RV *Investigator* Voyage Plan

VOYAGE #:	IN2023_V03		
Version Number:	Final		
Voyage title:	**SOTS: Southern Ocean Time Series automated moorings for climate and carbon cycle studies southwest of Tasmania**		
Mobilisation:	Hobart, Saturday 6 May – Tuesday 9 May 2023		
Pre-medical clearance period:	Hobart, Wednesday 10 May – Thursday 11 May 2023		
Depart:	Hobart, Friday 12 May 2023		
Return:	Hobart, Thursday 25 May 2023		
Demobilisation:	Hobart, Friday 26 May 2023		
Voyage Delivery Coordinator:	Margot Hind	**Contact:**	margot.hind@csiro.au
Voyage Manager:	Margot Hind	**Contact details:**	margot.hind@csiro.au
Chief Scientist:	Elizabeth Shadwick		
Affiliation:	CSIRO/IMOS	**Contact details:**	Elizabeth.Shadwick@csiro.au
Piggyback Projects			
Principal Investigators:	Alain Protat (Bureau of Meteorology), Jay Mace (Univesity of Utah), and Jessie Creamean (Colorado State Univesity).		
Project name:	Cloud Aerosol Precipitation Radiation Interactions eXperiment (CAPRIX)		
Affiliation:	Bureau of Meteorology	**Contact details:**	Alain.protat@bom.gov.au
Principal Investigators:	Ben Scoulding		
Project name:	Ecological and carbon sequestration role of mesopelagic organisms in the Southern Ocean		
Affiliation:	CSIRO	**Contact details:**	Ben.scoulding@csiro.au
Principal Investigators:	Katherina Petrou		
Project name:	Adding the Sub-Antarctic to an oceanic latitudinal study of diatom silica production rates		

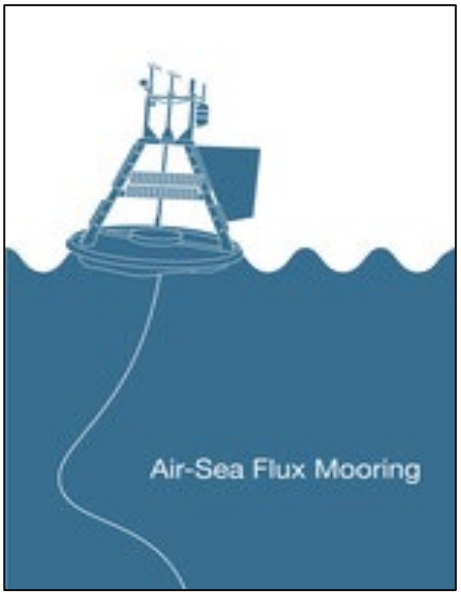
Affiliation:	University of Technology Sydney	**Contact details:**	Katherina.petrou@uts.edu.au
Principal Investigators:	Philippe Vandenbossche		
Project name:	Evolution of the Seafloor of the Australian-Antarctic Southern Ocean		
Affiliation:	University of Tasmania	**Contact details:**	Phil.vandenbossche@csiro.au

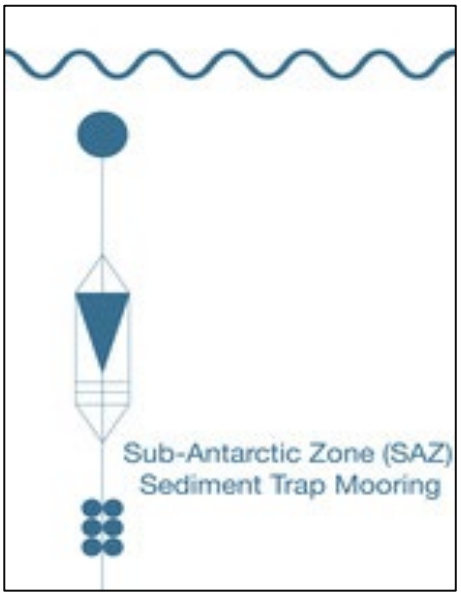
Voyage objectives

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





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 sub-facility uses a set of two automated moorings to measure these 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 objective is to first deploy a new set of SOTS moorings (SOFS-12 and SAZ-25) and then recover the existing SOTS moorings (SOFS-11 and SAZ-24). Each of the SOTS moorings delivers to specific aspects of the atmosphere-ocean exchanges:

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

Ancillary work will obtain supporting information on atmospheric and oceanographic conditions using CTD casts, underway measurements, Continuous Plankton Recorder and autonomous glider, and potentially casts of a bio-optical sensor package.

Voyage objectives

1. Deploy SOFS-12 meteorology/biogeochemistry mooring
2. Deploy SAZ-25 sediment trap mooring
3. Recover SOFS-11 meteorology/biogeochemistry mooring
4. Recover SAZ-24 sediment trap mooring

5. CTD sampling (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. Deployment of CSIRO glider for satellite calibration validation during the SWOT fast sampling phase, in support of IN2023_V07.
8. Potential recovery of BGC-Argo float, or CSIRO glider, using new recovery device
9. Tow CPR on transit to SOTS (after the seamount survey)
10. 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-12 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), followed by secondary voyage priorities (6-10).

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.

Voyage Risk Assessment

The MNF, in consultation with the science party and other relevant stakeholders, will develop a comprehensive Voyage Risk Assessment (VRA) to ensure voyage risks are identified and appropriately controlled.
The MNF will arrange a meeting to undertake this risk assessment process.
This voyage has undergone a comprehensive risk assessment process. The full VRA is at Appendix C.

Media Activities

CSIRO may seek to pursue opportunities that arise during the voyage to promote the science, scientists and ship, via conventional and social media channels. This would be undertaken in consultation and/or collaboration with the relevant voyage partner/s.

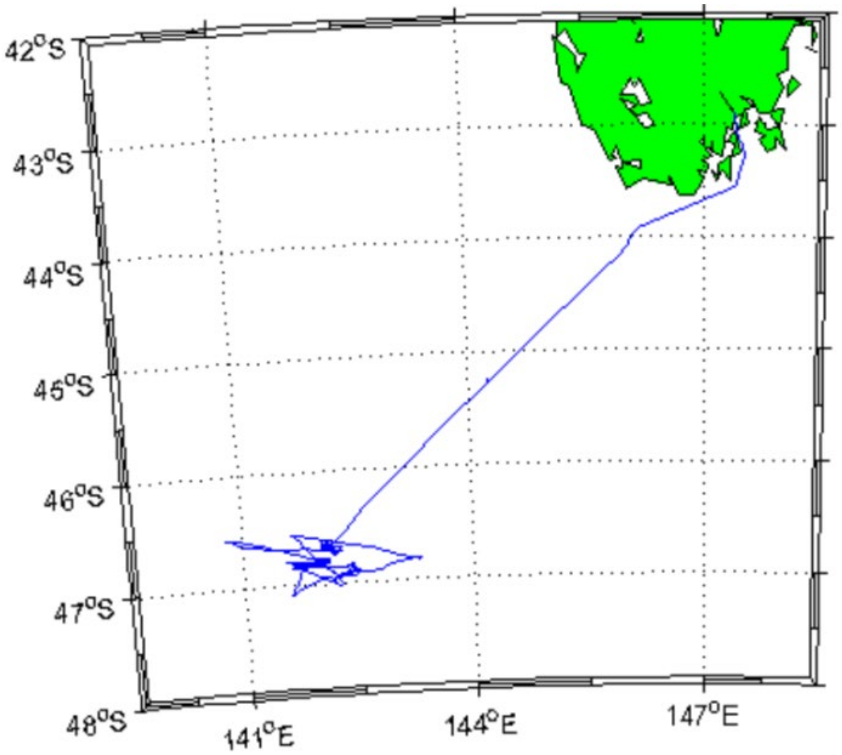
ORGANISATION	ACTIVITIES	RESPONSIBLE PERSON
CSIRO/IMOS	Refer to Voyage Communication Plan	Carla Howarth, CSIRO

Overall Activity Plan First 24hrs of Voyage

Plan of activities for the first 24 hours at sea. This may be weather dependent. If so, please indicate an alternative. This plan will allow the vessel crew to ready gear and personnel for the activities.

Day	Date	Time	Activity
Wed	10 May	All day	Pre-voyage medical clearance period onboard
Wed	10 May	1000	VM briefing 2/2 @ Aft Lounge
Wed	10 May	1030	Seagoing inductions for those >6 months since onboard @ Aft Lounge
Wed	10 May	1400	Muster drill @ 02 Deck – All participants wearing hard hat, closed shoes and PFD
Wed	10 May	1600	Voyage Management Team Meeting @ Bridge
Wed	10 May	0830 – 2000	Pre-spooling of moorings line and winches, mooring anchor dual lift
Thu	11 May	All day	Pre-voyage medical clearance period onboard
Thu	11 May	All day	Depart for bunkering @ Selfs Point – Return to PW04
Fri	12 May	0800	Depart PW04 (dependant on medical clearance results)
Fri	12 May	1000	In Adventure or Storm Bay, toolbox talk planning, testing of recovery device
Fri	12 May	1230 - 1300	Outbound: Calibrate backscatter of EM710 on GSM Line #2 @8kts
Fri	12 May	1300	Begin transit to the SOTS site with slight detour to Patience Seamount (147.38466, -44.1243)
Fri	12 May	1600	Perform Test CTD as soon as seawater is 1000m deep
Fri	12 May	1600	Launch balloon during CTD – glider testing and potential deployment

Voyage Track



Waypoints and stations

	Decimal Latitude	Decimal Longitude	Distance (nm)	Total Distance (nm)	Steaming time (hrs)	Total Steam (hrs)
Hobart	42.87	147.35				
Storm Bay	43.33	147.350	28	28	2.5	2.5
SOTS (nominal)	46.80	142	311	340	28	48
Hobart	42.87	147.35	352	749	32	68

Locations of moorings to be recovered

Mooring	Latitude	Longitude	Depth
SOFS-11	-46.96492	141.35117	4668m
SAZ-24	-46.80848	141.83198	4665m

Target locations for mooring deployments

Mooring	Latitude	Longitude	Depth
SOFS-12	-47.1697	141.2473	4270m
SAZ-25	-46.830	141.6496	4550m

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:	6
• Likely maximum depth of deepest cast:	4550
• Lowered ADCP required:	no
Instrumentation (maximum 6 auxiliary channels in addition to 2x DO):	
• Ian2x 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):	Yes
• Fluorometer – Chlorophyll-a (Chelsea Aquatracka III – 430/685nm):	Yes
• Fluorometer – CDOM (Wetlabs FLCDOM – 370/460nm)	
• Nephelometer (Seapoint Turbidity Meter)	
Hydrochemistry Analyses:	
• Salinity	144
• Dissolved Oxygen	144
• Nutrients: Nitrate	144
• Nutrients: Phosphate	144
• Nutrients: Silicate	144
• Nutrients: Nitrite	144
• Nutrients: Ammonia (special request after discussion with hydrochemistry)	

Activity Plan and 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 #1: MNF Hydrochemistry test CTD to 1000 m as noted above to be included in the Time Estimates table below.

Note #2: MNF GSM calibration lines of Storm Bay (outgoing and incoming) as noted above to be included in the Time Estimates table below.

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

Date	Month	Activity
Fri 12	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, recovery device 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 1600 – Launch Balloon during CTD
Sat 13	May	Transit to SOTS (via Patience Seamount) and underway sensor observations. Hold Mooring Procedures Familiarization Meeting with Science Party, Master, Mates and Crew. Potential deployment of CSIRO glider on the transit to the SOTS site.
Sun 14	May	1000: Arrive SOTS site (dependant on weather conditions, and acoustic survey timing) 1000: Launch Balloon during CTD (at convenient time during that period) 1000-1300: SOTS CTD cast to 600m (pre-deployment calibration of SOFS-12 sensors) 1300-1800: Ship-buoy comparison at SOFS-11 and inspection of the SOFS-11 float 1300 – 1800: Launch Balloon (at convenient time during that period) 1630-1700: SOFS-12 Deployment Meeting 1800-2200: Ship drift assessment at SOFS-12 site 2200: Launch Balloon (at convenient time during that period) 21
Mon 15	May	0400-0600 Reposition ship to SOFS-12 deployment start (~19.5 miles down-weather) 0645 SOTS: Toolbox on Bridge for SOFS-12 mooring deployment 0600-2000 SOTS: Deploy SOFS-12 mooring 2000-2400 SOTS: Triangulate SOFS-12 anchor, collect ship sensor observations close to SOFS-12 Launch 4 balloons at convenient times between 0600 and 2300
Tue 16	May	0000 – 0400: Hydrochemistry deep CTD cast (4000m)/ CTD wire calibration 0400-0800: Multi-nets #1 Rest/Spooling Day: Collect ship sensor observations close to SOFS-12 0800-1200: CTD Cast to 4550m (pre-deployment calibration of SAZ-25 sensors, SOTS sampling #1) 1000-1500: Spool on SAZ-25 Launch 4 balloons at convenient times between 0600 and 2300 1900-2100: Multi-net #2
Wed 17	May	0400-0600 SOTS: Transit to SAZ-25 deployment start (15 miles down-weather from target) 0645 SOTS: Toolbox on Bridge for SAZ-25 mooring deployment 0600-1500 SOTS: Deploy SAZ-25 mooring 1500-1800 SOTS: Triangulate SAZ-25 anchor location Launch 4 balloons at convenient times between 0600 and 2300 2000-2400 SOTS: Hydrochemistry Deep Cast (4000 m) or Calibration Lab Cast (1200m)
Thu 18	May	0100-0300: Multi-net #3

Date	Month	Activity
		0400-0600 Transit to SAZ-24 recovery site (1 mile down-weather from anchor location) 0645 Toolbox on Bridge for SAZ-24 mooring recovery 0600-1800 Recover SAZ-24 mooring Launch 3-4 balloons at convenient times between 0600 and 2300
Fri 19	May	0600-0800 SOTS: Transit to SOFS-11 site 0800-1800 SOTS: Spool off SAZ-24 mooring – deck ops only 0800-1000: (daytime) Multi-net #4 1000-1200 SOTS: Ship-buoy met comparison at SOFS-11 1200-1600 SOTS: CTD cast to 4000m (SOTS sampling #2) 1600-2400 SOTS: Ship-buoy met comparison at SOFS-11 Launch 4 balloons at convenient times between 0600 and 2300
Sat 20	May	0100-0300: Multi-net #5 0400-0600 SOTS: Transit to SOFS-11 recovery site (1 mile down-weather from anchor location) 0645 SOTS: Toolbox on Bridge for SOFS-11 mooring recovery, dummy float deployment 0600-2000: Recover SOFS-11, deploy dummy float 2200-2400: CTD cast to 600 m (post-recovery calibration of SOFS-11 and SAZ-24 sensors) Launch 4 balloons at convenient times between 0600 and 2300
Sat 21	May	Bad weather allowance – potential recovery of BGC-Argo float or CSIRO glider
Sun 22	May	Bad weather allowance - potential recovery of BGC-Argo float or CSIRO glider
Mon 23	May	Bad weather allowance - potential recovery of BGC-Argo float or CSIRO glider
Tue 24	May	Inbound: Calibrate backscatter of EM710 on GSM Line #3 @8kts Transit to Hobart towing magnetometer
Wed 25	May	Arrive Hobart, Demobilisation

Piggyback projects

Give title, Principal Investigator, scientific and voyage objectives, and explain how the piggy-back project fits into the time estimates.

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

Principal Investigator: Dr. Alain Protat – BoM and Dr. Jay Mace – Uni of Utah and Dr. Jessie Creamean – Colorado State University

Voyage Objectives (CAPRIX)

Currently there are errors in model predictions 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, IN2022_V03) indicate that distinct shortwave radiation biases exist north or south of about 55°S latitude in climate models.

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 in the equipment manifest, requiring coordination and installation during the mobilisation period. 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 and Sampling Strategy (CAPRIX)

The priority is to collect a suite of aerosol, ice nucleating particle (INP) concentration, cloud, surface radiation, and precipitation observations combined with the basic atmospheric state as measured by radiosonde launches from meteorological balloons every 4-6 hours within the seasonally transitioning open ocean waters during mid Autumn in the Subantarctic zone. We are expecting to launch 30 to 40 radiosondes over the duration of the experiment. These new datasets will be combined with the existing ones collected in 2016, 2018, and 2022 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.

#2. Adding the Sub-Antarctic to an oceanic latitudinal study of diatom silica production rates.

Principal Investigator: Katherina Petrou

Voyage Objectives

Diatoms are a key group of marine phytoplankton, responsible for 40% of ocean productivity. Their unique silica-based cell walls aid their export to the deep ocean making them an important link in marine silicon and carbon cycles. Changes in temperature are known to alter diatom silica production, yet, much of our understanding of the impacts of warming on diatoms comes from short-term laboratory studies that exclude long-term adaptive traits and inter-species interactions. For this reason, a significant knowledge-gap exists on actual rates and responses of individual diatoms and their communities adapted to their ecological niches. To improve the quality and accuracy of our understanding of ocean processes, better estimates of *in situ* silica production from thermally distinct regions are necessary.

The primary goal of this project is to obtain species-specific estimates of silica production within mixed natural phytoplankton communities from distinct latitudinal regions of the ocean to better understand rates

of silica production as a function of community composition and temperature. By obtaining upper and lower rates for communities and individual species within the community, we can start to gain a clearer and more precise picture of the ecological and biogeochemical role of diatoms in Australian waters. Therefore, there are two specific aims of this project:

1) To determine bulk rates of silicification in phytoplankton communities from latitudinally distinct bioregions (from tropics to sub-polar).

2) To evaluate species-specific silicification to identify the heavy weights in the community.

To date, data has been collected from the all four east coast NRS sites (Yongala, North Stradbroke Island, Port Hacking, and Maria Island. By including the SOTS site in our study, we can extend our latitudinal gradient to 47°S and thus temperature range from 6-30°C to include the Sub-Antarctic, which would provide invaluable information to the data set, as diatoms are a key component of cold-water communities and ocean warming will likely start to impact these cooler regions more rapidly. With this information, we can start to build a more complete picture of silicon cycling in regionally distinct oceanographic waters of Australia.

Fit with voyage plan

The time required to complete each silicification incubation study is around 36-48 hours. Ideally, we will obtain water from a CTD cast every few days for a series of incubations. While the ship needs to be stationary during CTD deployment and recovery, apart from this activity no additional stations or stops are required. No deviations from the current cruise plans are requested.

We believe that if we get water from two or three of the planned CTD casts at the SOTS sites (14th, 16th, 19th, 20th May), assuming water allowances can be met, our needs will be met. We would like 20L from surface and chlorophyll maximum from each CTD, with the possibility of obtaining 5 depths (surface down to 200m) for one of the casts (20L from each depth). Other than that, all other protocols and processes will be done on board in the lab, independent of the ship operations.

All other requests: cold lab and dry lab space, fridge and freezer storage have been listed in the application.

#3. Acoustic survey of basket eel on Patience seamount in Huon AMP and ecological and carbon sequestration role of zooplankton in the Southern Ocean

Principle Investigator: Ben Scoulding

We also seek to carry a short acoustic survey of Patience Seamount within the 'Huon' Marine Park (Huon MP) south of Tasmania. The Huon MP has been identified as the only known location of a spawning aggregation of the basketwork eel, *Diastobranchus capensis* – a globally distributed and ecologically important deep-sea species. In the austral autumn, the spawning aggregation is large and likely the regional-scale spatial anchor for the species. As such it represents a key natural value in Australia – one with a hypothesised trajectory of 'improving status' following decades long impact from bottom trawling before the Huon MP was established. The spatial concentration of eels in the aggregation (~2-3 km^2) and their high acoustic reflectivity are highly attractive characteristics that will enable the aggregation to be measured quantitatively with a hydroacoustic sensor (echosounder) and with very little further extractive sampling. As stated by Williams et al., (2021) "Monitoring the aggregation's status, and validating seasonal spawning, provide important opportunities to examine conservation-led recovery in the deep sea as part of Australia's new national strategy of Monitoring, Evaluation, Reporting, and Improvement (MERI) for conservation values within marine parks."

Zooplankton are a key biological component of the worlds' oceans with many making nightly migrations from mesopelagic 200-1000 m depths to the surface epipelagic 0-200m depths. During the cooler months (e.g. May) zooplankton reside at depth and do not undertake vertical migration. 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 are used to determine the taxonomy, size, biomass, trophic linkage, and energetics of zooplankton. The Mammoth net will be used to collect depth stratified data of zooplankton to determine their residence depth at the SOTS site in May.

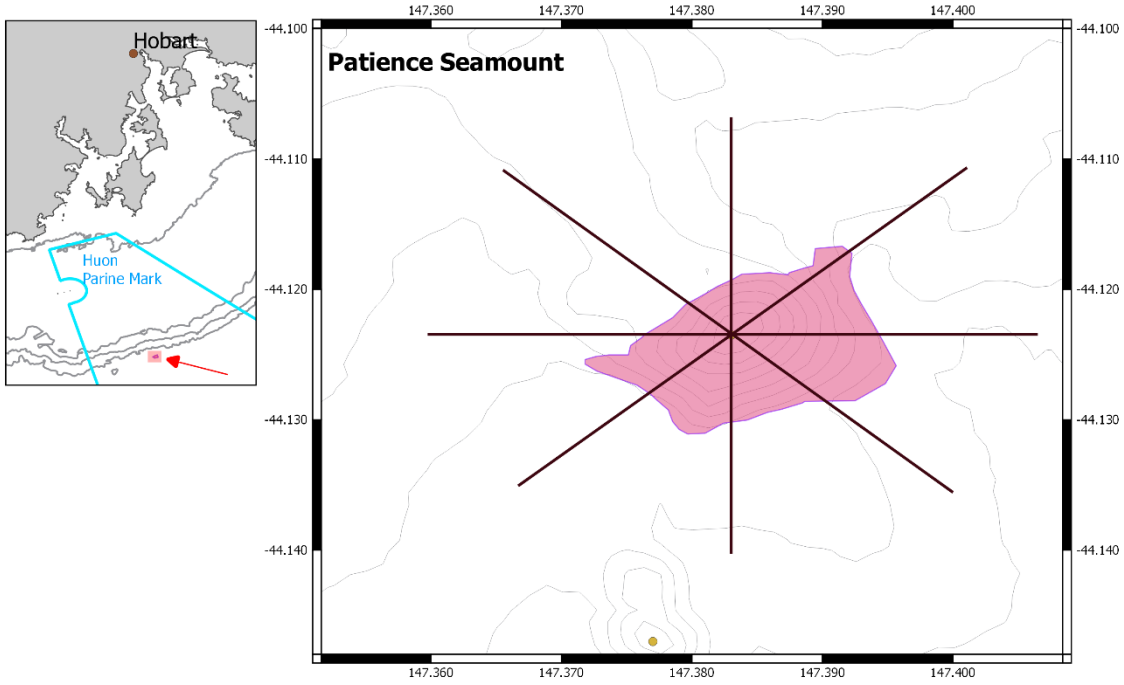


Figure. Proposed survey design for the acoustic survey of patience seamount. Each transect line is ~2 nmi in length.

Table. Start and end coordinates for the four transects of patience seamount shown in the above figure.

Direction	Acc_Line	StartLong	StartLat	EdLong	EndLat
N-S	1	147.383	-44.1069	147.383	-44.1402
SE-NW	2	147.3999	-44.1355	147.3656	-44.1109
W-E	3	147.3599	-44.1235	147.4064	-44.1235
SW-NE	4	147.3668	-44.135	147.401	-44.1107

#4. Evolution of the Seafloor of the Australian-Antarctic Southern Ocean

Principal Investigator: Philippe Vandenbossche

Voyage Objectives

The seafloor in the Southern Ocean records a 100+ million-year history of plate tectonic motions between Australia and Antarctica. Most of what we know about these plate tectonic motions and the formation of the seafloor, comes from satellite gravity data and ship-track magnetic data. However, in the past decade, progressively more multibeam ('swath') bathymetry data has been collected across vast swathes of the Australian Southern Ocean, particularly offshore southwestern Tasmania (in the SOTS – Southern Ocean Time Series region) and to the southwest of Perth (from the search for missing Malaysia Airliner, MH370).

These datasets provide detailed high-resolution information of the seafloor morphology across two areas of a similar age on the Australian plate but formed at opposite ends of the tectonic spreading system. This presents a unique opportunity to study and compare the seafloor at these locations, which will yield valuable new information as to how the seafloor has accreted and been influenced by processes such as plate tectonic motions, settings and reorganisations, mantle plumes, long-wavelength mantle flow as well as mantle geochemistry and temperature. This project therefore aims to provide new research insights into the evolution of the seafloor of the Australian-Antarctic Southern Ocean and East Gondwana region.

There are two primary objectives that will augment existing data in support of this research:

1. Acquire towed magnetometer data between the Tasman Fracture Zone and SOTS site (in an NNE-SSW orientation), as part of the transit to/from SOTS. No physical rock dating is known to exist in the study area and therefore magnetic data will provide valuable indicative ages of the seafloor crust across the region.
2. Acquire multibeam bathymetry data in areas previously unmapped. Areas to target lie to the west and south of the SOTS site. This will extend the seafloor mapping coverage in the region, thereby providing valuable new bathymetry data that will be used to analyse the seafloor morphology and tectonic fabric (and contribute to the International Seabed 2030 project).

Fit with voyage plan

While the magnetometer towing is expected to form part of the transit to and/or from SOTS, there is expected to be a course deviation to achieve this. The priority magnetometer survey line (Magnetometer Line 01) is estimated to add a transit deviation of 174 Km (or 94 NM), thus ~9.4 hours (at 10 knots). Multibeam mapping is divided into areas and can be targeted for periods when time allows, and the anticipated mapping timeframes have been listed in the application.

Waypoint/Line Name	**Latitude (Decimal Degree)**	**Longitude (Decimal Degree)**	**Latitude (Degree Decimal Minute)**	**Longitude (Degree Decimal Minute)**
Mag Line 01 – Start	-45.39791	144.666996	45°23.8746'S	144°40.01978'E
Mag Line 01 – End	-47.29856	143.783051	47°17.91342'S	143°46.98306'E
Mag Line 02 – Start	-45.65601	142.55337	45°39.36048'S	142°33.2022'E
Mag Line 02 – End	-47.09931	141.705067	47°59.5884'S	141°42.30402'E
BathyInfill Line01 – Start	-47.43501	142.665488	47°26.10072'S	142°39.92928'E
BathyInfill Line01 – End	-47.99798	141.944514	47°59.87862'S	141°56.67084'E

BathyInfill Line02 – Start	-47.39331	142.503835	47°23.59872’S	142°30.2301’E
BathyInfill Line02 – End	-47.99798	141.740831	47°59.87862’S	141°44.44986’E
BathyInfill Line03 – Start	-47.22287	141.873386	47°13.37232’S	141°52.40316’E
BathyInfill Line03 – End	-48.00123	141.267186	48°07.398’S	141°16.03116’E
BathyInfill Line04 – Start	-47.22067	141.742447	47°13.24014’S	141°44.54682’E
BathyInfill Line04 – End	-48.00015	141.147562	48°08.82’S	141°8.85372’E
BathyInfill Line05 – Start	-47.17439	141.13463	47°10.46334’S	141°08.0778’E
BathyInfill Line05 – End	-48.00123	140.504181	48°07.398’S	140°30.25086’E
BathyInfill Line06 – Start	-47.07398	141.019856	47°44.385’S	141°11.9136’E
BathyInfill Line06 – End	-48.00015	140.306964	48°08.82’S	140°18.41784’E
BathyInfill Line07 – Start	-46.74048	141.045721	46°44.42856’S	141°27.4326’E
BathyInfill Line07 – End	-48.00123	140.104897	48°07.398’S	140°06.29382’E
BathyInfill Line08 – Start	-46.38587	141.108765	46°23.15238’S	141°06.5259’E
BathyInfill Line08 – End	-48.00123	139.894748	48°07.398’S	139°53.68488’E
BathyInfill Line09 – Start	-46.31983	140.905082	46°19.1895’S	140°54.30492’E
BathyInfill Line09 – End	-47.84149	139.810688	47°50.48916’S	139°48.64128’E
BathyInfill Line10 – Start	-46.32319	140.673918	46°19.39116’S	140°40.43508’E
BathyInfill Line10 – End	-47.58399	139.809071	47°35.0391’S	139°48.54426’E
BathyInfill Line11 – Start	-46.3131	140.433054	46°18.78624’S	140°25.98324’E
BathyInfill Line11 – End	-47.27681	139.810688	47°16.60878’S	139°48.64128’E
BathyInfill Line12 - Start	-46.32095	140.248769	46°19.2567'S	140°14.92614'E

Permits

MNF

Australian Marine Park permit **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.

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

Other

- AAPP permit for import of samples – nPermit 0005254494

Signature

Your name	Elizabeth Shadwick
Title	Chief Scientist
Signature	
Date:	5 May 2023

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

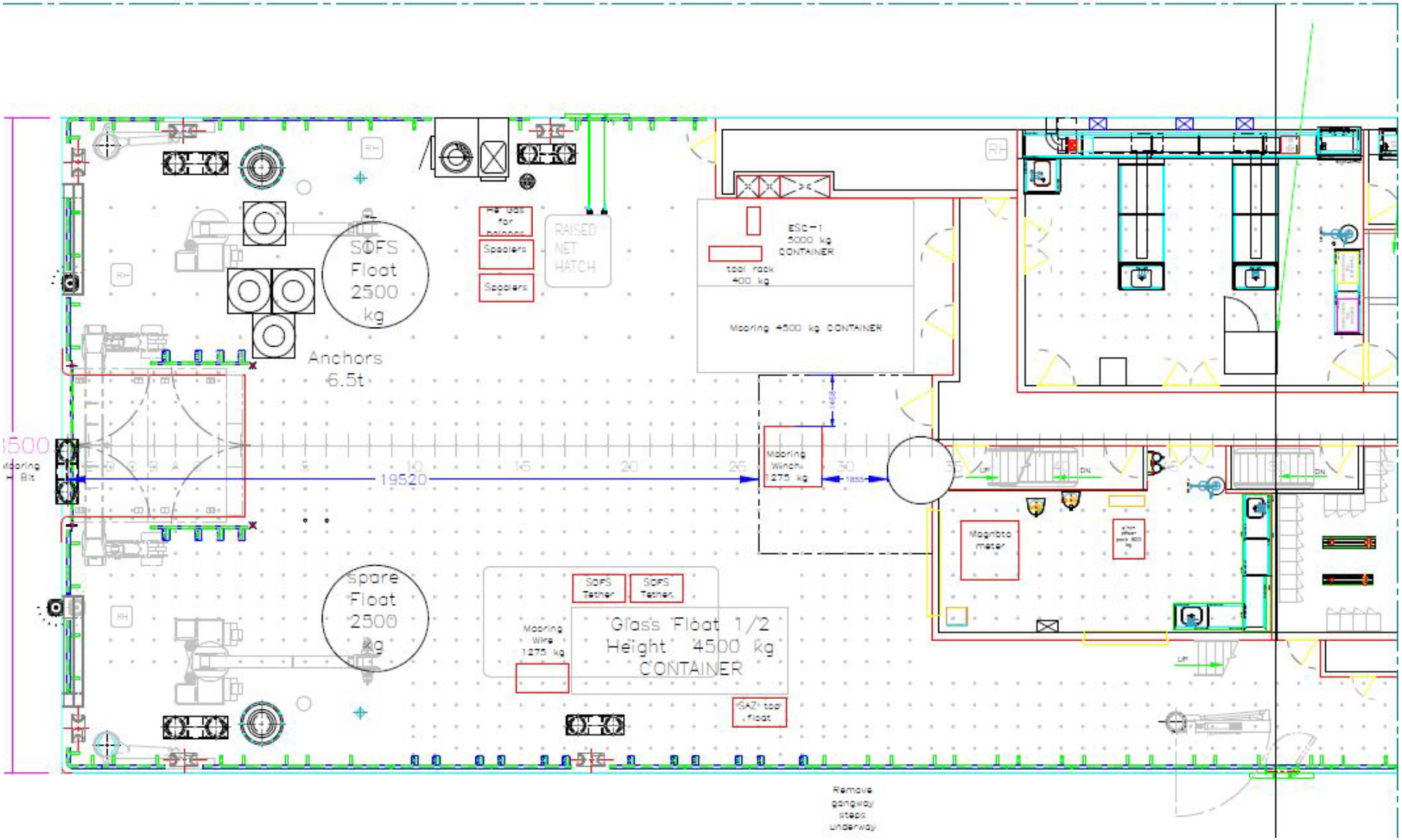
Attachment 5: Mooring Deployment Procedures (available separately)

Appendix A: MNF Equipment

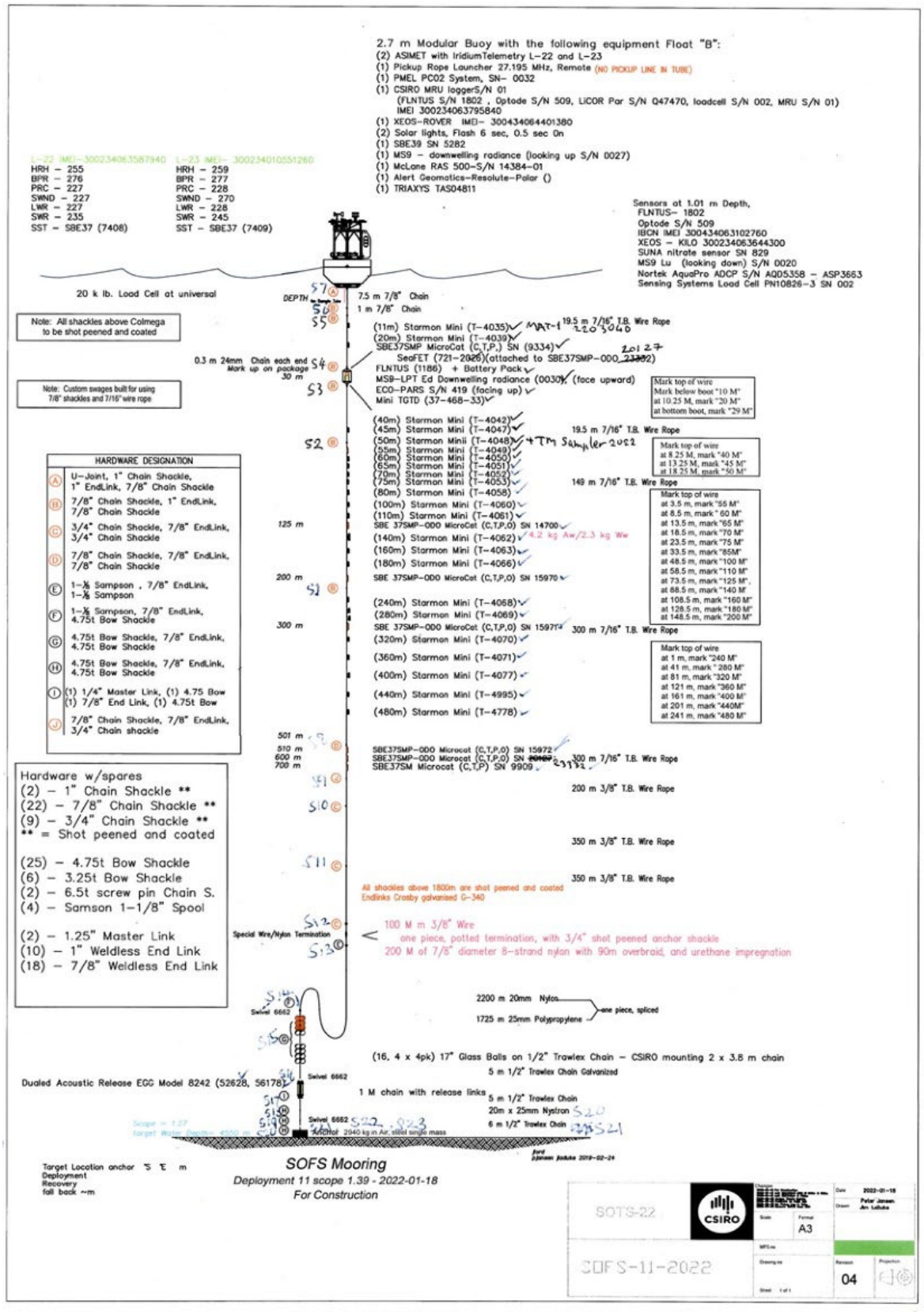
Appendix B: User Supplied Equipment

Appendix C: Hazardous Materials Manifest

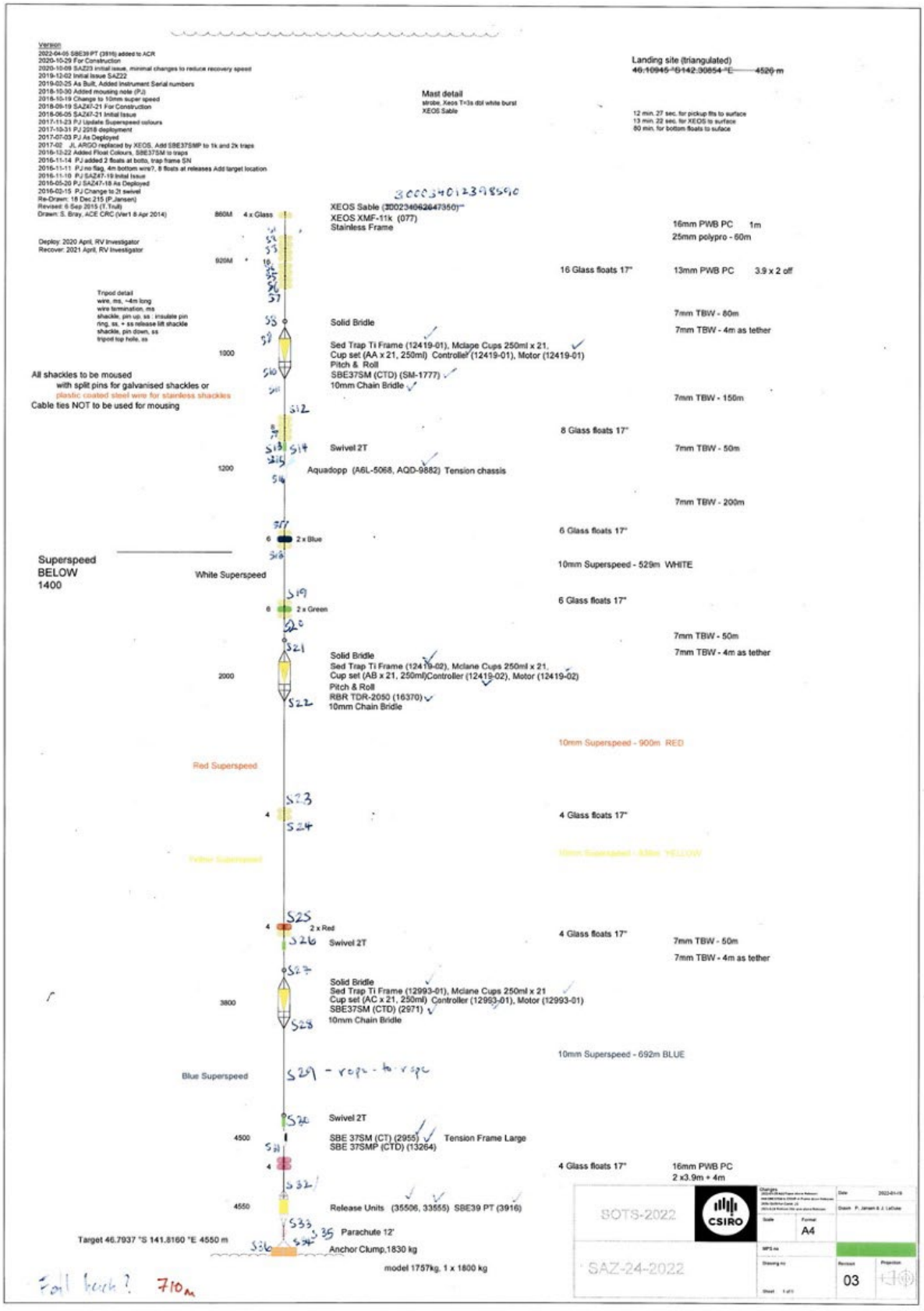
Attachment 1 – Deck plan



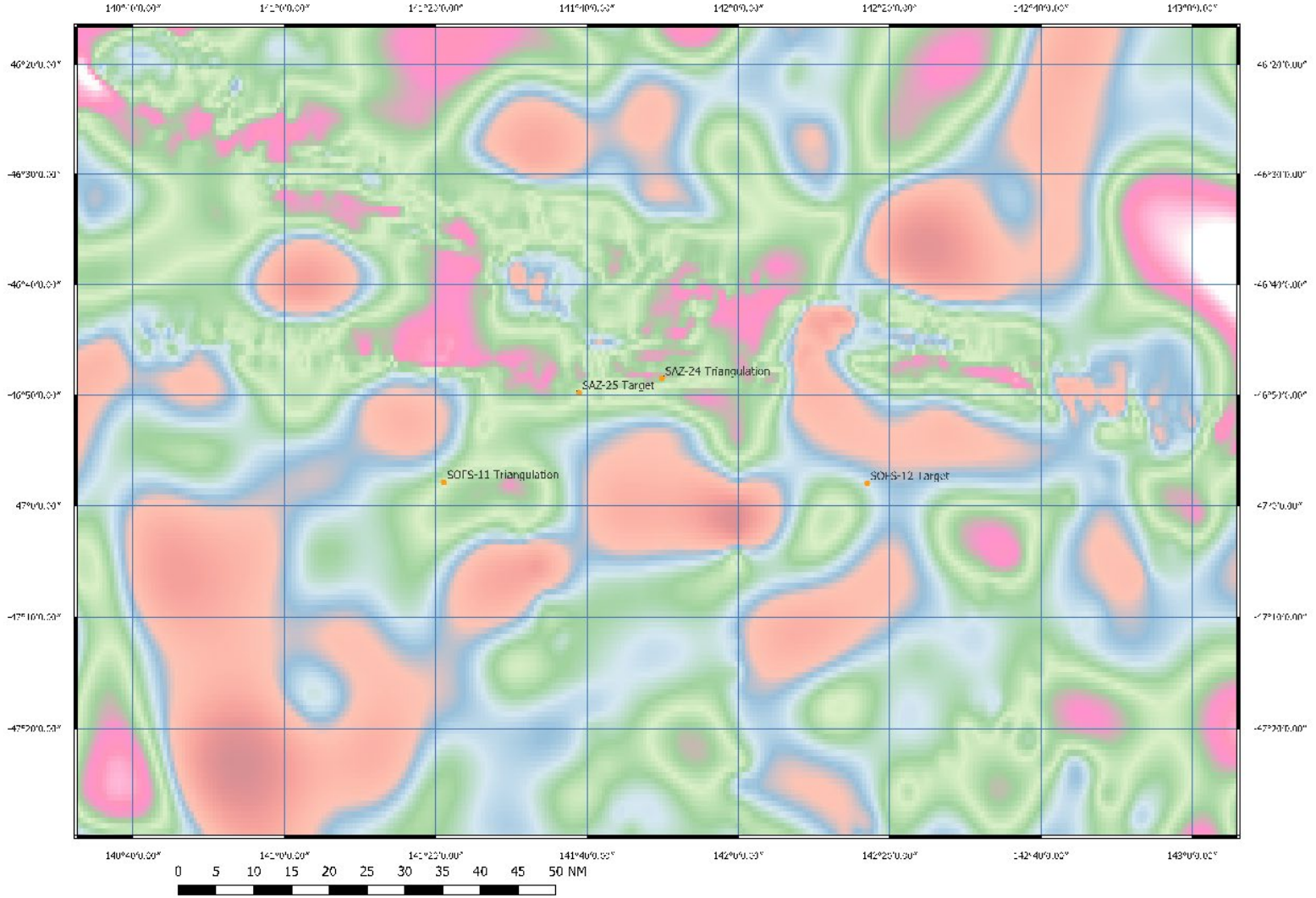
Attachment 2



Attachment 3



Attachment 4



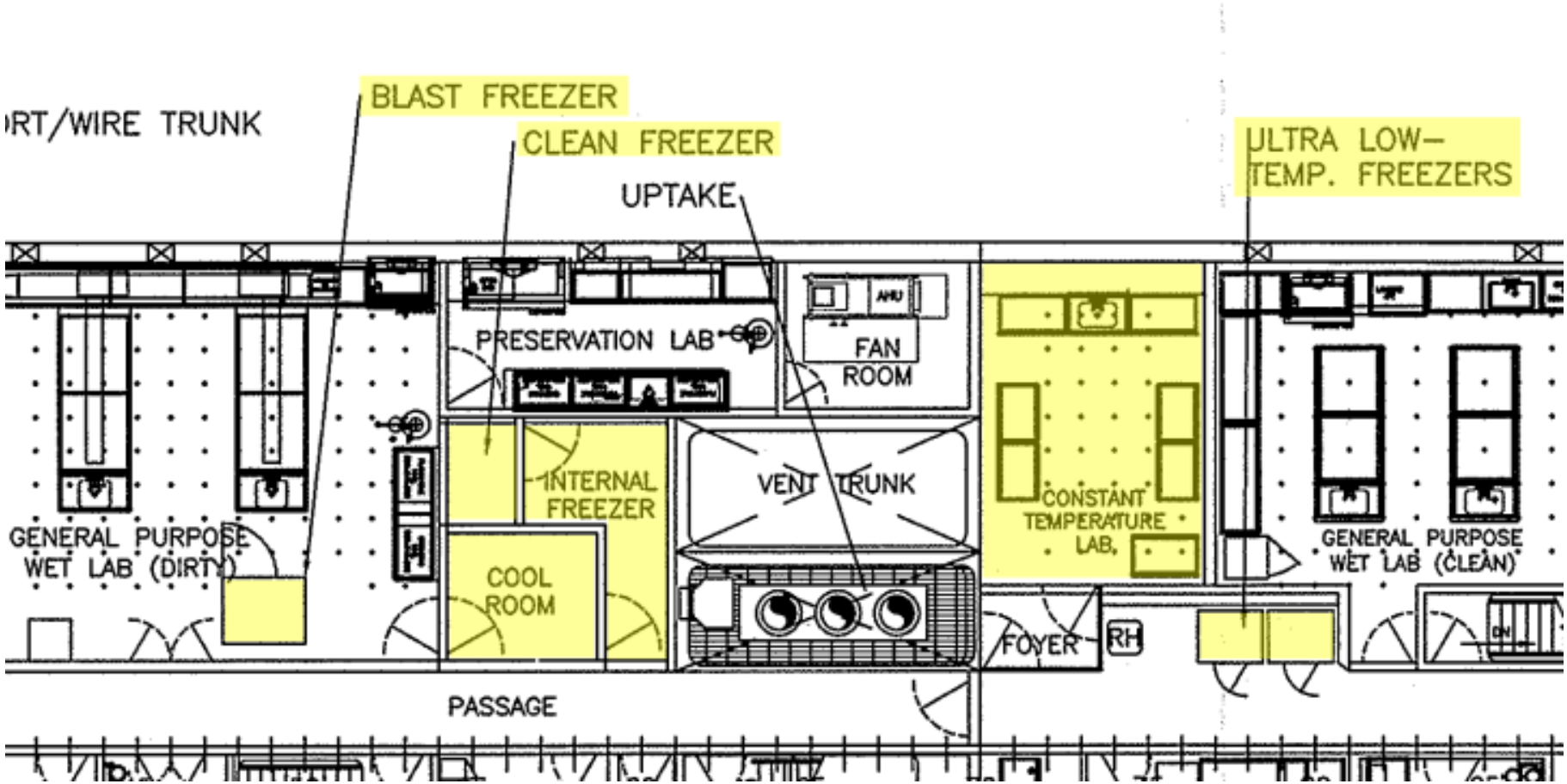
Appendix A

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.

STANDARD LABORATORIES AND FACILITIES		
NAME	**REQUIRED**	**NOTES/COMMENTS**
Aerosol Sampling Lab		
Air Chemistry Lab	X	• CAPRIX laptops to monitor instruments (x3)
Preservation Lab	X	• Petrou Piggyback
Constant Temperature Lab (Min temp: ~4°C / Max temp ~35°C)	X	Petrou Piggyback – please set to in situ water temperature at SOTS (4-6 ° C)
Underway Seawater Analysis Laboratory		
GP Wet Lab (Dirty)		
GP Wet Lab (Clean)		
GP Dry Lab (Clean)	X	• Petrou Piggyback
Sheltered Science Area		
Observation Deck 07 Level		
Internal Freezer (Dirty Wet lab) (Min temp -25°C / Max temp 0°C) Volume: >20m^3		
Clean Freezer (Dirty Wet lab) (Min temp -25°C / Max temp 0°C) Volume: >2.5m^3 Co-located within the Internal freezer and separated by a door		

STANDARD LABORATORIES AND FACILITIES		
NAME	**REQUIRED**	**NOTES/COMMENTS**
Blast Freezer (Dirty Wet lab) (Min temp -30°C / Max temp 0°C) Internal volume >1.5m^3 Capable of reducing the temperature of 150kg of water from +20C to -30C in one hour.	X	• Petrou Piggyback • Please indicate the required setpoint temperature • Please set to minimum temperature –30C
Cool Room (Dirty Wet lab) (Min temp 0°C / Max temp 10°C)		
Ultra-Low Temperature Freezers x2 (Main Deck) Min temp -80°C / Max temp -80°C)	X	• Petrou Piggyback
YODA Freezers (x2) (Clean Dry lab) (Min temp -20°C / Max temp 10°C)		



MOBILE LABORATORY AND FACILITIES *(MAY REQUIRE ADDITIONAL SUPPORT)*			
NAME	**ESSENTIAL**	**DESIRABLE**	**NOTES/COMMENTS**
Modular Isotope Laboratory			If nominated, additional processes to be completed.
Trace Metal Niskin Sampling Container (TM1-blue - 20ft)			• Used for the determination of trace metal concentrations. It is a clean laboratory containing laminar flow cabinets and is stored on the main deck (if possible).

MOBILE LABORATORY AND FACILITIES *(MAY REQUIRE ADDITIONAL SUPPORT)*			
NAME	**ESSENTIAL**	**DESIRABLE**	**NOTES/COMMENTS**
Trace Metal Seawater Analysis Laboratory (TM2-white - 20ft)			
Trace Metal Rosette and Niskin Storage Container			
Modular Hazchem Locker			
Stabilised Platform Container	X		Bureau Cloud Radar and Lidar
Clothing Container			

STANDARD SAMPLING EQUIPMENT			
NAME	**ESSENTIAL**	**DESIRABLE**	**NOTES/COMMENTS**
CTD - Seabird 911 with 36 Bottle Rosette	x		
CTD - Seabird 911 with 24 Bottle Rosette		x	
Lowered ADCP			
Continuous Plankton Recorder (CPR)	x		*Note: Use of this item must be flagged with the relevant CSIRO Environment team responsible for CPR cassette preparation and sample processing. Please discuss your planned CPR use with your VOM, who will assist in liaising with the CPR team.

SPECIALISED SAMPLING EQUIPMENT			
NAME	**ESSENTIAL**	**DESIRABLE**	**NOTES/COMMENTS (THESE ITEMS MAY REQUIRE ADDITIONAL MNF SUPPORT STAFF)**
TRIAXUS – Underway Profiling CTD			
Desired towing profile:			
Additional instrumentation: (please supply, make and model and datasheets and a contact person for discussion on integration)			

SPECIALISED 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			
Smith Mac Grab			
Rock Dredges			
Rock Saw			
Seaspy Magnetometer	x		For Vandenbossche Piggyback project
Portable Pot Hauler			
Equipment to measure seawater sound velocity/CTD:			
XBT System	x		2 per day provided
Valeport Rapid SV			
Valeport Rapid CTD			
Valeport SVX2		x	
Trace Metal Rosette and Bottles			
Trace Metal In-situ Pumps (x6)			
Deep Towed Camera			
Drop Camera			

SPECIALISED SAMPLING EQUIPMENT			
NAME	**ESSENTIAL**	**DESIRABLE**	**NOTES/COMMENTS (THESE ITEMS MAY REQUIRE ADDITIONAL MNF SUPPORT STAFF)**
Sherman Epibenthic Sled			
Brenke Sled			
Hydro-Bios MultiNet (Mammoth) (1m x 1m) *(has replaced the EZ net)*	x		Please specify 100-micron, 335-micron, or 500-micron mesh Can be used in a vertical or horizontal operations
Surface Net (1m x 1m)			
Bongo Net 485mm diameter			
Beam Trawl			
MIDOC			
Pelagic Trawl System (net, doors)			
Demersal Trawl System (net, doors)			
RMT-8 (Rectangular Midwater Trawl) Utilises a single warp so can be deployed on the general-purpose towing wire in self-contained mode. Must be deployed with stern ramp covered.			
RMT-16 (Rectangular Midwater Trawl) Utilises a single warp so can be deployed on the general-purpose towing wire in self-contained mode. Must be deployed with stern ramp covered.			
Trawl Monitoring Instrumentation (ITI) (2,000m depth limit)			
Stern ramp	**EXPOSED**	**INSTALLED**	

RESEARCH SUPPORT INFRASTRUCTURE			
NAME	**ESSENTIAL**	**DESIRABLE**	**NOTES/COMMENTS**
Saltwater Ice Machine (Dirty Wet lab)			
Radiosonde Receiver System	X		For the CAPRIX project
Laboratory Incubators (Clean Dry lab)	X		Petrou Piggyback
Deck Incubators		X	Temperature controlled deck incubators
Milli-Q System	X		Petrou Piggyback
Sonardyne USBL System			

SCIENTIFIC / SAMPLE ANALYSIS SYSTEMS				
MICROSCOPES:				**NOTES/COMMENTS**
BRAND / MODEL	**TYPE**	**ESSENTIAL**	**DESIRABLE**	Refer to the “MNF microscopes procedure” for more information
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			
Heavy Duty Electronic Balance (80kg)				
Medium Duty Electronic Balance (15kg/5g resolution)				
Light Duty Electronic Balance (3kg/1g resolution)				

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)	X		Vandenbossche Piggyback
Multi Beam Echo Sounder EM710 70-100kHz (0-1000m approx.)	X		Vandenbossche Piggyback
Sub-Bottom Profiler SBP120	X		Vandenbossche Piggyback
Scientific Narrowband Echo Sounders EK60 (6 bands, 18kHz-333kHz)			EK60s will be onboard for use as a backup for EK80s and set in narrowband mode Quantitative measurements from scientific echosounders requires sphere calibration in the watermass of sampling
Scientific Narrowband/Broadband Echo Sounders EK80 (6 bands, 18kHz-333kHz)	x		EK80s will be used in narrowband mode unless otherwise requested Quantitative measurements from scientific echosounders requires sphere calibration in the watermass of sampling
Multibeam Scientific Echo Sounder ME70 (70-100 kHz)			
Omnidirectional Echo Sounder SH90			
Gravity Meter		x	

ATMOSPHERIC UNDERWAY SENSORS			
NAME	**ESSENTIAL**	**DESIRABLE**	**NOTES/COMMENTS**
Nephelometer	X		For the CAPRIX project
Multi Angle Absorption Photometer (MAAP)	X		For the CAPRIX project
Scanning Mobility Particle Sizer (SMPS)	X		For the CAPRIX project
Radon Detector	X		For the CAPRIX project

ATMOSPHERIC UNDERWAY SENSORS			
NAME	**ESSENTIAL**	**DESIRABLE**	**NOTES/COMMENTS**
Ozone Detector	X		For the CAPRIX project
Condensation Particle Counter (CPC)	X		For the CAPRIX project
Picarro Spectrometer (analysis of CO_2/CH_4/H_2O)	X		For the CAPRIX project
Aerodyne Spectrometer (analysis of N_2O/CO/H_2O)	X		For the CAPRIX project
Cloud Condensation Nuclei (CCN)	X		For the CAPRIX project
Polarimetric Weather Radar	X		For the CAPRIX project
Filter Aerosol Sampling units (FAS) x 3	X		Used for collecting physical aerosol samples on filters. FAS includes pumps, filter holders, flow controllers, totalizer, Very Sharp Cut Cyclone (VSCC) PM1 and PM2.5. • User to specify how many units are required (maximum 3 supplied by MNF). • User to provide own filters. • User to outline sampling requirements with MNF Seagoing Instrumentation Team (SIT) i.e. ship exhaust sample avoidance etc.

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			

SEAWATER SYSTEMS			
NAME	**ESSENTIAL**	**DESIRABLE**	**NOTES/COMMENTS**
Scientific clean seawater supplied to laboratories	x		
Raw seawater available on deck and in laboratories			

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			

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 YOUR VOYAGE OPERATIONS MANAGER AS REQUIRED. ADDITIONAL STAFF MAY BE REQUIRED FOR THESE ACTIVITIES.**
D & N Francis winch			
Box Corer			
UTAS In-Situ Pumps (x2)			
EM2040			

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
Acoustic release deck unit	5kg	0.5 m2	Operations Room
Pigment filtration system and FIRE	25 kg	1 m2	Underway Seawater Lab
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)	ESC1
BASTA W-Band Doppler Radar	~60 kg	(LxWxH) 120x70x100cm	Stabilized platform container (Level 2, forward deck, starboard side)
RMAN Raman Lidar	~110 kg	(LxWxH) 80x65x115cm	Stabilized platform container (Level 2, forward deck, starboard side)

Micro Rain Radar	~20 kg	(LxWxH) 50x50x100cm	Deck 5 Railing
OceanRAIN disdrometer (NB : belongs to MNF but is not proposed in list !)			Main mast
23 and 31 GHz Microwave Radiometer	~30 kg	(LxWxH) 100x25x25cm	Deck 5 Railing
Radiosondes and Helium bottles	~400kg	Max. Height: 2141 MM (including frame). Width: 1045 MM x Depth: 1045 MM	Launch from back deck

Appendix C

Hazardous Materials Manifest

Hazardous Material Name	Risk Rating Colour Code	Hazardous Material UN Number	CAS number	Concentration	Poison Schedule Number	Class
mercuric chloride saturated solution	High	1624		7%	S7	Class 6 - Toxic
mercuric chloride seawater brine	Medium	1624		0.3%	S7	Class 6 - Toxic
Ethanol	Low	1170		99%	N/A	Class 3 - Flammable Liquid

Ethanol	Low	1170		99%	N/A	Class 3 - Flammable Liquid
Partially depleted lithium batteries	Low	3480		n/a	N/A	Class 4 - Flammable Solids
Triton X 100	Medium	3082		100%	N/A	Other - specify in notes
Helium (party balloon gas)	Low	124		0.9	N/A	Class 2.2 - Compressed Gas: Non-flammable
Lithium Metal Batteries	Low	3091		5%	N/A	Class 4 - Flammable Solids
Bis(tributyltin) oxide - "TBT"	Low	2788			N/A	Other - specify in notes
Ethanol - preservation	Low	1170		99%	N/A	Class 3 - Flammable Liquid
Formaline	Low	2209		37%	N/A	Class 8 - Corrosives
Glutaraldehyde	High		111-30-8	25%	S6	Class 6 - Toxic
Ethanol wipes	Medium		67-63-0	70%	N/A	Class 3 - Flammable Liquid