RV *Investigator* Voyage Summary

Voyage #:	**IN2017_V02**		
Voyage title:	SOTS: Southern Ocean Time Series automated moorings for climate and carbon cycle studies southwest of Tasmania		
Mobilisation:	Hobart, Wednesday, 15 March 2017		
Depart:	Hobart, 0800, Friday, 17 March 2017		
Return:	Hobart, 0800 Tuesday, 28 March 2017		
Demobilisation:	Hobart, Tuesday, 28 March 2017		
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Principal Investigators:	Eric Woehler		
Project name:	Spatial and Temporal Variability in the Distribution and Abundance of Seabirds		
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Principal Investigators:	Philip Boyd		
Project name:	Trace Element Cycling		
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Principal Investigators:	Rudy Kloser		
Project name:	Acoustic estimates of zooplankton and fish distributions		
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Voyage Summary

Scientific objectives

SOTS

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. SOTS uses a set of three 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.

SOTS will also support two efforts that aim to advance understanding of the controls on two aspects of biological processes that contribute to the control of carbon dioxide uptake– trace metal limitation and zooplankton grazing, as described in the Piggy-Back Projects section.

Supplementary Project: Nutrients

This project will centre on the investigation of seawater nutrient analysis, specifically looking at the differences in results obtained by a series of international groups. The analysis of seawater nutrients is completed all over the world, conducted with many different instruments and methodologies. This voyage will assist in the furthering of knowledge on the analysis as well as allowing different groups to highlight differences between attained results. With close collaboration between potentially 5 scientific parties, the science of seawater nutrient analysis can be improved or refined upon.

Many aspects of this analysis will be studied, spanning from the collection of water to the final data processing. This international collaboration is beneficial for all involved, allowing all teams to advance their analysis techniques. The impact of this voyage will be the improved knowledge of nutrient analysis techniques, potentially meaning future data will be of higher accuracy and precision, lowering the uncertainty associated with analysis of samples.

Supplementary Project: Seabirds

The project seeks to quantify the distribution and abundance of seabirds at sea around Australia using standardised seabird survey protocols. One or two dedicated observers will collect real-time data on seabirds observed within 300m transect during daylight hours while the vessel is underway. Incidental observations will be collected while the vessel is stationary (eg CTD stations) or while the vessel is deploying/recovering moorings. The data collected will be compatible with previous seabird at sea surveys conducted around Australia and farther south, allowing for analyses and assessments to be extended by the current surveys. The distribution of seabirds at sea is strongly linked with oceanographic features such as convergences that concentrate prey at densities that allow for efficient foraging by seabirds. Our surveys on the voyage will link with oceanographic investigations to identify the types and strengths of oceanographic features at which we observe different species of seabirds that utilise different methods of feeding (surface seizing, diving etc). No dedicated ship time is required for the seabird surveys. Surveys are conducted by observers while the vessel is underway during daylight hours.

Voyage objectives

SOTS

The primary objective is to first deploy a new set of SOTS moorings (SAZ-19 and SOFS-6) and then recover the existing SOTS moorings (FluxPulse-1 lower section, and SAZ-18). Additional work will obtain ancillary information on atmospheric and oceanographic conditions using CTD casts, underway measurements, the Triaxus towed body, and autonomous profiling “Bio-Argo” floats.

Each of the SOTS moorings delivers to specific aspects of the atmosphere-ocean exchanges, with some redundancy:

- 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) measures meteorological properties and ocean properties important to air-sea exchanges, ocean stratification, waves, and currents.
- the (now super-ceded) Pulse biogeochemistry mooring focused on processes important to biological CO2 consumption, including net community production from oxygen measurements and nitrate depletion, biomass concentrations from bio-optics and bio-acoustics, and collection of water samples for nutrient and plankton quantification.
- the FluxPulse mooring combines some elements of Pulse onto the SOFS platform to create a combined mooring, and was deployed for the first time in 2016, but broke into two sections. The top section has been recovered. The bottom section remains to be recovered. This combined mooring was intended to meet financial constraints. In 2017 we will use the simpler SOFS design, while redesigning FluxPulse for relaunch in 2018.

Supplementary Project: Nutrients

Key Voyage Objectives

1. Identify any differences in nutrient analysis accuracy and precision between scientific groups.
2. Assess different techniques of nutrient sampling, investigate areas of improvement.
3. Compare the different workflows for data processing between the groups.
4. Use and implications of international standard ‘Reference Material for Nutrients in Seawater’, produced by Kanso Co Ltd.

The exact location of CTD casts does not concern our project. Bottom casts are all that is needed.

10 CTDs are proposed, this includes 2 CTDs in conjunction with Tom Trull. It would be highly beneficial for this project to use the 36 bottle rosette, this allows the teams to collect much more water for analysis. This is vital, as the overall number of CTDs is rather low. CTDs are planned to operate at 0100 daily, this should hopefully be recovered before moorings work at first light.

CTD plan example

Date	CTD	CSIRO Hydro sampling	NIWA sampling	Group X sampling	Group Y sampling	Tom Trull sampling
19/03/17	1	X				
20/03/17	2	X	X	X	X	
21/03/17	3	X				X
22/03/17	4	X	X	X	X	
23/03/17	5	X				
24/03/17	6	X	X	X	X	
25/03/17	7	X				X
26/03/17	8	X	X	X	X	
27/03/17	9	X				
28/03/17	10	X				

A water budget is not necessary while using the 12L niskins, all of hydrochemistry sampling will not use more than 3L per bottle. Nutrient sampling completed by other groups should not be more than 2L per group, as only small (<50mL) samples are collected.

Sampling of water from the CTD will be done on every CTD by hydrochemistry, this will include salinity, dissolved oxygen and nutrients (number of replicates as required for each group). The nutrients will sample into Sarstedt 30mL tubes (62.543.001). The majority of the bottles fired will occur below the salinity minimum, within the Antarctic bottom water. This is to minimise any fluctuations in water collected by the niskins, such that samples are completely homogenous throughout nutrient sample collection. This approach will help characterise each groups results, aiding in the investigation of Key Objective 1. By comparing the different results attained, the accuracy and precision of each team can be assessed.

To address Key Objective 2, other scientific parties will be given the chance to sample on CTDs which will be analysed to determine if there is any differences between the sampling techniques. It would be best if all groups could analyse the samples, so that statistical analysis of sampling methods can be achieved. This however depends on the scientific group’s instrumentation capabilities as well as voyage time constraints.

We plan to hold a few workshops where each team will have a chance to discuss and demonstrate how the data is processed through their method. These workshops will help meet Key Objective 3 and allow the different groups to gain an understanding of potentially alternate processing workflows. This can provide each group with an insight on the quality and robustness of the processing methods, translating to future improvements within each groups preferred method.

The workshops will also serve as a platform for the groups to teach and share knowledge of the different instrumentation used. It will be beneficial for all involved to gain an extra understanding of the alternative instruments for nutrient analysis. Hopefully scientific personnel involved will be able to take away key information that can be applied to future nutrient analysis.

In order to track the results produced by each group CSIRO Hydrochemistry will be providing Reference Material for Nutrients in Seawater (RMNS) to each group. This is a commercially produced standard material of a known concentration. By running this with each run, utilising RMNS from the same batch results of each team can be easily compared and checked for accuracy. However, it is a Key Objective to investigate the implications of utilising this commercially produced standard. It is of interest to learn how other groups use and treat these standards, as well as interpretation of the results. Extending from this, in order to further characterise and track results a Bulk Quality Control (BQC) will be made and distributed between participants. The BQC will consist of water collected below the salinity minimum, filtered through a 10µm filter and then poisoned with Mercuric Chloride (CONC?). This will serve as a secondary standard which will be used for intra-run result tracking. It will also provide additional data for analysis, boosting the statistical power of the investigations.

<u>Supplementary Project: Seabirds</u>

The observations on this voyage will complement existing data from the survey area collected between 1980 and 2005. These earlier data were collected from Antarctic Division research and resupply voyages. The early data were collected between Tasmania and the Antarctic, and the spatial and temporal overlap between current voyage and previous efforts allow integration of the data sets. Seabird observations will commence in the Derwent River and continue while the vessel is underway and during daylight hours. At least one student will be on the seabird team, allowing for their training in seabird observation protocols. Incidental observations of marine mammals, marine debris and kelp masses at sea will be recorded consistent with previous surveys.

<u>Piggy-Back Project 1. Trace Element Cycling</u>

The voyage objective is to measure profiles of trace element dissolved and particulate concentrations, and to examine the processes that produce and recycle them. This work was trialled successfully during IN2016_v02 SOTS/Eddy/Capricorn voyage and will be expanded in a dedicated project during IN2018_V02. The work during IN2017_v02 will in combination with those efforts deliver observations from 3 successive years and thus contribute to defining the stability versus interannual variability in trace element levels.

<u>Piggy-Back Project 2. Acoustics Zooplankton and Fish Distributions</u>

The voyage objective is to map the top 1000m of the water column for micronekton organisms (small fish, crustaceans, gelatinous and squids of ~2-20 cm in length) at the SOTS site using the PLAOS acoustic optical system. 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. In particular 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 a new profiling multi-frequency acoustic optical system has been developed with the ultimate aim of it being used as a remote sampling tool. On this voyage we will be testing the next phase of a profiling lagrangian acoustic and optical probe (PLAOS) to sample these organisms to depths of 1000 m. These tests will involve detailed sampling of the repeatability of the measurements when varying lighting, using new broadband acoustic sensors and a new buoyancy engine to enable the system to do repeat profiles.

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 ACE CRC carbon program as well as the MESOPP ecosystem program.

Results

SOTS

1. Deploy SAZ-19
   Achieved.
2. Deploy SOFS-6
   Achieved
3. Recover SAZ-18
   Achieved
4. Recover FluxPulse-1 space junk
   Not achieved. We visited the location of FluxPulse-1 and talked to the acoustic release, confirming the position had not changed since the visits by Aurora Australis V1 & V1 in December 2016 and January 2017. For reasons of tight shiptime constraints this year and the need to develop more equipment to attempt a recovery, we have postponed consideration of this activity until next year.
5. Obtain ancillary information on atmospheric and oceanographic conditions using CTD casts, underway measurements, the Triaxus towed body, and autonomous profiling “Bio-Argo” floats.
   Mostly achieved. CTD, underway and Triaxus was successful. Bio-Argo floats were not used on this voyage. They will be deployed next year when a more concerted sampling program to support their interpretation can be undertaken owing to the longer voyage.

Nutrients

6. Identify any differences in nutrient analysis accuracy and precision between scientific groups.
   Achieved
7. Assess different techniques of nutrient sampling, investigate areas of improvement.
   Achieved
8. Compare the different workflows for data processing between the groups.
   Achieved
9. Use and implications of international standard ‘Reference Material for Nutrients in Seawater’, produced by Kanso Co Ltd.
   Achieved

Seabirds

10. Collect seabird observations during daylight hours for the duration of the voyage.

    Achieved. More than 13,000 birds from more than 30 species were recorded during the survey.

11. Incidental observations of marine mammals, marine debris and kelp masses at sea will be recorded consistent with previous surveys.

    Achieved.

Trace Element Cycling

12. Measure profiles of trace element dissolved and particulate concentrations, and to examine the processes that produce and recycle them.
    Achieved: Three TMR casts, two ISP casts, two RESPIRE drifting traps were completed, as well as oxygen uptake rate experiments.

Acoustics Zooplankton and Fish Distributions

13. Map the top 1000m of the water column using the PLAOS acoustic optical system.
    Achieved: The PLAOS was deployed 14 times.

Voyage Narrative

Friday 17 March

Departed Hobart on schedule at 0800 under fine conditions. Inductions at 0830 and general muster at 1030. Back deck practice moving a weight with the A-frame while cruising down the river, followed by a test CTD at 1130. The afternoon was spent in storm bay testing the following systems: ISP, TMR, PLAOS and TRIAXUS. Installation was finalised for all materials in CT lab (microbial respiration, aggregation devices), dry clean lab (FlowCAM, microscopy, POC/bSi filtration), wet dirty lab (RESPIRE traps), TM clean van (ISPs gear and TM clean niskin bottles), and TMR van (TM clean rosette and ISPs). Preparation of the TMR and ISPs consisted in battery check/replacement, communication tests and deployment trials. Five carboys of 20L were filled using the CTD1 conducted in the waters of Storm bay to test aggregation devices and microbial respiration chambers. The Voyage Manager's briefing was conducted at 1430. Commenced transit for the SOTS site 1830. All underway in-water logging systems were turned off while we traversed the marine park.

Saturday 18 March

Continued transit under fine conditions making around 10kts. Aggregation devices were cleaned and incubated with water from CTD1 (Storm bay). The ISPs heads and filters were cleaned in the TM clean van. The two RESPIRE traps were mounted on the frames and checked for communication and batteries. Each flow cells (90, 300, 600 and 800 µm) were set on the FlowCAM. Additional tests were made on the respiration chambers (O2 probe). All logging systems restarted around 1300.

Sunday 19 March

Arrived at SOTS site 0000 and set up 8nm down weather of the target site. Performed full depth CTD (Nutrients 1). 0600 Commenced pre-deployment for SOFS-6. Mooring deployment completed by 2109 under light to calm conditions, overcast and drizzly.

SOFS-6 Anchor released at 2017-03-19 1009 UTC, 46 01.82' S, 142 07.40'E, -46.030270, 142.123383. Water depth: 4482m. Surveyed anchor position: **46.02652S, 142.12901E** in 4603m depth.

Sampling of water from full depth CTD2 and incubation in roller bottles. After 24h of Storm bay water incubation in roller tank devices no aggregation visible (very likely due to too low particle concentration). Last preparation of the RESPIRE traps made before next day deployment.

Programming of the TMR and ISPs for next day deployment. First runs of the FlowCAM were conducted using standard beads for size calibration. Performed two PLAOS casts overnight within a few miles of the SOFS buoy for meteorological sensor comparisons with SOFS, completed by 0830.

Monday 20 March

The first TMR cast to 1550 m was initiated at 0600. Half of the Niskin bottles were not properly closed (bottom cap still slightly opened). Bottle nº12 did not fire. bottles sampled in the TM clean van. 0830 Shallow CTD3 to 200m for particle collection and test on observed noise on several CTD channels (conductivity, oxygen). Water collected at 40 and 20(0?)m. Water removed at 2130 to allow particles to settle. Very few particles visible in aggregation devices (CTD2) but too small to be sampled and studied. Commenced deploying the first RESPIRE drifting trap at 1030, completed1200. Calm conditions under a clear sunny sky. Visited by Pilot Whales in the early afternoon. Deployed six ISP to 500m three hours of pumping. Spooling for SAZ-19. Recovered ISP at 1900 and ISP filters subsampled for POC analysis. Ship-SOFS met comparisons commenced 8pm up to midnight.

Tuesday 21 March

Moved away from the SOFS mooring to 10NM East of SAZ-19 position and conducted full depth CTD cast for nutrients. In position for SAZ-19 mooring deployment at 0700. Commenced SAZ-19 deployment after breakfast and completed by1400.

SAZ-19 anchor released at 2017-03-21 0311 UTC, 46 06.38' S,142 18.01'E, -46.106285, 142.300106. Surveyed anchor position: **46.10945S, 142.30854E** in 4526m depth.

More Pilot whales sited in morning. PLAUS cast to completed, SAZ triangulation undertaken and transit to SAZ-18 site commenced at 1600. Full depth CTD, PLAOS and net drop conducted. First test runs on the FlowCAM using the Underway line supply. Plankton net (size mesh 100 µm) deployed at 30m for 10 min (integrated rotor to pump water in). Samples from the plankton net were used the same day for respiration rate experiments and FlowCAM observation (using the 800 µm flow cell).

Wednesday 22 March

Early morning full depth CTD cast for nutrients performed. Light conditions from the W-SW. SAZ-18 mooring release triggered 0800. The mooring came to the surface within 30 minutes and was grappled successfully on the first pass. The mooring was fully recovered by 1830, including two large tangles. We transited back to the SOFS-6, SAZ-19 site, detouring on the way to confirm the location of the FluxPULSE-1 fragment at 46.71974S, 141.96278E and with the release at a depth of 931 m. Incubation of water from shallow CTD3 (200m) in roller tank device prototype and traditional roller bottles. Less than an hour after incubation started, very large (10-15 cm) filamentous aggregates formed in the roller bottles incubated with water. Microscopy confirmed the high abundance of very long and sticky needle-shaped diatoms (Rhizolenia sp.) in the sample and high viscosity of the water suggested a high concentration in transparent exopolymer particles (TEP), possibly explaining the rapid formation of giant filamentous aggregates in roller bottles. First results of respiration experiments suggest a relationship between temperature and the O2 uptake rate of particle-attached organisms.

Thursday 23 March.

Early morning full depth CTD cast for nutrients performed. TMR deployed at 0630. Commenced recovery of drifting RESPIRE trap#1 at 0900. Completed at 1115. Weather was calm and overcast. The six ISP were deployed between 30 m and 500m. At 1900 a PLAOS cast and plankton net drop was performed. Plankton net samples were analysed with the FlowCAM and used to start a second oxygen uptake rate and aggregation experiments.

Friday 24 March

Early morning full depth CTD cast for nutrients performed. The second deployment of the drifting RESPIRE trap was performed in the morning (commenced 0830 and completed at 0950), followed by a PLAOS cast, plankton net, full depth nutrient CTD and another PLAOS cast sequence. The weather continued to be calm but overcast. Plankton net material was analysed with the FlowCAM and for a third oxygen uptake rate and aggregation experiment.

Saturday 25 March

Full depth CTD 3am, TMR 0700. Plankton net drop 1100. Ship-SOFS comparisons from 1300 until 2000. PLAOS cast were done to 500 m to trial new lighting arrangements. Undertook new O2 uptake experiment and particle aggregation incubations.

Sunday 26 March

Calm and foggy day. Full depth CTD cast at 0300. Recovered the drifting respire trap #2 by 0940 followed by a plankton net drop and final full depth CTD completed 1400. Triaxus deployed by 1430 and commenced transit for Hobart. Sampling on the UW line for future phytoplankton cultures in the lab and incubation. Entered the marine park around 2000 with all water sampling systems turned off.

Monday 27 March

Continued towing the Triaxus, exiting the marine park at 0610 at which time all systems were reinstated. Wind speed increasing throughout the day. Triaxus recovered around 1300 due to deteriorating conditions. Undertook final aggregation experiment using material from the UW seawater line.

Mooring	Latitude	Longitude	Depth
SOFS-6 anchor triangulation	46.02652 °S	142.12901 °E	4603 m
SAZ-19 anchor triangulation	46.10945 °S	142.30854 °E	4526 m
FluxPulse-1 Space junk	46.71974 °S	141.96278 °E	930.9 m

Summary

The voyage was successful. The weather and sea conditions were unusually calm throughout the duration of the voyage and allowed all science operation to proceed smoothly and even ahead of schedule at times.

SOTS: The mooring activities continued the sustainment of the multi-disciplinary ocean observatory aimed at understanding the carbon, heat and mass flux contribution of the Sub-Antarctic Zone to the global climate system.

Birds: More than 13,000 birds from more than 30 species were recorded during the survey. Several observations of multi-species feeding associations were observed and documented. Several papers are being formulated on the basis of observations made on this voyage and previous (IN2016_v06 Sloyan). All survey data will be submitted to GBIF later in 2017 once data checking has been completed.

Nutrients: This voyage provided a great opportunity to work with other international agencies on the collection, analyses and processing of nutrient data. This is certain an excellent step toward understanding the differences that occur with reported Nutrient values from agency all around the world. The opportunity to share techniques, methodologies, and the comparison of instrumentation and processing techniques was an invaluable exercise.

Trace metals: during this voyage three TMR casts and two ISP casts were conducted sampling the water column for dissolved and particulate trace elements over 12 and 6 depths respectively to further our understanding of trace element cycling and better identify the controlling mechanisms. In addition the RESPIRE traps were successfully deployed and recovered and one extra deployment was done to provide the first bacterial remineralisation rates in the mesopelagic at SOTS. Our oxygen uptake rates experiments showed clear relationship between temperature and the physiology of particle-attached microbes as suggested by the metabolic theory of ecology.

Acoustics Zooplankton and Fish Distributions: The PLAOS was deployed 14 times to characterise the mesopelagic micronekton habitat. Calibration of the narrow and broad band acoustic sensors was done on 4 deployments. A sequence of trials were done to test for the effects of video and strobe lights on organism behaviour with initial results suggesting that white video lights significantly impact the fish behaviour with both attraction and avoidance responses observed at night and only avoidance responses observed during the day. White strobe lights alone significantly reduced the avoidance response of organisms (mainly fish) with no obvious attraction response. When using no lights there was avoidance responses to the system from a few organisms (mainly fish) at ranges from 70 to 100 m. These findings will enable us to optimise deployment configurations to suit the purpose of the missions.

The new broad band acoustic system significantly improved the range of single targets detected (increasing from 20 to 75 m for these tests) as well as providing their spectral responses. A trial deployment of the PLAOS at dusk captured the vertical migration of organisms, their speed of ascent as well as their spectral acoustic signature. The video and still cameras of the PLAOS were optimised during the voyage to improve image quality and images captured of many potentially new to science species.

Noise trials of the acoustic system demonstrated that the bioacoustic echosounders are significantly affected by electrically induced noise reducing their effective operating range. Tests indicate that the electrically induced noise is occurring in the cable run from the keel-mounted transducers to the transceivers, most likely being induced from adjacent cables in the overhead cable tray. Improved cable shielding would be expected to resolve this issue. This could ideally be in the form of dedicated steel pipes for each cable or addition of extra shielding on the outer cable.

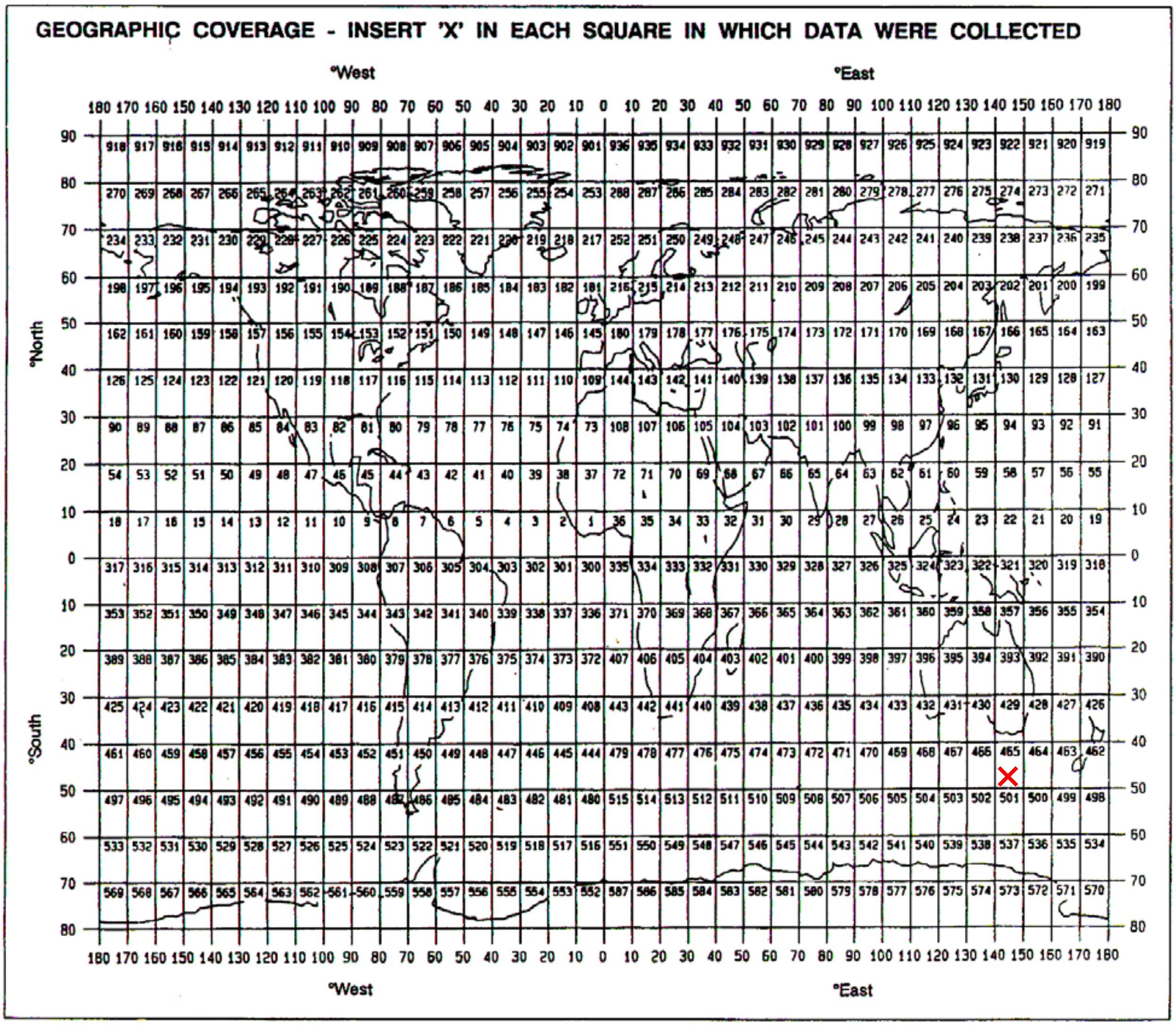
Significant progress was made to identify operating procedures for collecting IMOS bioacoustics data on board RV Investigator and a separate report summarises the findings with the key recommendations being:

- Unless voyage priorities dictate otherwise run with IMOS bio-acoustic settings at all times with keel at maximum depth
- Run bioacoustics asynchronously w.r.t swath and adcp in deep water
- For shallow water conduct further tests to establish depth below which all acoustic systems should be synchronised. Subsequently operate with synchronisation on when operating in waters below this established depth.
- Run Echoview Live viewing at all times, maintaining a level of vigilance that bio acoustic sounders are logging with correct range and settings.
- Further trials on Adaptive Echosounder Logger (EAL) software. Running this software will automate range settings to provide optimal data quality, maximum ping rate while reducing GSM workload.

The five teams were well coordinated and worked effectively to maximise the data collected at the SOTS site.

Marsden Squares

Move a **red "x"** into squares in which data was collected



Moorings, bottom mounted gear and drifting systems

This section should be used for reporting moorings, bottom mounted gear and drifting systems (both surface and deep) deployed and/or recovered during the voyage. Separate entries should be made for each location (only deployment positions need be given for drifting systems). This section may also be used to report data collected at fixed locations which are returned to routinely in order to construct 'long time series'. Delete section if not applicable.

Item No	PI See page above	APPROXIMATE POSITION						DATA TYPE enter code(s) from list on last page	DESCRIPTION
		LATITUDE			LONGITUDE				
		deg	min	N/S	deg	min	E/W		
1	Tom Trull/Eric Schulz	46	2	S	142	7	E	MO2 M71 M90 H17 D01 D71	Southern Ocean Times Series (SOTS) site: SOFS-6 surface meteorological mooring deployed for recovery in March 2018 See diagram in appendix detailing instruments and depths
2	Tom Trull	46	6	S	142	18	E	H17 B73 D01	Southern Ocean Times Series (SOTS) site: SAZ-19 sub-surface sediment trap mooring deployed for recovery in March 2018 See diagram in appendix detailing instruments and depths.
3	Tom Trull							H17 B73 D01	Southern Ocean Times Series (SOTS) site: SAZ-18 sub-surface sediment trap mooring recovered (deployed in March 2016)
4	Philip Boyd	45	98	S	142	1	E	H71, H11, H16, H17, B02, B71, H21, H24, H28	Drifting RESPIRE sediment traps (150 m)
5	Phillip Boyd	46	0	S	142	2	E	B07, B73,H21, H26, H27, H24, H23, P02, H30, H90, H32	Drifting RESPIRE sediment traps (150 m)

Item No	PI See page above	APPROXIMATE POSITION						DATA TYPE enter code(s) from list on last page	DESCRIPTION
		LATITUDE			LONGITUDE				
		deg	min	N/S	deg	min	E/W		
6	Mark Rayner	45	59	247	142	23	.288	H10	Deploy 36 bottle CTD (2) to 4579 metres
7	Mark Rayner	46	04	783	142	20	533	H10	Deploy 36 bottle CTD (4) to 4438 metres
8	Mark Rayner	46	43	540	141	56	350	H10	Deploy 36 bottle CTD (5) to 4667 metres
9	Mark Rayner	46	00	759	142	00	188	H10	Deploy 36 bottle CTD (6) to 4205 metres
10	Mark Rayner	46	55	605	142	02	705	H10	Deploy 36 bottle CTD (7) to 4079 metres
11	Mark Rayner	46	05	115	142	15	696	H10	Deploy 36 bottle CTD (8) to 4707 metres
12	Mark Rayner	46	03	712	142	13	.370	H10	Deploy 36 bottle CTD (9) to 4500 metres
13	Mark Rayner	46	04	409	142	12	646	H10	Deploy 36 bottle CTD (10) to 4628 metres
14	Mark Rayner	45	55	536	142	14	704	H10	Deploy 36 bottle CTD (11) to 4476 metres

Summary of measurements and samples taken

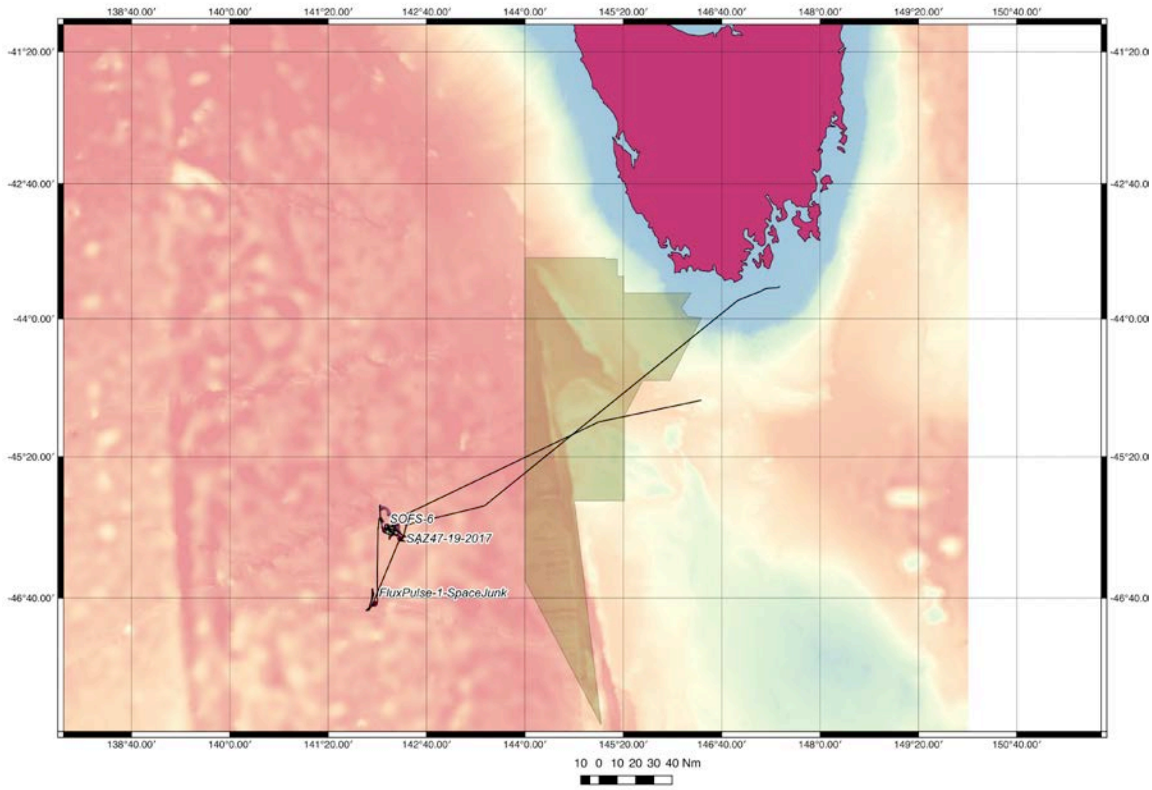
Item No.	PI see page above	NO see above	UNITS see above	DATA TYPE Enter code(s) from list at Appendix A	DESCRIPTION
1	Tom Trull	15	hours	H11 H16 H17	Triaxus undulating towed body transits across small thermal front near Southern Ocean Time series site. Triaxus oscillations between 10 and 200m depth, surfacing every 7 minutes. Sensors : pressure, temperature, conductivity, dissolved oxygen, PAR, 700nm beam transmission, chlorophyll fluorescence, backscatter, laser optical plankton counter, SUNA ultra-violet spectrometric nitrate analyser, FIRe fast repetition rate fluorometer.
2	Bronte Tilbrook	11	days		Continuous pCO2 measurements
4	Tom Trull	15	hours	B02	Surface underway measurements of phytoplankton physiology from the FIRe fast repetition rate fluorometer.
5	Rudy Kloser	14	profiles	B28, H17, H10, B90	The Profiling Lagrangian Acoustic Optical System (PLAOS) was designed and built at CSIRO and was deployed 14 times during the voyage between depths of 400 m to 1000 m. The PLAOS was lightly tethered to the vessel and descended to depth at a set rate of ~0.3 m s^{-1} recording 38 kHz, 70 kHz, 120 kHz and 333 kHz narrow and broadband acoustics at ~10 Hz, vertical video, vertical still photography (at 0.5 Hz) and oblique photos at 0.5 Hz. The system also recorded CTD data with all acoustic, optical, motion and CTD data recorded internally. The acoustic data provides an estimate of the number and composition of biota through the water column. Vertical imagery data is used to record the biota and to assist in cross checking the acoustic data. Oblique imagery data provides a uniform lighted scene of predominantly gelatinous material that can be used to provide a census and depth distribution of biota. Detailed station list in appendix.
5	Mark Rayner	45	hours	H10	Completed 10 CTD stations to the ocean floor for collection of discrete water sample through the water column for analyses of a suit on nutrient as a part of the Nutrient inter comparison.
6	Mark Rayner	1620	uM	H22	Nutrient samples were collected and analyses by the CSIRO hydrochemistry team and also by the international participants

Item No.	PI see page above	NO see above	UNITS see above	DATA TYPE Enter code(s) from list at Appendix A	DESCRIPTION
				H24 H25 H76 H26 H21	on the voyage. A total of 5600 individual analyses were completed for 5 major nutrients during the voyage
5	Philip Boyd	12	depths	B71 B72 H30	Particulate trace elements and organic carbon concentration from Mc Lane in situ pumps
6	Philip Boyd	27	depths	H30 H32	Dissolved trace element concentration from Trace Metal clean Rosette
7	Philip Boyd	4	deployments	B08, B09	Planktonic community (>100 µm) from plankton net.
8	Philip Boyd	7.5	hours	B08	Phytoplankton (size fraction between 210 and 20 µm) from underway seawater line.
9	Woehler	13000	Seabirds	B25	Seabird observations collected between sunrise and sunset on every day of cruise. Almost 13500 individuals recorded from more than 30 species. All data are geo-referenced and will be lodged with GBIF in 2017 following processing and checking.

Curation Report

Item #	DESCRIPTION
1.	SOTS Project : Water and particle samples collected from the CTD and underway system (detailed in the SOTS Metadata Report below) are returned to CSIRO Marine and Atmospheric Research for chemical analyses and then discarded following quarantine protocols.
2.	SOTS Project : Moored sediment trap samples recovered from the SAZ-18 mooring are processed at the ACE CRC. 7/10 of each sample is consumed by analyses for particulate organic carbon, particulate inorganic carbon, and biogenic silica. These results are provided for public use via the IMOS Ocean Data Portal. 2/10 are made available for biological studies by various groups via agreement with SOTS Chief Scientist Tom Trull. 1/10 is archived at the ACE CRC.
3.	SEABIRDS. All data will be lodged with GBIF in 2017 once data checking completed.

Track Chart



Personnel List

	Name	Organisation	Role
1.	Tegan Sime	CSIRO MNF	Voyage Manager
2.	Tom Trull	CSIRO	Chief Scientist
3.	Eric Schulz	BOM	Co-Chief Scientist
4.	Mark Rayner	CSIRO	LPI, Nutrients project
5.	Philip Boyd	UTAS	LPI, Trace metals project
6.	Rudy Kloser	CSIRO	PI, Acoustics, Zooplankton
7.	Eric Woehler	Birdlife Australia	PI, Bird monitoring project
8.	Matthieu Bressac	UPMC-CNRS	Trace metals project
9.	Manu Laurenceau-Cornec	IMAS	Trace metals project
10.	Xiaoyu Chen	ANU	Trace metals project
11.	Hangoo Kang	KIOST	Nutrients project
12.	Cloe Cummings	UTAS	Bird monitoring project
13.	Tracey-Ann Hooley	Birdlife Australia	Bird monitoring project
14.	Greg Olsen	NIWA	Nutrients project
15.	Graham Marshall	Global FIA	Nutrients project
16.	Mariko Hatta	Uni Hawaii	Nutrients project
17.	Purena Son	KIOST	Nutrients project
18.	Kendall Sherrin	CSIRO	Nutrients project
19.	Makito Yokota	JAMSTEC	SOTS
20.	Guicheng Zhang	CAS	Nutrients project
21.	Peter Jansen	UTAS	SOTS
22.	Haris Kunnath	CSIRO	Acoustics Zooplankton
23.	Jamie Derrick	CSIRO	SOTS
24.	Garry Curtis	CSIRO	SOTS
25.	Darren Moore	CSIRO	SOTS
26.	Emma Cavan	IMAS	Trace metals project
27.	Arti Verma	Curtin Uni	
28.	Tim Ryan	CSIRO	Acoustics Zooplankton
29.	Jeff Cordell	CSIRO	Acoustics Zooplankton
30.	Frances Cooke	CSIRO MNF	GSM
31.	Amy Nau	CSIRO MNF	GSM

	Name	Organisation	Role
32.	Aaron Tyndall	CSIRO MNF	SIT
33.	Ben Baldwinson	CSIRO MNF	SIT
34.	Steve Van Graas	CSIRO MNF	DAP
35.	Francis Chui	CSIRO MNF	DAP
36.	Cassie Schwanger	CSIRO MNF	Hydrochem
37.	Christine Rees	CSIRO MNF	Hydrochem
38.	Will Ponsonby	CSIRO MNF	SIT

Marine Crew

List all crew members and their position on the ship

Name	Role
Gurmukh Nagra	Master
Brendan Eakin	Chief Mate
Thomas Watson	Second Mate
James Hokin	Third Mate
Chris Minness	Chief Engineer
Mark Ellicott	First Engineer
Michael Sinclair	Second Engineer
Ryan Agnew	Third Engineer
John Curran	Electrical Engineer
Gary Hall	Chief Caterer
Kyra Hall	Caterer
Keith Sheperd	Chief Cook
Adrian Hughes	Cook
Graham McDougall	Chief Integrated Rating
Paul Langford	Integrated Rating
Timothy Freeman	Integrated Rating
Dennis Bassi	Integrated Rating
Daniel Morse	Integrated Rating
Matthew Schmierer	Integrated Rating
Roderick Langham	Integrated Rating

Acknowledgements

We are grateful to the MNF and ASP for ship access prior to the mobilization day, and for excellent support at sea.

SOTS: Superb preparation of our SOTS mooring equipment included major contributions from CSIRO and ACE CRC shoreside team members, Jim LaDuke, Diana Davies, Dave Hughes and Andreas Marouchos.   We thank the directors of the MNF, IMOS, and the ACE CRC (Ron Plaschke, Tim Moltmann, and Tony Worby, respectively) for support of SOTS.

Signature

Your name	Tom Trull
Title	Chief Scientist
Signature	Thomas W. Trull
Date:	27/3/2017

List of additional figures and documents

Appendix A Mooring Debrief Records and Recommendations

Debriefing notes for each mooring type follow. For all mooring operations, multiple steps in communications across the teams are needed. These include:

1. Provision of mooring drawings and procedures ahead of the voyage.
2. A familiarization session with bridge, deck, and science teams well before the first mooring operation
3. Go/No-go decision meetings on the bridge.
4. JHA and toolbox briefings, on the bridge and/or on the deck depending on the complexity of the operation.

SOFS-6 Deployment:

21:30 19 March 2017

Ship's Mess

Present: Tom Trull, Pete Jansen, Jamie Derrick, Gary Curtis, Darren Moore, Eric Schulz,

Makito Yokota, Graham McDougall (Bosun), Rod Langham (experienced IR),

James Hokin (Officer of Watch for SOFS top float and anchor deployments and on-deck during grappling; *consulted separately on the Bridge*)

1. Successful day with no incidents, fully functioning ship and project systems, with one exception – the ship camera recording did not work.
2. Excellent communication between bridge and deck. Good ship positioning.
3. Approach to retrieve drogue mid-section done steadily and slowly, and ability to move towards pick-up line using bow thruster very welcome.
4. 100m pickup line with 5 large floats made job very easy
5. Large pneumatic cannon achieved ~ 100m shot and modified grapple connected first time, though the leading plastic edge still initially hung up on the drogue pick-up line, despite modification to smooth this edge. No further modifications recommended.
6. More floatation yokes on-board would be useful.
7. Initial target site was overshot by ~8 miles. This occurred because we needed 1.5 knots of speed to keep tension on and had 0.5 knots of current pushing us. Future planning of starting point should work on 1.5 knots not 1.0 knots.
8. While the job went smoothly, it is a very long job (15 hours). Essentially a deployment/recovery/deployment sequence all in one day. Major time savings will only be possible if a method to deploy float first (instead of mid-section first) is found. This was done with the crane on Southern Surveyor, but Investigator's crane is non-functional at sea.
9. A smaller time savings might be possible by the deploying transition section from a bin instead of back-winding to the winch.

SOFS – Other time saving suggestions made separately by individuals, for future consideration.

i. Preparing the large float packs at the bulwarks while the tether is streaming and then bring them into place in one go (instead of assembling while stoppered off).

ii. Use slitted lay-flat or other protective wraps so the shackle connections on the winch are fully done up and don't have to be remade.
iii. Using Vemco connectors that allow them to be wound onto the winch.
iv. Walking more small items over the back, rather than lifting them with pendant winch, e.g. cages and wire-attached instruments less than 20 kg.
v. Using two teams to shackle both ends of inserted instruments at same time.
vi. Using a traction winch so that spooling-on is unnecessary.

SAZ-19 Deployment:

15:15 21 March 2017

Ship's Mess

Present: Tom Trull, Pete Jansen, Jamie Derrick, Gary Curtis, Darren Moore, Eric Schulz,

Makito Yokota, Graham McDougall (Bosun)

1. Job was done with minus one IR in the morning, because called away to work on blocked plumbing. Science party provided a person to fill this role. This worked fine, and reminds us that redundancy across the two teams is valuable.
2. The Ship video camera system again did not record the deck cameras, despite attempts to fix this by shutting of many cameras. Redundancy from individual Go-Pro style cameras on deck appears to still be required until ship system is reliable.
3. During instructing of a new IR by Bosun in use of the deck-box for the A-frame, movement of the A-frame pulled the hook on the end of the pendant winch line free from its storage at the bulwark. This interaction between the A-frame and the pendant winches was not anticipated and could have been dangerous. It would be useful to install pendant hook storage points at the base of the A-frame uprights, so that movement of the A-frame does not load the pendant lines.
4. 2 of the 3 sediment traps leaked a few drops of liquid into the sled. This could be either water from between the stator and rotator plates from trap cleaning, or poisoned brine from the mercuric chloride cups. It was washed away. Thus the containment procedures worked, but vigilance remains important.
5. The final float pack was provided without the chain tail specified on the build plan. Vigilance and rechecking procedures are required.
6. Shackling of the inboard 'dead' end before the outboard "live" end of inserted elements is preferable.
7. The decision to hold off on the anchor drop until the ocean depth was deeper came very late, at a time when the anchor parachute was already outboard. This is not a good position for extended towing to the target (20' of towing in this case), because the parachute could unfurl. In future, final checks on bathymetry will be made before putting the parachute outboard and once it is outboard extended towing is to be avoided.

SAZ-18 Recovery:

18:15 23 March 2017

Ship's Mess

Present: Tom Trull, Pete Jansen, Jamie Derrick, Gary Curtis, Darren Moore, Eric Schulz,

Makito Yokota, Graham McDougall (Bosun)

1. Three large tangles in the dynex lengths were encountered during recovery. These were managed well, systematically, and slowly, but made for a long day. The main recommendations are around how to reduce the likelihood of this in future.
2. The ship should attempt recovery as soon as possible to avoid the elements tangling on the surface.
   Recommendations:
   Ship to stand off 0.5 instead of 1 mile when mooring released
   More colouring of the float packs would be helpful to quickly identify them
   Easy review of video from prior deployments is helpful
   Use of a polypropylene rather than dynex pick-up line would make it easier to see.
3. The position of the mooring was NOT correct on the ship navigation system, apparently through a typo in entering the position.
   Recommendations:
   There should be the ability for the science team to input marker positions into the ship navigation system from the Ops room, so both teams are sure to have the same positions.
   The science team should formalize a check/recheck system for positions.
4. The recovery was worked going downwind – this was okay in very calm weather, but could lead to excess tension on the mooring line and the tightening of tangles.
   Recommendations:
   Turning the job to windward should be the standard practice.
5. Knowing the position of the ship relative to the mooring during the grappling is not easy from the back deck. Use of a mobile white board helped somewhat.
   Recommendations:
   Access to the ship and mooring positions on a mobile app would be very useful. Or a large screen on the back deck.
6. Working the complex tangles that formed was difficult.
   Recommendations:
   Two tugger winches would allow for easier stoppering off of multiple lines
7. The dynex floats and thus the tangles represent a greater risk to entanglement in the ship's propeller than wire. Conversely, the tangles are easier to work.
   Recommendations:
   Be sure to follow the "reconvene and go around" rule if the planned approach needs to be changed.
   Do not use DP mode that would allow the propellers to run in reverse.
   Preferably use only the bow thruster during the close stages of grappling.
   The mooring design team will consider use of sinking polymer line.

UTAS Respire/TM trap deployment and recovery:

18:15 23 March 2017

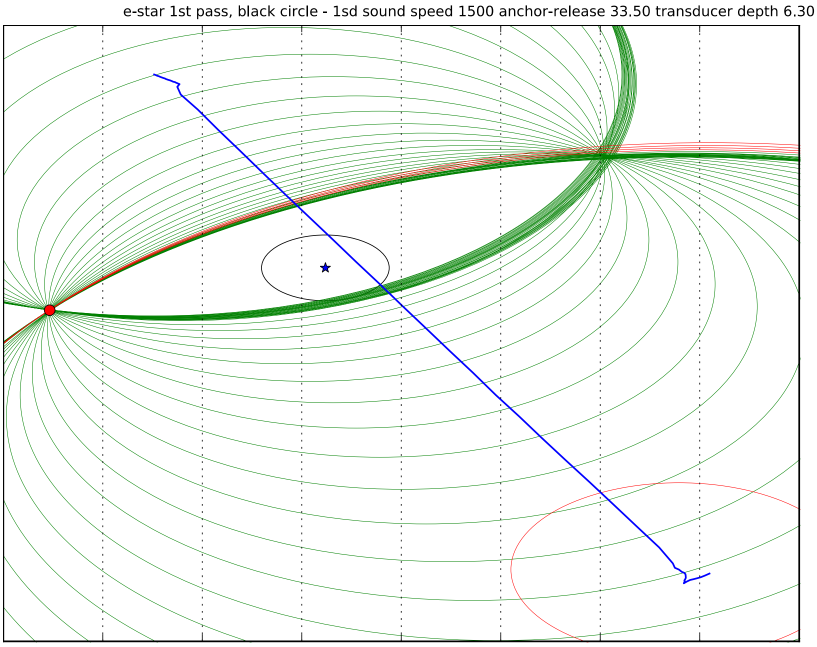
Ship's Mess

Present: Tom Trull, Pete Jansen, Jamie Derrick, Gary Curtis, Darren Moore, Eric Schulz,

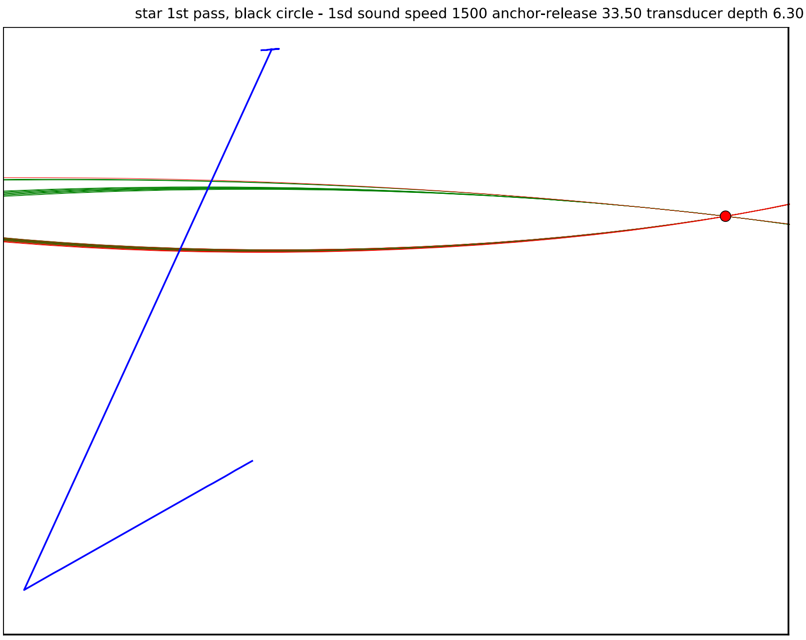
Makito Yokota, Graham McDougall (Bosun)

Recommendations:
1. Use polypropylene instead of dynex pick-up line
2. Provide an ASI beacon so float is visible on ship's navigation system
3. Provide a TM clean block
4. Consider a way to keep the trap closed until it is released from the ship, to avoid potential contamination. (Discussed separately with UTAS PI)

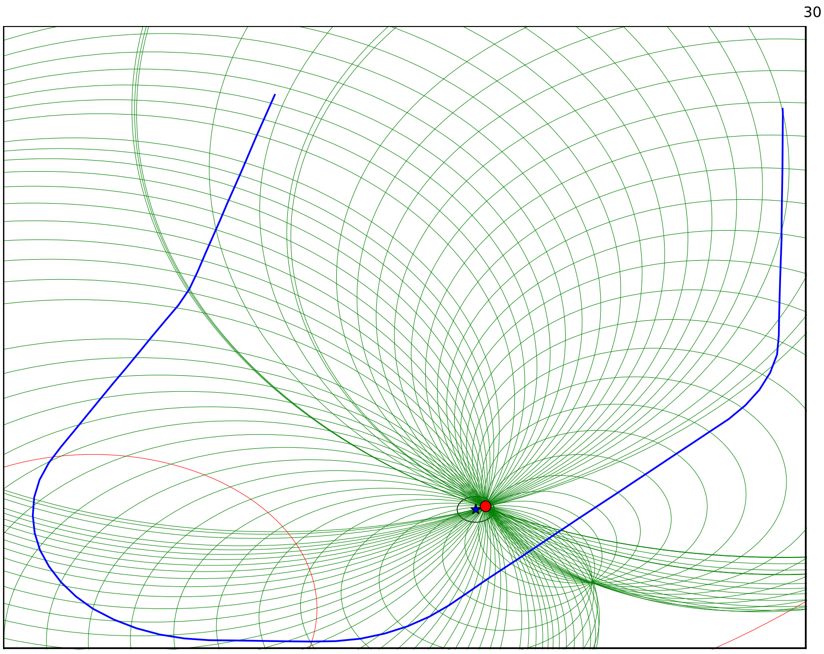
Appendix B Mooring triangulation



SOFS-6

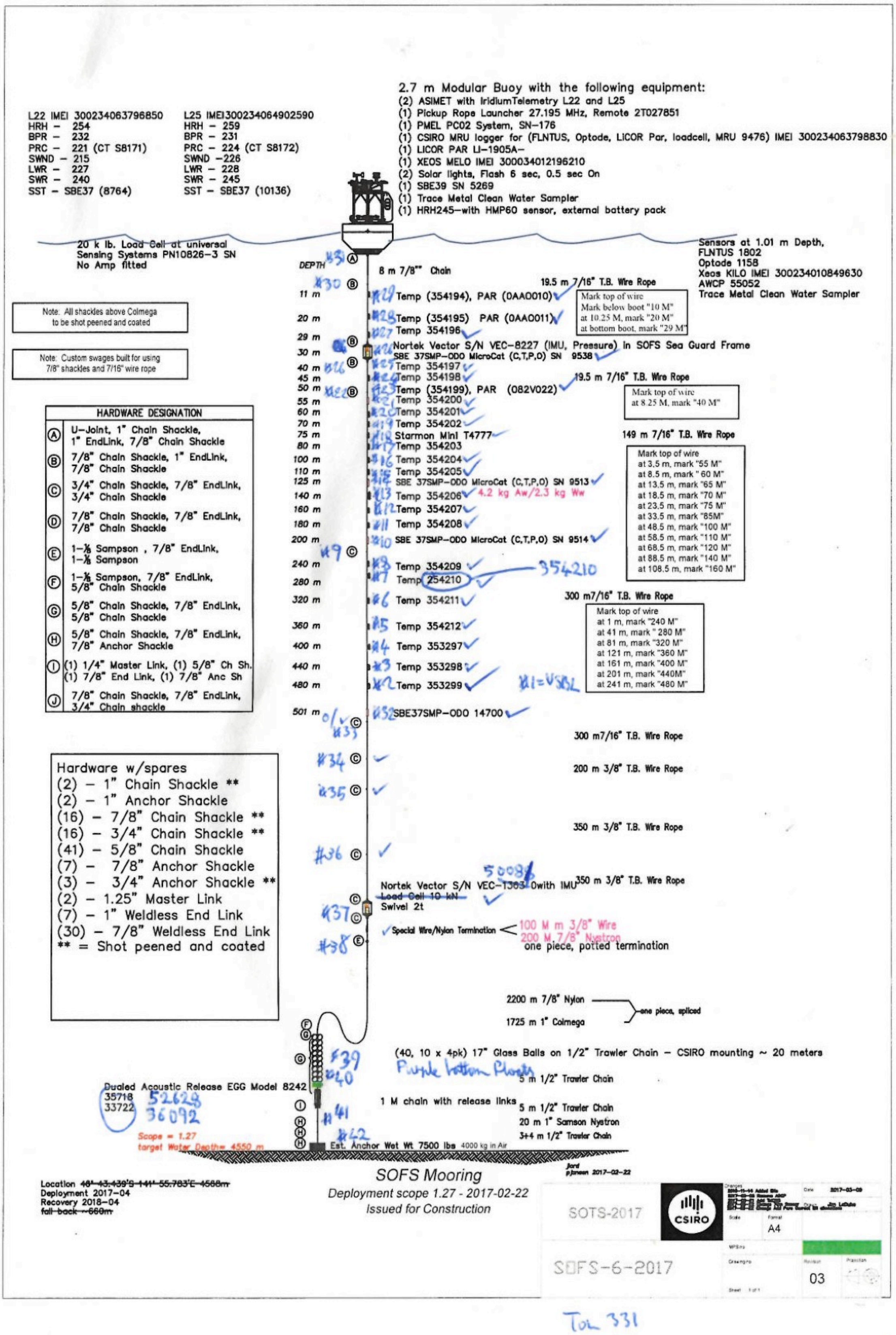


SAZ-19

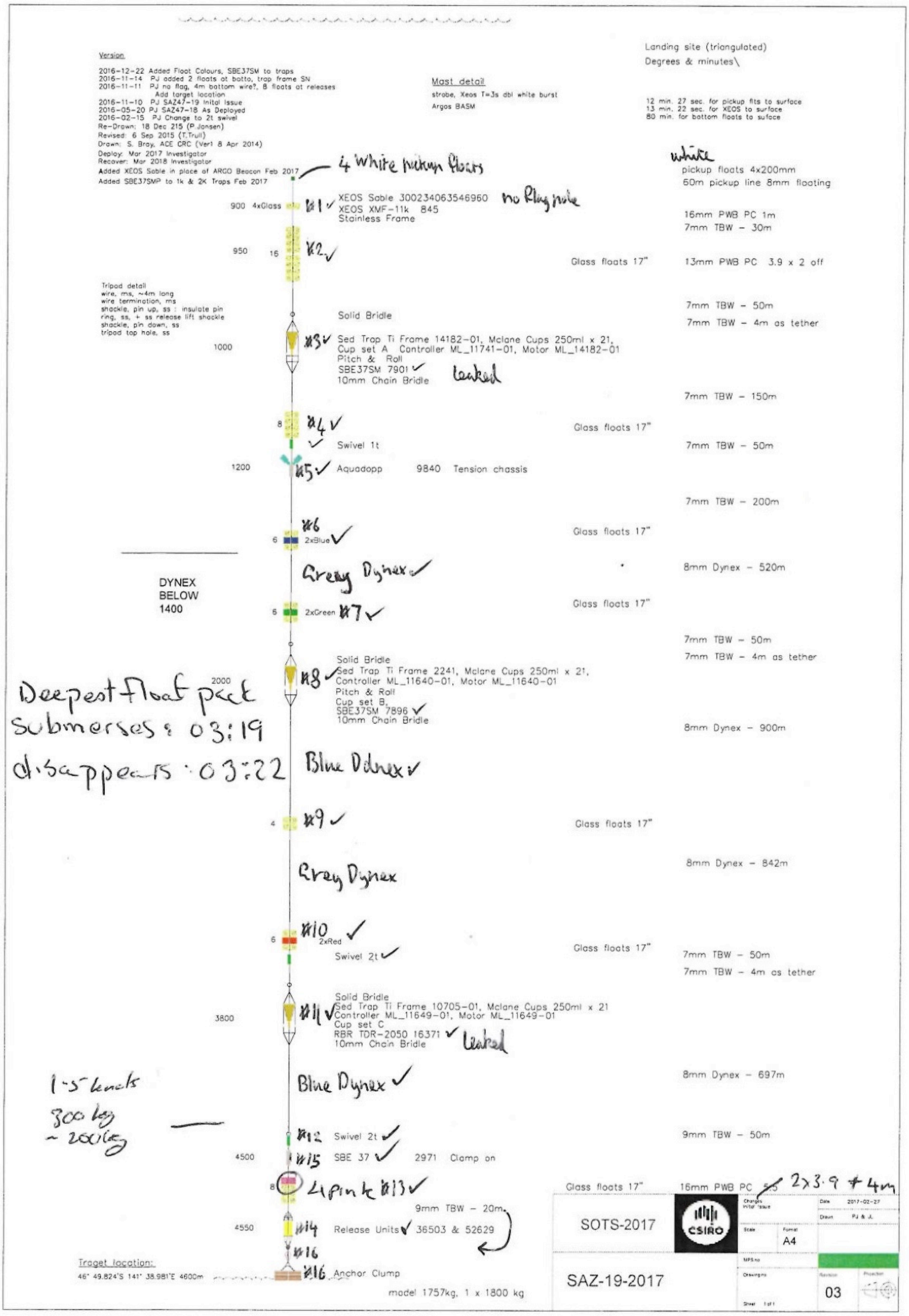


FluxPulse-1 fragment

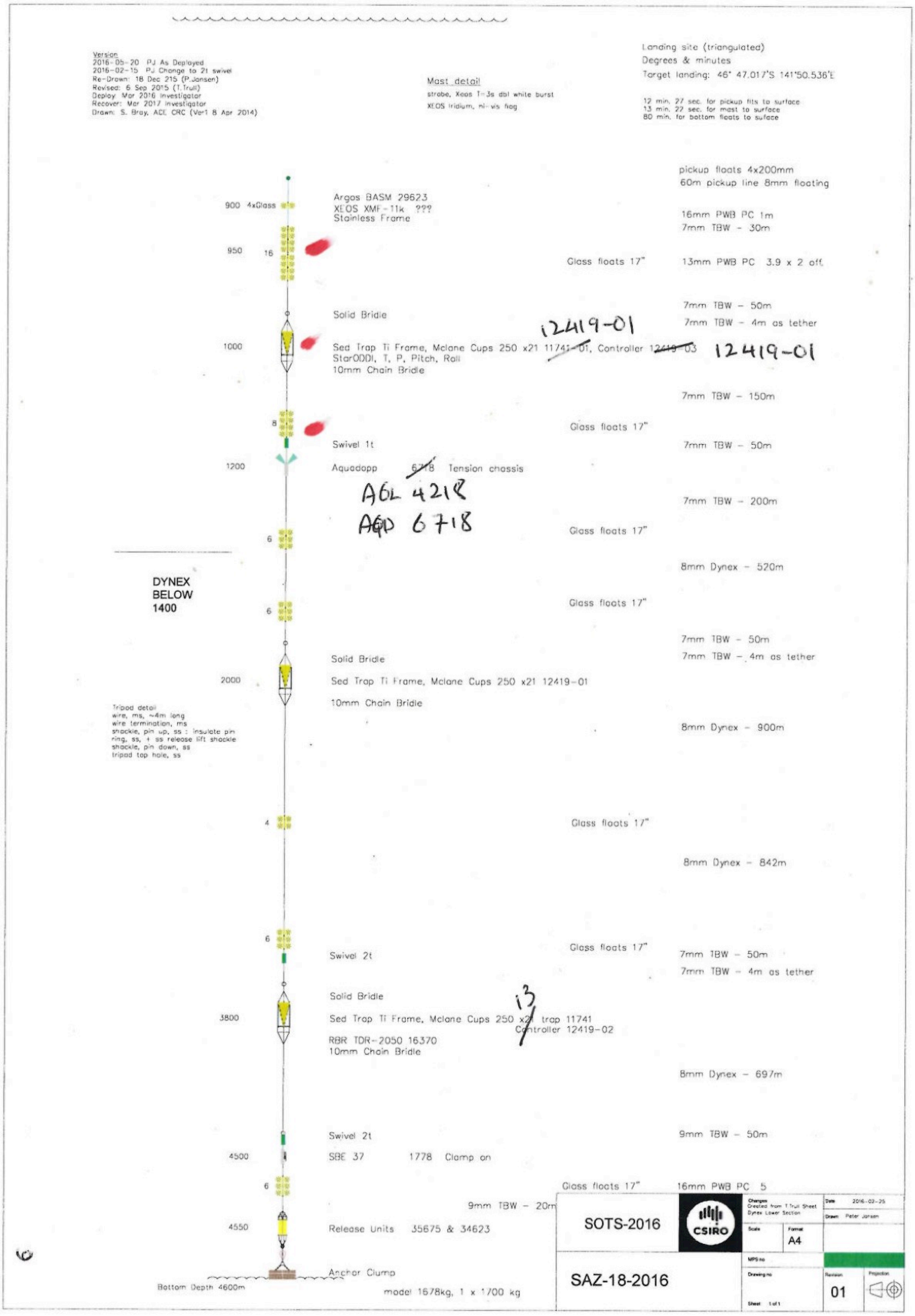
Appendix C Mooring diagrams



SOFS-6 as deployed



SAZ-19 as deployed



SAZ-18 as recovered

Appendix D – Station details for PLAOS

Table xx. Details of the station locations for the Profiling Lagrangian Acoustic Optical System (PLAOS).

Operation	Equipment	Date (UTC)	Start Time	Start Latitude	Start Longitude
1	PLAOS	17/03/2017	2:00	-43.408	147.456
2	PLAOS	19/03/2017	11:46	-45.991	142.106
3	PLAOS	19/03/2017	14:41	-45.990	142.117
4	Surface 38 kHz	19/03/2017	17:20	-45.978	142.129
5	PLAOS	21/03/2017	3:52	-46.101	142.303
6	PLAOS	21/03/2017	10:09	-46.739	141.942
7	PLAOS	21/03/2017	12:31	-46.740	141.944
8	PLAOS	23/03/2017	6:30	-45.938	142.060
9	PLAOS	23/03/2017	7:30	-45.938	142.060
10	PLAOS	23/03/2017	11:56	-45.930	142.047
11	PLAOS	24/03/2017	0:21	-46.085	142.255
12	PLAOS	24/03/2017	7:46	-46.076	142.243
13	PLAOS	24/03/2017	10:28	-46.074	142.241
14	PLAOS	25/03/2017	9:29	-46.054	142.190
15	PLAOS	25/03/2017	11:31	-46.078	142.221

Appendix E - CSR/ROSCOP Parameter CodeS

	METEOROLOGY
M01	Upper air observations
M02	Incident radiation
M05	Occasional standard measurements
M06	Routine standard measurements
M71	Atmospheric chemistry
M90	Other meteorological measurements

	PHYSICAL OCEANOGRAPHY
H71	Surface measurements underway (T,S)
H13	Bathythermograph
H09	Water bottle stations
H10	CTD stations
H11	Subsurface measurements underway (T,S)
H72	Thermistor chain
H16	Transparency (eg transmissometer)
H17	Optics (eg underwater light levels)
H73	Geochemical tracers (eg freons)
D01	Current meters
D71	Current profiler (eg ADCP)
D03	Currents measured from ship drift
D04	GEK
D05	Surface drifters/drifting buoys

	MARINE BIOLOGY/FISHERIES
B01	Primary productivity
B02	Phytoplankton pigments (eg chlorophyll, fluorescence)
B71	Particulate organic matter (inc POC, PON)
B06	Dissolved organic matter (inc DOC)
B72	Biochemical measurements (eg lipids, amino acids)
B73	Sediment traps
B08	Phytoplankton
B09	Zooplankton
B03	Seston
B10	Neuston
B11	Nekton
B13	Eggs & larvae
B07	Pelagic bacteria/micro-organisms
B16	Benthic bacteria/micro-organisms
B17	Phytobenthos
B18	Zoobenthos
B25	Birds
B26	Mammals & reptiles
B14	Pelagic fish
B19	Demersal fish
B20	Molluscs
B21	Crustaceans

D06	Neutrally buoyant floats
D09	Sea level (incl. Bottom pressure & inverted echosounder)
D72	Instrumented wave measurements
D90	Other physical oceanographic measurements

	CHEMICAL OCEANOGRAPHY
H21	Oxygen
H74	Carbon dioxide
H33	Other dissolved gases
H22	Phosphate
H23	Total - P
H24	Nitrate
H25	Nitrite
H75	Total - N
H76	Ammonia
H26	Silicate
H27	Alkalinity
H28	PH
H30	Trace elements
H31	Radioactivity
H32	Isotopes
H90	Other chemical oceanographic measurements

B28	Acoustic reflection on marine organisms
B37	Taggings
B64	Gear research
B65	Exploratory fishing
B90	Other biological/fisheries measurements

	MARINE GEOLOGY/GEOPHYSICS
G01	Dredge
G02	Grab
G03	Core - rock
G04	Core - soft bottom
G08	Bottom photography
G71	In-situ seafloor measurement/sampling
G72	Geophysical measurements made at depth
G73	Single-beam echosounding
G74	Multi-beam echosounding
G24	Long/short range side scan sonar
G75	Single channel seismic reflection
G76	Multichannel seismic reflection
G26	Seismic refraction
G27	Gravity measurements
G28	Magnetic measurements
G90	Other geological/geophysical measurements

	MARINE CONTAMINANTS/POLLUTION
P01	Suspended matter
P02	Trace metals
P03	Petroleum residues
P04	Chlorinated hydrocarbons
P05	Other dissolved substances
P12	Bottom deposits
P13	Contaminants in organisms
P90	Other contaminant measurements