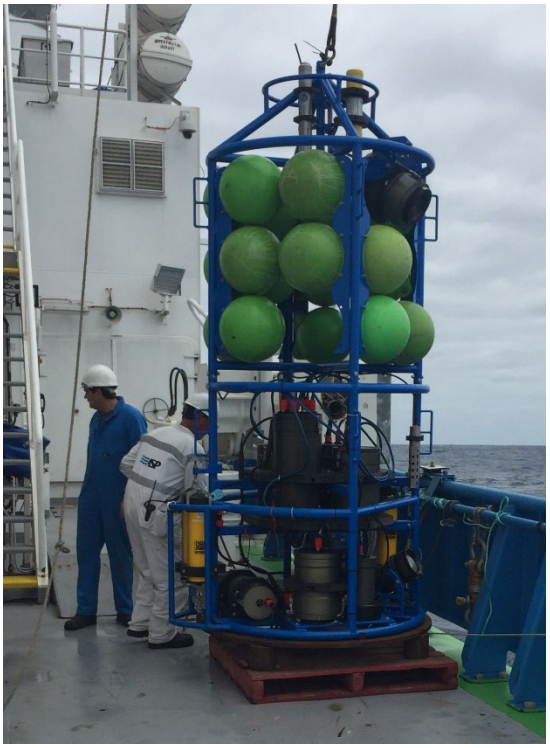


Figure 3. PLAOS prepared for starboard deployment

Operations (Scoulding)

It is envisaged that the majority of the sampling will be done at night for both the PLAOS and net sampling working around the other projects as needed. We envisage ~5 PLAOS deployments and 2-3 net deployments during the voyage.

The PLAOS and RMT 16 net trawl have been used on several previous voyages and have not been flagged as high risk so normal MNF procedures will be used.

Piggyback Projects:

#1. Cloud Aerosol Precipitation Radiation Interactions eXperiment (CAPRIX).

Principal Investigator: Dr. Alain Protat – BoM & Dr. Jay Mace – Uni of Utah

Voyage Objectives (CAPRIX)

Currently there are errors in calculations of absorbed solar radiation at the sea surface, linked to uncertainty in predicting global climate sensitivity under CO2 warming and sea surface temperature biases in climate models. It's hypothesised that microphysical properties of clouds (radiometry and aerosol cloud pre-cursors) in the Southern Ocean and coastal Antarctica are contributing factors. Previous voyages (IN2015_V02, IN2016_V02, IN2018_V01, IN2018_V02) indicate shortwave radiation biases north or south of about 55°S latitude.

What remains nearly unexplored is the seasonal response in cloud and precipitation properties during Autumn when the basin scale productivity declines and the aerosol background changes from sulfate dominant to sea salt dominant. 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. Increased samples are required during this time and location to draw statistically significant conclusions.

Proposed instruments and critical measurements needed for this project are listed below, requiring coordination and installation during port period (IN2022_P02). All instruments will operate continuously under supervision of MNF SIT engineers and on-board scientist(s) with ample experience manning this instrumentation on Southern Ocean voyages.

To improve, contextualise and rely on data measured as part of this project, PIs Mace and Protat have purchased helium and radiosondes (weather balloons) and both have experience launching radiosondes from the deck of RV *Investigator*. Assistance may be needed in inclement weather to assist in radiosonde launches from MNF staff.

Priorities & Sampling Strategy (CAPRIX)

The priority is to collect a suite of aerosol, cloud, surface radiation, surface eddy momentum, heat and moisture fluxes, and precipitation observations within the seasonally transitioning open ocean waters during early Autumn in the Subantarctic zone. These new datasets will be combined with the existing ones collected in 2016 and 2018 to continue to build a comprehensive understanding of the relationship between ocean productivity, aerosol formation, cloud microphysics and then link that understanding to rain- and snowfall properties and surface radiation. In particular, documenting the seasonal transitions

from high Summer to late Autumn will provide a completely unprecedented characterization of Southern Ocean aerosol-cloud-precipitation interactions that are critical to understanding the Earth's climate sensitivity.

Figure 4. Radiosondes shrouding and launching example from 2018.

#2. Quantification of dust deposition to the ocean using thorium isotopes in seawater and aerosol sampling.

Principal Investigator: Dr. Scott Meyerink (PI Onboard) – UTAS

Voyage Objectives (Chase)

This piggyback project is part of an ARC Discovery Project (CIs Zanna Chase, Andrew Bowie and Peter Strutton) entitled "Dust to the ocean: does it really increase productivity?" The purpose of the larger project and of this piggyback is to quantify dust deposition to the ocean and its chemical and ecological impact by using new geochemical techniques. The SOTS site is unique in the Southern Hemisphere because we can compare a number of different methods to estimate dust deposition and can also look at interannual variability in dust deposition.

In terms of national benefit, mineral dust is an important, yet difficult to quantify source of nutrients to the ocean. This project will deliver more accurate estimates of dust deposition to the ocean around Australia, a region where dust models perform poorly. The expected benefit of the project includes better dust models used to predict future changes in dust deposition to the ocean. Accurate dust predictions are critical for predicting future ocean fish production and carbon uptake.

Priorities & Sampling Strategy

Priority 1, is to collect filtered seawater samples (10L) from a depth profile at the SOTS site. Ideally the full water column depth, but if time is limited the upper 1,500m. These samples will be analysed for 230Th and 232Th concentrations at UTAS. We would also retain sample aliquots for possible future analysis of rare earth elements and Nd isotope composition, pending further funding. For this we would need the CTD-rosette (36 bottle ideally), a laminar flow bench and milli-Q water, all MNF-supplied. We would supply jerry-cans for sampling, storage boxes for the jerry-cans, cartridge filters, and HCl for acidification.

Priority 2, is to collect rainwater and aerosol samples using the ship's aerosol sampling apparatus. These samples would be analysed for labile and total bioactive trace metals, as well as 232Th, at UTAS. For this we would need the MNF aerosol sampling lab. We would supply filters and storage containers for filters.

The two sample types provide three independent measures of dust flux.

#3. ARGO Float Deployments (ARGO).

Principal Investigator: Craig Hanstein

Voyage Objectives (ARGO)

The Array for Real-Time Geostrophic Oceanography (ARGO) program is a collaboration of scientific institutions around the world, and includes an Australian contribution led by the CSIRO. Given the lifespan of ~3-5 years for each deployed float, the objective on this voyage is to deploy additional floats in strategic areas of the Southern Ocean to maintain geographic coverage of the data array.

Priorities & Sampling Strategy (ARGO)

ARGO floats will be deployed on an opportunistic basis, when weather and other voyage activities are not impacted.

The MNF has agreed to deploy #1 standard ARGO float at predetermined waypoints.

Voyage Risk Assessment

The MNF, in consultation with the science party and other relevant stakeholders, has undergone a comprehensive risk assessment process, including the assessment of risks specific to activities on this voyage. The full Voyage Specific Risk Assessment (VSRA) is available from the Voyage Delivery Coordinator as a separate document.

Primary voyage objectives of mooring deployment and recovery operations are high risk, management includes:

- Detailed procedures reviewed with the crew and science team before and during the voyage
- Job hazard analysis and toolbox meetings during voyage
- Restriction of trawl deck working areas to essential participants
- Mooring operations limited to daylight for high risk activities
- A designated safety observer
- Go/No-Go meeting with ship senior management just prior to operation for safety

The overall mooring protocols are in the ship's Safety Management System (SMS). Detailed mooring procedures are available separately for each operation.

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
IMOS	Social media campaign via owned channels to promote IMOS, the voyage and voyage activities.	Throughout Voyage	Marian Wiltshire, IMOS Comms Manager

Overall Activity Plan First 24hrs of Voyage

Day	Date	Time	Activity
Sun	01 May	All day	Pre-voyage medical clearance period onboard
Sun	01 May	1030	Seagoing inductions for those >6 months since onboard @ Aft Lounge
Sun	01 May	1400	Muster drill @ 02 Deck – All participants wearing hard hat, closed shoes and PFD
Sun	01 May	1600	Voyage Management Team Meeting @ Bridge
Sun	01 May	1030 – 2000	Pre-spooling of moorings line & winches, mooring anchor dual lift, toolbox talk & planning for PLAOS & RMT
Mon	02 May	All day	Pre-voyage medical clearance period onboard
Mon	02 May	1030	VM Briefing Part 3/3 Life Onboard (Backup for full brief if not during quarantine)
Tues	03 May	0800	Depart PW04 (dependant on medical clearance results)
Tues	03 May	1000	In Adventure or Storm Bay, toolbox talk planning & testing: Triaxus & Moorings (Test fire/training Pneumatic Line Thrower)
Tues	03 May	1230 - 1300	Outbound: Calibrate backscatter of EM710 on GSM Line #2 @8kts
Tues	03 May	1300	Begin transit to SOTS
Tues	03 May	1600	Perform Test CTD as soon as seawater is 1000m deep & Deploy Triaxus (0-200m) after test CTD

Voyage Track

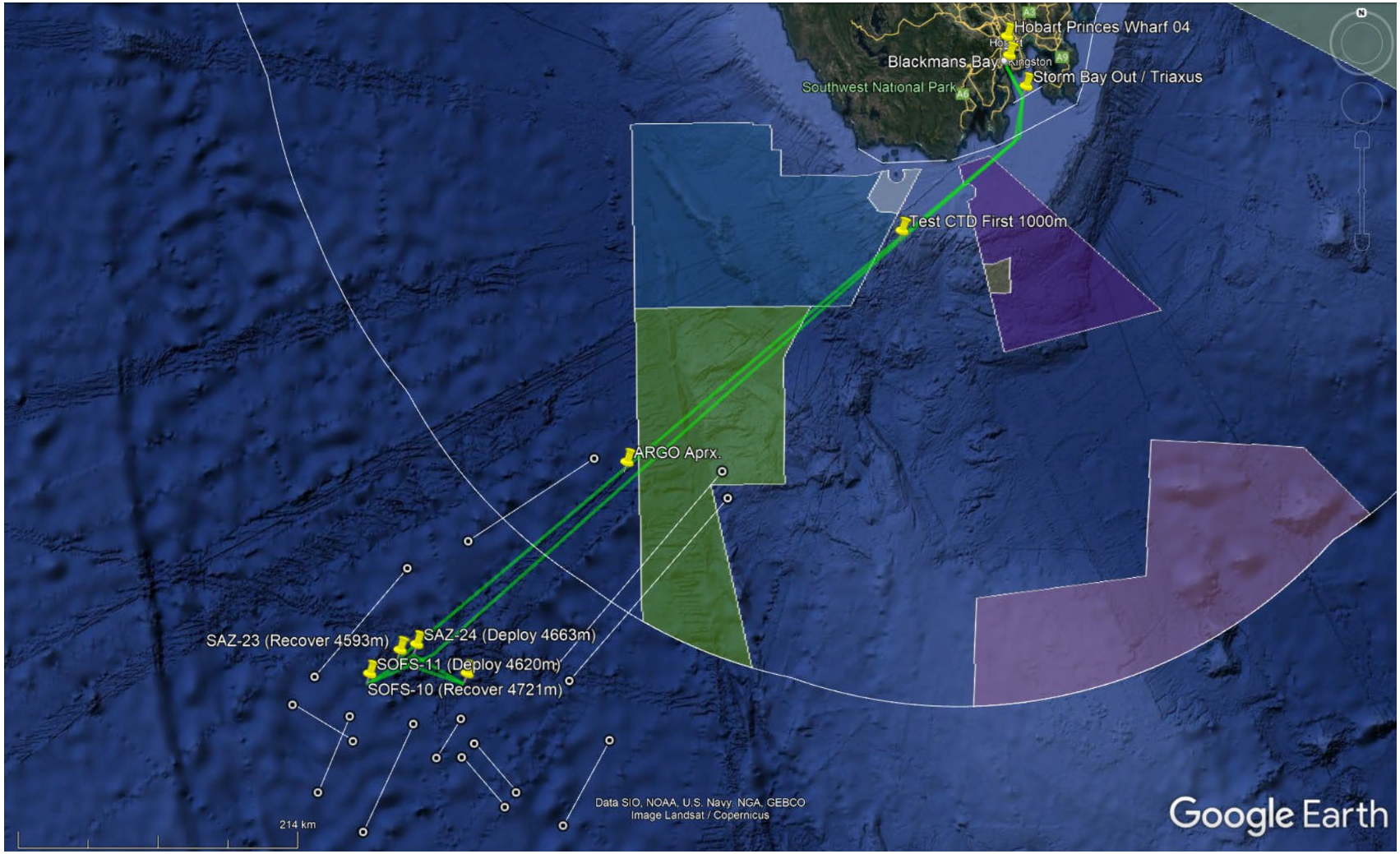


Figure 5. Proposed IN2022_V03 Voyage Track (Green) with opportunistic mapping lines (White), with Australia's EEZ and Southern Marine Parks outlined.

Waypoints and stations

Time estimates are at 10.5 knots									
Location	**Latitude, Degrees Decimal Minutes (DDM)**	**Longitude Degrees Decimal Minutes (DDM)**	**Latitude Decimal Degrees**	**Longitude Decimal Degrees**	**Distance (nm)**	**Total Distance (nm)**	**Steaming time (hrs)**	**Total Steam (hrs)**	**Depth (m)**
Hobart Princes Wharf #04	42° 53.186'S	147° 20.323'E	-42.88644	147.33872	0	0	0.0	0	10
Tranmere	42° 54.311'S	147° 22.727'E	-42.90518	147.37879	2	2	0.3	0	10
Blackmans Bay	43° 00.665'S	147° 21.605'E	-43.01108	147.36009	6	9	1.1	1	17
Storm Bay (Begin CPR / Triaxus Tow)	43° 12.711'S	147° 30.781'E	-43.21185	147.51301	14	22	2.0	3	40
GSM Backscatter Cal Line 2 Start	43° 24.478'S	147° 27.939'E	-43.40797	147.46565	12	34	1.1	4	70
GSM Backscatter Cal Line 2 End	43° 30.632'S	147° 26.618'E	-43.51053	147.44363	6	40	0.8	5	70
Test 1000m CTD cast (outside of Marine Parks – TBD Onboard)	44° 10.607'S	146° 23.805'E	-44.17678	146.39675	60	101	10.1	15	1000
SOTS (Nominal) + Finish CPR/Triaxus	46° 48.000'S	142° 00.000'E	-46.80000	142.00000	243	344	40.5	56	4530
SOFS-11 (deployment) target	46° 58.320'S	141° 20.864'E	-46.97201	141.34773	29	373	2.7	59	4,620
SAZ-24 (deployment) target	46° 47.622'S	141° 48.960'E	-46.79370	141.81600	22	395	2.1	61	4,663
SOFS-10 (recovery) anchor triangulation	46° 59.861'S	142° 17.068'E	-46.99768	142.28447	23	417	2.2	63	4,721
SAZ-23 (recovery) anchor triangulation	46° 49.573'S	141° 39.212'E	-46.82621	141.65353	28	445	2.7	65	4,593
GSM Backscatter Cal Line 3 End	43° 28.37'S	147° 29.713'E	-43.47283	147.49522	338	783	32.2	98	70
GSM Backscatter Cal Line 3 Start	43° 23.824'S	147° 29.656'E	-43.39707	147.49427	19	802	2.4	100	70
Storm Bay	43° 12.711'S	147° 30.781'E	-43.21185	147.51301	16	818	1.6	102	45
Blackmans Bay	43° 00.665'S	147° 21.605'E	-43.01108	147.36009	14	831	2.3	104	10
Tranmere	42° 54.311'S	147° 22.727'E	-42.90518	147.37879	6	838	1.1	105	10
Hobart Princes Wharf #04	42° 53.186'S	147° 20.323'E	-42.88644	147.33872	2	840	0.3	105	10

CTD Configuration (SOTS)

	Please select:
Fundamentals:	
• Which CTD rosette to be used for this voyage (24 Niskin bottles or 36):	36
• Likely total number of casts:	8
• Likely maximum depth of deepest cast:	4550
• 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):	
• Fluorometer – CDOM (Wetlabs FLCDOM – 370/460nm)	
• Nephelometer (Seapoint Turbidity Meter)	
Hydrochemistry Analyses:	
• Salinity	200
• Dissolved Oxygen	200
• Nutrients: Nitrate	200
• Nutrients: Phosphate	200
• Nutrients: Silicate	200
• Nutrients: Nitrite	200
• Nutrients: Ammonia (special request after discussion with hydrochemistry)	

SOTS and UTAS:

- We plan to collect 24 x dissolved inorganic carbon, alkalinity, pigments, and POC samples from the 2 deep casts (4000 m). There will be up to 5 additional UTAS CTD casts with 24 to 36 samples collected.
- A 3rd and 4th shallow (600m) SOTS CTD cast will be undertaken cast to post-calibrate sensors recovered from SOFS-8 (this exercise is an important quality control measure), we will collect samples at 3 depths.
- We require hydrochemistry analyses for all CTDs, as well as from ~ 12 underway samples to calibrate/validate the Triaxus sensors. We will supply an FlBb sensor for the CTD.

Aerosol sampling:

- 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.
- Access to aerosol sampling lab.

Activity Plan and Time Estimates

The following time estimates are based on a steaming speed of 10.5 knots, which will be reduced during transit to SOTS Nominal if towing Triaxus or CPR.

Any additional time on site to deploy/recover the moorings due to weather conditions can be discussed between the management team on board.

On board Management Team meeting time TBD.

Date	Month	Activity
Tue 03	May	0800 – Depart PW04 (dependant on medical clearance results) 0830 – Muster drill for all science party (if not already complete alongside) 1000 – In Adventure or Storm Bay, test the following: mooring anchor dual lift, RMT16, CTD, PLAOS (including options for winches etc), Triaxus, Add Gilson Winch Handshake to Orange rope for PLAOS. 1230 – 1300 Outbound: Calibrate backscatter of EM710 on GSM Line #2 @8kts 1300 – Begin transit to SOTS 1600 – Perform Test CTD as soon as seawater is 1000m deep & Deploy Triaxus (0-200m) after test CTD
Wed 04	May	Transit to SOTS towing Triaxus and perform underway sensor observations. Hold Mooring Procedures Familiarization Meeting with Science Party, Master, Mates and Crew
Thur 05	May	0600 – 1000: Arrive SOTS site (dependant on weather conditions) 1000-1300: SOTS CTD cast to 600m (pre-deployment calibration of SOFS-11 sensors) 1300-1800: Ship-buoy comparison at SOFS-10 and inspection of the SOFS-10 float 1630-1700: SOFS-11 Deployment Meeting 1800-2200: Ship drift assessment at SOFS-11 site 2200-2400: PLAOS #1 (NOT using net drum)
Fri 06	May	0400-0600 Reposition ship to SOFS-11 deployment start (~19.5 miles down-weather) 0645 SOTS: Toolbox on Bridge for SOFS-11 mooring deployment 0600-2000 SOTS: Deploy SOFS-11 mooring 2000-2400 SOTS: Triangulate SOFS-11 anchor, collect ship sensor observations close to SOFS-11
Sat 07	May	0100-0400: UTAS CTD #1 0400-0800: RMT nets #1 Rest Day: Collect ship sensor observations close to SOFS-11 0800-1200: CTD Cast to 4550m (pre-deployment calibration of SAZ-24 sensors, SOTS sampling #1) 1000-1500: Spool on SAZ-24 1500-1900: UTAS CTD #2 1900-2100: PLAOS #2 (possibly on net drum) 2100-2400: UTAS CTD #3
Sun 08	May	0100-0400: RMT nets #2 0400-0600 SOTS: Transit to SAZ-24 deployment start (15 miles down-weather from target)

Date	Month	Activity
		0645 SOTS: Toolbox on Bridge for SAZ-24 mooring deployment 0600-1500 SOTS: Deploy SAZ-24 mooring 1500-1800 SOTS: Triangulate SAZ-24 anchor location 2000-2400: UTAS CTD #4
Mon 09	May	0100-0300: PLAOS #3 (possibly on net drum) 0400-0600 Transit to SAZ-23 recovery site (1 mile down-weather from anchor location) 0645 Toolbox on Bridge for SAZ-23 mooring recovery 0600-1800 Recover SAZ-23 mooring 2200-2400: UTAS CTD #5
Tue 10	May	0200-0600: RMT nets #3 0600-0800 SOTS: Transit to SOFS-10 site 0800-1800 SOTS: Spool off SAZ-23 mooring – deck ops only 0800-1000: (daytime) PLAOS #4 (possibly on net drum) 1000-1200 SOTS: Ship-buoy met comparison at SOFS-10 1200-1600 SOTS: CTD cast to 4000m (SOTS sampling #2, UTAS CTD #6) 1600-2400 SOTS: Ship-buoy met comparison at SOFS-10
Wed 11	May	0100-0300: PLAOS #5 (possibly on net drum) 0400-0600 SOTS: Transit to SOFS-10 recovery site (1 mile down-weather from anchor location) 0645 SOTS: Toolbox on Bridge for SOFS-10 mooring recovery 0600-2000: Recover SOFS-10 2200-2400: CTD cast to 600 m (post-recovery calibration of SOFS-10 and SAZ-23 sensors)
Thur 12	May	Bad weather allowance
Fri 13	May	Bad weather allowance
Sat 14	May	Inbound: Calibrate backscatter of EM710 on GSM Line #3 @8kts Transit to Hobart towing CPR
Sun 15	May	Arrive Hobart, Demobilisation

Permits

Australian Marine Park permint **PA2020-00041-1** covers the Marine National Facility for use of most existing underway science systems within commonwealth marine parks. Specifically for this voyage only a transit through the 'Huon' and 'Tasman Fracture' marine parks are likely, with Triaxis towed body or CPR sampling all covered under the aforementioned permit.

The permit date range is from **24 June 2020**, to **20 August 2023** well within this voyage requirements. Notable activities that are covered under this permit and relevant to this voyage are:

- Use of the ship's underway systems, Triaxus and CPR.
- Mooring locations and buoy marking details will be provided to AMSA for notice to mariners.

Other permits:

- Collection of seawater and sediment trap samples for return to Hobart under ACE CRC Quarantine permit Department of Agriculture and Water Resources 5254494.
- PA2020-00051-1 Southeast Network for ARGO float deployments.
- Animal ethics permit for mid-water towing with RMT 16 net trawl #2022-04
- Quarantine permit for zooplankton and micronekton samples, #0003975507 – application filed number to be advised.
- Commonwealth MPA permit for logging acoustic sensors, #CMR-17-000471.

List of additional figures and documents

Attachment 1: SOTS Deck plan

Attachment 2: SOFS Mooring Diagrams, as deployed

Attachment 3: SAZ Mooring Diagrams, as deployed

Attachment 4: Oceanic SOTS Mooring Location Map

Attachment 5: Mooring Deployment Procedures (available separately)

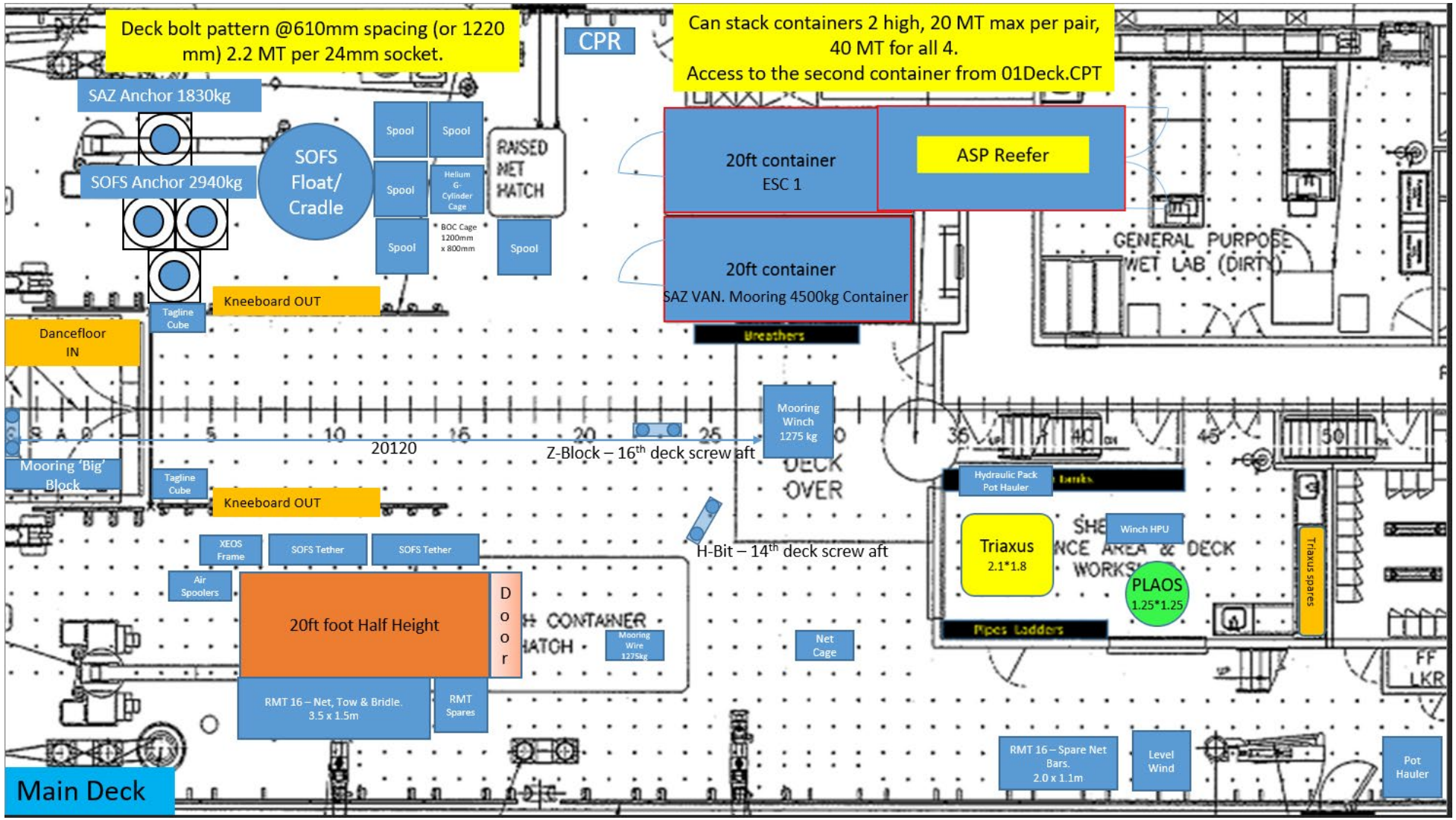
Attachment 6: CTD Water Sampling Collection and Labelling Plan (available separately)

Appendix A: MNF Equipment

Appendix B: User Supplied Equipment

Appendix C: Hazardous Materials Manifest

Attachment 1



Attachment 2

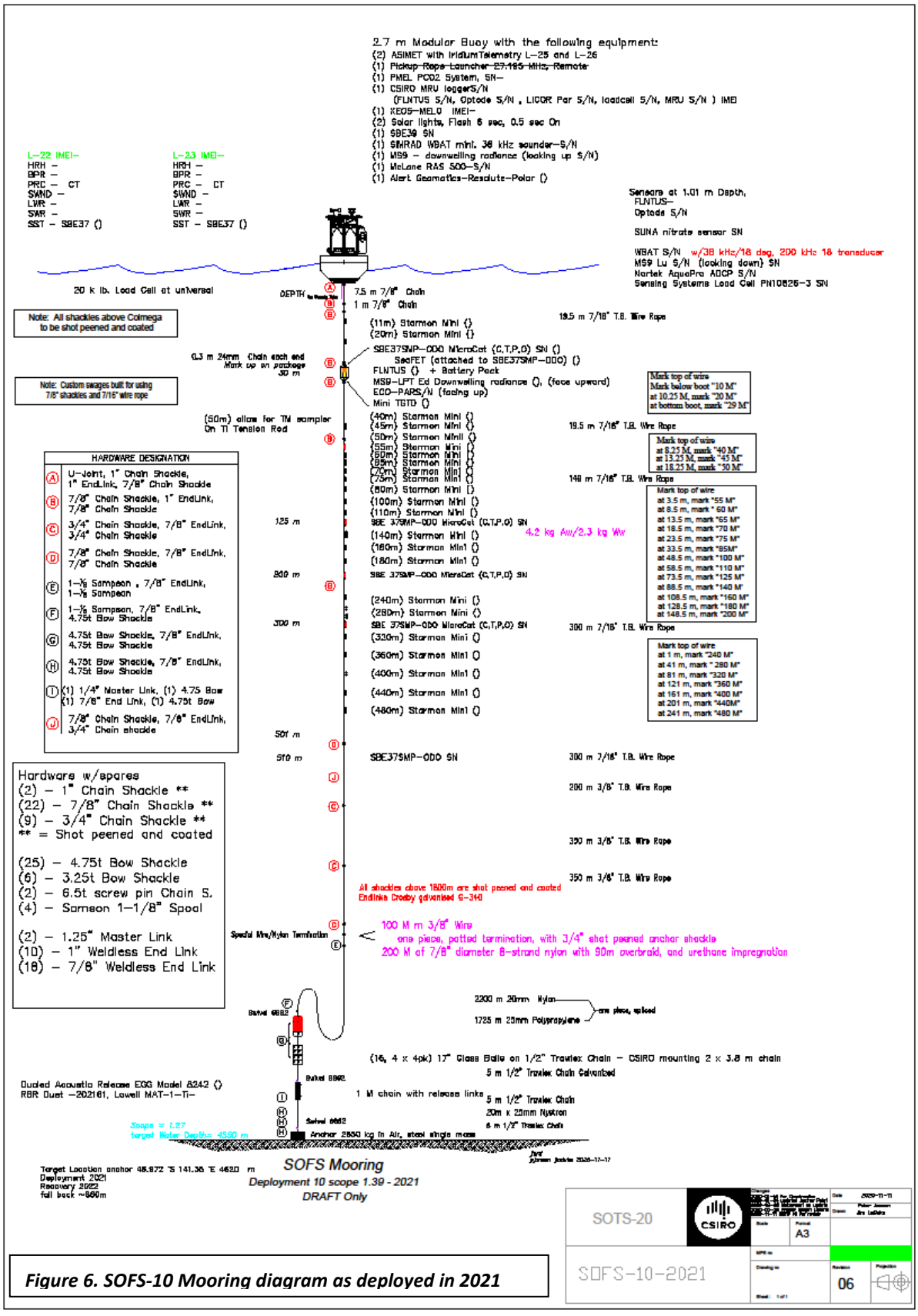


Figure 6. SOFS-10 Mooring diagram as deployed in 2021

Attachment 3

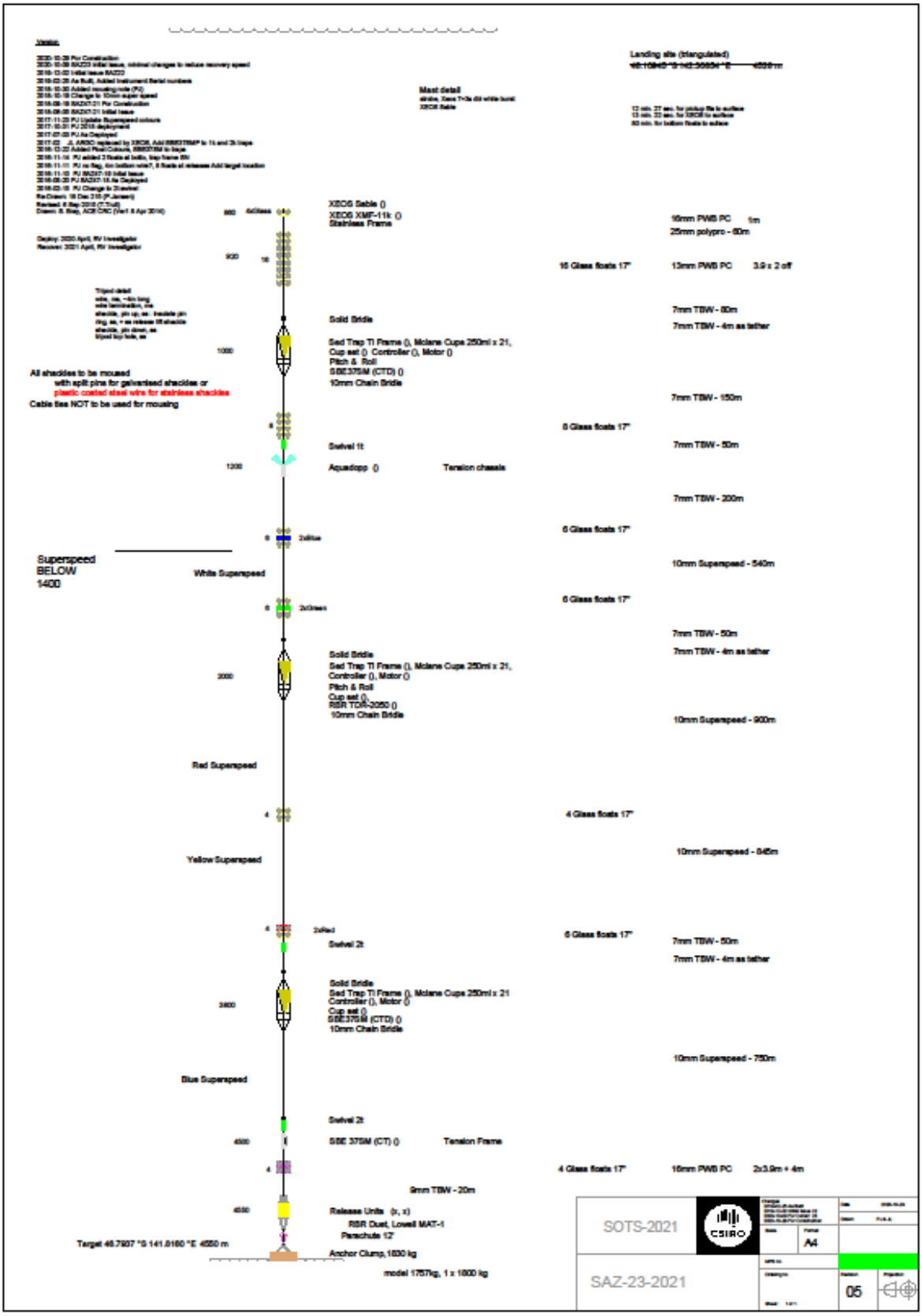


Figure 7. SAZ-23 Mooring diagram as deployed in 2021

Attachment 4

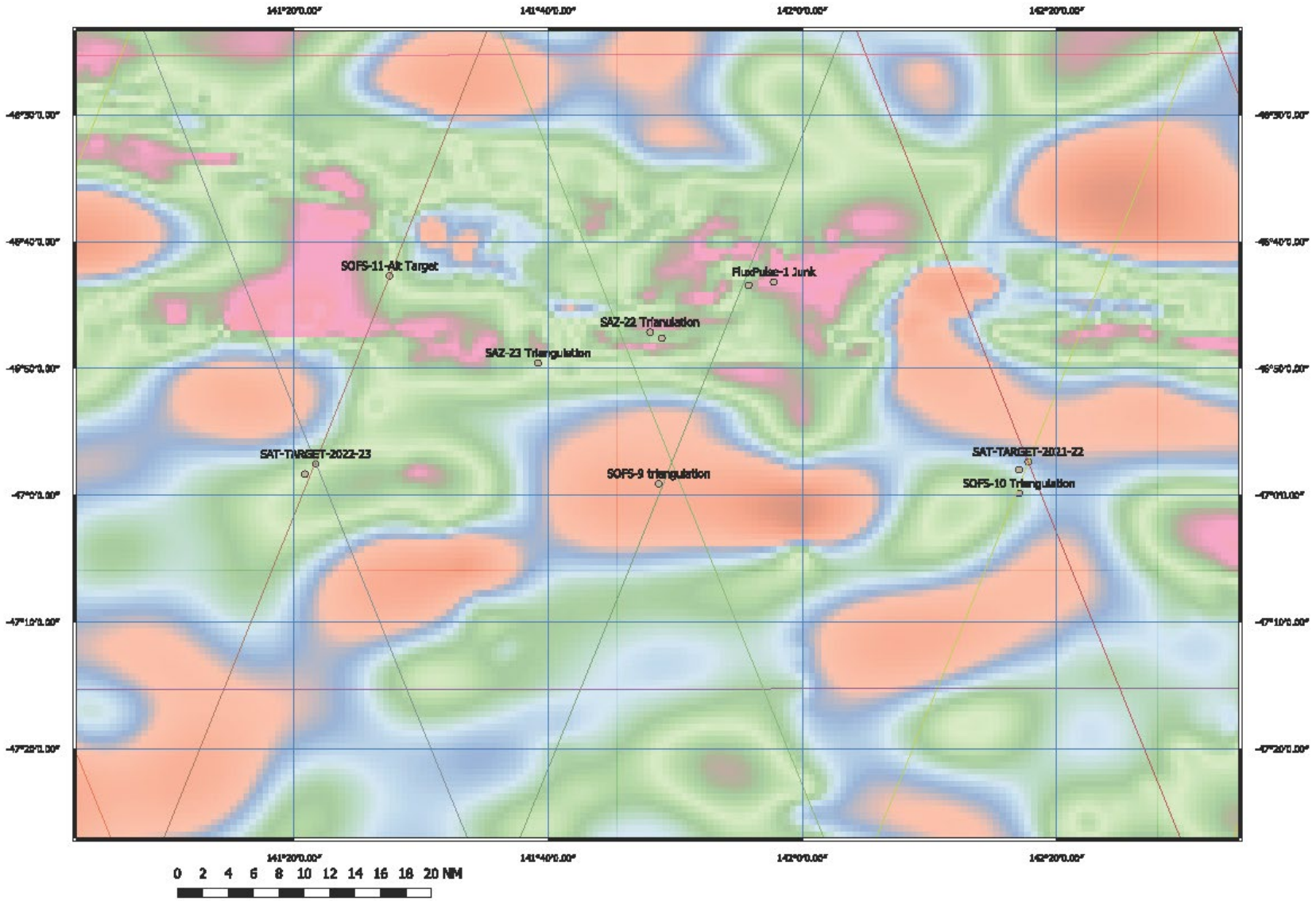


Figure 8. Previous moring triangulations and new deployment target locations for IN2022_V03.

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		RMT16 Net Catch sorting of samples, PLAOS data review,
Constant Temperature Lab			Please indicate the required setpoint temperature
Underway Seawater Analysis Laboratory	X		Required for the Chase Project.
GP Wet Lab (Dirty)	X		Moorings Team to use for instrument preparation and meetings with crew for operations. Scoulding team to use -20^{o}C freezer and ice machine during RMT net sampling.
GP Wet Lab (Clean)	X		
GP Dry Lab (Clean)	X		Require use of laminar flow bench in this lab. Moorings team require minimal bench space for engineering/planning. Chase team require majority of bench space for experiments and data analysis.
Sheltered Science Area	X		
Observation deck 07 level			
Walk in Freezer	X		
Blast Freezer	X		
Ultra-Low Temperature Freezer (-80^{0}C) X2	X		Used for storage of seawater pigment samples and returned to Hobart for analysis (no chemicals). Also used for storage of eDNA samples. Also used for aerosol filter samples from V02 and V03.
Walk in Cool Room	X		

(i) Standard laboratories and facilities

Name	Essential	Desirable	Notes/Comments
Salt water ice machine	X		Required for RMT16 net sampling

(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			•
Modular Hazchem Locker			
Deck incubators			
Stabilised Platform Container	X		For use with BASTA - 95 GHz cloud radar and RMAN Lidar
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	X		• With PAR, Transmissometer & user supplied FLBB, plus LADCP
CTD - Seabird 911 with 24 Bottle Rosette			
Lowered ADCP	X		
Sonardyne USBL System	X		
Milli-Q System	X		
Laboratory Incubators	X		
Heavy Duty Electronic Balance (80kg)			

(iii) Standard laboratory and sampling equipment

Name	Essential	Desirable	Notes/Comments
Medium Duty Electronic Balance (15kg/5g resolution)	X		
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			
Microscopes:			• Refer to the “MNF microscopes procedure” for more information
Brand / model	Type		
• Leica / M80	Dissecting		
• Leica / M80	Dissecting		
• Leica /MZ6	Dissecting		
• Olympus / CH	Compound		
• Olympus /CH	Compound		
• Leica / MTU282	Camera tube		
• Adapters for tube / Nikon	Pentax		
• Ring Light *2 / MEB121	LED		

(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:			Triaxis tow start in storm bay and end at the SOTS site. Closer to departure we will look at satellite sea surface height and temperature to determine whether an eddy is in the path of the transit and may need to change the course accordingly.
Additional instrumentation: (Please supply, make and model and datasheets. Also a contact person for discussion on integration.			
Continuous Plankton Recorder (CPR)	X		
Deep towed camera			
Piston Coring System			
Gravity Coring System			
Multi Corer			
Kasten Corer			
XBT System	X		• 2 per day provided
Trace Metal Rosette and bottles			

(iv) Specialised laboratory and sampling equipment

Name	**Essential**	**Desirable**	**Notes/Comments** **(These items may require additional MNF support staff)**
Sherman epibenthic sled			
Brenke Sled			
Rapid Cast SVP			
Magnetometer			
Drop Camera			
Trace metal in-situ pumps (x6)			
Rock Dredges			
~~EZ Net~~ Multi-Net 'Mammoth' (maximum of 10 nets for depth stratified sampling. Mouth area of 1m^2)	X		• ~~Please specify 335 micron, 500 micron, or~~ **1,000 micron mesh requested, minimum 5x nets.**
Rock saw			• Requires trained science personnel
Portable pot hauler			
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**		• Stern-ramp cover ("dance-floor") without overhanging lip on aft surface installed with gap protectors and mounts for user-supplied bullhorn fairlead.
		X	
Trawl monitoring instrumentation (ITI) (2,000m depth limit)			• Trawl net monitoring system for depth and wire out monitoring
A-frame utility winches.			• Tagging line cleat attachment points fitted.
Net drum winch	X		• Install *Investigator* net drum winch on Mezzanine with spooler-rail installed aft of it, as the best location as discussed with MNF and ASP for this voyage

(iv) Specialised laboratory and sampling equipment

Name	Essential	Desirable	Notes/Comments (These items may require additional MNF support staff)
Hull mounted 12 kHz Transducer	X		• Working hull mounted 12 kHz transducer for use with acoustic release deck unit
Meteorological Instrumentation	X		• Working and logging meteorological instruments including ISAR SST radiometer
Drop Keel	X		• Working drop keel for bioacoustics, thermosalinograph and ADCP data gathering deployed to >4 m.
Radiosonde Receiver System	X		

(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		• Working and logging underway ADCP, with real-time display
150kHz ADCP			
Multi Beam echo sounder EM122 12kHz (100m to full ocean depth)	X		•
Multi Beam echo sounder EM710 70-100kHz (0-1000m approx.)			• Multibeam/Multifrequency bio-acoustic system, with MNF supplied electronics, computing, and operational support

(vi) Underway systems

Acoustic Underway Systems

Name	Essential	Desirable	Notes/Comments
Sub-Bottom Profiler SBP120	X		• GSM to run this system throughout voyage
Scientific Echo Sounders EK60 (6 bands, 18kHz-333kHz)	X		• One setting to 1500m; to be monitored on board by DAP and on shore by GSM.
Multibeam Scientific Echo Sounder ME70 (70-100 kHz)			
Omnidirectional Echo Sounder SH90			
Gravity Meter			

Atmospheric Underway Sensors

Name	Essential	Desirable	Notes/Comments
Nephelometer			
Multi Angle Absorption Photometer (MAAP)	X		
Scanning Mobility Particle Sizer (SMPS)	X		
Radon detector	X		
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)	X		
Cloud Condensation Nuclei (CCN)	X		
Polarimetric Weather Radar			

Underway Seawater Systems and Instrumentation

Name	Essential	Desirable	Notes/Comments
Thermosalinograph	X		• Working and logging underway thermosalinograph and fluorometer and real-time display
Fluorometer	X		• Working and logging underway thermosalinograph and fluorometer and real-time display
Optode	X		
pCO2	X		

Seawater systems

Name	Essential	Desirable	Notes/Comments
Trace metal clean seawater supply	X		
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

Possible increased data requirements for ABC media has been communicated with DAP.

Appendix B

User Supplied Equipment

Item Name	Weight	Dimensions	Location on Vessel
Bullhorn mooring fairlead	100 kg	1m	Main deck
Mooring winch	1.5 tonne	2x1x1.5 m	Main deck / Sheltered Science Area
Half height open top moorings container	5 tonnes	20ft	Main deck
SOFS float and recovery cradle	2.5 tonnes	3x3 m	Main deck
Mooring anchor stacks	SOFS 2.94 tonnes + SAZ 1.84 tonnes	3x1 m	Main deck
Full height container for storing and working on sediment traps	4.5 tonnes	20ft	Main deck
6 cage pallets of mooring equipment	500kg per cage	1 x 2 m each	Main deck
Hand held and deck mounted pneumatic line throwers (grappling gun)	50 kg	0.5 m	Sheltered Science Area
Video cameras	0.5kg	0.1 m2	Main deck
Acoustic release deck unit	5kg	0.5 m2	Operations Room
Pigment filtration system and FIRE	25 kg	1 m2	Underway Seawater Lab
FLBB sensor	10 kg	1 m2	CTD room
POC particle filtration system	5 kg	1 m bench space	Clean Dry lab
Aerosol sampling	20 kg	1 m2	Aerosol lab
Precipitation (Rain) Sampler	10 kg	1 m3	to be installed on 05 level outside of bridge equipment room (no power required)
Hydraulic High Pressure Unit (HPU)	850kg	approx 120W x 100D x 140H (cm)	Sheltered workshop
2 x Air Spoolers	300kg	approx 120W x 120D x 100H (cm)	Main deck secured to half height
Tool Rack	500kg	approx 150W x 80D x 200H (cm)	Sheltered workshop secured to HPU

Appendix C

Hazardous Materials Manifest

RV INVESTIGATOR **HAZARDOUS MATERIALS MANIFEST**

Voyage Number	IN2022_V03	Chief Scientist	Dr. Elizabeth Shadwick	Elizabeth Shadwick

Responsible Person	Email	Hazardous Material Name	Risk Rating Colour Code	Hazardous Material UN Number	Poison Schedule Number	Permit held for Hazardous Material (relevant for Schedule 2,3,4,7,8,9 substances)	State or Territory in which Permit is held	Class	2nd Class (if applicable)	Concentration	Quantity: Total	Quantity: Units	Container Size (max 20L/kg for any single item)	Location of Use	Location of Storage (if different from Location of Use)	Method of Control (required by Handler)	Method of Use (Specify general use of Hazardous Material i.e. how the material will be controlled)	Method of Disposal (Specify how the material will be disposed of during and post voyage)	Notes / Documentation
e.g. John Smith	jsmith@example.com	Formaldehyde	Select from drop down *Risk rating must be populated in accordance with SDS	2209	drop down list	drop down list	TAS etc.	drop down list	drop down list	37%	500 1 5	mL Cylinder L	100mL plastic G 1L container	drop down list	drop down list	drop down list	drop down list	drop down list	Add any further documentation required or other relevant information
Elizabeth Shadwick	elizabeth.shadwick@csiro.au	mercuric chloride saturated solution	High	1624	57	Yes	Tasmania	Class 6 - Toxic		7%	100	mL	50mL (Plastic)	GP Wet Laboratory - Clean	GP Dry Laboratory - Clean	Safe Work Instruction	Wear PPE (goggles and gloves); Follow SWI. Store in HAZMAT Class 6 locker against aft wall of GP Wet Lab - Clean	Other - specify in notes	Neurotoxin, added to DIC/4lt seawater samples and taxonomy samples. Stored in GP wet clean lab poisons cabinet for use in CTD room, transferred to shore for disposal. POC filtration SWI provided.
Elizabeth Shadwick	elizabeth.shadwick@csiro.au	mercuric chloride seawater brine	Medium	1624	57	N/A	N/A	Class 6 - Toxic		0.3%	20	L	250ml bottles	Other (specify in notes)	GP Wet Laboratory - Clean	Safe Work Instruction	Preservation of... (specify in notes)	Other - specify in notes	Neurotoxin, added to sediment trap cups on back deck, cups stored in walk-in cool store, transferred to shore for disposal. SAZ cup handling SWI provided.
Elizabeth Shadwick	elizabeth.shadwick@csiro.au	Ethanol	Low	1170	N/A	No	N/A	Class 3 - Flammable Liquid		99%	400	mL	2x250mL (plastic)	Container: Other (specify in notes)	Container: Other (specify in notes)	Low Risk Material	Other - specify in notes	Other - specify in notes	Used with wipes (Kimtech) to clean bio-optical sensor windows, disposal by evaporation
Elizabeth Shadwick	elizabeth.shadwick@csiro.au	Ethanol	Low	1170	N/A	No	N/A	Class 3 - Flammable Liquid		99%	400	mL	0.5 litre bottle (plastic)	Underway Seawater Laboratory	Underway Seawater Laboratory	Low Risk Material	Other - specify in notes	Other - specify in notes	Used with wipes (Kimtech) to clean optical instrumentation, disposal by evaporation
Pete Jansen	peter.jansen@csiro.au	Partially depleted lithium batteries	Low	3480	N/A	No	N/A	Class 4 - Flammable Solids		n/a	24	AA batteries	50mm long 6mm diameter, stored in plastic tub	GP Wet Laboratory - Dirty	Container: Other (specify in notes)	Other (specify in notes)	Other - specify in notes	Other - specify in notes	Recovered from sea and returned to port.
Pete Jansen	peter.jansen@csiro.au	Triton X 100	Medium	3082	N/A	No	N/A	Other - specify in notes		100%	20	mL	25mL(plastic)	Container: Other (specify in notes)	Container: Other (specify in notes)	Low Risk Material	Other - specify in notes	Other - specify in notes	Sensor cleaning, all waste collected and returned to shore, environmental hazard, class 9
Elizabeth Shadwick	elizabeth.shadwick@csiro.au	mercuric chloride saturated aqueous solution	High	1624	57	Yes	Tasmania	Class 6 - Toxic		100%	100	mL	50mL (plastic)	Underway Seawater Laboratory	GP Wet Laboratory - Clean	Safe Work Instruction	Wear PPE (goggles and gloves); Follow SWI. Store in HAZMAT Class 6 locker against aft wall of GP Wet Lab - Clean	Other - specify in notes	Read MSDS and follow Safe Working Instruction; Wear PPE (goggles and gloves); Keep mercuric chloride bottle in its mount in retention tray at all times; transfer only the small volume needed for each seawater sample each time with the pipette. Poisoned seawater samples are NOT dangerous goods - ship to Hobart.
Tim Lane	tim.lane@csiro.au	Hydraulic Oil	Low	N/A	N/A	N/A	N/A	N/A		100%	100	L	Integrated storage	Main Deck	Main Deck	Low Risk Material	Other - specify in notes	Other - specify in notes	Oil contained in header tank of hydraulic Power Unit. Any spills dealt with using standard spill kit. Need to retain waste in carboys to dispose of onshore. Autoignition temp ~250C, non hazardous and non DG.
Meyerink	scott.meyerink@utas.edu.au	Hydrochloric Acid	High	1789	N/A	No		Class 8 - Corrosives		100%	500	mL	500 mL Teflon Container	CTD Laboratory	CTD Laboratory	Safe Work Instruction	Preservation of samples (specified in notes)	Neuatralisation	Safe Work Instruction
Meyerink	scott.meyerink@utas.edu.au	Hydrochloric Acid (BM)	High	1789	N/A	No		Class 8 - Corrosives		50%	2500	mL	2500 mL LDPE container	CTD Laboratory	CTD Laboratory	Safe Work Instruction	Preservation of samples (specified in notes)	Neuatralisation	Safe Work Instruction
Alain Protat	alain.protat@bom.gov.au	Helium (party balloon gas)	Low	124	N/A	N/A	N/A	Class 2.2 - Compressed Gas: Non-flammable		0.9	21	Cylinders	G size bottles (9.1m3)	Main Deck	Main Deck	Safe Work Instruction	Other - specify in notes	Other - specify in notes	Will be used to inflate meteorological balloons. Empty Helium bottles will be sent back to provider (BOC) at completion of the voyage
Craig Hanstein	craig.hanstein@csiro.au	Lithium Metal Batteries	Low	3091	N/A	N/A	N/A	Class 4 - Flammable Solids		5%	0.125	kg	ARGO Float	Main Deck	GP Wet Laboratory - Dirty	Safe Work Instruction	Other - specify in notes	Other - specify in notes	Lithium Batteries Contained inside equipment
Craig Hanstein	craig.hanstein@csiro.au	Bis(tributyltin) oxide - "TBT"	Low	2788	N/A	N/A	N/A	Other - specify in notes					ARGO Float	Inside of ARGO Float	Inside of ARGO Float	Safe Work Instruction	Other - specify in notes	Other - specify in notes	For use only in Sea-Bird Electonics conductivity sensors to control growth of aquatic organisms within sensors. Can only be harmful if ARGO is dismantled and anti-foulant is swallowed.
Ben Scoulding	ben.scoulding@csiro.au	Ethanol - preservation	Low	1170	N/A	No	N/A	Class 3 - Flammable Liquid		99%	10	L	10 L plastic	GP Wet Laboratory - Dirty	GP Wet Laboratory - Dirty	Safe Work Instruction	Preservation of... (specify in notes)	Other - specify in notes	Used to preserve micronekton samples - any unsed ethanol be taken ashore after the voyage
Ben Scoulding	ben.scoulding@csiro.au	Formaline	Low	2209	N/A	No	N/A	Class 8 - Corrosives		37%	5	L	5 L plastic	GP Wet Laboratory - Dirty	GP Wet Laboratory - Dirty	Safe Work Instruction	Preservation of... (specify in notes)	Other - specify in notes	Used for sample/specimen fixation - any used formalin will be returned to shore after the voyage