RV *Investigator* Voyage Plan

Voyage #:	**IN2019_V02**		
Co-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, Tuesday - Wednesday, 12-13 March 2019		
Depart:	Hobart, Thursday, 14 March 08:00 for equipment tests in Storm Bay and then transit to SOTS site		
Return:	Hobart, Friday, 5 April 2019, 0800		
Demobilisation:	Hobart, Friday, 5 April 2019		
Voyage Manager:	Tegan Sime	Contact details:	Tegan.Sime@csiro.au
Chief Scientist:	Thomas W. Trull		
Affiliation:	CSIRO	Contact details:	Tom.Trull@csiro.au
Principal Investigators:	Philip Boyd (Shore based), Mathew Bressac (Sea going), Robert Strzepek (Sea Going).		
Project name:	Subantarctic Biogeochemistry of Carbon and Iron, Southern Ocean Time Series site		
Affiliation:	UTAS	Contact details:	Philip.Boyd@utas.edu.au

Version Date: 5th March, 2019.

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-8 and SAZ-21) and then recover the existing SOTS moorings (SOFS-7.5 and SAZ-20). 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 for samples and bio-optical sensor data, underway measurements, Triaxus towed body, Continuous Plankton Recorder and autonomous profiling Biogeochemical-Argo floats.

The final and lowest priority SOTS objectives, for the purposes of furthering engineering analyses and cleaning up the SOTS site, are to: i) to recover the lower section of the SOFS-6 mooring (which broke at ~1800 m below the surface) and ii) deploy a test anchor equipped with a package of high engineering sensors which will be released and recovered.

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-8 meteorology/biogeochemistry mooring
2. Deploy SAZ-21 sediment trap mooring
3. Recover SAZ-20 sediment trap mooring
4. Recover SOFS-7.5 meteorology/biogeochemistry mooring
5. Do deep CTDs (2 casts to 2250m) at the SOTS site, including collecting samples for nutrients, oxygen, dissolved inorganic carbon, alkalinity, and particulate matter analyses
6. Do shallow CTDs (day/night pairs) and carry out underway air and water sampling and sensor measurements that support SOTS autonomous measurement calibrations, including bio-optics and bio-acoustics
7. Deploy 2-3 Biogeochemical-Argo autonomous profiling floats at the SOTS site, if available.
8. Tow MacArtney Triaxus on return to Hobart
9. Tow CPR on transit to SOTS site
10. Recover SOFS_6 lower mooring section for break analysis to advance mooring durability design
11. Deploy test anchor to study deployment dynamics and recover engineering package

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, marine snow catchers, ZOOrespire, 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 potentially 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.

The overall voyage 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.

Operational Risk Management

SOTS:

The mooring deployment and recovery operations are high risk, management includes:

- Detailed procedures reviewed with the crew and science team before and during the voyage
- Job hazard analysis and toolbox meetings
- Restriction of trawl deck working areas to essential participants
- Fatigue Management Training
- A designated safety observer

The mooring protocols are in the ship's Safety Management System (SMS)

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

Over-the-side operations using TMR, ISP, CTD, zooplankton nets and the TM clean tow fish will be deployed using ratified MNF Safe Working Procedures and Protocols. New Safe Work Instructions were developed for the 100L Marine Snow Catcher and the TM clean Towfish.

The deployment and recovery of the RESPIRE 300 m long surface tethered free drifting mooring has also been conducted successfully on to Investigator voyages. It is considered a medium/high risk operation and so risk management includes all of the checks and balances applied above to the SOTS moorings (the deployment and recovery will conducted by the SOTS mooring team).

Overall activity plan including details for first 24 hours of voyage

12-13	Mar	Mobilise: 1. SOTS: Load CSIRO winch and mooring containers (Sed trap and Half-Height) and other mooring gear (SOFS-8 large float, anchors) to main trawl deck. Spool moorings to winches. 2. BOYD: Load trace element lab vans (old white van, new blue van, TMR deck box, spare TMR) 3. SOTS/BOYD Load lab equipment and begin internal labs setup 4. SOTS: Load Triaxus
14	Mar	0800: Depart In Adventure or Storm Bay, test all of following: CTD, Triaxus, mooring anchor dual lift, A-frame and winch hydraulics. Depart following GSM standard tracks.
15	Mar	Transit to SOTS site towing CPR, doing underway sensor observations Hold Mooring Procedures Familiarization Meeting with Science Party, Master, Mates and Crew TMR shallow cast to start cleaning procedure for new bottles
16	Mar	Boyd: Triaxus bow-tie survey around SOTS site, informed by satellite remote sensing, depending on weather and how it impacts mooring and RESPIRE drifter deployment scheduling TMR shallow cast to finish cleaning procedure for new bottles
17	Mar	0000 return to central SOTS site - near SOFS-8 target deployment site 0000-0400 SOTS: CTD cast to 2250m 0400-0600 Boyd: TMR cast to 1500m 0600-1200 SOTS: Deployment#1 of RESPIRE drifting traps for Boyd 1200-1300 SOTS: bio-optical cast of CTD to 300m 1300-1500 Boyd: TM-clean fish (upper 50 m) 1500-1900 SOTS: ISP cast 1900-2100 Boyd: TMR cast to 1500m 2100-2300 Boyd: Zooplankton net hauls; Snowcatcher; ZooRespire (upper 100 m) 2300-2400 SOTS: bio-optical cast of CTD to 300m
18	Mar	0000-0400 SOTS: ship sensor data collection near SOFS-7.5 mooring 0400-0600 transit to SOFS-8 deployment start (9 miles down-weather from target location) 0600-2000 SOTS: deploy SOFS-8 mooring 2000-2400 SOTS: triangulate SOFS-8 anchor, collect ship sensor observations close to SOFS-8
19	Mar	0000-0400 SOTS: collect ship sensor observations close to SOFS-8 0400-0600 Boyd: TMR cast to 1500m 0600-1000 Boyd: ISP cast to 1500m [0800-1800 SOTS: spool on SAZ-21 mooring –deck ops only] 1000-1200 Boyd: TM-clean fish (upper 50 m) 1200-1300 SOTS: bio-optical cast of CTD to 300m 1300-1700 Boyd: ISP cast to 1500m

		1700-1900 Boyd: TMR cast to 1500m 1900-2300 Boyd: Zooplankton net hauls; Snowcatcher; ZooRespire (upper 100 m) 2300-2400 SOTS: bio-optical cast of CTD to 300m
20	Mar	0000-0600 SOTS: transit to SAZ-21 deployment start (8 miles down-weather target location) 0600-1500 SOTS: deploy SAZ-21 mooring 1500-1900 SOTS: recovery#1 RESPIRE drifting traps, if remaining daylight allows, otherwise at first light on 21 Mar 1900-2400 SOTS: triangulate SAZ-21 anchor location
21	Mar	0000-0400 SOTS: CTD cast to 2250m 0400-0600 Boyd: TMR cast to 1500m 0600-1000 SOTS: recover#1 alternate RESPIRE drifting traps (if not recovered on 20th) 0600-1000 Boyd: ISP cast to 1500m, if RESPIRE drifting traps recovered on 20 Mar 1000-1300 Boyd: TM-clean fish (upper 50 m) 1300-1600 SOTS: Deployment#2 RESPIRE traps for Boyd 1600-1800 Boyd: Zooplankton net hauls; Snowcatcher; ZooRespire (upper 100 m) 1800-2000 Boyd: TMR cast to 1500m 2000-2400 Boyd: ISP cast to 1500m
22	Mar	0000-0500 SOTS: transit to SAZ-20 recovery site (1 mile down-weather from anchor location) 0600-1800 SOTS: recover SAZ-20 mooring 1800-2400 SOTS: transit back to near SOFS-8
23	Mar	0000-0400 SOTS: CTD cast to 2250m 0400-0600 Boyd: TMR cast to 1500m 0600-1000 Boyd: ISP cast to 1500m [0600-1800 SOTS: spool off SAZ-20 mooring –deck ops only] 1000-1200 Boyd: TM-clean fish (upper 50 m) 1000-1200 SOTS: Deploy Bio-Argo floats 1200-1300 SOTS: bio-optical cast of CTD to 300m 1300-1600 Boyd: ISP to 1500 m 1600-1900 Boyd: Zooplankton net hauls; Snowcatcher; ZooRespire (upper 100 m) 1900-2100 Boyd: TMR cast to 1500m 2100-2300 SOTS: ship sensor observations near SOFS-8 2300-2400 SOTS: bio-optical cast of CTD to 300m
24	Mar	0000-0400 SOTS: continue ship sensor observations near SOFS-8 0400-0600 Boyd: TMR cast to 1500m 0600-1000 Boyd: ISP cast to 1500m 1000-1200 Boyd: TM-clean fish (upper 50 m) 1300-1800 SOTS: Recovery#2 RESPIRE trap for Boyd 1800-2000 Boyd: Zooplankton net hauls; Snowcatcher; ZooRespire (upper 100 m)

		2000-2200 Boyd: TMR cast to 1500m 2200-2400 SOTS: ship sensor observations nears SOFS-7.5
25	Mar	0000-0600 SOTS: ship sensor observations nears SOFS-7.5 0600-1800 SOTS: recovery of SOFS-7.5 1800-2400 SOTS: transit back to SOFS-8 site (possibly towing Triaxus, depending on remote sensing)
26	Mar	0000-0400 SOTS: : transit back to SOFS-8 site (possibly towing Triaxus, depending on remote sensing) 0400-0600 Boyd: TMR cast to 1500m 0600-1000 Boyd: ISP cast to 1500m 1000-1200 Boyd: TM-clean fish (upper 50 m) 1200-1300 SOTS: bio-optical cast of CTD to 300m 1300-1600 SOTS: Deployment#3 RESPIRE trap for Boyd 1600-1900 Boyd: Zooplankton net hauls; Snowcatcher; ZooRespire (upper 100 m) 1900-2100 Boyd: TMR cast to 1500m 2100-2300 time available (catch-up) 2300-0000 SOTS: bio-optical cast of CTD to 300m
27	Mar	0000-0400 Boyd: Zooplankton net tows; Snowcatcher; ZooRespire (upper 100 m) 0400-0600 Boyd: TMR cast to 1500m 0600-1000 Boyd: IISP cast to 1500m 1000-1200 Boyd: TM-clean fish (upper 50 m) 1200-1300 SOTS: bio-optical cast of CTD to 300m 1500-1800 Boyd: Zooplankton net hauls; Snowcatcher; ZooRespire (upper 100 m) 1800-2000 Boyd: TMR cast to 1500m 2000-2300 time available (catch-up) 2300-2400 SOTS: bio-optical cast of CTD to 300m
28	Mar	0000-0400 Boyd: Snowcatcher; ZooRespire 0400-0600 Boyd: TMR cast to 1500m 0600-1000 Boyd: IISP cast to 1500m 1000-1200 Boyd: TM-clean fish (upper 50 m) 1200-1300 SOTS: bio-optical cast of CTD to 300m 1700-1800 1900 Boyd: Zooplankton net hauls; Snowcatcher; ZooRespire (upper 100 m) 1900-2100 Boyd: TMR cast to 1500m 2100-2300 time available (catch-up) 2300-2400 SOTS: bio-optical cast of CTD to 300m
29	Mar	0000-0400 Boyd: Snowcatcher; ZooRespire 0400-0600 Boyd: TMR cast to 1500m 0600-1000 Boyd: ISP cast to 1500m 1000-1200 Boyd: TM-clean fish (upper 50 m) 1200-1700 SOTS: Recovery #3 RESPIRE trap for Boyd

		1700-1900 Boyd: Zooplankton net hauls; Snowcatcher; ZooRespire (upper 100 m) 1900-2100 Boyd: TMR cast to 1500m 2100-0000 time available (catch-up)
30	Mar	0000-0800 Boyd: Snowcatcher; ZooRespire 0800-1100 SOTS: Deployment #4 RESPIRE trap for Boyd 1200-1300 SOTS: bio-optical cast of CTD to 300m 1300-1400 SOTS: deploy test anchor 1400-2300 time available (catch-up) 2300-2400 SOTS: bio-optical cast of CTD to 300m
31	Mar	Weather day; full diel cycle of sensor comparisons with SOFS-8
1	Apr	Weather day; full diel cycle of sensor comparisons with SOFS-8
2	Apr	0000-0800 Boyd: Snowcatcher; ZooRespire 0800-1300 SOTS: Recovery#4 RESPIRE trap for Boyd 1300-1700 SOTS: Recover test anchor engineering package 1700-2400 Transit to towards SOFS-6 lower section site
3	Apr	0000-0600 continue transit towards SOFS-6 lower section site 0600-1200 SOTs: Recover SOFS-6 lower section; 1200-2400 begin Triaxus tow towards Hobart
4	Apr	Transit to Hobart towing Triaxus via eddy/jet targets
5	Apr	Return following GSM standard tracks. Arrive Hobart 08:00 Demobilisation

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Table of Triaxus Tows:

Date	Research Goal	Maximum Tow Duration (hours)
16 March	SOTS site mesoscale eddy context	24
25/26 March	SOFS-7.5 vs SOFS-8 comparison	10
3/4 April	EAC extension inputs to SOTS region	36

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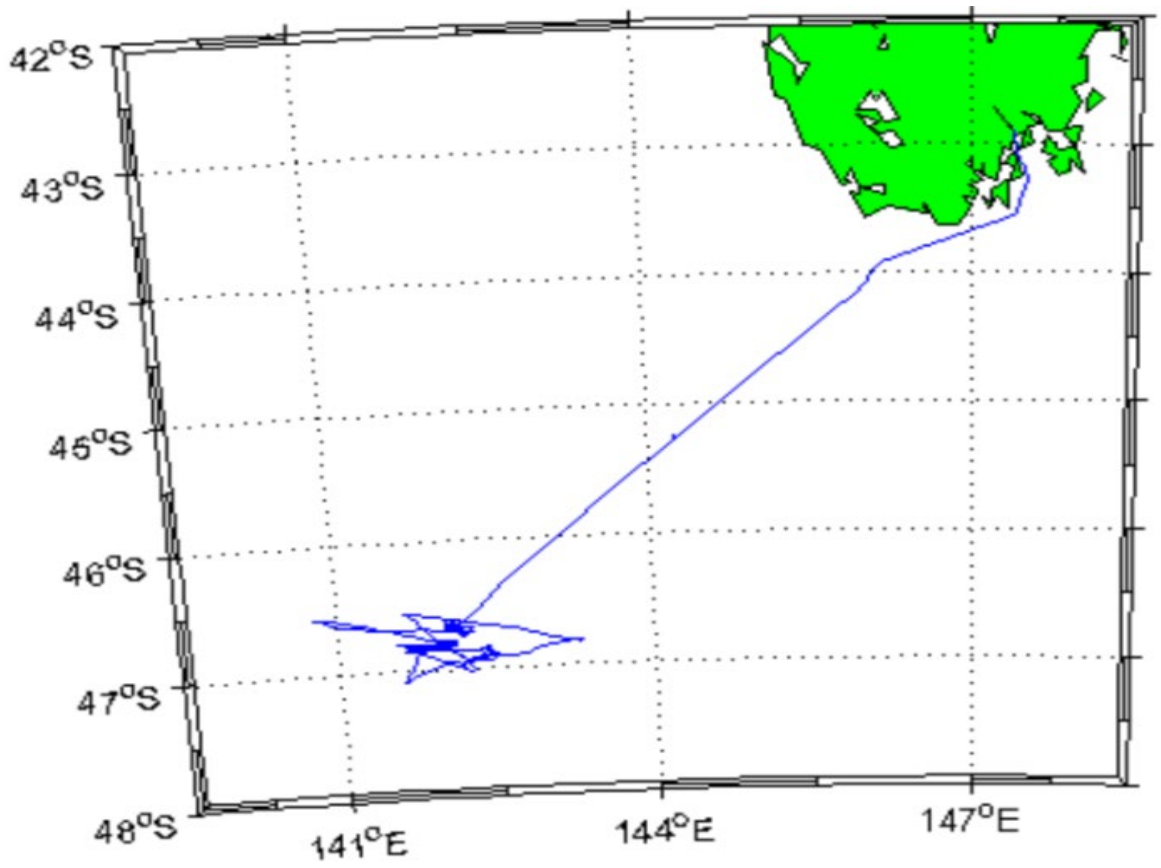
Voyage track example



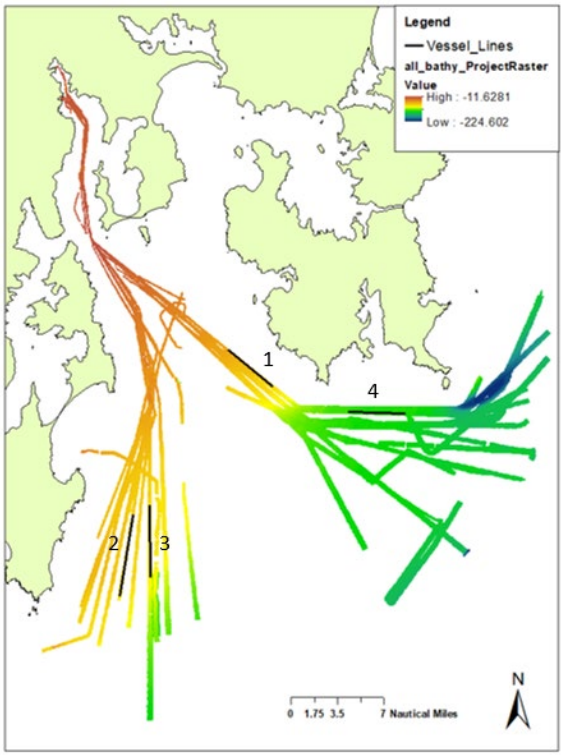
Waypoints and stations

Time estimates are at 11 knots

	Decimal Latitude	Decimal Longitude	Distance (nm)	Total Distance (nm)	Steaming time (hrs)	Total Steam (hrs)
Hobart	42.87	147.35				
Storm Bay	43.33	147.350	27.62	27.62	2.51	2.51
SOTS	46.80	141.884	311.50	339.12	28.32	30.83
Hobart	42.87	147.35	352.44	748.98	32.04	68.09

Location of GSM Backscatter Calibration Lines on Storm Bay Exit (preferred line highlighted)

Line	Start		End	
	Latitude	Longitude	Latitude	Longitude
1	-43° 11.935’	147° 37.513’	-43° 14.911	147° 42.601’
2	**-43° 24.478’**	**147° 27.939’**	**-43° 30.632’**	**147° 26.618’**
3	-43° 23.824’	147° 29.656’	-43° 28.37’	147° 29.713
4	-43° 16.541’	147° 50.1’	-43° 16.629’	147° 56.081



Locations of moorings to be recovered

Mooring	Latitude	Longitude	Depth
SOFS-7.5 anchor triangulation	47° 1.36' S 47.02274 °S	142° 14.05' E 142.2341 °E	4540 m
SAZ-20 anchor release (no triangulation)	46° 47.52' S 46.792048 °S	141° 47.66' E 141.794356 °E	4518 m
SOFS-6 anchor triangulation	46° 1.59' S 46.02652 °S	142° 7.74' E 142.12901 °E	4603 m

Target locations for mooring deployments

Mooring	Latitude	Longitude	Depth
SOFS-8 target	46° 53.7’ S 46.895°S	142° 21’ E 142.35 °E	4300 m
SAZ-21 target	46° 49.824'S 46.83040 °S	141° 38.981'E 141.64968 °E	4600 m
Test Anchor	46° 36.8’ S 46.613714 °S	141° 32.7’ E 142.544681 °E	3900m

Locations to be avoided

Mooring	Latitude	Longitude	Depth
FluxPulse-1 lower section, last acoustic sounding location	46° 43.44’ S -46.72399 °S	141° 55.78’ E 141.92972 °E	top of section at ~800 m

Investigator equipment (MNF)

SOTS

Trawl Deck Equipment and Support

- Install CSIRO mooring winch on mid-line forward on deck.
- Stern-ramp cover ("dance-floor") without overhanging lip on aft surface installed with gap protectors and mounts for user-supplied Bulls Horns fairlead.
- A-frame utility winches.
- Tagging line cleat attachment points fitted.
- SOTS sediment trap van (see user supplied equipment) – requires 240V monophase power and Ethernet cable.
- deck space for half-height container with mooring gear on starboard aft quarter
- see deck loading plan for further details

Deck Equipment and Support

- Install Investigator net drum winch on Mezzanine with spooler-rail installed aft of it, as the best location as discussed with MNF and ASP for this voyage.

CTD Equipment and Support

- 24 bottle CTD-rosette with 12L Niskin bottles and MNF-O_2, MNF-PAR, MNF-Wetlabs CStar 25cm pathlength, 700nm red light transmissometer, MNF Chelsea Aquatracker III fluorometer sensors mounted. Also mount User-supplied Wetlabs FLBB-RTD sensor (full ocean depth) – face downward with clear field of view.
- Lowered ADCP with all heads working and logging
- CTD voltage inputs calibrated to correctly log sensor inputs
- MNF supplied hydrochemists to carry out oxygen, salinity and nutrient analyses. SOTS requires ~160 analyses of each type (to cover deep and shallow CTDs and Underway sample analyses especially during Triaxus tows).
- WOCE/Go-Ship compliant CTD data processing and output files to be provided, including error estimates for oxygen and nutrient parameters

TRIAXUS Equipment and Support

- Triaxus towed body and towed body winch, equipped with:
- MNF supplied electronics, data display and logging, and piloting support
- MNF dual CTs with oxygen electrodes
- MNF-LOPC
- user-supplied SUNA and FIRe sensors

Underway Equipment and Support

- Multibeam/Multifrequency bio-acoustic system, with MNF supplied electronics, computing, and operational support
- Working and logging underway echosounder with bottom detection and real-time display
- Working and logging underway ADCP, with real-time display
- Working and logging underway thermosalinograph and fluorometer and real-time display
- Working hull mounted 12 kHz transducer for use with acoustic release deck unit
- Working drop keel for bioacoustics, thermosalinograph and ADCP deployed to >4 m
- Working and logging meteorological instruments including ISAR SST radiometer
- Working underway seawater supply in Underway Lab for MNF fluorometer and pCO2 system

Boyd Subantarctic Biogeochemistry of Carbon and Iron

In addition to the facilities requested by SOTS, this project requires:

1. Both trace metal clean containers (MNF and CSIRO, one for sampling and the other for Flow Injection Analysis) to be mounted one on top of the other on the trawl deck (abutting the aft-most part of the ships superstructure).
2. TMR Deck Box installed on trawl deck (to house the TMR).
3. The MNF Rad van along with the MNF deckboard incubation platform (both in their usual positions).
4. Working MNF TMR and Kevlar on the associated winch, along with all of the operational MNF ISP's.
5. We will bring a Trace Metal clean fish that will be deployed mid-ship off the starboard side. We will require the ships compressor to drive the air pumps and the forward boom is required along to tow the fish.
6. Zooplankton nets, Snowcatcher and ZooRespire will be deployed off the winch on the starboard side at midships. UTAS will supply some nets and others from MNF will be required.
7. MNF supplied hydrochemists to carry out oxygen, salinity and nutrient analyses. Boyd requires 400 analyses of each type.

User Equipment

SOTS

For Installation on Trawl Deck (see deck loading plan)

- Bullhorn mooring fairlead to be mounted on ship stern – this will mean that great care will be needed to avoid it for Triaxus deployments and recoveries.
- CSIRO mooring winch - requires hydraulic leads to power supply installed in shelter-shed
- 1xhalf-height open-top containers to hold mooring equipment

- Full height ACE Sediment Trap Container for storing and working on sediment traps, – requires monophase 240V 15 amp power supply and Ethernet cable to ship LAN. This container will also house the in-situ pumps for use during Boyd component, and Bio-Argo Floats (if available).
- SOFS float and recovery cradle
- mooring anchor stacks – 3 to be combined into SOFS-8 anchor, plus single stack for SAZ anchor
- ~6 cage pallets of mooring equipment
- Handheld and deck mounted pneumatic line throwers ("grappling gun")
- Video cameras installed on trawl deck

For Installation in Shelter Science area

- Power Supply for CSIRO Mooring Winch
- TRIAXUS
- Pallet of mooring gear
- Pump for towed fish trace clean water supply
- Potentially bio-optical sensor package
- Marine Snow Catcher

For Installation in Ops room

- acoustic release deck unit to be mounted in the Ops room (and spare unit stored)

For Installation in Underway Lab

- Trull pigment filtration system in sink and FIRe instrument on bench.
- Trull/Schallenberg/Clementson AC-9 bio-optical instrument on bench

For installation in the General Purpose (Dry Clean) Laboratory,

- Trull particle filtration system, on forward inboard bench next to sink,
- (also requires use of laminar flow bench in this lab)
- Turner Fluorometer for Chla analyses by C. Schallenberg
- FlowCAM for rapid particle imaging, particle size spectra.

For installation in the CTD room (on athwartship bench next to sink)

- Trull/Bodrossy cartridge filtration system
- FLBB-RTD sensor to be installed on CTD

For installation on the Triaxus towed body

- SUNA nitrate sensor
- FIRE fluorescence induction and relaxation sensor (maximum depth 200m)
- LOPC (MNF)

Boyd: Subantarctic Biogeochemistry of Carbon and Iron

We will bring a Trace Metal clean fish that will be deployed mid-ship off the starboard side. We will require the ships compressor to drive the air pumps and the forward boom is required along to tow the fish.

Zooplankton nets, marine snowcatcher (MSC) and ZooRespire will be deployed off the winch on the starboard side at midships. UTAS will supply some nets and others from NF will be required.

RESPIRE particle interceptors for deployment by the SOTS team will be brought by UTAS and stored in the ships General Purpose Dirty Wet lab.

Temperature manipulation studies will be installed in CT room.

Incubations will be carried out on the upper deck next to the Rad van, which will be used to conduct radio-isotope incubations (based on the same plan as the March and September 2018 INV voyages).

Spare Trace Element Rosette for storage on Trawl Deck.

Permits

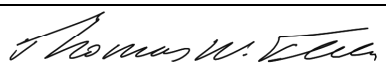
SOTS

- Collection of seawater and sediment trap samples for return to Hobart under ACE CRC Quarantine permit AQIS #IP0001721265.
- Mooring locations and buoy marking details will be provided to AMSA for notice to mariners.
- Towing of the CPR, Triaxus, and operation of underway ship scientific seawater supply through the Tasman Fracture Zone under Commonwealth Marine Reserve Permit PA2018-0005-1, issued to MNF.

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

- Quarantine permit for phyto- and zoo-plankton and trace metal samples, UTAS IMAS AQIS #IP0001285143.

Signature

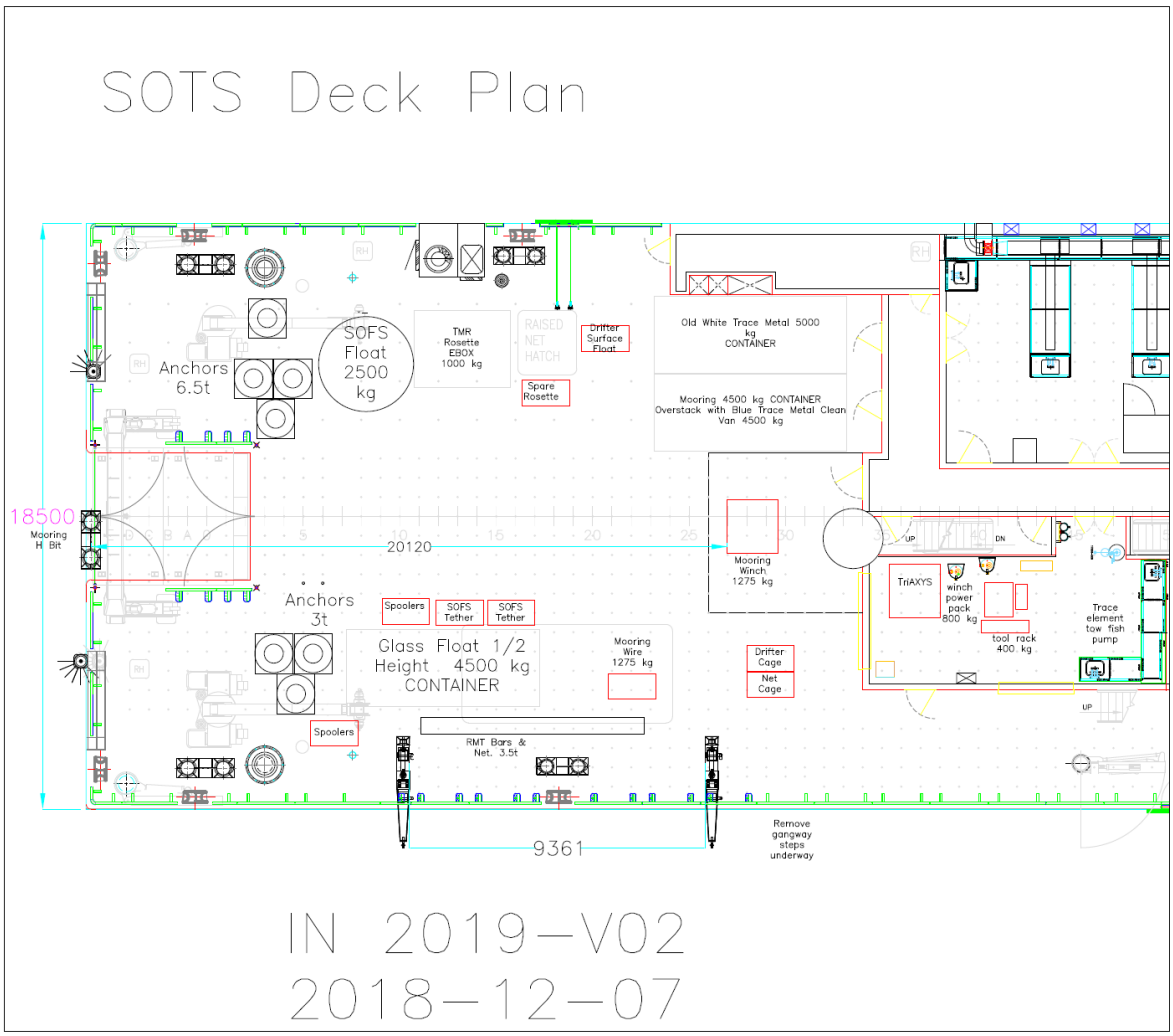
Your name	Thomas W. Trull
Title	Chief Scientist
Signature	
Date:	26 February 2019

Appendices

1. Deck Loading Plan
2. SOTS (SOFS and SAZ) mooring diagrams
3. Map of SOTS mooring locations
4. UTAS RESPIRE drifting traps diagram
5. CTD Water Sample Collection and Labelling Plan (available separately)
6. Mooring Deployment Procedures (available separately)

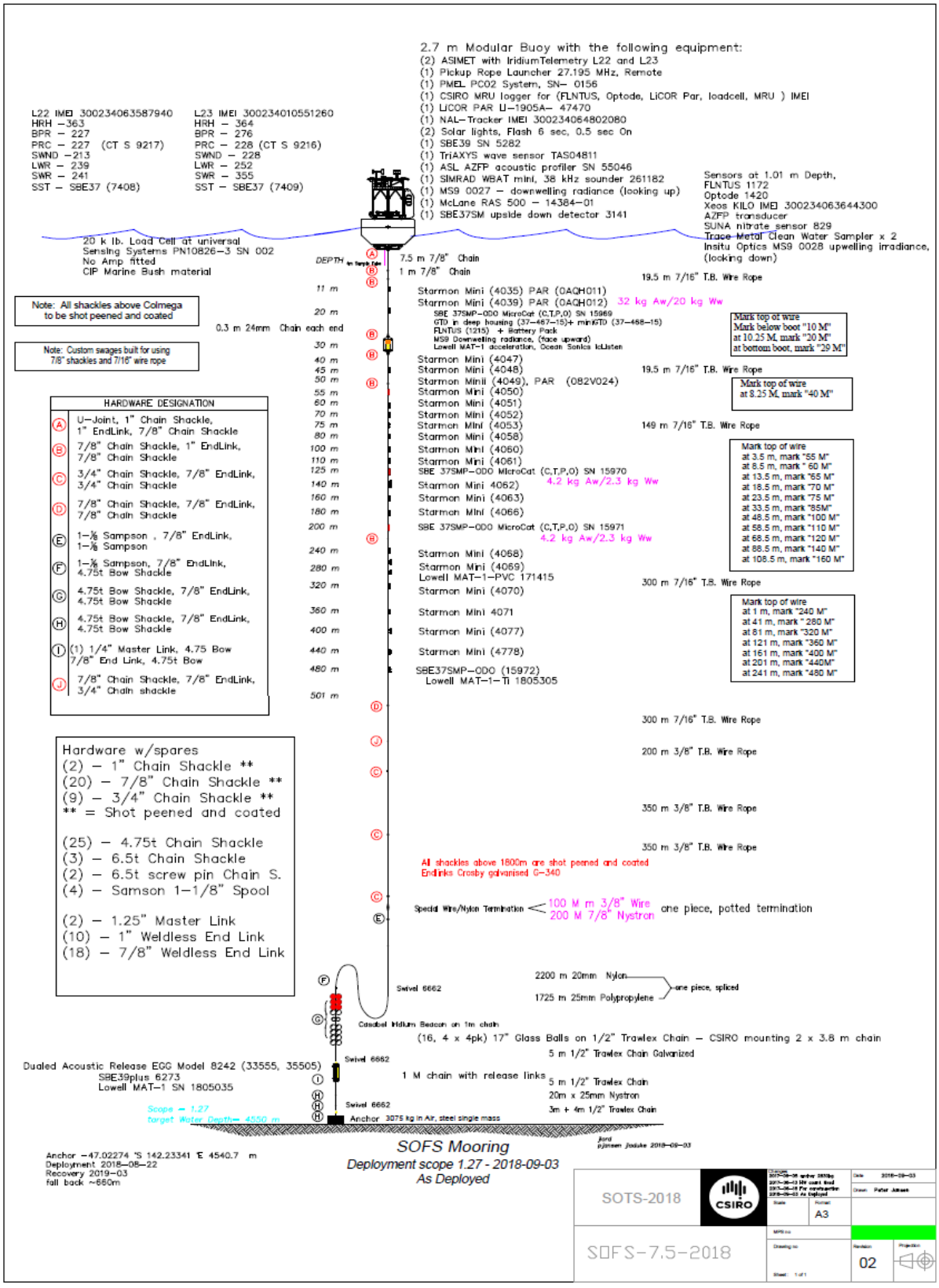
Appendix 1

Deck Plan

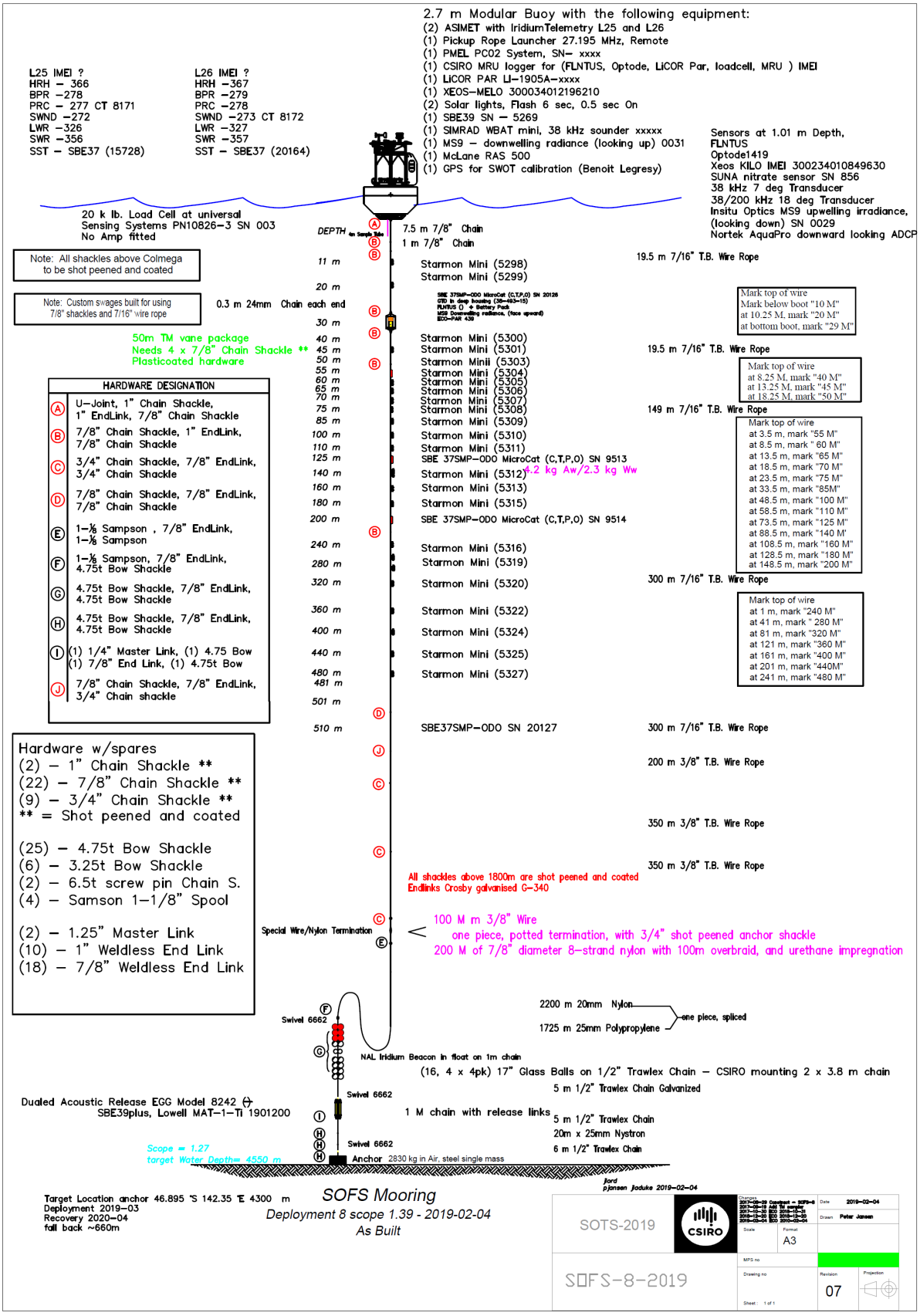


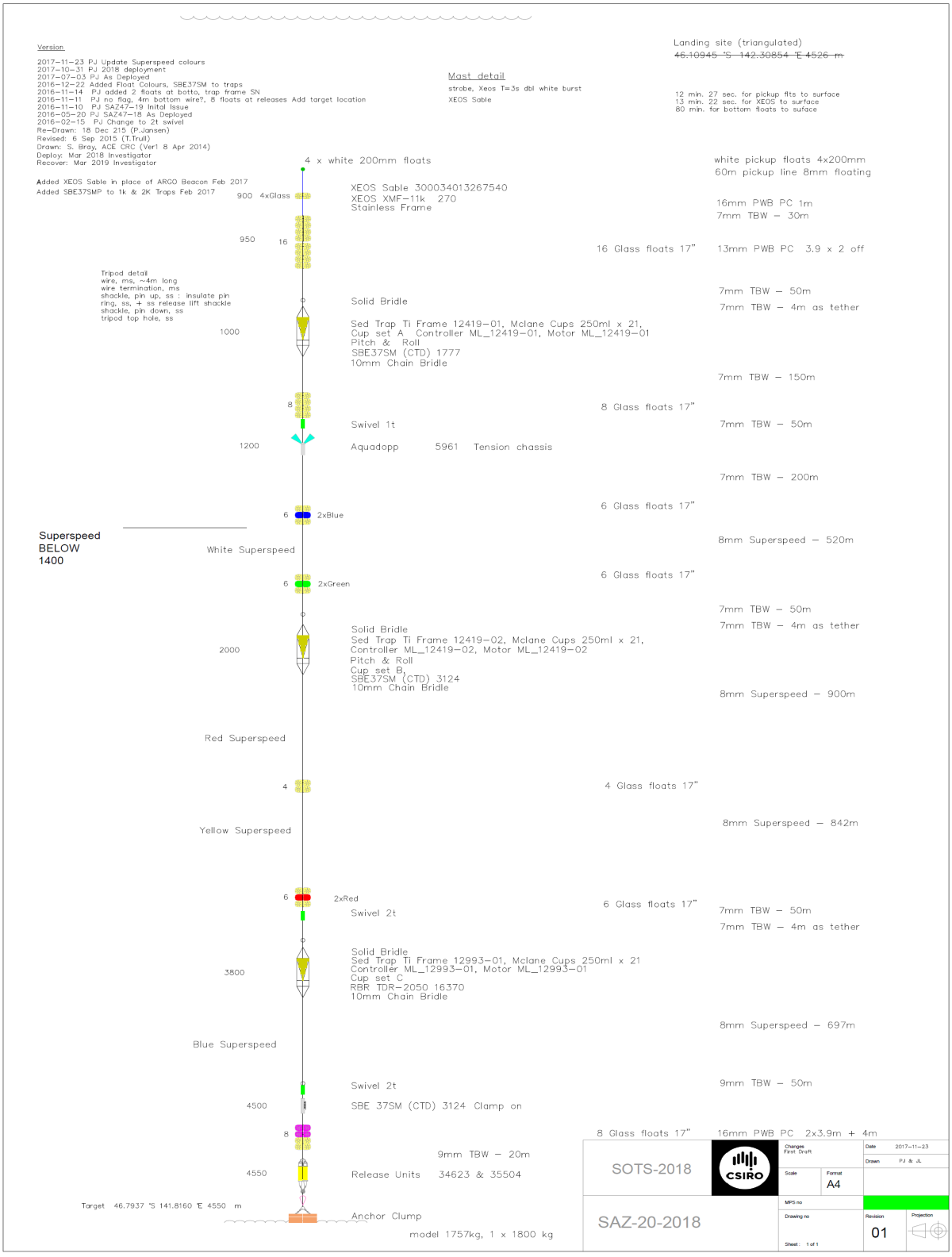
Appendix 2

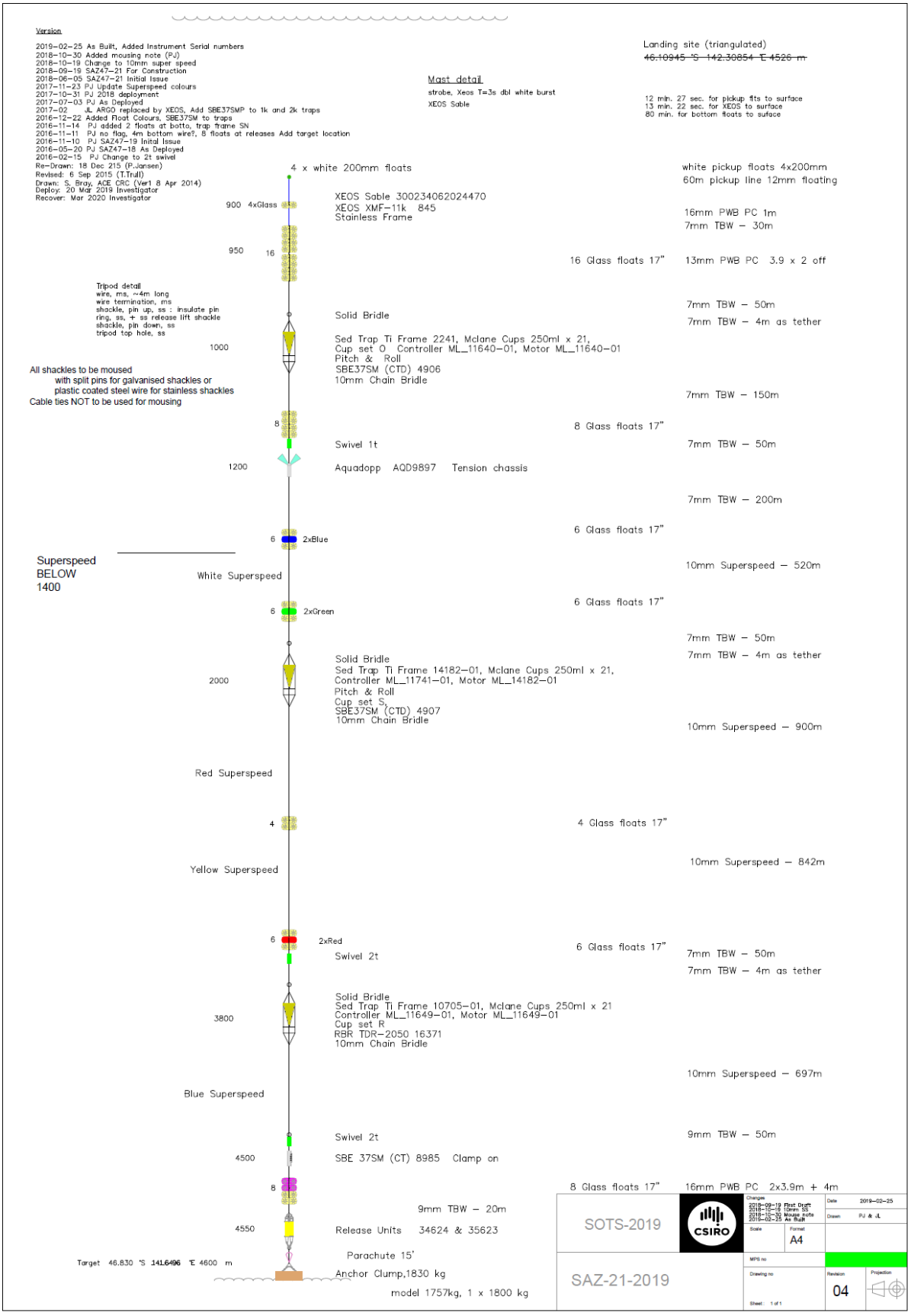
SOFS-7.5



SOFS-8

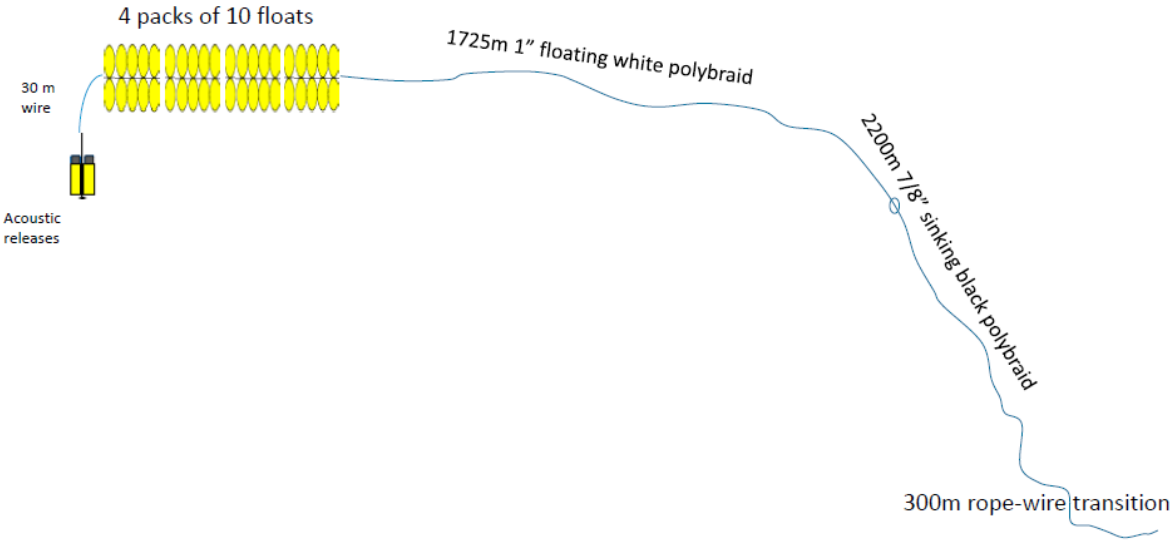

2.7 m Modular Buoy with the following equipment:
(2) ASIMET with IridiumTelemetry L25 and L26
(1) Pickup Rope Launcher 27.195 MHz, Remote
(1) PMEL PC02 System, SN– xxxx
(1) CSIRO MRU logger for (FLNTUS, Optode, LiCOR Par, loadcell, MRU) IMEI
(1) LiCOR PAR LI–1905A–xxxx
(1) XEOS–MELO 300034012196210
(2) Solar lights, Flash 6 sec, 0.5 sec On
(1) SBE39 SN – 5269
(1) SIMRAD WBAT mini, 38 kHz sounder xxxxx
(1) MS9 – downwelling radiance (looking up) 0031
(1) McLane RAS 500
(1) GPS for SWOT calibration (Benoit Legresy)
L25 IMEI ?
HRH – 366
BPR –278
PRC – 277 CT 8171
SWND –272
LWR –326
SWR –356
SST – SBE37 (15728)
L26 IMEI ?
HRH –367
BPR –279
PRC –278
SWND –273 CT 8172
LWR –327
SWR –357
SST – SBE37 (20164)
Sensors at 1.01 m Depth,
FLNTUS
Optode1419
Xeos KILO IMEI 300234010849630
SUNA nitrate sensor SN 856
38 kHz 7 deg Transducer
38/200 kHz 18 deg Transducer
Insitu Optics MS9 upwelling irradiance, (looking down) SN 0029
Nortek AquaPro downward looking ADCP
20 k lb. Load Cell at universal Sensing Systems PN10826–3 SN 003
No Amp fitted
DEPTH
7.5 m 7/8" Chain
1 m 7/8" Chain
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
0.3 m 24mm Chain each end
50m TM vane package
Needs 4 x 7/8" Chain Shackle **
Plasticoated hardware
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, 4.75t Bow Shackle
G 4.75t Bow Shackle, 7/8" EndLink, 4.75t Bow Shackle
H 4.75t Bow Shackle, 7/8" EndLink, 4.75t Bow Shackle
I (1) 1/4" Master Link, (1) 4.75 Bow (1) 7/8" End Link, (1) 4.75t Bow
J 7/8" Chain Shackle, 7/8" EndLink, 3/4" Chain shackle
11 m
20 m
30 m
40 m
45 m
50 m
55 m
60 m
65 m
70 m
75 m
85 m
100 m
110 m
125 m
140 m
160 m
180 m
200 m
240 m
280 m
320 m
360 m
400 m
440 m
480 m
481 m
501 m
510 m
Starmon Mini (5298)
Starmon Mini (5299)
SBE 37SMP–ODO MicroCat (C,T,P,O) SN 20126
GTD in deep housing (30–693–15)
FLNTUS () + Battery Pack
MS9 Downwelling radiance, (face upward)
ECO–PAR 439
Starmon Mini (5300)
Starmon Mini (5301)
Starmon Minii (5303)
Starmon Mini (5304)
Starmon Mini (5305)
Starmon Mini (5306)
Starmon Mini (5307)
Starmon Mini (5308)
Starmon Mini (5309)
Starmon Mini (5310)
Starmon Mini (5311)
SBE 37SMP–ODO MicroCat (C,T,P,O) SN 9513
Starmon Mini (5312)
4.2 kg Aw/2.3 kg Ww
Starmon Mini (5313)
Starmon Mini (5315)
SBE 37SMP–ODO MicroCat (C,T,P,O) SN 9514
Starmon Mini (5316)
Starmon Mini (5319)
Starmon Mini (5320)
Starmon Mini (5322)
Starmon Mini (5324)
Starmon Mini (5325)
Starmon Mini (5327)
SBE37SMP–ODO SN 20127
19.5 m 7/16" T.B. Wire Rope
Mark top of wire
Mark below boot "10 M"
at 10.25 M, mark "20 M"
at bottom boot, mark "29 M"
19.5 m 7/16" T.B. Wire Rope
Mark top of wire
at 8.25 M, mark "40 M"
at 13.25 M, mark "45 M"
at 18.25 M, mark "50 M"
149 m 7/16" T.B. Wire Rope
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 73.5 m, mark "125 M"
at 88.5 m, mark "140 M"
at 108.5 m, mark "160 M"
at 128.5 m, mark "180 M"
at 148.5 m, mark "200 M"
300 m 7/16" T.B. Wire Rope
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"
300 m 7/16" 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
All shackles above 1800m are shot peened and coated
Endlinks Crosby galvanised G–340
Hardware w/spares
(2) – 1" Chain Shackle **
(22) – 7/8" Chain Shackle **
(9) – 3/4" Chain Shackle **
** = Shot peened and coated
(25) – 4.75t Bow Shackle
(6) – 3.25t Bow Shackle
(2) – 6.5t screw pin Chain S.
(4) – Samson 1–1/8" Spool
(2) – 1.25" Master Link
(10) – 1" Weldless End Link
(18) – 7/8" Weldless End Link
Special Wire/Nylon Termination
100 M m 3/8" Wire
one piece, potted termination, with 3/4" shot peened anchor shackle
200 M of 7/8" diameter 8–strand nylon with 100m overbraid, and urethane impregnation
2200 m 20mm Nylon
1725 m 25mm Polypropylene
one piece, spliced
Swivel 6662
NAL Iridium Beacon in float on 1m chain
(16, 4 x 4pk) 17" Glass Balls on 1/2" Trawlex Chain – CSIRO mounting 2 x 3.8 m chain
5 m 1/2" Trawlex Chain Galvanized
Swivel 6662
Dualed Acoustic Release EGG Model 8242
SBE39plus, Lowell MAT–1–TI 1901200
1 M chain with release links
5 m 1/2" Trawlex Chain
20m x 25mm Nystron
6 m 1/2" Trawlex Chain
Swivel 6662
Anchor 2830 kg in Air, steel single mass
Scope = 1.27
target Water Depth= 4550 m
Target Location anchor 46.895 'S 142.35 'E 4300 m
Deployment 2019–03
Recovery 2020–04
fall back ~660m
SOFS Mooring
Deployment 8 scope 1.39 - 2019-02-04
As Built
jord pjansen jaduke 2019–02–04
SOTS-2019
CSIRO
Date 2019–02–04
Drawn Peter Jansen
Format A3
SOFS–8–2019
Revision 07


Version
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 botto, 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 2t swivel
Re-Drawn: 18 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
Landing site (triangulated)
46.10945 °S 142.30854 °E 4526 m
12 min. 27 sec. for pickup flts 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
60m 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 A 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
2xBlue
6 Glass floats 17"
Superspeed
BELOW
1400
8mm Superspeed – 520m
White Superspeed
6
2xGreen
6 Glass floats 17"
7mm TBW – 50m
Solid Bridle
7mm TBW – 4m as tether
2000
Sed Trap Ti Frame 12419-02, Mclane Cups 250ml x 21,
Controller ML_12419-02, Motor ML_12419-02
Pitch & Roll
Cup set B,
SBE37SM (CTD) 3124
10mm Chain Bridle
8mm Superspeed – 900m
Red Superspeed
4
4 Glass floats 17"
8mm Superspeed – 842m
Yellow Superspeed
6
2xRed
6 Glass floats 17"
Swivel 2t
7mm TBW – 50m
7mm TBW – 4m as tether
Solid Bridle
3800
Sed Trap Ti Frame 12993-01, Mclane Cups 250ml x 21
Controller ML_12993-01, Motor ML_12993-01
Cup set C
RBR TDR-2050 16370
10mm Chain Bridle
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 Clamp
model 1757kg, 1 x 1800 kg
SOTS-2018
SAZ-20-2018
CSIRO
Changes
First Draft
Date 2017-11-23
Drawn PJ & JL
Scale
Format A4
MPS no
Drawing no
Sheet: 1 of 1
Revision 01
Projection


Version
2019-02-25 As Built, Added Instrument Serial numbers
2018-10-30 Added mousing note (PJ)
2018-10-19 Change to 10mm super speed
2018-09-19 SAZ47-21 For Construction
2018-06-05 SAZ47-21 Initial Issue
2017-11-23 PJ Update Superspeed colours
2017-10-31 PJ 2018 deployment
2017-07-03 PJ As Deployed
2017-02 JL ARGO replaced by XEOS, Add SBE37SMP to 1k and 2k traps
2016-12-22 Added Float Colours, SBE37SM to traps
2016-11-14 PJ added 2 floats at botto, 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 2t swivel
Re-Drawn: 18 Dec 215 (P.Jansen)
Revised: 6 Sep 2015 (T.Trull)
Drawn: S. Bray, ACE CRC (Ver1 8 Apr 2014)
Deploy: 20 Mar 2019 Investigator
Recover: Mar 2020 Investigator
Mast detail
strobe, Xeos T=3s dbl white burst
XEOS Sable
Landing site (triangulated)
~~46.10945 'S 142.30854 'E 4526 m~~
12 min. 27 sec. for pickup flts 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
60m pickup line 12mm floating
900 4xGlass
XEOS Sable 300234062024470
XEOS XMF-11k 845
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 2241, Mclane Cups 250ml x 21,
Cup set O Controller ML_11640-01, Motor ML_11640-01
Pitch & Roll
SBE37SM (CTD) 4906
10mm Chain Bridle
All shackles to be moused
with split pins for galvanised shackles or
plastic coated steel wire for stainless shackles
Cable ties NOT to be used for mousing
7mm TBW – 150m
8
8 Glass floats 17"
Swivel 1t
7mm TBW – 50m
1200
Aquadopp AQD9897 Tension chassis
7mm TBW – 200m
6
2xBlue
6 Glass floats 17"
Superspeed
BELOW
1400
White Superspeed
10mm Superspeed – 520m
6
2xGreen
6 Glass floats 17"
7mm TBW – 50m
Solid Bridle
7mm TBW – 4m as tether
2000
Sed Trap Ti Frame 14182-01, Mclane Cups 250ml x 21,
Controller ML_11741-01, Motor ML_14182-01
Pitch & Roll
Cup set S,
SBE37SM (CTD) 4907
10mm Chain Bridle
10mm Superspeed – 900m
Red Superspeed
4
4 Glass floats 17"
10mm Superspeed – 842m
Yellow Superspeed
6
2xRed
6 Glass floats 17"
Swivel 2t
7mm TBW – 50m
7mm TBW – 4m as tether
Solid Bridle
Sed Trap Ti Frame 10705-01, Mclane Cups 250ml x 21
Controller ML_11649-01, Motor ML_11649-01
Cup set R
RBR TDR-2050 16371
10mm Chain Bridle
3800
10mm Superspeed – 697m
Blue Superspeed
Swivel 2t
9mm TBW – 50m
4500
SBE 37SM (CT) 8985 Clamp on
8
8 Glass floats 17"
16mm PWB PC 2x3.9m + 4m
9mm TBW – 20m
4550
Release Units 34624 & 35623
Parachute 15'
Target 46.830 'S 141.6496 'E 4600 m
Anchor Clump,1830 kg
model 1757kg, 1 x 1800 kg
SOTS-2019
CSIRO
SAZ-21-2019
Date 2019-02-25
Drawn PJ & JL
Format A4
Revision 04
Projection

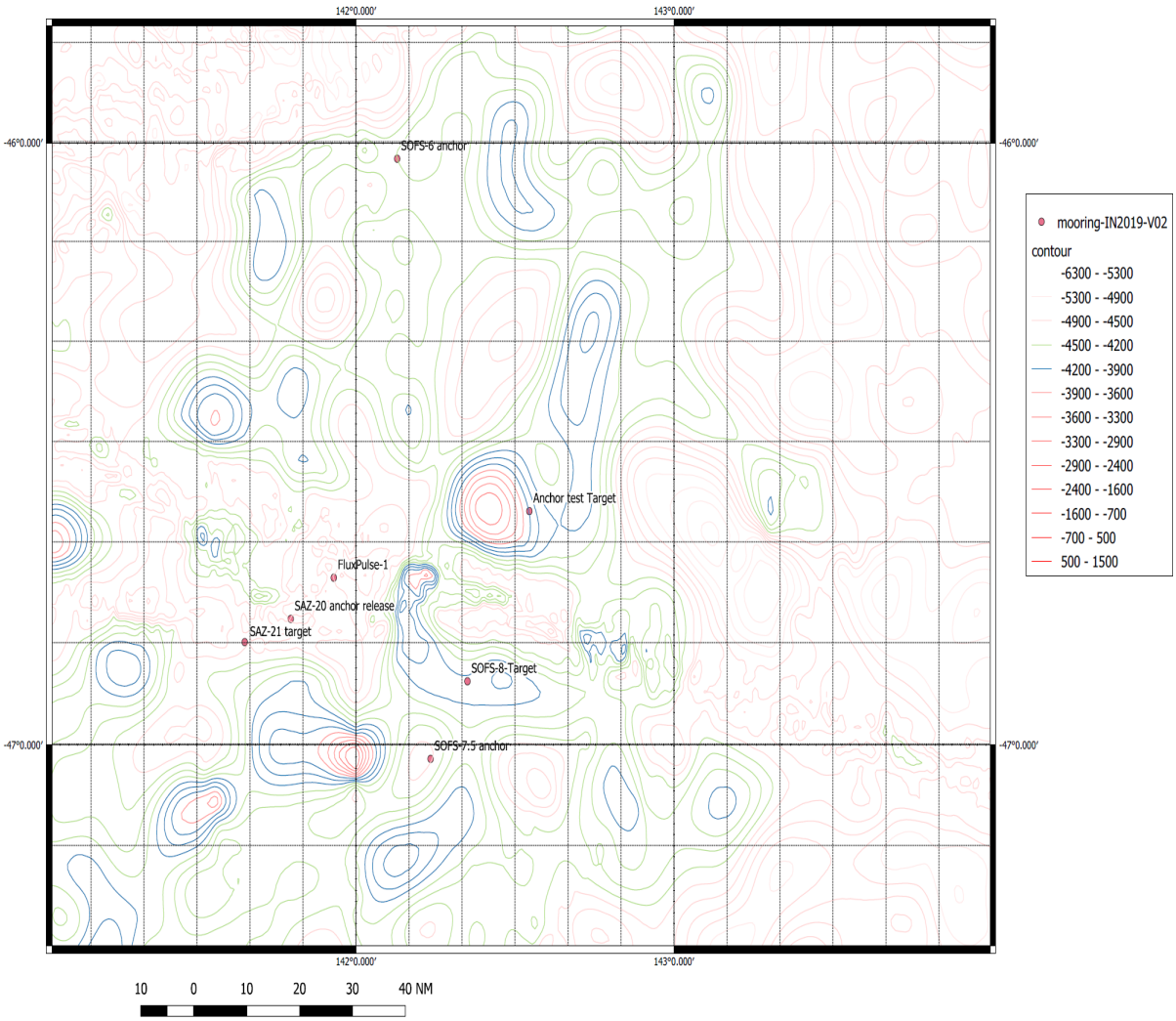
Test Anchor

SOFS-6 lower section expected surface layout

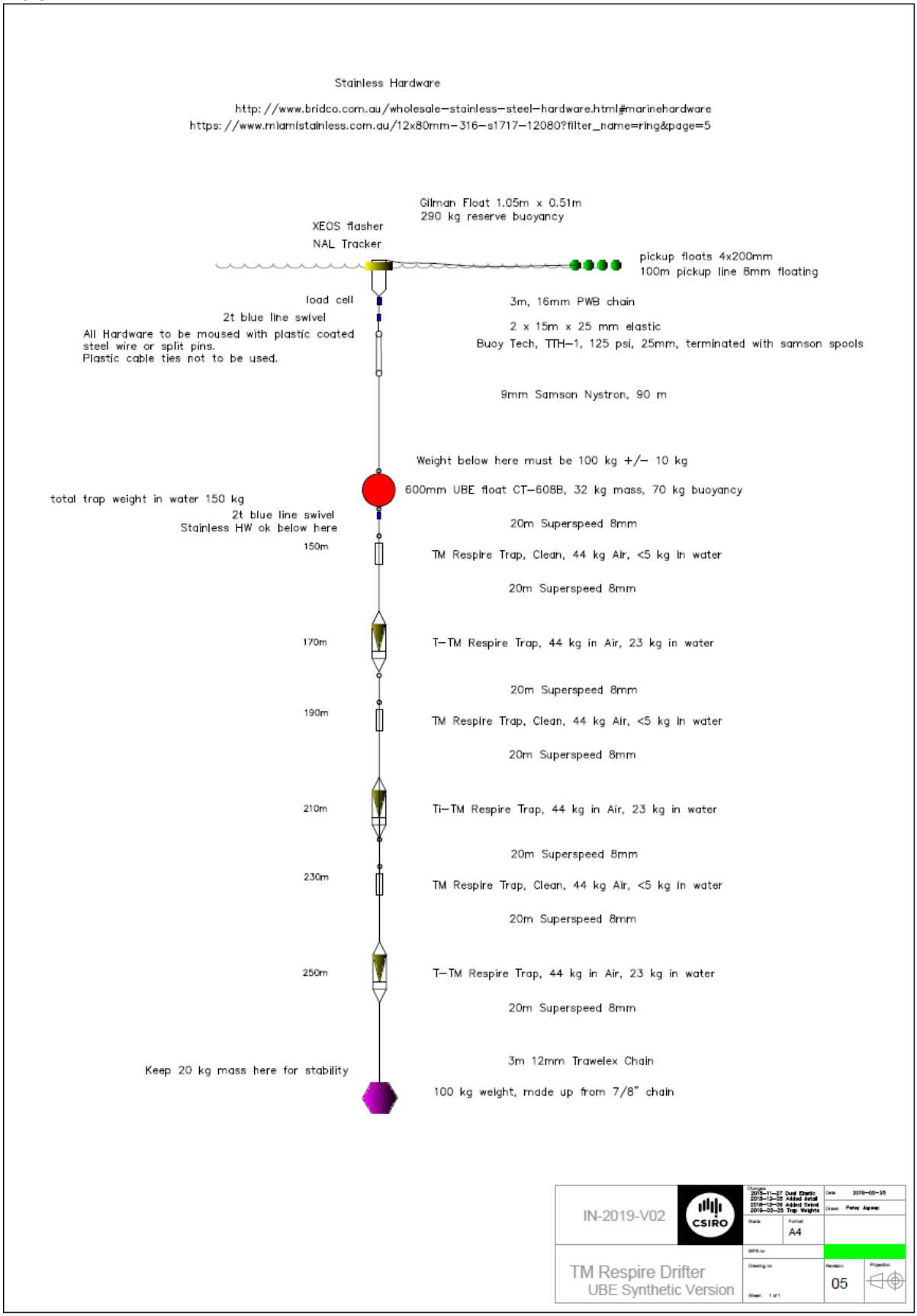


Appendix 3

Mooring Location Map



Appendix 4


Stainless Hardware
http://www.bridco.com.au/wholesale-stainless-steel-hardware.html#marinehardware
https://www.miamistainless.com.au/12x80mm-316-s1717-12080?filter_name=ring&page=5
Gilman Float 1.05m x 0.51m
290 kg reserve buoyancy
XEOS flasher
NAL Tracker
pickup floats 4x200mm
100m pickup line 8mm floating
load cell
3m, 16mm PWB chain
2t blue line swivel
2 x 15m x 25 mm elastic
All Hardware to be moused with plastic coated steel wire or split pins.
Plastic cable ties not to be used.
Buoy Tech, TTH-1, 125 psi, 25mm, terminated with samson spools
9mm Samson Nystron, 90 m
Weight below here must be 100 kg +/- 10 kg
total trap weight in water 150 kg
600mm UBE float CT-608B, 32 kg mass, 70 kg buoyancy
2t blue line swivel
Stainless HW ok below here
20m Superspeed 8mm
150m
TM Respire Trap, Clean, 44 kg Air, <5 kg in water
20m Superspeed 8mm
170m
T-TM Respire Trap, 44 kg in Air, 23 kg in water
20m Superspeed 8mm
190m
TM Respire Trap, Clean, 44 kg Air, <5 kg in water
20m Superspeed 8mm
210m
Ti-TM Respire Trap, 44 kg in Air, 23 kg in water
20m Superspeed 8mm
230m
TM Respire Trap, Clean, 44 kg Air, <5 kg in water
20m Superspeed 8mm
250m
T-TM Respire Trap, 44 kg in Air, 23 kg in water
20m Superspeed 8mm
3m 12mm Trawelex Chain
Keep 20 kg mass here for stability
100 kg weight, made up from 7/8" chain
IN-2019-V02
CSIRO
A4
TM Respire Drifter
UBE Synthetic Version
05

Scientific equipment and facilities provided by the Marine National Facility

Some equipment items on the list may not be available at the time of sailing. Applicants will be notified directly of any changes.

Indicate what equipment and facilities you require from the Marine National Facility by placing an **X** in the relevant box.

(i) **Standard laboratories and facilities**

Name	Essential	Desirable
Aerosol Sampling Lab	X	
Air Chemistry Lab	X	
Preservation Lab	X	
Constant Temperature Lab	X	
Underway Seawater Analysis Laboratory	X	
GP Wet Lab (dirty)	X	
GP Wet Lab (Clean)	X	
GP Dry Lab (Clean)	X	
Sheltered Science Area	X	
Observation deck 07 level		
Walk in Freezer	X	
Clean Freezer	X	
Blast Freezer	X	
Ultra-Low Temperature Freezer	X	
Walk in Cool Room	X	

(ii) **Specialised laboratory and facilities**

May require additional support

Name	Essential	Desirable
Modular Radiation Laboratory	X	
Modular Trace Metal Laboratories	X	
Modular Hazchem Locker		
Deck incubators	X	
Stabilised Platform Container		

(iii) **Standard laboratory and sampling equipment**

Name	Essential	Desirable
CTD - Seabird 911 with 36 Bottle Rosette		
CTD -Seabed 911 with 24 Bottle Rosette	X	
LADCP	X	
Sonardyne USBL System	X	
Milli -Q System	X	
Laboratory Incubators	X	
Heavy Duty Electronic Balance		
Medium Duty Electronic Balance	X	
Light Duty Electronic Balance	X	
Surface Net	X	
Bongo Net	X	
Smith Mac grab		
Dissecting Microscopes	X	

(iv) **Specialised laboratory and sampling equipment**

May require additional support

Name	Essential	Desirable
TRIAXUS – Underway Profiling CTD	X	
Continuous Plankton Recorder (CPR)	X	
Deep tow camera		
Piston Coring System		
Gravity Coring System		
Multi Corer		
XBT System	X	
Trace Metal Rosette and Bottles, and TMR Deck Box	X	
Sherman epibenthic sled		
Trace- metal in-situ pumps	X	
LADCP		
Rock Dredges		
EZ Net		
Rock saw		
Portable pot hauler		
Beam Trawl		
Trawl doors (pelagic or demersal)		
Stern Ramp NEEDS TO BE COVERED WIITH DANCE FLOOR	X	
Trawl monitoring instrumentation (ITI)	X	
Radiosonde		

(v) **Equipment and sampling gear requiring external support**

May require additional support from applicants

Name	Essential	Desirable
Seismic compressors		
Seismic acquisition system		

(vi) **Underway systems**

Acoustic Underway Systems

Name	**Essential**	**Desirable**
75kHz ADCP	X	
150kHz ADCP		
Multi Beam echo sounder EM122 12kHz (100m to full ocean depth)	X	
Multi Beam echo sounder EM710 70-100kHz (0-1000m approx.)	X	
Sub-Bottom Profiler SBP120		
Scientific Echo Sounders EK60 (6 bands, 18kHz-333kHz)	X	
Gravity Meter		
Trace metal clean seawater supply		

(vii) **Atmospheric Underway Sensors**

Name	**Essential**	**Desirable**
Nephelometer		
MAAP (multi angle absorption photometer)	x	
SMPS (scanning mobility particle sizer)	x	
Radon detector	x	
Ozone detector		
Manifold instrumentation (intake temperature and humidity)	X	
Picarro spectrometer (analysis of CO_2/CH_4/H_2O)		
Aerodyne spectrometer (analysis of N_2O/CO/H_2O)	X	
O2 analyser		
Manifold instrumentation (intake temperature and humidity)	X	
CCN (Cloud Condensation Nuclei)	x	
MOUDI (Micro-Orifice Uniform Deposit Impactors)	X	
Polarimetric Weather Radar		

(viii) **Underway Seawater Instrumentation**

Name	**Essential**	**Desirable**
Thermosalinograph	X	
Fluorometer	X	
Optode	X	
PCO2	X	