RV *Investigator* Voyage Summary

Voyage #:	**IN2018_V02**		
Voyage title:	SOTS: Southern Ocean Time Series automated moorings for climate and carbon cycle studies southwest of Tasmania; Subantarctic Biogeochemistry of Carbon and Iron, Southern Ocean Time Series site		
Mobilisation:	Hobart, Thurs, 1-2 March 2018		
Depart:	Hobart, Friday 3 March 08:00 for equipment tests in Storm Bay and then transit to SOTS site		
Return:	Hobart, Wednesday, 21 March 2018, 0900		
Demobilisation:	Hobart, Wednesday, 21 March 2018		
Voyage Manager:	Lisa Woodward	Contact details:	Lisa.Woodward@csiro.au
Chief Scientist:	Thomas W. Trull		
Affiliation:	CSIRO	Contact details:	Tom.Trull@csiro.au
Principal Investigators:	Philip Boyd		
Project name:	Subantarctic Biogeochemistry of Carbon and Iron, Southern Ocean Time Series site		
Affiliation:	UTAS	Contact details:	Philip.Boyd@utas.edu.au

Voyage Summary

Objectives and brief narrative of voyage

Scientific objectives

Trull: Southern Ocean Time Series

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 two automated moorings to measure these processes under extreme conditions, where they are most intense and have been least studied. The atmosphere-ocean exchanges occur on many timescales, from daily insolation cycles to ocean basin decadal oscillations and thus high frequency observations sustained over many years are required. The current context of anthropogenic forcing of rapid climate change adds urgency to the work.

The primary objective is to first deploy a new set of SOTS moorings (SOFS-7 and SAZ-20) and then recover the existing SOTS moorings (SOFS-6 and SAZ-19). Each of the SOTS moorings delivers to specific aspects of the atmosphere-ocean exchanges:

- the SAZ sediment trap mooring collects samples to quantify the transfer of carbon and other nutrients to the ocean interior by sinking particles, and investigate their ecological controls.
- the Southern Ocean Flux Station (SOFS) mooring measures meteorological and ocean properties important to air-sea exchanges, ocean stratification, waves, and currents. Additional sensors quantify CO_2 partial pressure, net community production from oxygen and total dissolved gases and nitrate depletion, biomass from bio-optics and bio-acoustics. Water samples are collected for nutrient and plankton measurements after recovery.

Ancillary work will obtain supporting information on atmospheric and oceanographic conditions using CTD casts, underway measurements, Triaxus towed body, Continuous Plankton Recorder and autonomous profiling Biogeochemical-Argo floats, and potentially casts of a bio-optical sensor package.

Boyd: Subantarctic Biogeochemistry of Carbon and Iron, Southern Ocean Time Series site

The subantarctic water mass forms a circumpolar ring which comprises half of the open waters of the Southern Ocean. Complex environmental forcing controls its productivity, ecology and biogeochemistry both in the present day and in the geological past. An improved mechanistic understanding of these controls on the marine biota is needed, and will provide the context to better interpret observations being obtained at unparalleled resolution by the SOTS moorings. Our study will forge strong links with SOTS by determining how environmental forcing manifests itself in biological and biogeochemical signatures across a range of scales. A better understanding of this relationship will aid the development of a state-of-the-art coupled iron and carbon biogeochemical model which will be validated using future multi-property time-series observations.

Our main aim is to enhance our understanding of the interlinked biogeochemical cycles of iron and carbon in the Southern Ocean to better understand how intra-seasonal, seasonal and interannual variability in iron supply and recycling influences the productivity and export of carbon into the ocean's interior in the subantarctic circumpolar ring. Additional aims include:

- Elucidation of the relative roles of iron supply versus biological and photochemical recycling in driving subantarctic primary productivity and export fluxes.
- Resolution of the interplay of multiple environmental controls – irradiance, mixed layer depth, trace element supply (zinc, copper etc), silicate supply, iron availability – across a range of temporal and spatial scales – to better predict changes in rates of primary productivity.
- Enhancement of knowledge on the interplay of mesoscale and submesoscale physics and biogeochemistry in the vicinity of the SOTS site to better understand the degree of coupling and integration of surface ocean processes with those in the subsurface ocean (such as the sensors and particle traps on the SOTS mooring).

Voyage objectives

SOTS

1. Deploy SOFS-7 meteorology/biogeochemistry mooring
2. Deploy SAZ-20 sediment trap mooring
3. Recover SAZ-19 sediment trap mooring
4. Recover SOFS-6 meteorology/biogeochemistry mooring (lower portion only)
5. Do CTDs (2 casts to 2250m) at the SOTS site, including collecting samples for nutrients, oxygen, dissolved inorganic carbon, alkalinity, and particulate matter analyses
6. Carry out underway air and water sampling and sensor measurements, including bio-optics and bio-acoustics
7. Deploy 2-3 Biogeochemical-Argo autonomous profiling floats at the SOTS site, potentially augmented by casts of a bio-optical sensor package.
8. Tow MacArtney Triaxus on return to Hobart
9. Tow CPR on transit to SOTS site

Boyd: Subantarctic Biogeochemistry of Carbon and Iron, Southern Ocean Time Series site

1. Underway oceanographic sampling of mesoscale and sub-mesoscale physics and biogeochemistry in the vicinity of the SOTS mooring (sampling underway seawater, TM clean tow-fish)
2. Repeat temporal vertical physics, chemistry, bio-optics and biological profiles near the SOTS mooring (using ISP, TMR, TM clean tow fish, CTD)
3. Process studies of key questions including the supply of recycled versus new iron (using zooplankton nets, ISP, TMR, TM clean tow fish, CTD, MNF rad van and deckboard incubators)
4. Ocean and atmospheric sampling to develop a stable isotopic budget for iron (using atmospheric chemistry lab, and zooplankton net tows, ISP, TMR, TM clean tow fish)
5. Deployment and recovery of the free-drifting RESPIRE sinking particle traps (with traps for trace elements, in-situ oxygen respiration, and particle forms as isolated into polyacrylamide gels).
6. Targeted experimental manipulations, such as fluctuating light incubations to better understand data obtained from 1. and 2. (using walk-in CT room, other lab temp-controlled incubators and the MNF deckboard incubation platform). Particles collected using Niskin bottles, nets and the underway seawater supply will provide material for aggregation and sinking experiment using

the SNOWMAN (Simulator of Non-finite, Open Wheeled Marine Aggregation and siNking) and traditional roller tank + table. These experiments target a better understanding of the dynamics of carbon export in the SOTS area related to surface planktonic communities.

Kloser Acoustic zooplankton and fish Piggy-Back Project:

1. With vessel stationary, deploy PLAOS acoustic-optical profiling device to 1000m depth, 2 times per night for up to 5 nights. Each cast takes ~1.5 hours. Protocols have been developed for the PLAOS operations on previous trials and operational voyages. The deployments need to commence at night at least 1 hour after sunset and finish at least 1 hours before sunrise. Deploy the PLAOS during the day for 1 -2 casts to characterise the vertical flux of organisms to assist with zooplankton grazing experiments.
2. Operate the ships underway bio-acoustic sensors during the voyage to characterise the epipelagic and mesopelagic scattering (IMOS bioacoustics). Trials of broadband acoustics from the vessels transducers and CTD casts to 1000 m will also be done on an opportunistic basis. Test the reduction in noise on the acoustic systems from previous voyage recommendations.
3. Capture key zooplankton/micronekton organisms using a single wire ISAAC Kid (or RMT25) trawl towed obliquely to 600 m depth and a 1 m surface net for species identification, isotope and acoustic reflectance studies. Three to five night time tows and two day time tows are envisaged (~3 hrs per operation).

The overall priority is the SOTS moorings (SOTS objectives 1-4), because these cannot be downscaled and have the highest dependence on weather. The next priority is to complete Boyd objectives, then remaining SOTS objectives, then Kloser piggy-back objectives, with the intent to reduce the number of each of these operations (CTDs, TMRs, drifting traps, PLAOS, nets, etc.) so that some results are achieved for all.

Results

SOTS

1. Deploy SOFS-7 meteorology/biogeochemistry mooring
   Not achieved. The mooring tether failed between the acoustic releases and anchors on deployment. Following a return trip to Hobart to obtain spare components the mooring was redeployed, but a similar failure mode occurred again. The mooring was then recovered and returned to Hobart.
2. Deploy SAZ-20 sediment trap mooring
   Achieved
3. Recover SAZ-19 sediment trap mooring
   Achieved
4. Recover SOFS-6 meteorology/biogeochemistry mooring (lower portion only)
   Not Achieved. There was not sufficient time to attempt this due to poor weather, the unscheduled return trip to Hobart, and the extra day spent recovering SOFS-7.
5. Do CTDs (2 casts to 2250m) at the SOTS site, including collecting samples for nutrients, oxygen, dissolved inorganic carbon, alkalinity, and particulate matter analyses
   Achieved
6. Underway air and water sampling and sensor measurements, bio-optics and bio-acoustics
   Achieved

7. Deploy 2-3 BGC-Argo autonomous profiling floats at the SOTS site, potentially augmented by casts of a bio-optical sensor package.
   Achieved
8. Tow MacArtney Triaxus on return to Hobart
   Not achieved. Due to rough conditions on return transit.
9. Tow CPR on transit to SOTS site
   Achieved

Boyd: Subantarctic Biogeochemistry of Carbon and Iron, Southern Ocean Time Series site

1. Underway oceanographic sampling of mesoscale and sub-mesoscale physics and biogeochemistry in the vicinity of the SOTS mooring
   Achieved
2. Repeat temporal vertical physics, chemistry, bio-optics and biological profiles near the SOTS mooring
3. Achieved
4. Process studies of key questions including the supply of recycled versus new iron
   Achieved
5. Ocean and atmospheric sampling to develop a stable isotopic budget for iron
   Achieved
6. Deployment and recovery of the free-drifting RESPIRE sinking particle traps.
   Not achieved due to loss of RESPIRE traps.
7. Targeted experimental manipulations, such as fluctuating light incubations to better understand data obtained from 1. and 2.
   Achieved

Kloser Acoustic zooplankton and fish Piggy-Back Project:

1. PLAOS profiling to 1000m depth, 2 times per night for up to 5 nights and during the day for 1 -2 casts.
   Achieved. The PLAOS was deployed 9 times during the voyage
2. Ship underway bio-acoustic sensors. Trials of broadband acoustics from the vessels transducers and CTD casts to 1000 m.
   Achieved using an alternative approach. The ships underway bioacoustics sensors were logged throughout the voyage. No broadband trials of vessel transducers or CTD casts were done as these were done on the PLAOS.
3. Capture key zooplankton/micronekton organisms using a single wire ISAAC Kid (or RMT25) trawl towed. Three to five night time tows and two day time tows are envisaged.
   Achieved. The RMT25 was not deployed due to time constraints, instead the smaller RMT8 net was deployed 7 times throughout the voyage with six being successful. The nets targeted the 0-200 m and 200 to 600 m strata both day and night.

Voyage Narrative

All times in the Voyage Narrative are local shiptime = UTC+11.

TABLE OF ACRONYMS

Acronym	Name
RMT25/8	Trawl net
TMR	Trace Metal Rosette
TM Fish	Towed intake to supply trace metal clean water
Motor head net	Plankton net with forced water supply
RESPIRE drifting trap	Drifting particle traps measuring oxygen consumption
ISP	In situ pump for particle collections
PLAOS	Profiling Lagrangian Acoustic and Optical System
CPR	Continuous Plankton Recorder

Saturday 3 March

After on-time departure at 08:00 (UTC+11), we headed down the Derwent River and into Storm Bay to perform a test CTD deployment, Anchor movement, and PLAOS deployment. The final members of the science party arrived by launch and the media contingent filming for “Coast Australia” departed at 1400. Inductions were held at 1400. Trial set-up of the RMT25 net at 1500. The voyage science briefing was held at 1600 while we set course for the SOTS site. Labs were inspected at 1800 to ensure all items were secured for increased ship motion overnight. The CPR was deployed at 1910 for a planned overnight tow.

Sunday 4 March

The ship continued the transit to the SOTS site under moderate conditions, towing the CPR and collecting underway observations. During the day various meetings were held, The CTD water budget meeting after breakfast (1030) and moorings operations familiarisation meetings after lunch (1400). The inaugural science presentation was provided after dinner by Tom Trull on “Intro to SOTS” and including an introduction to IMOS Ocean Current tool to assist in understanding the mesoscale physical oceanographic context of the region. A discussion was held on the best location for the SOTS process site and selected high-nutrient, low chlorophylil waters west of the mooring deployment site.

Monday 5 March

Arrived at the SOTS Process study site (47S, 142E) at 0500 under light conditions and recovered the CPR before commencing an intensive set of observations for the day and into the night comprising:

Start Time (local)	**Activity**
0515	CTD to 2250m
0815	TMR
1000	TM Fish
1330	Motor head net
1400	UTas RESPIRE drifting trap
1700	ISP
1800	Plankton net
2230	PLAOS #2
0230 (6th March)	PLAOS #2

Tuesday 6 March

The ship was positioned 10NM down weather of the SOFS-7 site at first light. Conditions were light, cool and foggy throughout the day. Following a go/no-go meeting at 0645, deployment commenced after breakfast at 0730 and the surface float was in the water by 1300. The anchor was deployed at around 20:30 in 4520m water depth at 47 00.78'S, 142 14.54E. Communications with the acoustic releases (to establish the position of the anchor) was unsuccessful. Given the uncertain status of the SOFS-7 deployment, and the possibility that the mooring was not secure, the ship moved away and proceeded to the SOTS Process study site.

Wednesday 7 March

At the SOTS Process study site we spent the day continuing the intensive set of observations comprising:

Start Time (local)	**Activity**
0500	CTD to 500m
0815	TMR to 1500m
0930	Motor head net
1030	ISP to 1500m
1200	RMT25 Net
1740	Vertical Plankton Net
1500	TM Fish
1820	TMR
2020	PLAOS #4
2330	PLAOS #5
0130 (8th March)	PLAOS #6

Deployment of the RMT25 net was unsuccessful due to the limited lift of the winches and an alternative deployment system needed to be developed using the Gilson winches.

Thursday 8 March

The ship was positioned 8M down weather of the SAZ-20 site at first light. Conditions were light with seas from the SW and winds from the WNW throughout the day. Deployment commenced after breakfast and completed at 14:30. The anchor was deployed at 46 47.5S, 141 47.54E 4518m water depth. We established communications with the acoustic releases at 1605, but did not perform a triangulation of the position due to time pressure to recover the drifting RESPIRE trap before dark.

SAZ-20 anchor released at 2018-03-08 03:26:12 UTC, 46 47.52' S, 141 47.66'E,-46.792048,141.794356. Water depth under ship 4518m. . **No surveyed anchor position.**

We headed 20M to the drifting RESPIRE trap and the recovery was completed by 1830. The assembly had parted directly below the surface float and the lower sections were lost. The ship then returned to the SOTS Process site towing the RMT8 net and then conducted:

Start Time (local)	**Activity**
2100	RMT-01
0030 (9th March)	CTD to 2250m
0400	TM Fish

Friday 9 March

At first light we went to the SOFS-7 anchor deployment site and confirmed that the acoustic releases were not present and therefore that the tether had parted. We then moved over to the drifting SOFS-7 buoy where the float pack was sighted in the vicinity of the buoy and communication established with the acoustic releases. The failure was determined, based on a visual inspection (from a few hundred meters distance) to have occurred between the float pack and anchor. Rough conditions were forecast to arrive on the weekend (Sunday and Monday) when operations would be closed down and we decided that would be an opportunity to return to Hobart to retrieve a new mooring assembly from the float-packs down (including an anchor).

We returned to the SOTS Process site around 1100 and performed:

Start Time (local)	**Activity**
1200	ISP cast for incubations
1700	TMR
1800	TMR
2000	ISP
0000 (10th March)	Vertical Plankton net

Saturday 10 March

The ship was positioned 1NM down weather of the SAZ-19 site at first light. Conditions were overcast with 15-20 kts wind from NW and slight seas from the West. The acoustic releases were triggered around 0700 and the floats sighted around 0750. After confirming the lay-out of the string of floats the ship was brought around and the pickup line grappled successfully on the first attempt from the port quarter. The mooring was recovered by 1730 and this was followed by a CTD, launch of three bio-Argo floats and then ISP until 1145 when we headed for Hobart.

Sunday 11 March

Transited to Hobart under moderate conditions with a following sea.

Monday 12 March

We docked in Hobart 0900 and commenced unloading excess mooring components and loading new gear. Departed Hobart 1400 in windy conditions and rough conditions during the night. The CPR was deployed at 1630.

Tuesday 13 March

Transited to the SOTS site under moderating conditions from the South West.

Wednesday 14 March

We arrived back at the SOTS Process study site in moderate conditions, retrieved the CPR at 0630 and then performed:

Start Time (local)	**Activity**
0638	CTD to 500m
0830	TM Fish
1300	ISP
1620	Vertical Plankton net
1730	RMT8-02
1720	Vertical Plankton net
1730	RMT8-02
2213	Vertical Plankton net
2230	RMT8-03

Thursday 15 March

The process study continued under moderate conditions:

Start Time (local)	**Activity**
0214	RMT8-04
0813	ISP
1400	TM Fish
1606	RMT8-05
2054	RMT8-06

Friday 16 March

The ship was positioned 3M East of the SOFS-7 buoy at first light. Conditions were overcast with 3m swell from the SW and light winds from the North. The float pack was sighted around 7:30 (around 1.5km North of the buoy) and the first failed grappling attempt around 8:30. The floats were grappled numerous times before being successfully grappled around 9:30 on the third attempt, but lost before the full hookup at 1030. Attached with a strop at 1130. SOFS-7 anchor deployed at 1713 in 4341m depth. SOFS-7 tether failed and float pack appeared on surface ½ hour after deployment.

Start Time (local)	**Activity**
2004	PLAOS #7
2230	RMT 8 - failed
2315	PLAOS #8
0100 (17th March)	RMT8-07
0500	PLAOS #9
0538	CTD

Saturday 17 March

The ship was positioned 3Nm South the SOFS-7 buoy at first light. Conditions were overcast with low swell and 20-30kts wind from the North. The float pack was sighted around 7:30 and successfully grappled by 0930. Floats, wire and rope were retrieved and the buoy and last 600m wire released at 1900. The mooring was fully recovered by 2215. We headed towards the SOTS Process study site some 80 Nm to our south.

Sunday 18 March

Start Time (local)	**Activity**
0615	TMR
1120	ISP

We departed the site at 0200 but were quickly overtaken by severe weather. The ship made little progress and spent the night hove to.

Monday 19 March

The stormy weather continued and the ship spent the day and night hove to.

Tuesday 20 March

The weather improved and by 0600 the ship set course for Hobart with conditions improving as the transit proceeded.

Wednesday 21 March

The ship docked in Hobart at 0900.

Summary

SOTS: The voyage was successful in sustaining the Southern Ocean Time Series and extending it's role as a collaborative platform for process studies that benefit from the seasonal and inter-annual context it delivers. The sediment traps continue to be routinely deployed and recovered with good data return now spanning twenty years. Although the more challenging air-sea flux and biogeochemical mooring was not successful during this voyage, the science of SOTS continued to advance – particularly the bridging of biology to physics with simple models as noted in the scientific highlights section.

Trace metals: during this voyage TMR casts and ISP casts were conducted sampling the water column for dissolved and particulate trace elements to further our understanding of trace element cycling and better identify the controlling mechanisms. Oxygen uptake rates experiments showed clear relationship between temperature and the physiology of particle-attached microbes as suggested by the metabolic theory of ecology.

Micronekton sampling – fish, crustaceans, squids and gelatinous.

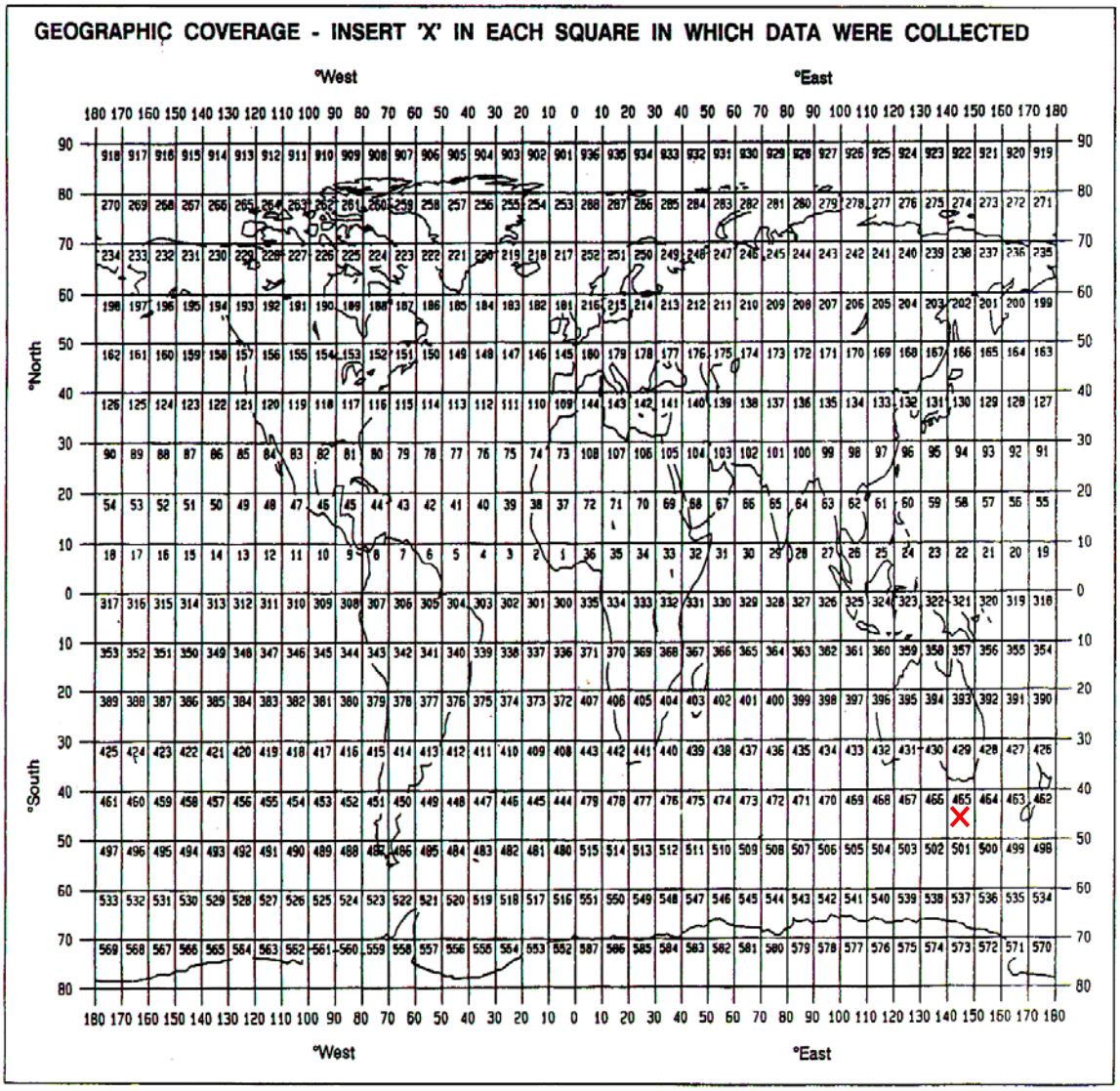
The profiling lagrangian acoustic optical sampler (PLAOS) was deployed 8 times to characterise the mesopelagic micronekton habitat, due to vessel availability only one deployment was done during the day. Most notable was the extensive avoidance/attraction behaviour of mesopelagic fish to the PLAOS with continuous white light as observed with concurrent vessel and PLAOS measurements. Fish from their epi pelagic depths of 0-200 m were moved to 500 to 900 m depth depending on the species. Using this behaviour may enable specific dominant fish species and their biomass to be better determined. Scoring of the PLAOS oblique and vertical cameras recorded the depth distribution of many invertebrate organisms (Figure 1) notably the gelatinous siphonophores and the numerous worms (chaetognaths). It was noteworthy that high numbers of chaetognaths were also retained in the trawls. Calibration of the narrow and broad band PLAOS acoustic sensors were done on 2 deployments using two calibration spheres suspended below the system. A trial of continuous red light for video showed greatly reduced impact of fish behaviour when compared to continuous white light. Further trials of broadband acoustic technology highlighted the advanced spectral and target detection capability at range of this technology.

An RMT8 (8 m^2 mouth area when fishing) midwater trawl was deployed six times to characterise micronekton species diversity in two integrated depth strata: 0-200 m (epipelagic zone) and 600-200 m (upper and lower mesopelagic zone). These depth strata were sampled during the day and the night. The RMT8 sampled a wide range of size classes and catches were generally in very good condition. Fishes, crustaceans, cephalopods and gelatinous zooplankton were identified in catches and shipboard identifications were to the lowest possible level of classification. The two most abundant fish species in most trawls were *Lampanyctus australis* (relatively large-bodied but juveniles also recorded) and *Electrona carlsbergi* (relatively small-bodied).

These two species represented key components of the acoustically-sensed vertically migrating scattering layers and were observed in pLOAS imagery. Night-time epipelagic strata were also characterised by a relatively high abundance of krill and other crustacea. *Nematoscelis megalops* was the dominant krill species and the likely species associated with acoustically-sensed swarms (high density patches with characteristic shape and acoustic signature). *Stylocheiron maximum* was also common in catches. *Solmissus* sp. jellyfish, siphonophore bracts and chaetognaths were the most dominant gelatinous zooplankton recorded in trawls, aligning with the taxa frequently observed in pLAOS deployments.

Marsden Squares

XXX



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	46	47.5	S	141	47.54	E	H17 B73 D01	Southern Ocean Times Series (SOTS) site: SAZ-20 sub-surface sediment trap mooring deployed for recovery in March 2019 See diagram in appendix detailing instruments and depths.
2	Tom Trull	46	6.0	S	142	18	E	H17 B73 D01	Southern Ocean Times Series (SOTS) site: SAZ-19 sub-surface sediment trap mooring recovered (deployed in March 2017) See diagram in appendix detailing instruments and depths.

Summary of Measurements and samples taken

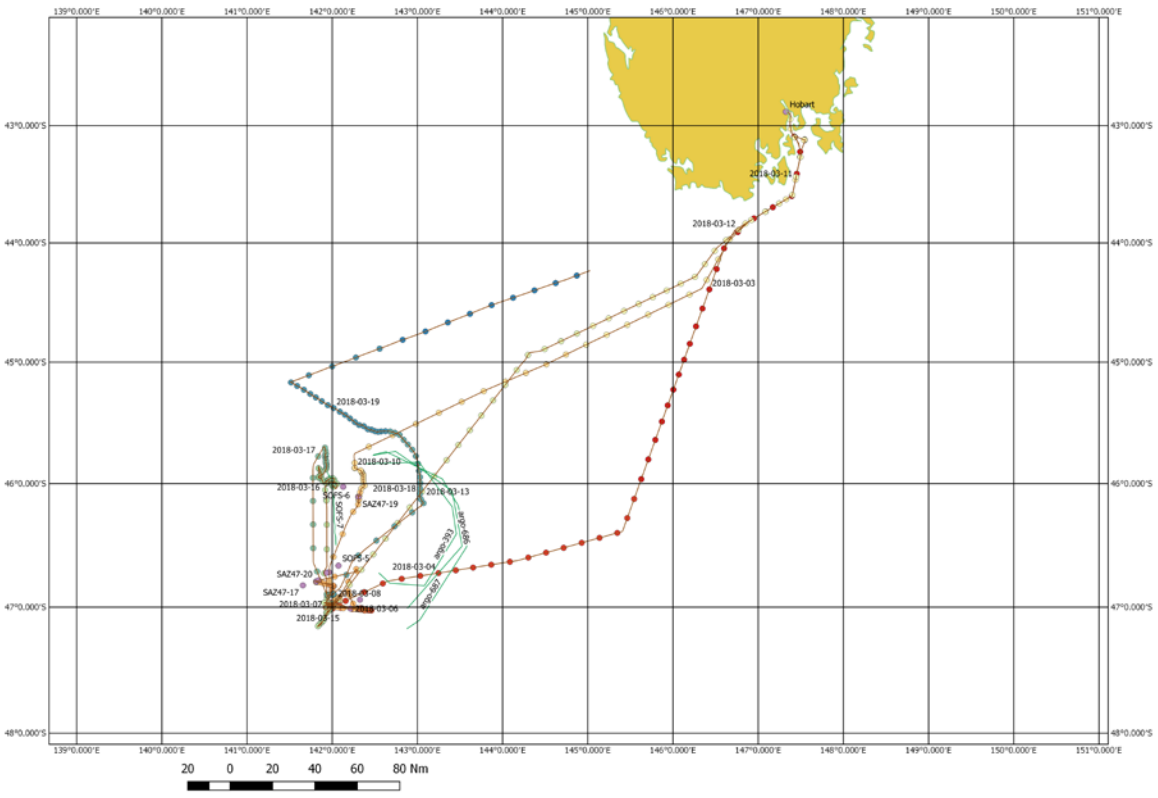
Item No.	PI see page above	NO see above	UNITS see above	DATA TYPE Enter code(s) from list at Appendix A	DESCRIPTION
1	Tom Trull	38	Hours	B08	CPR – Continuous Plankton Recorder
2	Bronte Tilbrook	17	days		Continuous pCO2 measurements
3	Tom Trull	15	hours	B02	Surface underway measurements of phytoplankton physiology from the FIRe fast repetition rate fluorometer.
4	Rudy Kloser	9	profiles	B28, H17, H10, B90	The Profiling Lagrangian Acoustic Optical System (PLAOS) was designed and built at CSIRO and was deployed 9 times during the voyage between depths of 300 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	Tom Trull	5?	Casts	H10	Completed 5 CTD stations for collection of discrete water and particle samples.
7	Philip Boyd	8	casts	B71 B72 H30	Particulate trace elements and organic carbon concentration from Mc Lane in situ pumps
8	Philip Boyd	10?	casts	H30 H32	Dissolved trace element concentration from Trace Metal clean Rosette

Item No.	PI see page above	NO see above	UNITS see above	DATA TYPE Enter code(s) from list at Appendix A	DESCRIPTION
9	Philip Boyd	4	deployments	B08, B09	Planktonic community (>100 µm) from plankton net.
11	Rudy Kloser	7	trawls	B09, B21, B14, H10	The Rectangular Midwater Trawl (RMT8) net has a mouth area of 8 m^2 when fishing. The body of the net is made from 6 mm knotless Nitex mesh and the codend has 700 µm mesh. The net was deployed on the General Purpose wire and the depth was monitored in real time via USBL beacon. The net was programmed to open at the desired depth and close after a set elapsed time. During a trawl, the net controller logged depth and temperature. Catch species composition, lengths and weights were recorded. Photographs were taken of the sorted catch. Trawl RMT-04 failed and no catch was recorded..
					Please continue on separate sheet if necessary

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.

Track Chart


Hobart
2018-03-11
2018-03-12
2018-03-03
2018-03-19
2018-03-17
2018-03-10
2018-03-16
2018-03-18
2018-03-13
SOFS-6
SAZ47-19
SOFS-7
SOFS-5
SAZ47-20
2018-03-04
SAZ47-17
2018-03-08
2018-03-07
2018-03-06
2018-03-15
20 0 20 40 60 80 Nm

Personnel List

	Name	Organisation	Role
1.	Lisa Woodward	MNF	Voyage Manager
2.	Rod Palmer	MNF	MNF SIT support
3.	Nicole Morgan	MNF	MNF SIT support
4.	Pamela Brodie	MNF	DAP computing support
5.	Karl Malakoff	MNF	DAP computing support
6.	Bernadette Heaney	MNF	GSM support
7.	Julie Janssens	MNF	Hydrochemist
8.	Peter Hughes	MNF	Hydrochemist
9.	Tom Trull	CSIRO-ACE	SOTS: Chief Scientist
10	Eric Schulz	BOM	SOTS: Co-Chief Scientist
11	Peter Jansen	ACE-CSIRO	SOTS: Managing Engineer
12	Phil De Boer	CSIRO	SOTS: Mooring Supervisor
13	Gary Curtis	CSIRO	SOTS: Mooring deck work
14	Darren Moore	CSIRO	SOTS: Mooring deck work
15	Diana Davies	ACE	SOTS: sediment traps
16	Christina Schlallenberg	ACE	SOTS: incubations
17	Rudy Kloser	CSIRO	Kloser- PI
18	Ben Scoulding	CSIRO	Kloser – PLAOS- Nets
19	Jeff Cordell	CSIRO	Kloser – PLAOS technology
20	Haris Kunnath	CSIRO	Kloser – PLAOS – post Doc
21	Caroline Sutton	CSIRO	Kloser – Nets biologist
22	Adrian Flynn	Fathom Pacific	Kloser – Acoustics/Nets
23	Philip Boyd	UTAS	Boyd: PI
24	Emma Cavan	UTAS	Boyd: Microbes
25	Mathieu Bressac	UTAS	Boyd: RESPIRE traps
26	Manu Laurenceau-Cornec	UTAS	Boyd: Particles
27	Svenja Haftner	UTAS student	Boyd: Zooplankton, student
28	Robert Strzepek	UTAS	Boyd: Phytoplankton
29	Michael Ellwood	ANU	Boyd: Iron chemsitry
30	David Janssen	ANU Student	Boyd: Iron chemistry
31	Robin Grun	ANU Student	Boyd: zinc chemistry
32	Viena Puigcorbe Lacueva	Edith Cowan Univ.	Boyd: radionuclides
33	Michal Strzelec	ACE-CRC/UTAS student	Boyd: aerosols, student
34	Flavia Tarquinio	Edith Cowan Univ.	Boyd: radionuclides
35	Gary Le Cleir	U. Tennessee	Boyd: viruses
36	Naomi Gilbert	U.Tennessee	Boyd: viruses/omics
37	Ben Twining	Bigelow (USA)	Boyd: Iron particles
38	Dan Ohnemus	Bigelow (USA)	Boyd: Iron particles
39	Kiefer Forsch	Scripps Institute of Ocean.	Boyd: microbes/ligands

Marine Crew

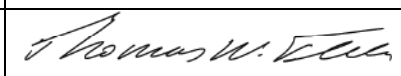
Name	Role
John Highton	Master
Gurmukh Nagra	Chief Mate
Brenden Eakin	Second Mate
Samuel Edwards	Third Mate
Christopher Minness	Chief Engineer
Ryan Agnew/Sam Benson	First Engineer
Michael Sinclair	Second Engineer
Damien Wright	Third Engineer
Robert Kinsey	Electrical Engineer
Cassandra Rowse	Chief Caterer
Kyra Lade	Caterer
Paul Stanley	Chief Cook
Adrian Hughes	Cook
James Hogg	Chief Integrated Rating
Christopher Dorling	Integrated Rating
Paul Langford	Integrated Rating
Roderick Langham	Integrated Rating
Dennis Bassi	Integrated Rating
Peter Taylor	Integrated Rating
Daniel Morse	Integrated Rating

Acknowledgements

We are grateful to the MNF and ASP for excellent support at sea and flexibility in accommodating an unscheduled return to Hobart mid-voyage.

SOTS: We acknowledge the mooring preparation work done by CSIRO and ACE CRC shoreside teams. We thank the directors of the MNF, IMOS, and the ACE CRC (Barbara Musso, Tim Moltmann, and Mark Kelleher, respectively) for support of SOTS.

Signature

Your name	Thomas W. Trull
Title	Chief Scientist
Signature	
Date:	21 March 2018

List of additional figures and documents

Appendix A CSR/ROSCOP Parameter CodeS

Appendix B Mooring diagrams

Appendix C Mooring debriefing notes

Appendix D Subantarctic biogeochemistry of carbon and iron science report

Appendix A - 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

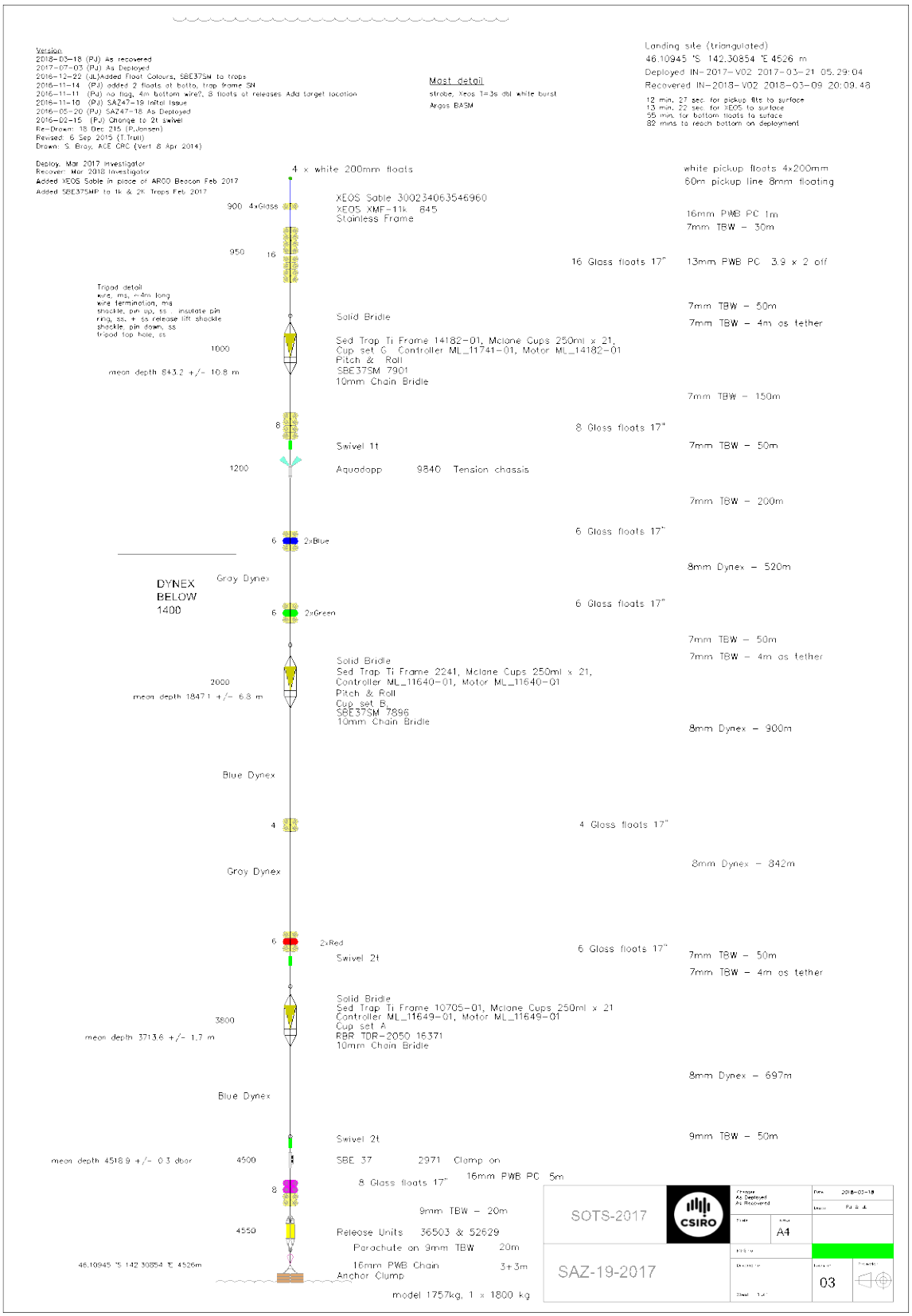
	CHEMICAL OCEANOGRAPHY
H21	Oxygen
H74	Carbon dioxide
H33	Other dissolved gases
H22	Phosphate
H23	Total – P
H24	Nitrate
H25	Nitrite
H75	Total – N
H76	Ammonia
H26	Silicate
H27	Alkalinity
H28	PH
H30	Trace elements
H31	Radioactivity
H32	Isotopes
H90	Other chemical oceanographic measurements

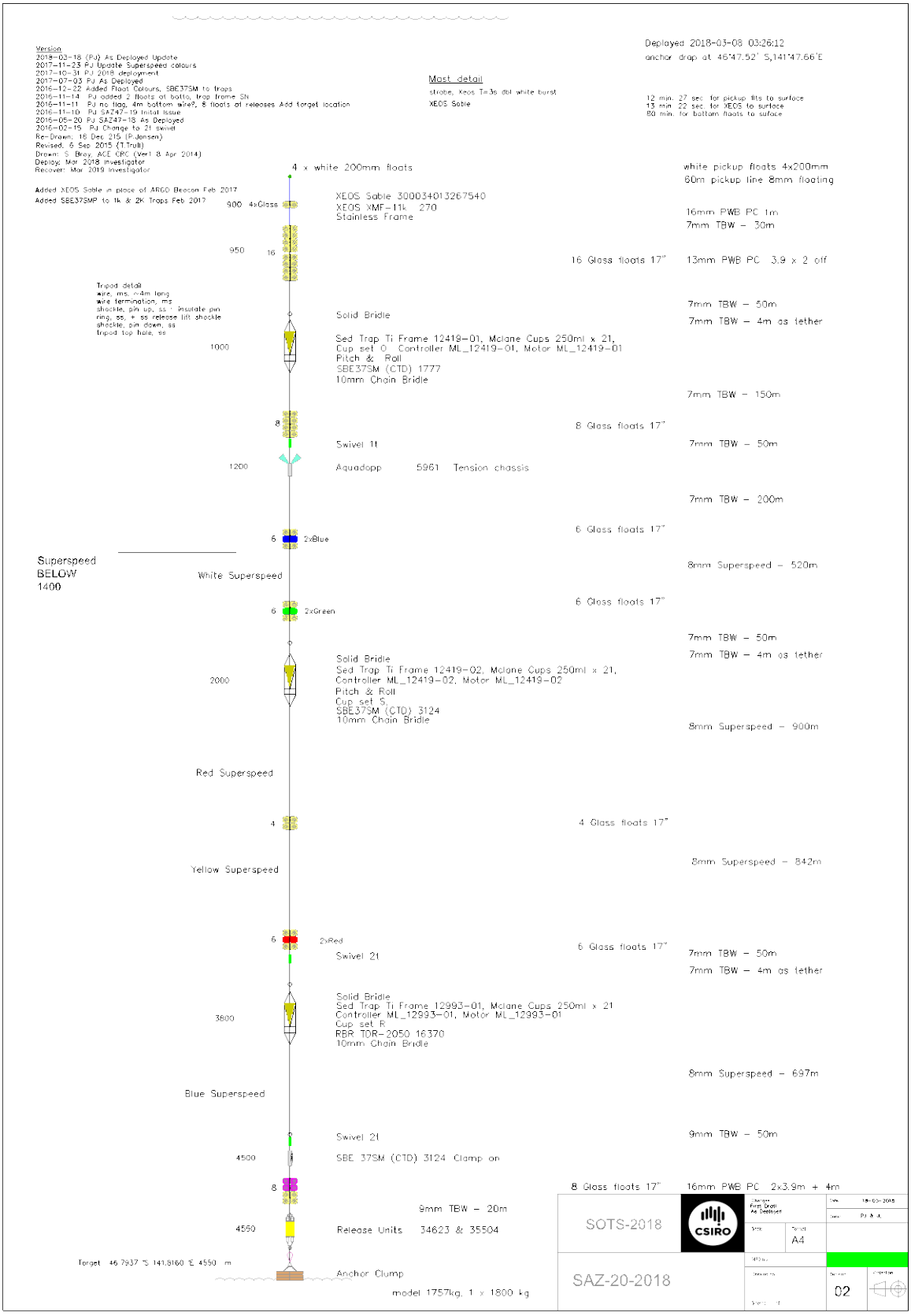
B28	Acoustic reflection on marine organisms
B37	Taggings
B64	Gear research
B65	Exploratory fishing
B90	Other biological/fisheries measurements

	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

Appendix B – Mooring diagrams




Version
2018-03-18 (PJ) As Deployed Update
2017-11-23 PJ Update Superspeed colours
2017-10-31 PJ 2018 deployment
2017-07-03 PJ As Deployed
2016-12-22 Added Float Colours, SBE37SM to traps
2016-11-14 PJ added 2 floats at bottp, trap frame SN
2016-11-11 PJ no flag, 4m bottom wire?, 8 floats at releases Add target location
2016-11-10 PJ SAZ47-19 Initial Issue
2016-05-20 PJ SAZ47-18 As Deployed
2016-02-15 PJ Change to 21 swivel
Re-Drawn: 16 Dec 215 (P.Jansen)
Revised: 6 Sep 2015 (T.Trull)
Drawn: S. Bray, ACE CRC (Ver1 8 Apr 2014)
Deploy: Mar 2018 Investigator
Recover: Mar 2019 Investigator
Added XEOS Sable in place of ARGO Beacon Feb 2017
Added SBE37SMP to 1k & 2K Traps Feb 2017
Mast detail
strobe, Xeos T=3s dbl white burst
XEOS Sable
Deployed 2018-03-08 03:26:12
anchor drop at 46°47.52' S,141°47.66'E
12 min. 27 sec. for pickup 8ts to surface
13 min. 22 sec. for XEOS to surface
80 min. for bottom floats to suface
4 x white 200mm floats
white pickup floats 4x200mm
80m pickup line 8mm floating
900 4xGlass
XEOS Sable 300034013267540
XEOS XMF-11k 270
Stainless Frame
16mm PWB PC 1m
7mm TBW - 30m
950
16
16 Glass floats 17"
13mm PWB PC 3.9 x 2 off
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
7mm TBW - 50m
Solid Bridle
7mm TBW - 4m as tether
1000
Sed Trap Ti Frame 12419-01, Mclane Cups 250ml x 21,
Cup set 0 Controller ML_12419-01, Motor ML_12419-01
Pitch & Roll
SBE37SM (CTD) 1777
10mm Chain Bridle
7mm TBW - 150m
8
8 Glass floats 17"
Swivel 1t
7mm TBW - 50m
1200
Aquadopp 5961 Tension chassis
7mm TBW - 200m
6
6 Glass floats 17"
2xBlue
Superspeed
BELOW
1400
White Superspeed
8mm Superspeed - 520m
6
6 Glass floats 17"
2xGreen
7mm TBW - 50m
7mm TBW - 4m as tether
Solid Bridle
Sed Trap Ti Frame 12419-02, Mclane Cups 250ml x 21,
Controller ML_12419-02, Motor ML_12419-02
Pitch & Roll
Cup set 5,
SBE37SM (CTD) 3124
10mm Chain Bridle
2000
8mm Superspeed - 900m
Red Superspeed
4
4 Glass floats 17"
8mm Superspeed - 842m
Yellow Superspeed
6
2xRed
6 Glass floats 17"
7mm TBW - 50m
Swivel 2t
7mm TBW - 4m as tether
Solid Bridle
Sed Trap Ti Frame 12993-01, Mclane Cups 250ml x 21
Controller ML_12993-01, Motor ML_12993-01
Cup set R
RBR TDR-2050 16370
10mm Chain Bridle
3800
8mm Superspeed - 697m
Blue Superspeed
Swivel 2t
9mm TBW - 50m
4500
SBE 37SM (CTD) 3124 Clamp on
8
8 Glass floats 17"
16mm PWB PC 2x3.9m + 4m
9mm TBW - 20m
4550
Release Units 34623 & 35504
Target 46.7937 'S, 141.8160 'E, 4550 m
Anchor Clump
model 1757kg, 1 x 1800 kg
SOTS-2018
CSIRO
First Draft
As Deployed
A4
SAZ-20-2018
02

SAZ-20

Appendix C – SOTS mooring operations debriefing notes

Three debriefing sessions were held:

i. After the initial UTAS Respire and SOFS-7 deployments
ii. After the SAZ-20 deployment and SAZ-19 recovery
iii. After the second deployment and recovery of SOFS-7

These notes provide a summary of those discussions:

1. All back deck operations went very smoothly. Most were done while keeping loads low to the deck and personnel far from the edge and behind the bulwarks. The few exceptions included
   a. deployment of the combined surface and subsurface UTAS RESPIRE float packs (separating these to allow a two-step deployment will allow the loads to stay lower to the deck).
   b. recovery and deployment of the SOFS-7 large float pack (deploying this in sections avoids some complications; also it may be possible to make this easier by operating without the dance floor – subject to further investigations).
2. Communications with the Bridge were generally very clear
3. Ship handling was careful and steady and became increasingly adept at holding the ship close to float packs and surface floats during their recovery.
4. The main problems with achieving full success with the mooring deployments were the result of mooring design shortcomings, not deployment or recovery procedures. Specifically the loss of the anchors during the two deployments of SOFS-7 and the loss of the UTAS RESPIRE traps occurred in the ocean as a result of hardware failures.
5. Navigation relative to the moorings on the surface has greatly improved with the provision of drawings of expected layouts, colour-coding of float packs, and additional transponders on the equipment. Multiple observers and the use of layout sketches on the bridge were helpful for the approaches. The AIS location systems on the RESPIRE and SOFS-7 surface floats worked well, but the Cassabel GPS systems on the SOFS-7 anchor-end float pack did not function (batteries broke free from their fastenings inside these floats and they failed electrically).
6. Grappling continues to be a difficult operation:
   For the SAZ mooring, the pickup floats were tangled with the mooring but nonetheless the grapple was able to pull this section of the mooring to the ship as intended. No changes are required.
   For the SOFS mooring, the acoustic release float pack is too large to move towards the ship using the pneumatic grapple, and separating a section of it from the main pack using a floating line may improve this.
   For the RESPIRE trap the pickup line functioned very well with the use of the new bridle on the surface float protecting this connection from snap-loading damage.
7. Deployment of the SOFS mooring remains a difficult and long operation, requiring a deployment/recovery/deployment sequence. There is not yet an engineering solution.
8. Recovery of the SOFS mooring is also a difficult and long operation, requiring two recoveries. It could be tried using a single recovery starting with the surface float to avoid having to grapple the large anchor end float pack. This will require a mooring winch able to lift the 1800m wire section.
9. Picture books showing each step in the operations are very useful, and should continue to be expanded.
10. Mock role play of difficult operations such as SOFS surface float grappling may be useful.

Appendix D -Subantarctic biogeochemistry of carbon and iron science report

Philip Boyd IMAS Philip.boyd@utas.edu.au

Iron and Carbon Biogeochemistry

The activities from this component of the voyage are as follows:

1) Drivers of the biological carbon pump
2) Iron biogeochemistry – external supply and internal cycling
3) Phytoplankton dynamics and photo-physiology

Drivers of the biological carbon pump

This theme investigated the relative roles of surface and subsurface plankton in particle formation (aggregation, Emmanuel Laurenceau-Cornec; export flux (Thorium, Viena Puigcorbe Lacueva, Flavia Tarquinio), particle degradation (remineralisation, Matthieu Bressac; respiration Emma Cavan; Thorium), and particle transformations (faecal pellet production, Svenja Hafner). This research also enabled comparisons of the relative roles of zooplankton and microbes in setting the vertical attenuation of downward export flux. The central integrator of this theme was the RESPIRE particle interceptor/incubator array (which was not recovered during deployment 1). The theme also has strong links with the iron biogeochemistry theme.

Iron biogeochemistry – external supply and internal cycling

This voyage has been ratified as a GEOTRACES process study. External supply was investigated by sampling for aerosols and rain (Michal Strzlec) and indirectly by intercomparing vertical profiles of dissolved iron, particulate iron, iron stable isotopes (Michael Ellwood, Robert Grun) with those for ligands (Kiefer Forsch) and physics/nutrients (MNF). Internal cycling was investigated by the deployment of the TM RESPIRE array (not recovered during deployment 1) in tandem with a suite of three trace metal biogeochemical perturbation experiments. Each experiment sampled from the depths of the TM RESPIRE traps and conducted a wide range of measurements ranging from geochemistry (CHN, Emma Cavan; nutrients MNF) to biogeochemistry (trace metal particle maps, Ben Twining, Dan Ohnemus; dissolved trace metals and isotopes Michael Ellwood, Robert Grun; ligands, Kiefer Forsch; other trace metals such as chromium Dave Janssen) and biology (viral dynamics Naomi Gilbert; metatranscriptomics, Gary LeCleir, iron and carbon uptake, Robert Strzepek, proteomics Philip Boyd/Brook Nunn; flow cytometry (Emma Cavan); particle characteristics (FLOW-CAM) Emmanuel Laurenceau-Cornec). Experiment 1 was run at the ambient temperature of each of the depths of the TM RESPIRE traps, and experiments 2 and 3 were run on samples from one depth at ambient temperature and at 1C (to minimise biological activity in the samples).

These data were to be cross-referenced to the TM RESPIRE datasets (Matthieu Bressac) and to other biogeochemical sampling for stocks (dissolved, particulate, stable isotopes) and rates (column-integrated iron uptake, Robert Strzepek). Additional samples were taken for the TM content of mesopelagic organisms, and further experiments were run for particle scavenging (Matthieu Bressac), iron bioavailability (Gary LeCleir), and upper ocean iron cycling (Robert Strzepek, Philip Boyd). Samples were collected for zooplankton stocks and community structure (Svenja Hafner) and for lab culture isolation (Robert Strzepek).

Phytoplankton dynamics and photo-physiology

Samples were obtained from both underway, vertical profiles, experiments and incubations for a series of metrics using active fluorometry (Robert Strzepek) that will be linked with upper ocean bio-optics and additional photophysiological assays (Christina Schallenberg).

Table summarising samples taken, proposed repository for the data, and the final location of data.

Samples	**Contact person**	**Proposed data repository**	**Final location (if known)**	**Contact details**
Phytoplankton counts; Flow cytometry	Boyd	Publication	IMAS	Philip.boyd@utas.edu.au
Plankton and particle counts; Flow cam	Laurenceau-Cornec	Publication	IMAS	emmanuel.laurenceau@utas.edu.au
Dissolved trace metals	Ellwood	Publication	GEOTRACES IDP	Michael.Ellwood@anu.edu.au
Dissolved stable isotopes (metals)	Ellwood	Publication	GEOTRACES IDP	Michael.Ellwood@anu.edu.au
Particulate trace metals	Elwood/Twining	Publication	GEOTRACES IDP	Michael.Ellwood@anu.edu.au btwining@bigelow.org
Particle 2D elemental maps (SXRF)	Twining	Publication	GE OTRACES IDP	btwining@bigelow.org
Trace metal binding siderophores	Forsch	Publication	GEOTRACES IDP	kforsch@ucsd.edu
Metatranscriptomics	LeCleir	Publication		glecleir@utk.edu
Metaproteomics	Boyd	Publication		Philip.boyd@utas.edu.au
Viral lysis	Gilbert	Publication		glecleir@utk.edu
Iron and carbon uptake rates	Strzepek	Publication	GEOTRACES IDP	Robert.strzepek@utas.edu.au
Downward carbon export (Thorium and Polonium)	Puigcorbe Lacueva	Publication	ECU	v.puigcorbelacueva@ecu.edu.au
Zooplankton stocks and rates	Hafner	Publication	IMAS	Svenja.hafner@utas.edu.au
Microbial particle degradation	Cavan	Publication	IMAS	emma.cavan@utas.edu.au
Active Fluorescence	Strzepek	Publication	IMAS	Robert.strzepek@utas.edu.au
Chromium isotopes	Janssen	Publication		david.janssen@geo.unibe.ch

Samples	Contact person	Proposed data repository	Final location (if known)	Contact details
CHN	Cavan	Publication	IMAS	emma.cavan@utas.edu.au

Svenja Hafner (UTAS)

A ZOONET (200 µm) was used on four sampling days during the cruise, including three afternoon and four evening/night casts. The upper 50 (first day) and 100 m (remaining days) of the water column were sampled in triplicates (except the first day, due to the loss of the cod end). The first sample was always preserved for community composition analyses in Hobart. The remaining two tows were used to identify zooplankton for faecal pellet production experiments. Chaetognaths, salps, copepods (large and small species), krill and amphipods were incubated in seawater, filtered with 200 µm to exclude other mesozooplankton. In the last incubation round, feeding of the animals with a particle suspension was tested.

The best results, i.e. highest survival rates, sufficient faecal pellet production, were reached with the copepod Calanus propinquus. The individual faecal pellet production rate could be calculated for this species from incubations over 24 hours. Additionally, faecal pellets were produced for further experiments: (1) The sinking rate of faecal pellets in the water was tested with the SETCOL method, described by Bienfang (1981). (2) The bacterial remineralisation of faecal pellet material was measured as oxygen decrease over 24 hours. (3) The nutrient release of both faecal pellet material and zooplankton carcasses were measured over 24 and 36 hours, respectively. (4) Faecal pellets were sampled to analyse the bacterial community (70s) and viral activity.

Literature:

Bienfang, P. K. (1981) 'SETCOL — A Technologically Simple and Reliable Method for Measuring Phytoplankton Sinking Rates', Canadian Journal of Fisheries and Aquatic Sciences, 38(10), pp. 1289-1294.

Emmanuel Laurenceau-Cornec UTAS

Particle aggregation (SNOWMAN)

The SNOWMAN (Simulator of Non-finite Open-Wheeled Marine Aggregation and siNking) was used for the second time on the SOTS2018 voyage. A new improved design of the device was tested at sea to address one issue revealed by the 2017 tests: the too small size of the apertures on the inner drum did not fully allow the particles to leave it and then sink in the settling column. A new drum was 3D printed with dimensions and number of the holes twice their initial values.

Particles used in the incubations were sourced from the ship underway supply filtered with 142mm filter holders mounted with polycarbonate 1.0 µm filters. A concentrate of particles resulting from approximately 2 days of filtration was incubated in the SNOWMAN. A volume between 400 and 1200 mL of this concentrate was incubated for each experiment.

A first incubation intended to be an initial test of the potentials for particle aggregation demonstrated that the new design permitted the particles to aggregate in the inner drum and leave it when their size and density exceeded a threshold. In addition, the large size and number of the holes seemed to still permit a solid body rotation to occur — ensuring particle aggregation by differential settling only — but only for a certain range of drum rotation speed (approximately between 0.33 and 0.89 rpm).

Two other experiments were conducted in order to reproduce and document particle aggregation and trajectories out of the drum but unfortunately no particle reached a size big enough to leave the drum again as initially observed. However, high resolution pictures taken at time intervals ranging from 10 minutes to several hours over up to 48 hours (fig. 1) revealed a continuous loss of particles from the drum suggesting that particles might still leave the tank but in a much smaller size range than expected.

Figure 1. Left: image of the water inside the drum 10 minutes after particle incubation; Right: same image 48 hours after particle incubation.

The range of drum rotation speeds valid to sustain a solid body rotation might be responsible for the absence of aggregation: at too high rotation speed, the particles are entrained in the body of water making their collision very rare and slowing down considerably the aggregation process; at too low rotation speed, the solid body rotation is not sustained and particles leave the drum in the very first hours of incubation.

Emma Cavan (IMAS)

Organic remineralisation experiments.

Microbial incubations were set up to track the organic changes that occur during organic particle remineralisation microbial incubations. Particles were collected using the in situ pumps from 40, 70 and 100 m. The particles were resuspended in unfiltered water from the same depth collected using Niskin bottles. The slurry was then split into 20 ml micro-respiration vials and submerged in a water bath. Oxygen concentration was measured over a 36 hour period and at 12, 24 and 36 h the vials were emptied for POC, amino acid isotopes, lipids transcriptomics and bacterial counts. Full results should be available in 6-10 months. This was funded by IMAS through the research enhancement program.

Viena Puigcorbe Lacueva, Flavia Tarquinio (ECU)

^{234}Th and ^{210}Po as tracers of POC export

Contact: v.puigcorbelacueva@ecu.edu.au

Objectives

Our objective is to quantify the ^{234}Th and ^{210}Po export flux by measuring the depletion of these radionuclides with respect to their parents in the upper water column. The integrated radionuclide depletion will allow the calculation of the downward flux of particulate ^{234}Th and ^{210}Po out of the surface water. In order to convert the radionuclide fluxes to a POC export fluxes, we will determine

the POC/^{234}Th and POC/^{210}Po ratios in sinking particles collected with in situ pumps for two different particle sizes (1-53 µm and >53 µm). Additionally, some samples were collected to analyze the 16S rRNA and 18S rRNA from CTDs and also from the in situ pumps.

No data is available yet. Results are expected to be ready by beginning of 2019. The data will be stored at Edith Cowan University Data Center prior publication.

Samples were collected at the following depths from the following CTD and ISP casts:

-

Date 5-Mar-18 CTD#2
Lat 47°0.035' S
Long 142°1.267'E

ID	Niskin bottle	Depth (m)
Po_1	34 & 33	25
Po_2	31 & 30	50
Po_3	28 & 27	80
Po_4	26 & 25	100
Po_5	23 & 24	125
Po_6	22 & 20	150
Po_7	19 & 18	200
Po_8	17 & 16	300
Po_9	15 & 14	400
Po_10	12 & 10	800
Po_11	9 & 8	1000
Po_12	6 & 5	1200
Po_13	4 & 3	1600

Date 9-Mar-18 CTD # 4
Lat 47°0.17'S
Long 142°0.171'E

ID	Niskin	Depth (m)
Th_1	35	5
Th_2	33	25
Th_3	32	40
Th_4	31	50
Th_5	29	75
Th_6	27	100
Th_7	26	125
Th_8	25	150
Th_9	22	175
Th_10	21	200
Th_11	19	250

Date 9-Mar-18 CTD # 4 Lat 47°0.17'S Long 142°0.171'E		
Th_12	18	300
Th_13	14	350
Th_14	13	450
Th_15	12	500
Th_16	9	600
Th_17	8	700
Th_18	7	800
Th_19	6	1000
Deep 1	4	1400
Deep 2	4	1400
Deep 3	2	1800
Deep 4	2	1800

ID	Niskin bottle	Depth (m)
BAC 1	32	40
BAC 2	28	100
BAC 3	24 & 23	150
BAC 4	17 & 16	300
BAC 5	11 & 10	500

ISP Cast #4	
ID	Depth (m)
ISP 1 QMA	500
ISP 2 QMA	300
ISP 2 Screen	300
ISP 3 QMA	150
ISP 4 QMA	100
ISP 4 Screen	100
ISP 5 QMA	70
ISP 5 Screen	70
ISP 6 QMA	40
ISP 6 Screen	40

14-Mar-18	CTD #6
Lat 46°59.679’ S	
Long 142°0.541’ E	

ID	Niskin	Depth
Th_20	36	5
Th_21	35	15
Th_22	34	25
Th_23	33	40
Th_24	32	50
Th_25	30	75
Th_26	29	90
Th_27	27	100
Th_28	26	125
Th_29	25	150
Th_30	23	175
Th_31	22	200
Th_32	21	225
Th_33	20	250
Th_34	19	275
Th_35	18	300
Th_36	16	325
Th_37	15	350
Th_38	14	375
Th_39	13	400
Th_40	12	425
Th_41	11	450
Th_42	10	475
Th_43	9	500
Th_44	7	550
Th_45	6	600
Th_46	5	650
Th_47	4	700
Th_48	3	800
Th_49	2	900
Th_50	1	1000

ID	Niskin	Depth
BAC 6	33	40
BAC 7	28,27	100
BAC 8	25,24	150
BAC 9	18,17	300
BAC 10	9,8	500

ISP Cast #8	
ID	Depth (m)
ISP 1 QMA	300
ISP 1 Screen	300
ISP 2 QMA	150
ISP 2 Screen	150
ISP 5 QMA	70
ISP 5 Screen	70
ISP 6 QMA	40
ISP 6 Screen	40

1) Iron biogeochemistry – external supply and internal cycling

Michael Ellwood, Robin Grun, David Janssen ANU and Berne

Trace metal cycling at the Southern Ocean Time Series (SOTS) voyage

Aim: Characterise the iron and the trace metal status of SOTS site (47 °S) and undertake incubation experiments to determine the degree of iron regeneration from suspended and sinking matter.

Sample collection

During the voyage, the MNF trace metal rosette was used to collect shallow (0-500 m) and deep (0-1500m) water casts for trace metals and their isotopes. In addition, water was drawn for primary production (14C), iron uptake (55Fe), iron speciation, chromium isotopes, omics, particulate trace metals and nutrients (Figure 1). A total of five TMR casts conducted on the voyage around 47°S; 142°E.

To complement the collection of dissolved metal depth profiles, six Mclane pumps were used to collect particulates in situ for trace metals and isotope analysis. In addition, samples were collected for chromium isotopes, omics and particulate regeneration experiments. These profiles were collected between 40 and 500 m. A total of eight deployments were undertaken during the voyage.

Analysis of samples collected on the voyage will be undertaken ashore at various laboratories but voyage participants (Table 1).

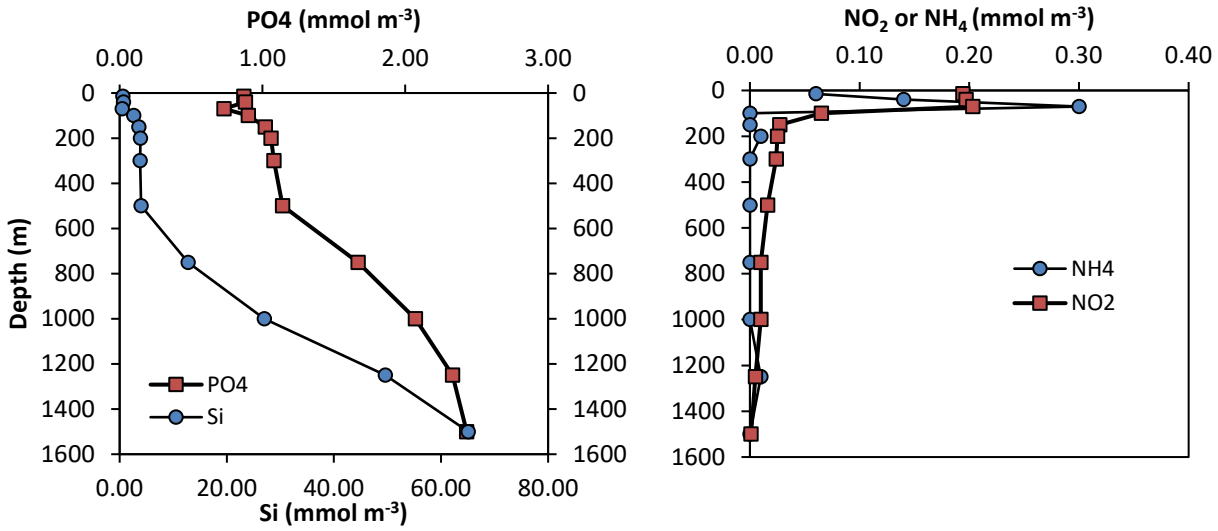


Figure 1. Nutrient profiles for NO2, NH4, Si and PO4 collected from TMR cast 3.

David Janssen (University of Bern, Bern Switzerland) – Preliminary data has shown that dissolved chromium (Cr) is reduced at the cell surfaces of marine phytoplankton, and that this reduced Cr then adsorbs to the cells. Dissolved samples (<0.2 um filtered) were collected from the trace metal rosette for dissolved Cr stable isotope composition (dδCr) and redox speciation (Cr(III)) and suspended particulate samples (<0.8 um) were collected for particulate Cr stable isotope composition (pδCr) from the in-situ pumps. The goal of these samples is to test the potential for Cr and δCr to serve as a paleoceanographic proxy for productivity. Additionally dδCr, Cr(III) and pδCr samples were collected from a series of three regeneration incubation experiments, during which concentrated particles were resuspended in filtered seawater and sampled over the course of a 5-6 day incubation. The goal of these samples is to test the effects of regeneration and repackaging of particles on the δCr of those particles. Finally, Cr(III) samples were collected from two particle aggregation experiments to track redox cycling in aggregates.

I would like to thank the Captain and crew for their assistance in TMR, in-situ pump and fish deployments.

Michal Strzelec UTAS

Dry and wet atmospheric deposition of micro nutrients

To study atmospheric micro nutrients deposition fluxes and sources aerosol and rain samples were collected in the Subantarctic Southern Ocean. At the next stage we would like to determine soluble and total trace elements fluxes.

Total Suspended Particulates samples were collected on the 47mm diameter cellulose Whatman 41 filters, previously cleaned according to the Geotraces protocol. The double air pump filtering aerosol system (Aerosol Laboratory) is connected to the sector control* to avoid sampling the ship exhaust. Two sampling lines provide duplicates for all samples. To assess contamination form air transport system, filter changeover etc. the procedural and exposure blanks are collected between normal sampling periods.

The rain samples are collected on the front of deck 5 using the in house-made rain sampler constrained with HDPE funnel and LDPE bottle attached to the plastic box.

*The following wind conditions must be meet: direction between 280 to 80 deg. and speed between 10 and 80 knots.

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Kiefer Forsch (SIO)

Type of measurement and purpose: I seek to understand the role of iron-binding ligands in the supply of the micronutrient iron in the ocean, and related impacts on biogeochemistry. Iron-binding organic ligands synthesized by heterotrophic bacteria (e.g. siderophores, or L1 ligand class) during the remineralization of particle substrates could aid in regeneration of bioavailable iron. I am measuring iron-binding ligands, combining both large-scale oceanographic observations with mechanistic microcosm incubation experiments. In these experiments, the production of iron-binding ligands is determined via electrochemistry, and a key aspect of the biogeochemical cycling of iron may be examined.

Sample/measurement coverage: To date, I have sampled 3 trace metal casts (TMR1, TMR2, TMR3). This includes iron-binding ligand profiles, which target tracer features of microbial remineralization (TMR1, TMR2: Chlorophyll, nitrite, and ammonium maxima) and a full water column characterization (TMR3). I have also sampled all three particle regeneration experiments for ligands. The first incubation experiment, emphasizing differences in initial particle assemblage and microbial community, were sampled at every time point for single analytical window (SAW) analyses. The second and third incubation experiments, which were designed to distinguish microbial (biotic) and abiotic particle dynamics, were sampled at the initial and final timepoints for multiple analytical window (MAW) analyses. The MAW method allows for the detection of cryptic (weaker) ligand classes and more robust definitions of stability constants of each ligand class identified.

Methods: Trace metal clean water column samples were collected using Teflon-coated 12-L Niskin-X bottles (Ocean Test Equipment) mounted on a powder-coated rosette, equipped with an auto-firemodule (Seabird Electronics), suspended from a metal-free hydroline. Bottles were tripped at preprogrammed depths during the up-cast, while moving upward at a reduced winch speed. Upon retrieval, the bottles were transferred into a Class 100 trace metal clean van and gravity filtered in-line using acid-washed Teflon tubing and acid-washed Acropak-200 (0.2 um) capsule filter. Filtered samples for iron speciation (FeL) analysis were placed in 500 mL acid-cleaned fluorinated high-density polyethylene bottles, and stored at -20degC until analysis in the laboratory. Near-surface large volume seawater collection, for incubation experiments 1-3, was carried out using a trace metal clean “fish” and filtered in-line by 0.2um acropak into acid-washed, 20-L low-density polyethylene cubitainers. Incubation experiments were routinely for a suite of parameters, of which dissolved trace metals and metatranscriptomics will be especially useful for interpreting FeL data.

Ben Twining and Dan Ohnemus (Bigelow)

The Twining group (PI Ben Twining and post-doc Dan Ohnemus) collected samples to study the behaviour of trace metals during the degradation of particulate material as it sinks through the water column. Samples of particulate matter were collected from different depths of the water column through casts of the Trace Metal Rosette. Particles were collected onto filters for later digestion with strong acids and analysis of metals associated with all material. Some of the samples were also collected onto transparent membranes and electron microscopy grids for later analysis of individual particles with synchrotron x-ray fluorescence analysis.

We also conducted experiments in which particles collected with in situ pumps were incubated with filtered surface water in the dark at ambient temperature to determine how particles were degraded by microbes over several days. Three of these experiments were conducted during the voyage. In two of them, half of the samples were incubated at 1°C in order to stop most biological processes. From these experiments we also collected total bulk particle samples and also individual-particle samples. A goal is to combine these with measures of microbial transcriptomics conducted by the Wilhelm group (lead by Gary LeCleir on the voyage). Finally, a third type of experiment was conducted in which collected particles were rotated slowly to increase shear in the water and the tendency for particles to aggregate into larger particles. In these experiments, as well, we collected samples for total and single-particle element analysis. In total, approximately 100 bulk particle samples and about 50 single-particle samples were collected. All samples will be analyzed back in our home laboratory over the coming year.

Gary LeCleir and Naomi Gilbert (University of Tennessee)

For the particle incubation experiments mentioned above, the Wilhelm group (composed of Gary LeCleir and Naomi Gilbert from the University of Tennessee) collected nucleic acids for 16S rRNA gene analysis of the microbial community and the transcriptomic response of microbes involved in particle colonization and degradation. Additionally, we conducted two separate iron availability incubation experiments in which we manipulated the microbially available pool of iron. We then collected the cells from these incubation experiments to analyze the ways these microbes respond and adapt to stresses associated with decreased iron availability. Experiments designed to quantify the rate at which viruses are produced in incubation experiments as well as in surface water were performed daily.

Matthieu Bressac (UTAS)

My main goal during the IN2018_V02 voyage was to investigate the bacterial remineralization of sinking particles and the associated release rates of trace elements (with a focus on iron) within the mesopelagic. For this purpose, three titanium and two trace-metal RESPIRE (REspiration of Sinking Particles In the subsuRface ocean) particle interceptors were deployed within the upper mesopelagic zone (between 100 and 200 m depth). However, the mooring line was lost after the first deployment and only the surface buoy was recovered.

After the loss of the mooring line, I performed a 4-day incubation experiment. Particles (and the associated particle-attached bacterial community), collected at 90 m depth using an In Situ Pump (McLane), were resuspended in filtered surface seawater collected using the trace-metal clean tow-fish. This incubation experiment (in the dark at 10°C) should allow us to investigate the scavenging and wall adsorption processes that could occur in the trace-metal RESPIRE particle interceptors during the incubation of sinking particles.

Robert Strzepek UTAS / ACE CRC

Phytoplankton dynamics and photo-physiology

Overview of Experiments

Spokes of the Ferrous Wheel

An experiment was conducted to examine the relative contribution to iron uptake and regeneration by the autotrophic nanoflagellate, heterotrophic (bacterial) and whole community at the SOTS process site. Surface seawater was collected from the trace metal fish (March 10, 2018) and incubated for three days. Whole and <2 µm fraction samples were prepared, and incubated either in the dark (controlled temperature room), and at ~%50 incident irradiance (deckboard incubator) either in the presence or absence of the photosynthetic inhibitor DCMU (dichlorophenyl 1,2-dimethyl urea) and subsampled every 24 hrs for:

1) 55Fe/14C uptake

2) fast repetition rate fluorometry (FRRF)

3) flow cytometry

In addition, a < 5 µm fraction sample was collected for SXRF elemental analysis and for inoculum for samples to be brought back to IMAS for isolation of species for future laboratory experiments.

Overview of Measurements

1) In addition to the preceding experiment, FRRF measurements were performed at four excitation wavelengths using the Solience Light Induced Fluorescence Transient (LIFT) fluorometer on the following samples:

- initial samples from 6 depths for simulated in situ deployments (ISI 1,2)

- initial and final timepoints for Gary LaClaire's two FeDFB manipulation experiments (38 samples)

- opportunistic comparisons (with C. Schallenberg) between the two benchtop fast repetition rate fluorometers (the Chelsea Technology Group FRRF, and the LIFT)

The maximum photochemical efficiency of photosystem II (Fv/Fm), the functional absorption cross section of PSII (PSII), and photosynthetic electron transport (,) was measured for all samples. In all experiments, samples were blank corrected and low light-acclimated for 30 - 60 min. prior to induction measurements that were conducted in the dark.

2) Two 24 h in situ 14C / 55Fe uptake incubations (ISI 1,2) were completed during the voyage. For each incubation, six 310 mL samples were prepared from water collected from 6 depths (15 – 100 M) using the trace metal rosette (TMR). The samples were incubated with tracer amounts of 55Fe

and 14C in six light-attenuating mesh bags (that simulated light levels from which the water samples were collected) at ambient seawater temperature (~10°C) in the deckboard incubator for 24 hrs. After 24 hrs, the samples were processed as follows:

- 2 size-fractionated (0.2, 2.0 and 20 µm 47 mm polycarbonate (PC) filters), washed with TiEDTA citrate solution to remove extracellular iron and hence determine intracellular Fe:C ratios,

- 2 size-fractionated (0.2, 2.0 and 20 µm 47 mm PC filters), without the TiEDTA citrate wash to determine both intra- and extracellular Fe,

- 1 total (> 0.2 µm) (no TiEDTA citrate wash), and

- 1 dark 'control' bottles (> 0.2 µm).

Twenty-four hour 14C and 55Fe incubations were also conducted at each sampling point of the three regeneration experiments (Boyd, Twining, et al.). All samples were filtered onto 0.2 µm filters and were not washed with TiEDTA citrate solution.

Status of Samples

All FRRF data have been analyzed but require quality control. 14C / 55Fe samples will be analyzed by April 2018. Glutaraldehyde-preserved flow cytometry samples will be analyzed within 6 months.