RV *Investigator* Voyage Summary

Voyage #:	**IN2016_V02**		
Voyage title:	SOTS+CAPRICORN+Eddy		
Mobilisation:	Hobart, Friday-Sunday, 11-13 March 2016		
Depart:	Hobart, 1000 Monday, 14 March 2016		
Return:	Hobart, 0930 Saturday, 16 April 2016		
Demobilisation:	Hobart, Saturday, 16 April 2015		
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Objectives and brief narrative of voyage

Voyage IN2016_V02 combined three projects: SOTS, CAPRICORN and EDDY. The projects were originally formulated as separate entities, and then melded to achieve both logistical and scientific synergies within the constraints of the voyage allocation of 30 days (in comparison to the original summed individual requests for 45 days).

Scientific objectives

SOTS - Southern Ocean Time Series automated moorings for climate and carbon cycle studies southwest of Tasmania

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.

CAPRICORN - Clouds, Aerosols, Precipitation, Radiation, and Atmospheric Composition over the Southern Ocean

Cloud-aerosol-precipitation processes over the Southern Ocean (SO) are one of the largest sources of uncertainties in future climate projections. The CAPRICORN proposal aims to advance our knowledge of the SO cloud systems, aerosol properties, surface energy budget, upper ocean biological aerosol production, and atmospheric composition, in order to improve the characterization of their physical properties from satellite platforms and global models. The cloud morphological, microphysical and thermodynamical properties and boundary layer structure are very poorly observed over the SO. Climate and numerical weather prediction models also poorly represent the cloud and precipitation fields over the Southern Ocean and, as a consequence, appear to poorly predict the energy balance. The objectives of this proposal are to (i) characterize the cloud, aerosol, and precipitation properties, boundary layer structure, biological production and cycling of dimethyl sulfide (DMS) in the upper ocean, atmospheric composition, and surface energy budget, as well as their latitudinal variability; (ii) evaluate and improve satellite estimations of these properties, and (iii) evaluate and improve the representation of these properties in the Australian ACCESS regional and global model.

Eddy - Linking eddy physics and biogeochemistry in the Antarctic Circumpolar Current south of Tasmania

Our ultimate goal is to understand how eddy circulation impacts elemental cycling, and how this scales up to the eddy field of the Southern Ocean. We will conduct a process study of two contrasting eddies, one cyclonic and one anti-cyclonic, during the MNF voyage and expand our results to the Southern Ocean more broadly through data analysis and modelling efforts.

Voyage objectives

SOTS

The primary objective is to first deploy a reduced set (SAZ and FluxPulse) and then recover a full set of SOTS moorings (SOFS, Pulse, and SAZ). Additional work will obtain ancillary information on the 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 focuses on quantifying the transfer of carbon and other nutrients to the ocean interior by sinking particles, and collecting samples to investigate their ecological controls.
- the Southern Ocean Flux Station (SOFS) focuses on air properties, ocean stratification, waves, and currents.
- the Pulse biogeochemistry mooring focuses 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, which will be deployed for the first time in 2016. This combination meets financial constraints while still measuring almost all planned parameters

CAPRICORN

- The primary objective is to collect cloud, aerosol, precipitation, radiation and atmospheric composition measurements over the Southern Ocean over 30 days, and to capture the latitudinal variability of these properties from the latitude of Hobart down to 55-60S if time allows. The Investigator will be equipped with a state-of-the art suite of instruments for that purpose (see list below).
- In order to address the "satellite validation" objectives, we need to locate the research vessel under the track of the CloudSat-CALIPSO instrument and within the larger swath of the NASA GPM and A-Train radars and radiometers. This will be achieved in coordination with the requirement to sample a mesoscale oceanic eddy using a dedicated pattern that will include satellite track following and mesoscale eddy sampling using radial transects, after the SOTS moorings are deployed and recovered.
- In order to address the "ACCESS model validation" objectives, we need to sample the sub-grid scale variability of the atmospheric properties, therefore we will undertake some periods of intensive sampling of 12*12 km2 grids with small-scale lawnmower patterns, ensuring that the aerosol measurements are not perturbed by the ship exhaust. The timing and location of these grids will be determined during the voyage.

Eddy

- Deploy a suite of floats, two different designs per eddy, to obtain profiles of temperature, salinity, velocity, oxygen, nitrate, pH and bio-optics near the eddy centre while we perform spatial surveys.
- Measure the velocities and mixing in the two eddies.
- Quantify the elemental fluxes associated with the eddy circulation, including nutrient transport and air-sea CO_2 flux.
- Measure the biological response to the circulation and nutrient transport, including primary productivity, trace metal biogeochemistry, new production and the respiration of downward carbon flux (using free-drifting RESPIRE sediment traps).

Our combined ship-satellite-float observations will provide the most comprehensive view thus far of Southern Ocean eddies. Our work also contributes to emerging international programs in the Southern Ocean that are combining expanded autonomous observations with large scale modelling efforts.

Results

SOTS:

1. The two new moorings were successfully deployed: FluxPulse-1 (combining instruments from previous platforms SOFS and Pulse examining air-sea fluxes and upper ocean biogeochemical processes), and SAZ-18 (measuring deep ocean sinking particle fluxes, currents and heat content). 100% success.
2. The three existing moorings were successfully recovered: SOFS-5, Pulse-11, and SAZ-17. 100% success.
3. CTDs (2 casts to 2250m) were undertaken at the SOTS site, including collecting samples for nutrients, oxygen, dissolved inorganic carbon, alkalinity, and particulate matter analyses. 100% success.
4. Carried out underway air and water sampling and sensor measurements, including bio-acoustics. 100% success.
5. Towed the MacArtney Triaxus one or more nights while at SOTS site. 100% success.
6. Deployed 2 SOCCOM autonomous profiling floats at the SOTS site, subject to availability. 100% success.
7. Tow CPR to SOTS site. Not achieved. SOTS team were not provided with CPR cartridges for the voyage.

CAPRICORN

All instruments worked very well to characterize clouds, aerosol, radiation, surface energy fluxes, and in-situ and vertical profiles of rainfall properties. The cloud radar / lidar / microwave radiometer (MWR) combination will allow for a comprehensive documentation of the microphysical properties of clouds that are relevant to the climate model biases in the region. Supercooled liquid water clouds, which are potentially one of the main causes of the climate models failing to reproduce the surface shortwave radiation budget in this region, have been clearly identified during the voyage. Very different cloud, aerosol, and

surface flux signatures have been observed in pre-frontal, post-frontal, as well as within the cold-core and warm-core eddies.

Regarding the satellite validation objectives, we have collected measurements within the CloudSat-CALIPSO swath three times, including two times with interesting clouds and aerosol layers. Opportunities for collocated measurements with the GPM rainfall satellite were numerous, but the MNF weather radar failed early in the voyage, which did not allow these objectives to be completed.

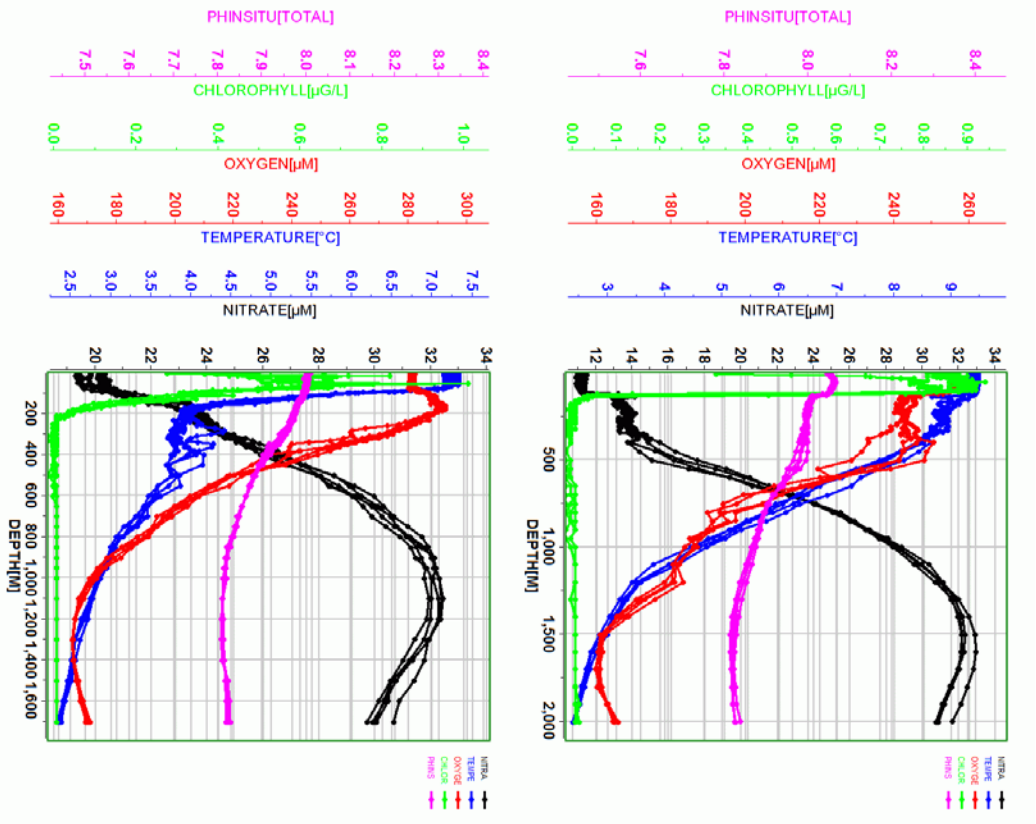
Regarding the modelling objectives, the CAPRICORN team feels that although we have given up on the lawnmower patterns to save ship time, we will still be able to address our model validation objectives using more traditional statistical comparisons.

Eddy

1. **Deploy a suite of floats, two different designs per eddy, to obtain profiles of temperature, salinity, velocity, oxygen, nitrate, pH and bio-optics near the eddy centre while we perform spatial surveys.**

   A biogeochemically enhanced Argo float (T, S, nitrate, oxygen, pH, chlorophyll fluorescence, optical backscatter) was deployed at the centre of each type of eddy (cyclonic and anticyclonic). The eddy centre was identified from a prior TRIAXUS and shipboard ADCP survey through the expected eddy location (from satellite altimetry). These floats were supplied through a collaborative arrangement with the US Southern Ocean Carbon and Climate Observations and Modelling (SOCCOM) program, led by Princeton University.

   We successfully lobbied the SOCCOM program to change the profiling frequency of the floats to daily for the first 6 days (rather than once every 9-10 days) to increase the potential for intercomparison of our high resolution CTD data with float observations. The plots below show the accumulated profiles from the two floats as of time of writing. Preliminary nutrient analyses indicate an offset between the float and CTD observations of about 3 uM for float 9631 – this is precisely why these intercomparison data are important. The floats will likely stay in the eddies until the beginning of winter mixed layer deepening, providing valuable context for our relatively short 6 day occupation of each eddy.



We have collected excellent initial data but this objective was not 100% successful because a second type of float that was to be deployed for comparison did not arrive in time for our voyage. These floats will be deployed on the next Investigator voyage (Sloyan, IN2016_V03) which will transit through these subantarctic waters on the way to the start of the GO-SHIP line in the outer Ross Sea.

2. Measure the velocities and mixing in the two eddies.

Deployments of the Vertical Microstructure Profiler (VMP) were not possible due to poor weather and time constraints. The lowered Acoustic Doppler Current Profiler (LADCP) on the CTD rosette will provide vertical velocity (w, through advances in data processing) as well as the usual horizontal velocities and will allow estimation of vertical diffusivity (Kz). These parameters in part control the physical structure of the eddies. This objective was 100% successful but would have been enhanced by direct observations of Kz from the VMP to compare with parameterised estimates from the CTD/LADCP.

3. **Quantify the elemental fluxes associated with the eddy circulation, including nutrient transport and air-sea CO_2 flux.**

   Water samples from the CTD were analysed by the MNF hydrochemists for dissolved nitrate, nitrite. ammonium, phosphate and silicate. These nutrient profiles, at relatively high vertical resolution, when combined with the estimates of w and Kz will enable us to calculate vertical nutrient fluxes. Dissolved concentrations of iron and other trace metals were measured at lower vertical resolution and at fewer stations (because the methods are more time-consuming), but they will also provide estimates of trace metal supply into the upper ocean using the vertical velocities and diffusivities. The air-sea CO_2 flux will be calculated from the CSIRO/MNF-maintained underway observations. This objective was 100% successful but would have been enhanced by direct observations of Kz from the VMP to compare with the parameterised estimates from the CTD/LADCP.

4. **Measure the biological response to the circulation and nutrient transport, including primary productivity, trace metal biogeochemistry, new production and the respiration of downward carbon flux (using free-drifting RESPIRE sediment traps).**

   Depth-resolved measurements of primary productivity (C uptake) and new production (N uptake) were made at about 7 stations across the two eddies. The number of stations would have been greater were it not for the bad weather during the anticyclone occupation. Depth-resolved measurements of trace metal biogeochemistry (dissolved and particulate iron and other bioactive metals such as zinc, iron-binding ligands, iron stable isotopes, biological iron uptake by small and large phytoplankton) were made at 8 stations across the two eddies. Drifting RESPIRE sediment traps were deployed in each eddy to measure particulate organic carbon export flux, in situ microbial breakdown and consumption of this export signal. A novel prototype Trace Metal RESPIRE particle interceptor was also successfully field-tested and provided samples for particulate iron remineralisation rates from deployment 1 (the second deployment was compromised due to contamination issues).

   The export flux and remineralisation data will be compared with other proxies for export processes including Thorium disequilibria (Edith Cowan team), barium (IMAS/European collaborators), and zooplankton respiration (IMAS). This objective was mostly met, although more stations in the anticyclonic eddy would have been better, and strong winds moved the RESPIRE sediment trap in the anticyclone well out of the eddy towards the end of its deployment (at which point it was no longer intercepting particles, but incubating them in situ).

   Additional achievements: We did not explicitly list TRIAXUS observations in our research goals, but with excellent MNF support we successfully obtained a sustained transect through each eddy. These detailed sections of eddy physics, chemistry and biology help us better understand eddy processes and aid the interpretation of all other observations at lower spatial resolution.

Problems: There were three issues that impacted our ability to achieve all of our goals 100%. (1) the week long delay caused by the propeller tangle meant that we missed a window of very good weather to start observations of the cyclonic eddy. This was partly compensated for by the extension of the voyage. (2) The A frame failure on April 4th set us back more than just the time lost during RESPIRE trap recovery, because some time-sensitive operations that followed had to be cancelled. (3) We lost almost three days to bad weather during the occupation of the anticyclonic eddy. This is not unexpected in the Southern Ocean but it meant that the CTD coverage for that eddy was about half that of the cyclonic eddy.

Voyage Narrative

All times in the Voyage Narrative are local shiptime = UTC+10.

Monday 14 March

After on-time departure at 09:00 (UTC+10), three hours were spent in the Derwent Estuary testing the weather radar while rotating and rolling the ship and then three radar engineers were offloaded using the fast rescue craft. The testing of the weather radar demonstrated that the new motion compensation system works well and adjusts pointing angles of the radar quickly and accurately. Operation rehearsals began with deployment of the trace metal clean intake towed fish, followed towing of 400m of nylon braid for retrieval to the mezzanine net drum using the newly installed spooling rack and air-tuggers. Both systems functioned acceptably. Planned tests of the CTD, Triaxus, and Trace Metal Rosette (TMR) were deferred owing to the need to focus on getting the thermosalinograph to record correctly. Accordingly we departed at ~1800 local time.

Tuesday 15 March

The day was spent transiting toward the SOTS site. In the afternoon the CTD and TMR were tested. The CTD secondary salinity channel was over 1 ppt higher than the primary cell and was swapped out. The TMR functioned correctly. A first training for CTD sampling was provided by the hydrochemistry team. There is a high pressure south of Tasmania, which should last until Thursday, then a low is approaching. Wave forecast was 2-4 m maximum. Nice weather, some thin cirrus, very thin stratocumulus from 1500 UTC, turning into drizzling stratocumulus. First downlink issues were noted for the weather radar on that day.

Wednesday 16 March

FluxPulse-1 was successfully deployed in low winds and seas, mixed sun and drizzle The operation took 13 hours, 1 longer than in 2015 (despite streamlined deck operations) as a result of requiring three passes with the ship to re-grapple the mooring top section. This reflected the difficulty of operating without a bow thruster. Overnight the mooring was triangulated and ship sensor data was collected near the mooring. The operations were started 6.5 miles southeast and finished 1 mile beyond the drop site, with correct anchor depth achieved.

Thursday 17 March

The Triaxus was deployed and operated all day, while simultaneously spooling on the SAZ-18 mooring. After two transits of a small east-west thermal front near 46. 5 S, 141-142 E, with oscillations between 10 and 200m with the SUNA and FIRe instruments mounted, the primary and secondary salinity channels displayed aberrant behaviour and Triaxus recovery revealed clogging of their intakes by salps. After cleaning and swapping out the secondary conductivity sensor (suspected of having additional problems), Triaxus was redeployed and mapping continued overnight. A small additional Triaxus data loss occurred as a result of a prolonged computer reboot. Two attempts to launch weather balloons were not successful owing to windy conditions that separated the probes from the balloons (one by wrapping the cord around the overhead Triaxus tow wire, the other by energetic wind – operator interactions).

Friday 18 March

Triaxus was recovered at 0330 while operating well, in order to make the deployment start position by 0630. This revealed damaged left-side rails (apparently as a result of insufficient weld strength) and a non-responding aft lower control flap (traced to loose axle screws). Both problems were repaired at sea. A weather balloon radiosonde was successfully launched from the fantail rail at 0730, and deployment of SAZ-18 began immediately thereafter, starting 8 miles northeast of the drop site in sunny and calm weather, and finishing at 1500. SAZ-18 triangulation was performed following recovery. CTD commenced at 2030 near FluxPulse-1. EEC weather radar engineers connected to the radar remotely and confirmed that there was nothing we could do to fix the radar. So the weather radar will be down for the whole voyage.

Saturday 19 March

Meteorological comparisons with FluxPulse-1 performed until 0300 when the TMR was deployed. Ship positioned ~1Nm from SAZ-17 at 0630 for recovery. SAZ-17 releases triggered 0700 and floats sighted shortly thereafter. Recovery proceeded smoothly with only one tangle and completed by 1600. A weather balloon radiosonde was successfully launched from the rear deck at 1615 before steaming back to the FluxPulse-1 site for further meteorological comparisons spooling of the mooring. A zooplankton net haul down to 30m was conducted at 2000.

Sunday 20 March

The TMR was deployed to 1500m depth at 0300. We then transited to the Pulse-11 site, 19Nm to the SW, arriving at 0630. Weather conditions are very light with sea from SW, low winds from the NW and some rain in the area. Pulse-11 releases triggered at 0700 and floats sighted shortly thereafter. While grappling the floats from the stern the ship drifted back down over the mooring, catching mooring line around the starboard rudder stock and propeller blade at 0920. “Camera on a stick” and ROV confirmed the tangle. The day was spent recovering loose line floating neat the ship and attempting to free the rudder and propeller. The top ¾ of the mooring parted ~mid-afternoon (~1500). Deployed a marker drifting buoy alongside Pulse-11 around 1800 and then commenced transit to Hobart under port propeller only at 7kts. The CAPRICORN team organized to collect measurements under the CloudSat-CALIPSO track but there was no cloud there.

Monday 21 March

Overnight the port propeller started to squeak and ship speed was reduced to 2 kts in light conditions from the SW. Successful balloon launch at 1400.

Tuesday 22 March

Continued transit towards home at reduced speed. Trace metal 'fish' deployed ~0800. Side booms supporting the trace metal fish and sea snake retracted ~1130. Radiosonde launched 1250. Dive boat arrived 1330. Diver in the water 1457. Diver assessed conditions as too risky and attempt to untangle propeller aborted. Radiosonde launched 1910. Steaming for Adventure Bay at 7 knots. Front passing over ship during the night. 4-hourly radiosonde launches to analyse the atmospheric structure across the front. More balloon launches ~ 0000, 0400.

Wednesday 23 March

Balloon launch 0820 and 1200.

Thursday 24 March

Arrived at adventure Bay ~0600. Diver commenced clearing props ~0800. Mooring polymer (dynex) line was found around both props, and the port propeller rope guard was found to be displaced so that it rubbed on the prop – the probable source of the rubbing/squeaking noise during transit back towards Tasmania. The fouling line and the port prop guard were both removed. Sea trials performed in Adventure Bay 1300-1430 cleared the ship for operation with no limitations. Departed 1530 heading due south at 11kts for CloudSat overpass site (45S, 141E).

Friday 25 March

Arrived at location for CloudSat overpass at 0200. Balloon launches at 0400, 0800, 1400. Cloud Sat overpass at 1430, with an interesting aerosol layer with some depolarization (interesting for CALIPSO aerosol type classification algorithms). We then headed off slowly to the west to gain some distance towards the SOFS site while keeping north of the rough conditions developing south. Radiosondes continue to be deployed regularly throughout the night. Frontal passage at about 0430 LT.

Saturday 26 March

Continued making slow progress to the West. Continued balloon launched as another front passed through the area.

Sunday 27 March

Turned south at 1000 to head for the Pulse-11 mooring that is continuing to drift to the East. Easter eggs were consumed. Beam seas causing some rolling. Successfully test fired the pneumatic grapple gun.

Monday 28 March

Arrived at the drifting Pulse-11 location. Conditions light to moderate from the SW, some squalls coming though during the morning. Floats found by mid-morning. Mooring in three clumps – top float, large tangle of around 23 floats and string of pearls, 5-pack floats with long tope tail. Made four grappling attempts in the "string of pearls" mid-section. All hooked on, but were ultimately unsuccessful due to: failed knot, bent tine, twice the line slipped free. Abandoned effort ~ 1600.

Tuesday 29 March

Resumed attempt to grapple Pulse-11.Conditions light 15kts wind, sea 3m from SW. The bosun suggested a change in strategy, and this worked. We grappled the loose trailing 800m dynex section that had been previously cut by the prop and successfully secured it 0830. Mooring all on board 1600. We turned south and commenced transit to the site of the "Eddy" component of the voyage. Very interesting mixed-phase clouds sampled by the cloud radar – lidar on the foredeck, with supercooled liquid water on top of precipitating ice fall streaks (those clouds are typical of post-frontal situations, and are common in the Arctic, but they have never been really observed over the Southern Ocean).

Wednesday 30 March (start of cyclonic eddy sampling)

Investigator continued the transit south from the Pulse mooring recovery to intersect with a CloudSat overpass at 50.3°S 144.7°E, at 14:45, which was successful. A cirrus cloud was sampled at the same time as the satellite. From there Investigator transited to the western edge of the cyclonic (cold core) eddy at 146.01°E, 50.37°E, for a TRIAXUS deployment at about 1900. Before that waypoint there was a decrease in temperature at 1800 indicating the edge of the eddy, so the ship backtracked and TRIAXUS was deployed at 2040. The eddy was surveyed by TRIAXUS west-to-east, toward a waypoint at 148.75°E, 50.37°S. The transect went very smoothly with no stops.

Thursday 31 March

Investigator continued the TRIAXUS transect W-E at about 8 knots in good weather with following seas. Reached the eastern edge of the eddy at 1000, recovered TRIAXUS and did 1500m CTD, the first of 6 back to the eddy centre. The TRIAXUS data showed a complete transect of the eddy based on the temperature and salinity data returning to the values seen at the western edge of the eddy. TRIAXUS performed flawlessly for about 14 hours.

Investigator completed the 6 CTDs along the transect from the eastern edge of the cold core eddy to the centre (Transect A). CTDs A1-A5 were all to 1500 m depth. CTD A6 was the calibration CTD for the SOCCOM float, to 2250m. Float 9631 ('moby dick') was deployed at 1856 UTC 31-Mar-2016 (0456 local 1-Apr-2016) at 147° 04.788'E, 50° 23.230'S.

The start position and UTC time of the CTD stations are shown below.

Station ID	Start Latitude	Start Longitude	Date (UTC)	Start Time (UTC)
CTD 3 (A1)	50° 23.00'S	148° 25.20'E	31/3/2016	0153
CTD 4 (A2)	50° 23.00'S	148° 09.12'E	31/3/2016	0460
CTD 5 (A3)	50° 23.00'S	147° 53.04'E	31/3/2016	0750
CTD 6 (A4)	50° 23.00'S	147° 36.96'E	31/3/2016	1044
CTD 7 (A5)	50° 23.00'S	147° 20.88'E	31/3/2016	1346
CTD 8 (A6)	50° 23.00'S	147° 04.80'E	31/3/2016	1632

A very interesting day for the CAPRICORNers too. A layer of thick sea fog was observed as soon as we reached the eddy location, and some drizzling stratocumulus precipitating on the sea fog layer, then cirrus clouds. Lots of multi-layer clouds on that day, which will require specific studies.

Friday 1 April

Back at the centre of the eddy, the Investigator steamed 1 nm south and set up for deployment of the first RESPIRE sediment trap (traps at 170m and 190m). Deployment was completed by 0830 local, followed by a TMR, a 500m CTD and ISP deployment, and then departure for a CloudSat overpass at 1130 on the eastern side of the eddy. Failed balloon launch due to rough conditions. CloudSat overpass was characterized by rain attenuating strongly the cloud radar signal. This case will be very interesting to evaluate the retrieval of light precipitation using path-integrated attenuation techniques applied to CloudSat. There was also a very good signal from the micro-rain radar and the OceanRAIN disdrometer on that overpass. After the Cloudsat overpass at 1435 local, we steamed to the edge of the cold eddy to the position of station A1. We started Transect B, CTDs B1-B6 that were the same as A1-A6. The eddy was rotating at approximately 2 degrees per hour so that in eddy coordinates, our B transect was rotated 62 degrees counter clockwise from the A transect.

Saturday 2 April

Both the RESPIRE sediment trap and to a lesser extent the SOCCOM float had moved well south of their deployment locations based on GPS positions received on board, so B6 was performed at the same location as A6 (i.e. hitting the drifter and float was not a concern).

Station ID	Start Latitude	Start Longitude	Date (UTC)	Start Time (UTC)
CTD 10 (B1)	50° 23.01'S	148° 25.41'E	1/4/2016	0739
CTD 11 (B2)	50° 23.04'S	148° 09.15'E	1/4/2016	1051
CTD 12 (B3)	50° 22.88'S	147° 53.07'E	1/4/2016	1325
CTD 13 (B4)	50° 22.84'S	147° 37.03'E	1/4/2016	1644
CTD 14 (B5)	50° 23.01'S	147° 20.80'E	1/4/2016	1945
CTD 15 (B6)	50° 22.93'S	147° 04.85'E	1/4/2016	2319

After the completion of the B transect, a 1000m CTD (CTD16) was performed to get 1000m water for MNF and 170m particle and zooplankton samples for Boyd, then in situ pumps were deployed for 3 hours and a 500m CTD (CTD17) was done for the Thorium/Barium sampling. Investigator then steamed roughly NW to 49° 40'S, 146° 30'E. Shallow convection has been sampled by the cloud radar and the MRR during a GPM overpass on that day (0757 LT). Multiple cloud layers with supercooloed liquid water have again been observed on that day. A balloon was launched at about 0930.

Sunday 3 April

Investigator arrived at the NW edge of the eddy around 0300 local Sunday and set up for a zooplankton tow (0330 – aborted due to high wind) and Trace Metal Rosette (TMR) deployment (0400), followed by a 1500m CTD (CTD 18) which was the first of six stations back to the eddy centre.

Station ID	Start Latitude	Start Longitude	Date (UTC)	Start Time (UTC)
CTD 18 (C1)	49° 40.67'S	146° 30.09'E	2/4/2016	2000
CTD 19 (C2)	49° 48.51'S	146° 37.07'E	2/4/2016	2246
CTD 20 (C3)	49° 57.05'S	146° 43.87'E	3/4/2016	0213
CTD 21 (C4)	50° 05.47'S	146° 51.20'E	3/4/2016	0457
CTD 22 (C5)	50° 13.80'S	146° 57.77'E	3/4/2016	0735
CTD 23 (C6)	50° 22.20'S	147° 04.78'E	3/4/2016	1009

After completing Transect C around 2135 we set off on an ADCP survey from the centre to 51° 11.767'S, 147° 19.587'E. This bearing (170°) was to sample the southern side of the eddy across its 50nm radius, and to get multibeam data along a sharp ridge to the west, as well as not running over the drifting sediment trap. Very interesting day or CAPRICORN with intense shallow convection in the morning, followed by more supercooled liquid water layers nucleating ice fall streaks.

Monday 4 April

We spent most of the day in the warm sector of a front with early morning stratiform precipitation. The return to the centre was moved west by approx. 10 miles to sample more of the ridge. The ship speed was set to 10nm to return to eddy centre by 0900, where a deep (1500m) TMR was performed, followed by another aborted net tow and a 500m Thorium CTD (CTD24). Investigator then steamed to the drifting RESPIRE sediment trap, ~10nm SW of the eddy centre to begin recovery, which was interrupted by the failure of the A frame. The A frame started working again around 1630 but overheated again around 1730. The sediment traps finally came on board intact around 2000 - a 7 hour operation. We then set off back toward the centre of the eddy on a roughly northeast bearing.

Tuesday 5 April

Investigator continued to the northeast for an underway ADCP survey, to be back at the eddy centre by 0500 to do in situ pumps (on board 0930) and tow fish (on board 1100). A balloon was successfully launched in the morning. A SW transect (D) out of the eddy was planned but cancelled due to damage to the CTD and rough weather. A CTD next to SOCCOM float 9361 was among those cancelled. We reached the southwest edge of the eddy around 2000 and started a transit south to 53°S, 147° 6'E, the southern side of a jet of the Subantarctic Front. On the way we detoured slightly to pass through a patch of elevated MODIS chlorophyll, that coincided with a patch of moderate retention (28 days) from FSLE (finite size Lyaponov exponent). A lot of stratiform rain today, with different characteristics from other frontal passages: the MRR only showed modest reflectivities (15-20 dBZ) but the lidar was completely attenuated, like in very intense fog, so presumably the drop size distribution from the disrometer will show an anomalously large number of small drops.

Wednesday 6 April (start of anticyclonic eddy sampling)

Investigator continued approximately southwards in relatively heavy seas and winds to the waypoint at 53°S, 147° 6'E at about 0900. After several hours of waiting for the weather to improve, CTD25 was deployed at 1130 and recovered around 1300. Conditions were still not good enough for TRIAXUS so Investigator steamed 10 nm towards the anticyclone centre waypoint (51° 54'S, 148° 31'E) for a CTD (number 26) and a reassessment of TRIAXUS conditions. Word is the A-frame is fixed. TRIAXUS was in the water about 1700 and started undulating, back on the line towards the anticyclone centre, at 1745. The weather continued to improve and the TRIAXUS transect continued through the night.

Thursday 7 April

TRIAXUS was recovered in deteriorating conditions around 0400. The vehicle had performed flawlessly for about 11 hours. Investigator steamed back to the 'centre of anticyclone' waypoint (51° 54'S, 148° 31'E) for a TMR at 0530, followed by a 2250 m CTD (number 27, in water around 0700) and the drifting sediment trap (RESPIRE) deployment (170m and 190m traps) completed by midday. SOCCOM float 9744 ('frodo'), was deployed at 0250 7-Apr UTC (1250 local) at 148.51°E, 51.90°S, the same location as CTD 27. Conditions were deemed too rough for further CTDs so Investigator steamed almost due east towards the centre of a cool eddy/meander at 151° 10.2'E, 52° 7.86'S, collecting ADCP and underway data. Around 2100 conditions improved and the CTD transect (E) from east to west was started. CTD E5 went into the water just after midnight.

Friday 8 April

At station E4 around 0400 the weather was judged to be too windy to start a CTD so Investigator hove to. At 1830 the weather was slightly better so we started CTD E4. After water sampling was completed, CTD space locked, and coring boom unisolated, we put the tow fish in the water (2100) and towed it for approximately 3 hours at 3 knots toward Station E3. Another frontal passage at 0700 LT, and the GPM satellite passed over us about one hour before rained (at 2237 LT). The dataset will still be good for statistical comparisons within that rain event. Two very intense shallow convective cells were observed at about 1930 and 2000 LT.

Saturday 9 April

The CTD at E3 scheduled for 0130 was delayed since winds were 35-40 knots with no sign of abating. Hove-to on station. Another productive session brought to you by the morning shift. The CTD wire mechanical connection was reterminated to remove some kinks in the wire, without doing an electrical retermination, which took about 2 hours. The winds eased and we deployed CTD 31 at E3 for a 500m cast for Barium/Thorium samples. This site was chosen because the sediment trap looked to be within 7nm. We followed this with a regular 1500 m CTD 32 (E3) and CTD 33 at station E2 around 2300.

Station ID	Start Latitude	Start Longitude	Date (local)	Start Time (local)
CTD 28 (E6)	52° 01.97'S	149° 50.75'E	7/4/2016	2100
CTD 29 (E5)	52° 00.05'S	149° 34.68'E	8/4/2016	0030
CTD 30 (E4)	51° 58.78'S	149° 18.51'E	8/4/2016	1828
CTD 32 (E3)	51° 57.22'S	149° 02.65'E	9/4/2016	1757
CTD 33 (E2)	51° 55.66'S	148° 46.89'E	9/4/2016	2109
CTD 35 (E1)	51° 54.00'S	148° 31.00'E	10/4/2016	0300

Another frontal passage today (started yesterday evening at 2300 LT), with mostly stratiform precipitation.

Sunday 10 April

Investigator arrived at the centre station E1 around 0100. The order of operations was: 500m Th/Ba CTD (CTD34) on deck at 0200, CTD 35 to 1500m from 0300 to 0430 and in situ pumps from 0500 to 0930. From the eddy centre, a transect was started from the centre towards the NW as follows.

Station ID	Start Latitude	Start Longitude	Date (local)	Start Time (local)
CTD 35 (E1/F1)	51° 54.00'S	148° 31.00'E	10/4/2016	0258
CTD 36 (F2)	51° 46.89'S	148° 19.55'E	10/4/2016	1040
CTD 37 (F3)	51° 39.84'S	148° 08.25'E	10/4/2016	1401
CTD 38 (F4)	51° 32.74'S	147° 56.91'E	10/4/2016	1709
CTD 39 (F5)	51° 25.66'S	147° 45.59'E	abandoned	-
CTD 40 (F6)	51° 18.59'S	147° 34.40'E	abandoned	-

Work was suspended once CTD 38 (F4) was on deck due to strong winds, gusting to 45 kn. Moved slowly to F5 and hove to there. Today we experienced the most active convection of the voyage so far, with even some short graupel episodes (1230 and 1330 LT), indicative of supercooled liquid water (graupel growth requires liquid water). Cloud tops of individual cells reached 5-6 km height, and strong attenuation was observed on the cloud radar.

Monday 11 April

Checked with the bridge at 0115. Conditions still not suitable for CTDs. Will check again at 0200 but they don't expect work to start until 0400. We abandoned stations F5 and F6 and proceeded to the new centre of the warm core at 51° 29'S, 148° 14'E. Work recommenced after lunch with a TMR. We began the transit to the drifting sediment trap, then 75nm to the NW, stopping on the edge of the warm eddy at 51° 24'S, 148° 55.8'E for 1 hour of ISP sampling (1930-2030) and 500m CTD 39, on deck at 2145. Set sail for latest sediment trap position.

Tuesday 12 April

Finished RESPIRE sediment trap recovery at 1100 and followed with a balloon launch. A planned to detour via the centre of the cyclonic eddy en route to SOTS was abandoned because the ship was unable to maintain speed greater than 10 knots over ground and would have delayed our arrival at SOTS. A whole day of stratocumulus with drizzle, with sometimes very low cloud tops (1 km or less).

Wednesday 13 April

Transited to SOTS site in moderate conditions. The CAPRICORN team had their second science team meeting to organize collaborations, discuss upcoming papers to be prepared (short-term and longer term), and how to interact when everyone gets back to work. We agreed to organize a videoconference in July, and a longer meeting in December 2016 (and we will invite the eddy team to participate, since synergies have been established during the voyage). We discussed the possibility to organize a special JGR collection of papers, and we will discuss with the eddy team if this special collection should include the eddy work or not. The CAPRICORN team is supportive of this.

Thursday 14 April

Arrived at SOTS site before dawn. Heavy fog & very calm conditions. A top-down mooring recovery operation was adopted for SOFS-5 due to the current limitations of ship manoeuvrability. This consisted of grappling with the top buoy, lifting it on board and then winching in the line while removing instruments. This occurred while maintaining the ship position within 1 NM of the anchor position to keep minimal tension on the slack-line mooring line. The wind was light (less than 15kts), and from the NE with swell less than 3 m and from the SW. The surface float was in the NE quadrant and on the edge of the watch circle. The ship set up within a few hundred metres of the buoy at first light and SOFS-5 recovery commenced after breakfast. The auto recovery line launcher on the buoy failed to activate. The FRC was deployed with thee crew and one mooring tech to take a messenger line out and hook onto buoy. This was successful, and after FRC recovery the mooring operation continued around 0930 with the ship moving slowly forward SW at ~0.5kt towards the anchor. The surface float was lifted on board flawlessly late morning as the ship passed over the anchor and the acoustic release triggered at 1217 as the ship continued 1 mile past the anchor. The remainder of the mooring recovery went smoothly and was completed by 1830. A CTD to 2250m depth as conducted and then we departed the SOTS site around 2100.

Friday 15 April

We continued transit to Hobart. Balloon launches were unsuccessful or cancelled due to high winds. The rest of the helium has been used for a helium party to celebrate Viena's birthday. A final SOCCOM float (6364) was launched at 45Deg 30.036’ S, 145Deg 59.698’E, 0212UTC 15 April.

Saturday 16 April

Met by the pilot and tug at 0800. Dockside at 0930 and demobilisation commenced.

Deployed Mooring Locations

Mooring	Latitude	Longitude	Depth
FluxPulse-1 anchor triangulation	46° 46.635'S 46.77725 °S	141° 59.573'E 141.99289 °E	4658m
SAZ-18 anchor triangulation	46° 47.017'S 46.78361 °S	141° 50.536'E 141.84226 °E	4582m

Summary

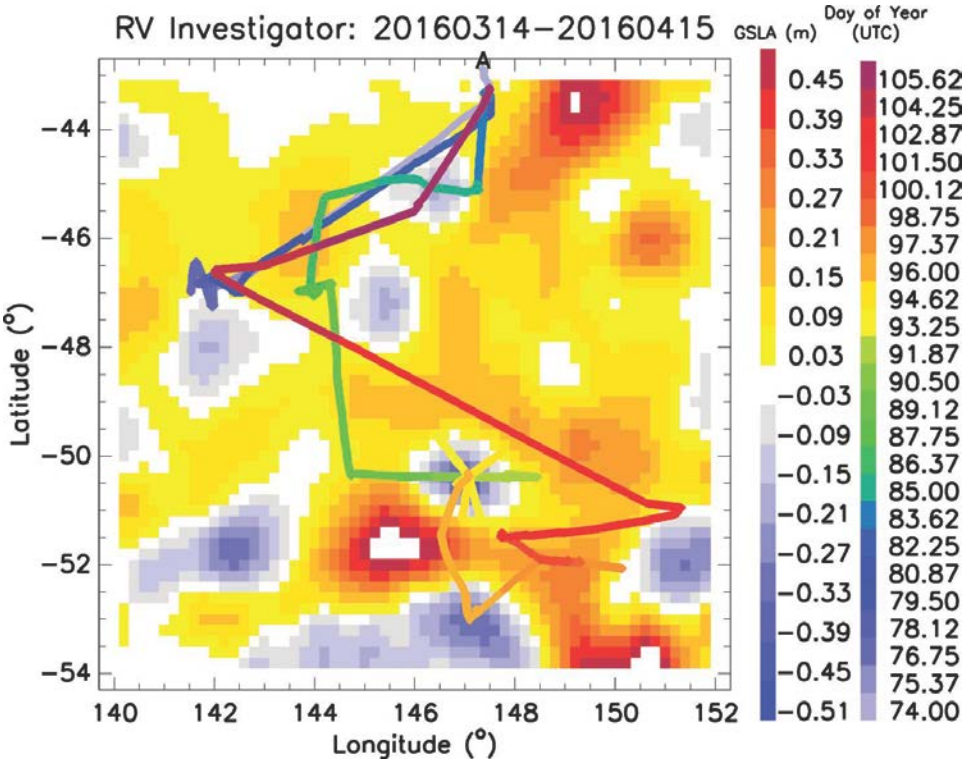
The extension of the voyage was crucial for the Eddy team. Without it we wouldn't have come close to achieving our objectives. We were able to achieve most of them at close to 100%. The sampling of the anticyclonic eddy was more challenging than the cyclonic due to weather, but this is typical for the Southern Ocean. The crew and MNF provided excellent support. Having a working bow thruster may have allowed CTD operations to continue into higher wind conditions.

The CAPRICORN team is extremely satisfied with the dataset collected for clouds, aerosols, surface energy fluxes, atmospheric state (using balloons). First precipitation measurements will allow unique studies of the statistical properties of Southern Ocean rainfall. However, the failure of the weather radar at the start of the voyage will not allow the satellite precipitation validation objectives to be completed. This dataset should nevertheless be collected in the next voyage if the weather radar can be fixed.

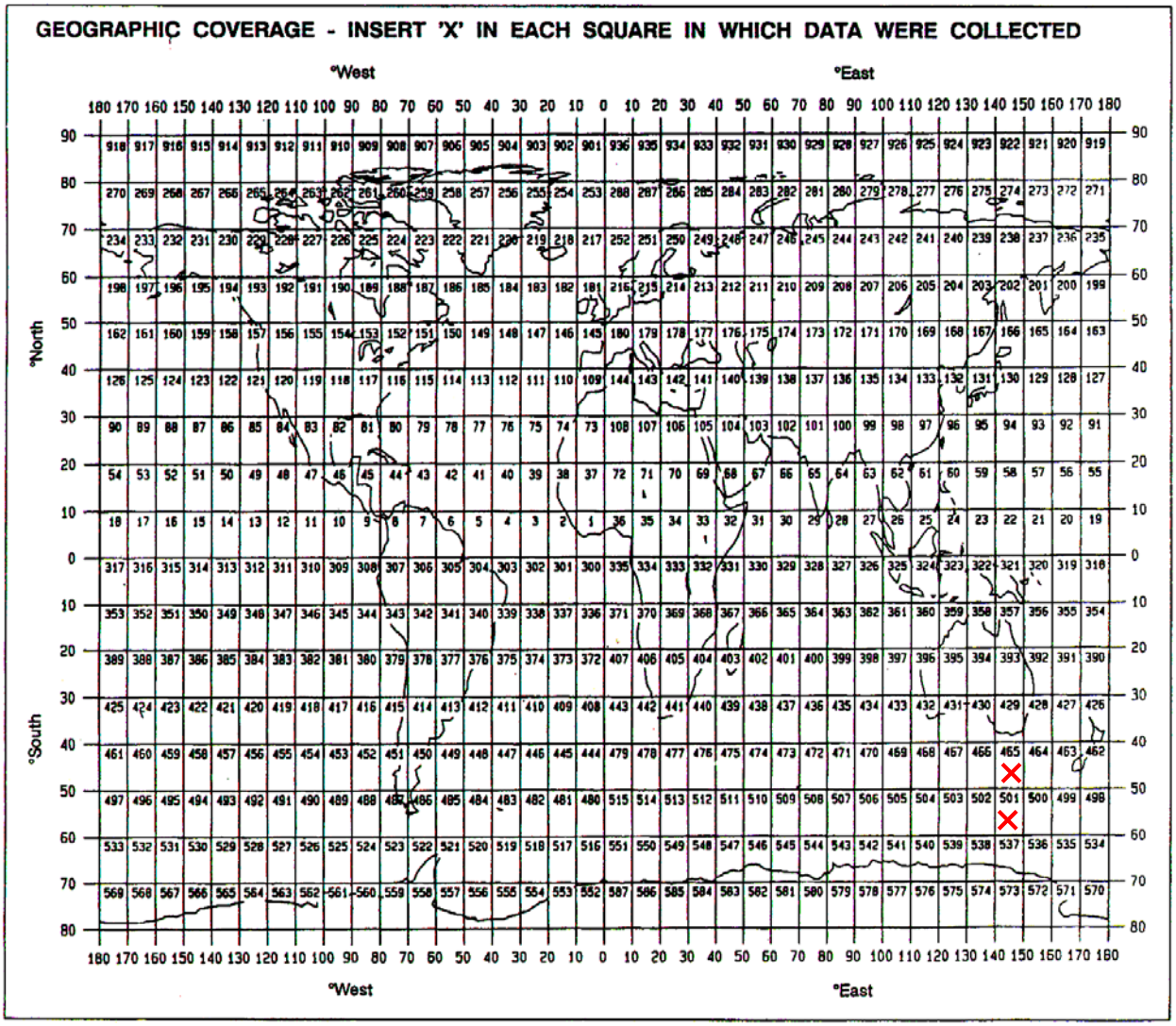
The mooring activities continued the sustainment of the multi-disciplinary ocean observatory aimed at understanding the carbon, heat and mass flux contribution of the Sub-Antarctic Zone to the global climate system.

Bringing together the three teams on the one voyage was a success with many ideas exchanged and opportunities for multi-disciplinary research explored. Many instruments were deployed for the first time on the Investigator and the operation of equipment and collection of data performed successfully.

Voyage Track



Marsden Squares



Moorings, bottom mounted gear and drifting systems

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	46.6	S	141	57.6	E	MO2 M71 M90 H17 D01 D71	Southern Ocean Times Series (SOTS) site: FluxPulse-1 surface meteorological mooring deployed for recovery in March 2017 See diagram in appendix detailing instruments and depths
2	Tom Trull	46°	47.017'	S	141	50.536'	E	H17 B73 D01	Southern Ocean Times Series (SOTS) site: SAZ-18 sub-surface sediment trap mooring deployed for recovery in March 2017 See diagram in appendix detailing instruments and depths.
3	Tom Trull	46°	49.494’	S	141°	39.354'	E	H17 B73 D01	Southern Ocean Times Series (SOTS) site: SAZ-17 sub-surface sediment trap mooring recovered (deployed in March 2015)
4	Tom Trull	46°	56.430'	S	142°	19.566'	E	H17 D01 D71	Southern Ocean Times Series (SOTS) site: Pulse-11 surface biogeochemical mooring recovered (deployed in March 2015)
5	Tom Trull/Eric Schulz	46°	40.020'	S	142°	04.392'	E	MO2 M71 M90 H17	Southern Ocean Times Series (SOTS) site: SOFS-5 surface meteorological mooring

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		
								D01 D71	recovered (deployed in March 2015)
6	Philip Boyd, Michael Ellwood, Helen Phillips, Pete Strutton	50°	23.23’	S	147°	4.79’	E	H71, H11, H16, H17, B02, B71, H21, H24, H28	SOCCOM bio-Argo float 9361 ‘moby dick’
7	Philip Boyd, Michael Ellwood, Helen Phillips, Pete Strutton	51°	54.00’	S	148°	30.60’	E	H71, H11, H16, H17, B02, B71, H21, H24, H28	SOCCOM bio-Argo float 7944 ‘frodo’
8	Philip Boyd, Michael Ellwood, Helen Phillips, Pete Strutton	50°	23.30’	S	147°	04.85’	E	B07, B73,H21, H26, H27, H24, H23, P02, H30, H90, H32	Drifting RESPIRE sediment traps (170 and 190 m)
9	Philip Boyd, Michael Ellwood, Helen Phillips, Pete Strutton	51°	54.07’	S	148°	30.68’	E	B07, B73,H21, H26, H27, H24, H23, P02, H30, H90, H32	Drifting RESPIRE sediment traps (170 and 190 m)
6	Philip Boyd, Michael Ellwood, Helen Phillips, Pete Strutton	50°	23.23’	S	147°	4.79’	E	H71, H11, H16, H17, B02, B71, H21, H24, H28	SOCCOM bio-Argo float 9361 ‘moby dick’
7	Philip Boyd, Michael Ellwood, Helen Phillips, Pete Strutton	51°	54.00’	S	148°	30.60’	E	H71, H11, H16, H17, B02, B71, H21, H24, H28	SOCCOM bio-Argo float 7944 ‘frodo’
8	Philip Boyd, Michael Ellwood, Helen Phillips, Pete Strutton	50°	23.30’	S	147°	04.85’	E	B07, B73,H21, H26, H27, H24, H23, P02, H30, H90, H32	Drifting RESPIRE sediment traps (170 and 190 m)
9	Philip Boyd, Michael Ellwood, Helen Phillips, Pete Strutton	51°	54.07’	S	148°	30.68’	E	B07, B73,H21, H26, H27, H24, H23, P02, H30, H90, H32	Drifting RESPIRE sediment traps (170 and 190 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		
10	Philip Boyd, Michael Ellwood, Helen Phillips, Pete Strutton	50°	23.23’	S	147°	4.79’	E	H71, H11, H16, H17, B02, B71, H21, H24, H28	SOCCOM bio-Argo float 9361 ‘moby dick’
11	Philip Boyd, Michael Ellwood, Helen Phillips, Pete Strutton	51°	54.00’	S	148°	30.60’	E	H71, H11, H16, H17, B02, B71, H21, H24, H28	SOCCOM bio-Argo float 7944 ‘frodo’
12	Philip Boyd, Michael Ellwood, Helen Phillips, Pete Strutton	50°	23.30’	S	147°	04.85’	E	B07, B73,H21, H26, H27, H24, H23, P02, H30, H90, H32	Drifting RESPIRE sediment traps (170 and 190 m)
13	Tom Trull	45°	30.036’	S	145°	59.698’	E	H71, H11, H16, H17, B02, B71, H21, H24, H28	SOCCOM bio-Argo float 6364

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 on last page	DESCRIPTION
1	Tom Trull	17	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	35	days		Continuous pCO2 measurements
3	Philip Boyd, Michael Ellwood, Helen Phillips, Pete Strutton	30	hours	H11 H16 H17	Triaxus undulating towed body transits across each eddy. See above for parameters and resolution.
4	Philip Boyd, Michael Ellwood, Helen Phillips, Pete Strutton	100	hours	B02	Surface underway measurements of phytoplankton physiology from the FIRe fast repetition rate fluorometer.
5	Philip Boyd, Michael Ellwood, Helen Phillips, Pete Strutton	35	CTD profiles	B02	Chlorophyll concentration from 8-9 discrete samples in the upper 200m

Item No.	PI see page above	NO see above	UNITS see above	DATA TYPE Enter code(s) from list on last page	DESCRIPTION
6	Philip Boyd, Michael Ellwood, Helen Phillips, Pete Strutton	12	CTD profiles	B71	Particulate organic carbon (POC) concentration from 3 samples in the upper 200m
7	Philip Boyd, Michael Ellwood, Helen Phillips, Pete Strutton	35	CTD profiles	B08	Preserved samples for phytoplankton ID via flow cytometry from 4 depths in the upper 200m
8	Philip Boyd, Michael Ellwood, Helen Phillips, Pete Strutton	7	CTD profiles	B01	Nitrate and ammonium uptake by phytoplankton at 6 depths in the upper 100m
9	Philip Boyd, Michael Ellwood, Helen Phillips, Pete Strutton	7	TMR profiles	H30	Dissolved trace metal samples at 12 depths were collected from 0-1500 m.
10	Philip Boyd, Michael Ellwood, Helen Phillips, Pete Strutton	4	McLane pump profiles	H30	Particulate trace metal samples at 12 depths were collected from 0-500m.

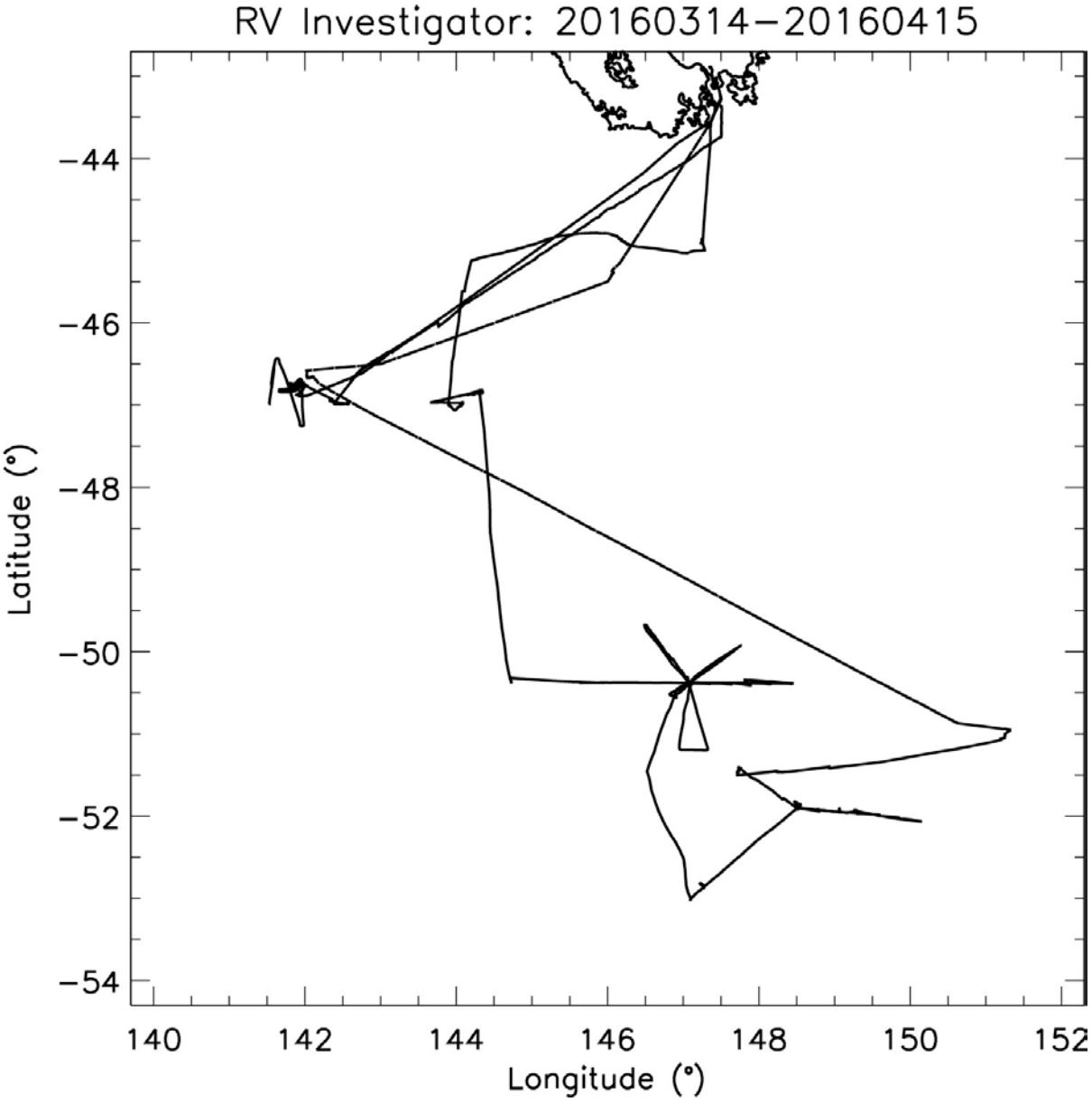
Item No.	PI see page above	NO see above	UNITS see above	DATA TYPE Enter code(s) from list on last page	DESCRIPTION
11	Philip Boyd, Michael Ellwood, Helen Phillips, Pete Strutton, Robert Strzepek	4	TMR Profiles	B01, B07, B08	Primary and bacterial production, plus iron uptake profiles across 6 depths were collected from 0-100m.
12	Alain Protat	32	days		BASTA cloud radar : Cloud reflectivity and Doppler velocity vertical profiles from 0 to 12 km height in clouds and precipitation
13	Alain Protat	32	days		RMAN-511 cloud and aerosol lidar: Lidar backscatter and linear depolarization vertical profiles from 0 to 12 km height in clouds and aerosols
14	Alain Protat, Jay Mace	28	days		Micro rain radar (MRR-2): Vertical profiles of Doppler spectra, reflectivity and Doppler velocity in precipitation
15	Jay Mace	32	days		Microwave radiometer : brightness temperatures at 22 and 31 GHz, integrated water vapour and liquid water path in clouds.
16	Ruhi Humphries	33	days		Aerosol size distribution – using 3 different instruments (APS, long SMPS and nano SMPS), the size distribution of the atmospheric aerosol population was determined between 5 nm and 10 µm.
17	Ruhi Humphries	33	days		Aerosol number concentration – determined in duplicate using two condensation particle counters.
18	Ruhi Humphries	33	days		Cloud condensation nuclei (CCN) – the number of CCN in the atmosphere calculated at 0.5% supersaturation.
19	Ruhi Humphries	28	Days		MOUDI filter samples - Aerosol composition and chemistry integrated over weekly samples.

Item No.	PI see page above	NO see above	UNITS see above	DATA TYPE Enter code(s) from list on last page	DESCRIPTION
20	Ruhi Humphries	33	Days		ToF-ACSM – real-time aerosol composition.
21	Ruhi Humphries	33	days		Atmospheric Volatile Organic Compounds – concentrations measured utilising two techniques: PTR-MS for real time measurements, and the VOC sequencer for daily integrated samples.
22	Christina McCluskey	~20	Data points		CFDC: : number of ice nucleating particles
23	Christina McCluskey	33	days		Ice spectrometer filters: number of ice nucleating particles daily
24	Luke Cravigan	33	days		VH-TDMA – 40, 100 and 150 nm aerosol hygroscopic growth factors and volatility at 250°C
25	Luke Cravigan	15	samples		TEM grid sampling – aerosol particle morphology and composition.
26	Byron Blomquist	33	days		Bulk meteorological parameters, including T/RH, wind, pressure, short- and long-wave down-welling radiation, and sea surface temperature. Turbulent flux parameters @ 10Hz, including 3D wind, water vapour, and 3-axis acceleration and angular rate. Navigation parameters, including 10 Hz heading and 1 Hz position/speed/course. Wave height at 10Hz from bow tower mounted lidar.
27	Murray Hamilton	34	radiosondes		Radiosonde launches : profiles of pressure, temperature, humidity and horizontal winds.

Curation Report

Item No.	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-17 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.	CAPRICORN Project : Seawater samples collected from the CTD are shipped directly to Colorado State Univeristy Department of Atmospheric Science for ice nucleating particle analysis. Samples are consumed by analyses.
4.	CAPRICORN Project : Suspended atmospheric aerosol samples collected on Ice Spectrometer sampling manifold. Samples are shipped directly to Colorado State Univeristy Department of Atmospheric Science for ice nucleating particle analysis. Samples are consumed by analyses.
5.	CAPRICORN Project : Integrated atmospheric aerosol samples were collected over a period of a week on size segregated filter platforms. Samples are shipped to CSIRO Aspendale for further chemical analysis. The quartz filters used and the samples are destroyed during chemical analyses.
6.	CAPRICORN Project : Atmospheric aerosol samples collected on Transmission Electron Microscopy grids will be transferred (following IN2016_V03) to the Queensland University of Technology (QUT) for particle morphology and composition analyses. 14 samples were taken between 21/03 and 13/04/16, with sampling times of 12 to 24 hours. Samples will be archived at QUT following analysis.
7.	Eddy : no retained samples after analysis.

Track Chart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−44
−46
−48
−50
−52
−54
Latitude (°)
140
142
144
146
148
150
152
Longitude (°)

Personnel List

1.	Tegan Sime	MNF	Voyage Manager
2.	Steve Thomas	MNF	SIT electronics support
3.	Will Ponsonby	MNF	SIT electronics support
4.	Pamela Brodie	MNF	DAP computing support
5.	Stewart Wilde	MNF	DAP computing support
6.	Dave Watts	MNF	GSM support
7.	Cassie Schwanger	MNF	Hydrochemist
8.	Kendall Sherrin	MNF	Hydrochemist
9.	Ben Baldwinson	MNF	SIT electronics support
10.	Tom Trull	CSIRO-ACE	SOTS: Chief Scientist
11.	Eric Schulz	BOM	SOTS: Co-Chief Scientist, Dogger
12.	Peter Jansen	IMOS-UTAS	SOTS: Managing Engineer
13.	Jamie Derrick	CSIRO	SOTS: Mooring Technical Supervisor
14.	Gary Curtis	CSIRO	SOTS: Mooring Technical Supervisor
15.	Jim LaDuke	CSIRO	SOTS: Mooring deck work
16.	Alice della Penna	UTAS-UParis	SOTS: Triaxus sensors, particle filtrations
17.	Alain Protat	BOM	CAPR: PI+cloud data collection
18.	Ruhi Humphries	CSIRO	CAPR: Aerosol PI+data collection
19.	Luke Cravigan	QUT	CAPR: Aerosol QUT data collection
20.	Christina McCluskey	CSU	CAPR: Aerosol CFDC+ IS data collection
21.	Murray Hamilton	Univ. Adelaide	CAPR: radiosonde launch
22.	Yi Huang	Monash Uni	CAPR: radiosonde launch
23.	Gerald G. Mace	Univ. Utah	CAPR: cloud radar
24.	Byron Blomquist	NOAA	CAPR: Surface Energy Fluxes
25.	Kaitlyn Lieschke	U. Wollongong	CAPR: radiosonde launch + aerosol
26.	Peter Strutton	UTAS	Eddy: PI, New production and optics
27.	Sebastien Moreau	UTAS	Eddy: New production and optics
28.	Philip Boyd	UTAS	Eddy: Microbial processes
29.	Matthieu Bressac	UTAS	Eddy: Microbial processes
30.	Marion Fourquez	UTAS	Eddy: Microbial processes
31.	Helen Phillips	UTAS	Eddy: CTD and underway physics, VMP
32.	Eldene Oshea	UTAS	Eddy: CTD and underway physics, VMP
33.	Michael Ellwood	ANU	Eddy: Trace metals
34.	Robert Strzepek	ANU	Eddy: Trace metals
35.	Sam Eggins	ANU	Eddy: Trace metals
36.	Viena Puigcorbe	ECU	Eddy: Th-based export
37.	Gloria Salgado Gispert	ECU	Eddy: Th-based export
38.	Joan Llort	UTAS	Eddy: Underway and TRIAXUS optics
39.	Ramkrushnbhai Patel	UTAS	Eddy: Underway and TRIAXUS optics

Marine Crew

Name	Role
John Highton	Master
Adrian Koolhof	Chief Mate
Andrew Roebuck	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
Alan Martin	Chief Caterer
Kyra Lade	Caterer
Rebecca Lee	Chief Cook
Alin Muresan	Cook
Graham McDougall	Chief Integrated Rating
Paul Langford	Integrated Rating
Christopher Dorling	Integrated Rating
Jarod Ellis	Integrated Rating
Dennis Bassi	Integrated Rating
Peter Taylor	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 Darren Moore, Stephen Bray, 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.

Eddy: The performance of TRIAXUS was outstanding and exceeded our expectations. This will form a cornerstone data set for our ongoing work. The vehicle was expertly supported by Steve Thomas, Will Ponsonby and Ben Baldwinson, who also provided excellent support for other activities such as CTD deployments, RESPIRE trouble shooting and underway data acquisition. The crew had to contend with some challenging conditions during TRIAXUS recovery and we are grateful for their efforts. Deployments of the in situ pumps and the trace metal rosette were very well supported by the crew and MNF staff. The MNF hydrochemists Cassie Schwanger and Kendall Sherrin had to contend with occasional very heavy demands on their time for nutrient analysis but did so efficiently and to a very high standard. The computing support by Pamela Brodie and Stewart Wilde was excellent.

CAPRICORN: Our team is also very grateful to MNF IT and engineering support before and during the research voyage. The help from Ben Baldwinson and Will Ponsonby to solve the humidity issue in the container has been greatly appreciated, as was the repair of the MRR antenna by Steve Thomas in very harsh conditions on the level 4 deck. We would also like to thank Tegan Sime (aka the Iron Lady) for her expert management of difficult situations during this challenging voyage. Pamela Brodie and Stewart Wilde are warmly thanked by all our team for their continuous support with a smile.

Signature

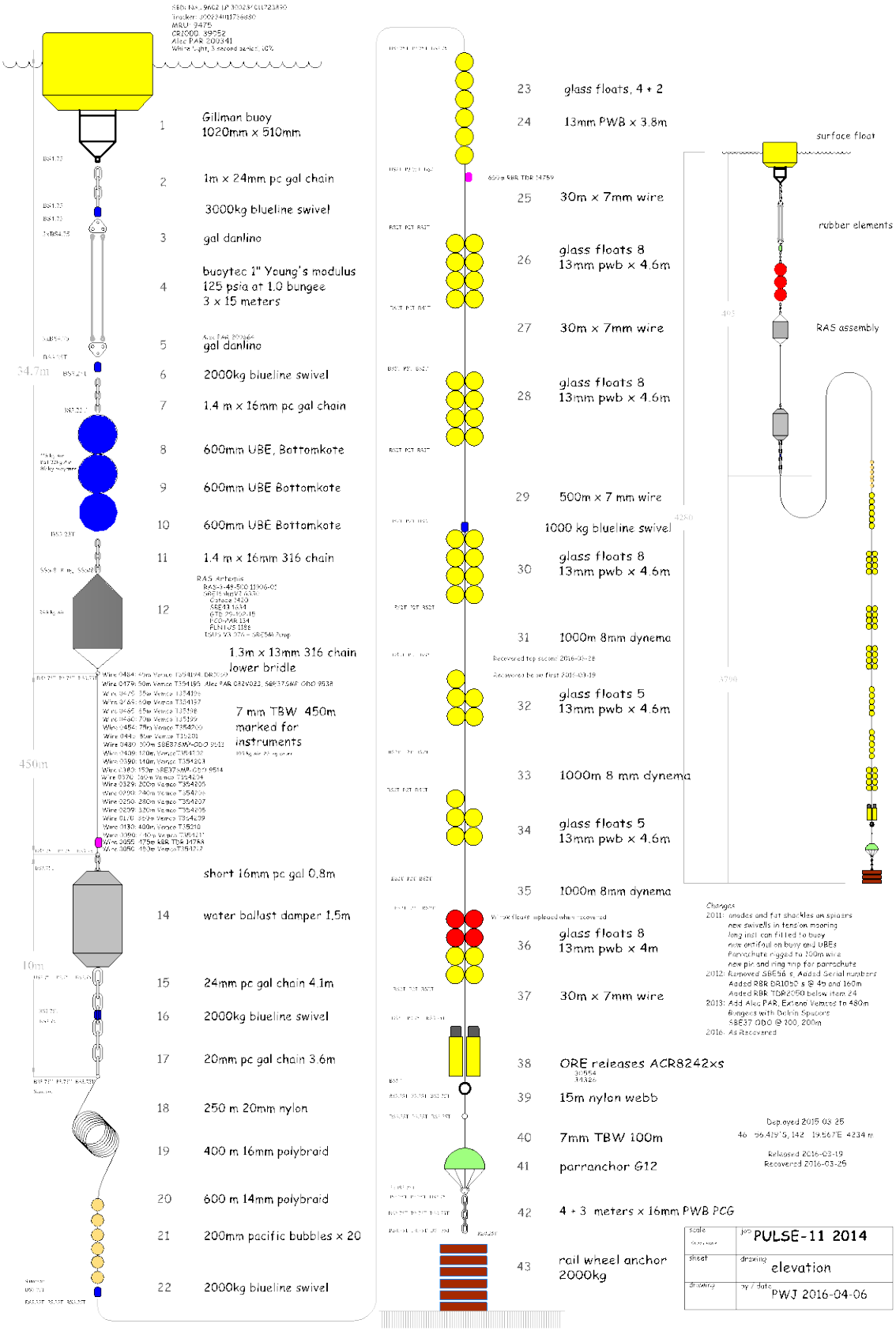
Your name	Thomas W. Trull
Title	Chief Scientist
Signature	
Date:	18 April 2016

List of additional figures and documents

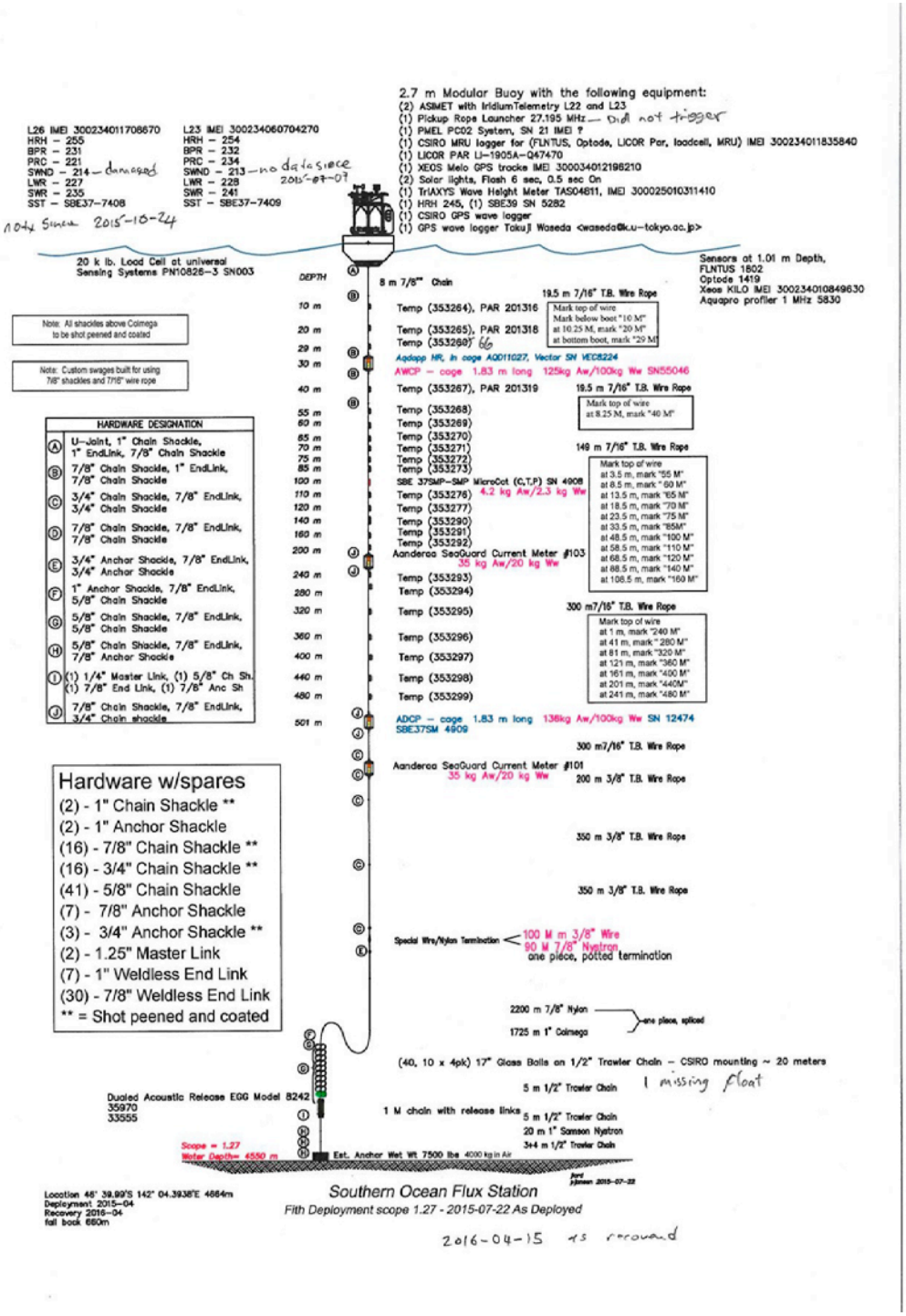
Appendix 1 SOTS Mooring Diagrams

Appendix 1 Mooring Diagrams

Pulse11 as recovered

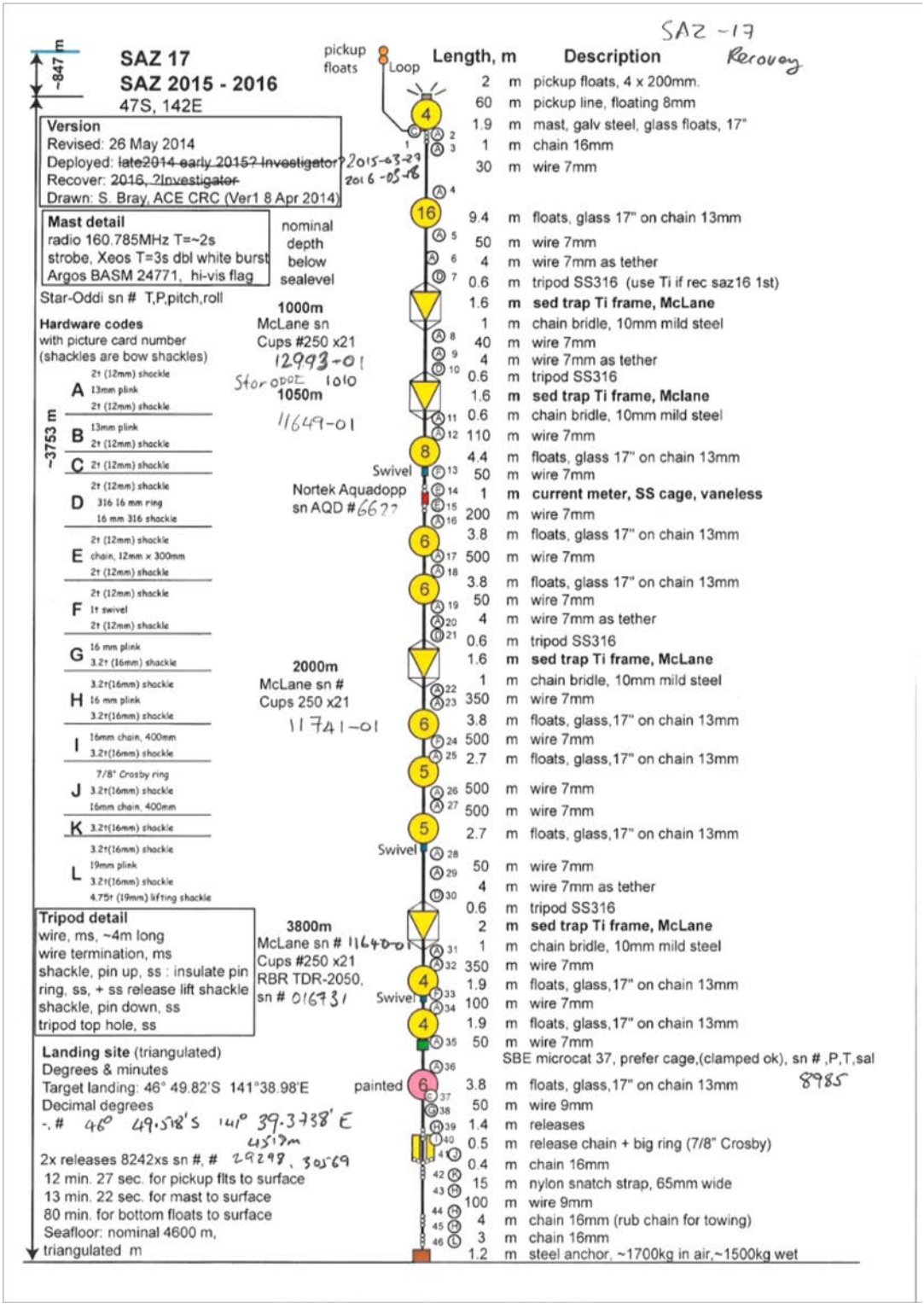


SOFS-5 as recovered

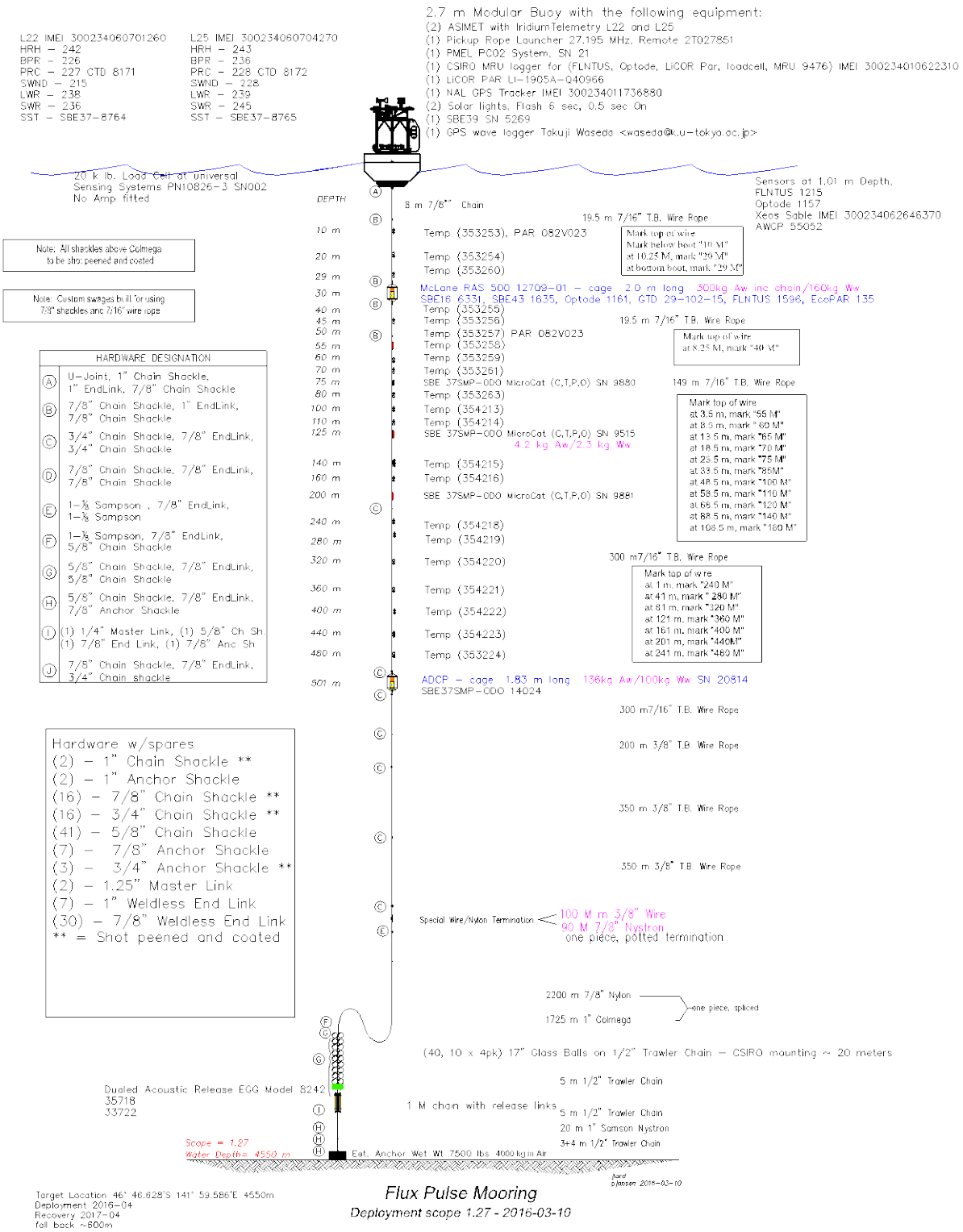


FluxPulse-1

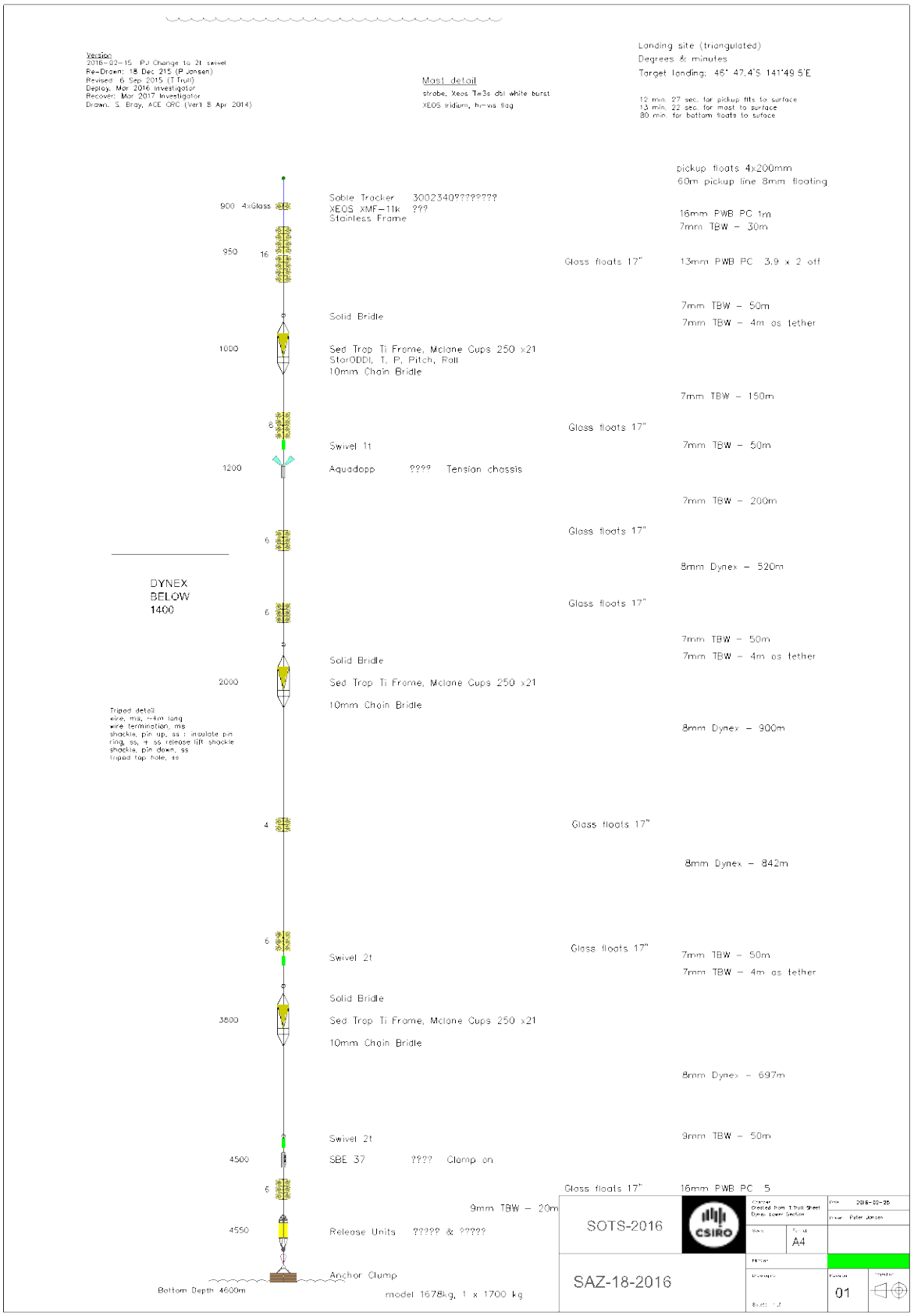
SAZ-17 as recovered



FluxPulse-1


2.7 m Modular Buoy with the following equipment:
(2) ASIMET with IridiumTelemetry L22 and L25
(1) Pickup Rope Launcher 27.195 MHz, Remote 2T027851
(1) PMEL PC02 System, SN 21
(1) CSIRO MRU logger for (FLNTUS, Optode, LiCOR Par, loadcell, MRU 9476) IMEI 300234010622310
(1) LiCOR PAR LI-1905A-040966
(1) NAL GPS Tracker IMEI 300234011736880
(2) Solar lights, Flash 6 sec, 0.5 sec On
(1) SBE39 SN 5269
(1) GPS wave logger Tokuji Waseda <waseda@k.u-tokyo.ac.jp>
L22 IMEI 300234060701260
HRH – 242
BPR – 226
PRC – 227 CTD 8171
SWND – 215
LWR – 238
SWR – 236
SST – SBE37-8764
L25 IMEI 300234060704270
HRH – 243
BPR – 236
PRC – 228 CTD 8172
SWND – 228
LWR – 239
SWR – 245
SST – SBE37-8765
20 k lb. Load Cell at universal Sensing Systems PN10826-3 SN002 No Amp fitted
Sensors at 1.01 m Depth,
FLNTUS 1215
Optode 1157
Xeos Sable IMEI 300234062646370
AWOP 55052
Note: All shackles above Colmega to be shot peened and coated
Note: Custom swages built for using 7/8" shackles and 7/16" wire rope
HARDWARE DESIGNATION
A U-Joint, 1" Chain Shackle, 1" EndLink, 7/8" Chain Shackle
B 7/8" Chain Shackle, 1" EndLink, 7/8" Chain Shackle
C 3/4" Chain Shackle, 7/8" EndLink, 3/4" Chain Shackle
D 7/8" Chain Shackle, 7/8" EndLink, 7/8" Chain Shackle
E 1-⅛ Sampson , 7/8" EndLink, 1-⅛ Sampson
F 1-⅛ Sampson, 7/8" EndLink, 5/8" Chain Shackle
G 5/8" Chain Shackle, 7/8" EndLink, 5/8" Chain Shackle
H 5/8" Chain Shackle, 7/8" EndLink, 7/8" Anchor Shackle
I (1) 1/4" Master Link, (1) 5/8" Ch Sh (1) 7/8" End Link, (1) 7/8" Anc Sh
J 7/8" Chain Shackle, 7/8" EndLink, 3/4" Chain shackle
DEPTH
10 m
20 m
29 m
30 m
40 m
45 m
50 m
55 m
60 m
70 m
75 m
80 m
100 m
110 m
125 m
140 m
160 m
200 m
240 m
280 m
320 m
360 m
400 m
440 m
480 m
501 m
8 m 7/8"" Chain
19.5 m 7/16" T.B. Wire Rope
Temp (353253), PAR 082V023
Mark top of wire
Mark below boot "10 M"
at 10.25 M, mark "29 M"
at bottom boot, mark "29 M"
Temp (353254)
Temp (353260)
McLane RAS 500 12709-01 – cage 2.0 m long 300kg Aw inc chain/160kg Ww
SBE16 6331, SBE43 1635, Optode 1161, GTD 29-102-15, FLNTUS 1596, EcoPAR 135
Temp (353255)
Temp (353256)
19.5 m 7/16" T.B. Wire Rope
Temp (353257) PAR 082V023
Mark top of wire
at 8.25 M, mark "40 M"
Temp (353258)
Temp (353259)
Temp (353261)
SBE 37SMP-ODO MicroCat (C,T,P,O) SN 9880
149 m 7/16" T.B. Wire Rope
Temp (353263)
Temp (354213)
Temp (354214)
SBE 37SMP-ODO MicroCat (C,T,P,O) SN 9515
4.2 kg Aw/2.3 kg Ww
Mark top of wire
at 3.5 m, mark "55 M"
at 8.5 m, mark "60 M"
at 13.5 m, mark "65 M"
at 18.5 m, mark "70 M"
at 23.5 m, mark "75 M"
at 33.5 m, mark "85M"
at 48.5 m, mark "100 M"
at 58.5 m, mark "110 M"
at 68.5 m, mark "120 M"
at 88.5 m, mark "140 M"
at 108.5 m, mark "160 M"
Temp (354215)
Temp (354216)
SBE 37SMP-ODO MicroCat (C,T,P,O) SN 9881
Temp (354218)
Temp (354219)
300 m7/16" T.B. Wire Rope
Temp (354220)
Mark top of wire
at 1 m, mark "240 M"
at 41 m, mark "280 M"
at 81 m, mark "320 M"
at 121 m, mark "360 M"
at 161 m, mark "400 M"
at 201 m, mark "440M"
at 241 m, mark "480 M"
Temp (354221)
Temp (354222)
Temp (354223)
Temp (353224)
ADCP – cage 1.83 m long 136kg Aw/100kg Ww SN 20814
SBE37SMP-ODO 14024
300 m7/16" T.B. Wire Rope
200 m 3/8" T.B. Wire Rope
350 m 3/8" T.B. Wire Rope
350 m 3/8" T.B. Wire Rope
Special Wire/Nylon Termination
100 M m 3/8" Wire
90 M 7/8" Nystron
one piece, potted termination
2200 m 7/8" Nylon
1725 m 1" Colmega
one piece, spliced
(40, 10 x 4pk) 17" Glass Balls on 1/2" Trawler Chain – CSIRO mounting ~ 20 meters
5 m 1/2" Trawler Chain
Dualed Acoustic Release EGG Model 8242
35718
33722
1 M chain with release links
5 m 1/2" Trawler Chain
20 m 1" Samson Nystron
3+4 m 1/2" Trawler Chain
Scope = 1.27
Water Depth= 4550 m
Est. Anchor Wet Wt 7500 lbs 4000 kg in Air
Hardware w/spares
(2) – 1" Chain Shackle **
(2) – 1" Anchor Shackle
(16) – 7/8" Chain Shackle **
(16) – 3/4" Chain Shackle **
(41) – 5/8" Chain Shackle
(7) – 7/8" Anchor Shackle
(3) – 3/4" Anchor Shackle **
(2) – 1.25" Master Link
(7) – 1" Weldless End Link
(30) – 7/8" Weldless End Link
** = Shot peened and coated
Target Location 46° 46.628'S 141° 59.586'E 4550m
Deployment 2016-04
Recovery 2017-04
fall back ~600m
Flux Pulse Mooring
Deployment scope 1.27 - 2016-03-10

SAZ-18


Version
2016-02-15 PJ Change to 2t swivel
Re-Drawn: 18 Dec 215 (P Jansen)
Revised: 6 Sep 2015 (T Trull)
Deploy: Mar 2016 Investigator
Recover: Mar 2017 Investigator
Drawn: S. Bray, ACE CRC (Ver1 8 Apr 2014)
Mast detail
strobe, Xeos Te3s dbl white burst
XEOS Iridium, hi-vis flag
Landing site (triangulated)
Degrees & minutes
Target landing: 46° 47.4'S 141°49.5'E
12 min. 27 sec. for pickup flts to surface
13 min. 22 sec. for mast to surface
80 min. for bottom floats to suface
pickup floats 4x200mm
60m pickup line 8mm floating
900 4xGlass
Sable Tracker 3002340?????????
XEOS XMF-11k ???
Stainless Frame
16mm PWB PC 1m
7mm TBW – 30m
950 16
Glass floats 17"
13mm PWB PC 3.9 x 2 off
7mm TBW – 50m
Solid Bridle
7mm TBW – 4m as tether
1000
Sed Trap Ti Frame, Mclane Cups 250 x21
StorODDI, T, P, Pitch, Roll
10mm Chain Bridle
7mm TBW – 150m
8
Glass floats 17"
Swivel 1t
7mm TBW – 50m
1200
Aquadopp ???? Tension chassis
7mm TBW – 200m
6
Glass floats 17"
DYNEX
BELOW
1400
8mm Dynex – 520m
6
Glass floats 17"
7mm TBW – 50m
Solid Bridle
7mm TBW – 4m as tether
2000
Sed Trap Ti Frame, Mclane Cups 250 x21
10mm Chain Bridle
Tripod detail
wire, ms, ~4m long
wire termination, ms
shackle, pin up, ss + insulate pin
ring, ss, + ss release lift shackle
shackle, pin down, ss
tripod top hole, ss
8mm Dynex – 900m
4
Glass floats 17"
8mm Dynex – 842m
6
Glass floats 17"
Swivel 2t
7mm TBW – 50m
7mm TBW – 4m as tether
Solid Bridle
3800
Sed Trap Ti Frame, Mclane Cups 250 x21
10mm Chain Bridle
8mm Dynex – 697m
Swivel 2t
9mm TBW – 50m
4500
SBE 37 ???? Clamp on
6
Glass floats 17"
16mm PWB PC 5
9mm TBW – 20m
4550
Release Units ????? & ?????
Anchor Clump
Bottom Depth 4600m
model 1678kg, 1 x 1700 kg
SOTS-2016
CSIRO
A4
SAZ-18-2016
01

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
D06	Neutrally buoyant floats

	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
B28	Acoustic reflection on marine organisms

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

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