

RV Investigator Voyage Scientific Highlights and Summary

Voyage #:	IN2018_V07		
Voyage title:	SOTS: Southern Ocean Time Series automated moorings for climate and carbon cycle studies southwest of Tasmania		
Mobilisation:	Hobart, Monday, 6 August 2018 0800		
Depart:	Hobart, Monday, 20 August 2018, 1200		
Return:	Hobart, Friday, 24 August 2018, 0800		
Demobilisation:	Hobart, Friday, 24 August 2018, 0800		
Voyage Manager:	Rod Palmer	Contact details:	rod.palmer@csiro.au
Chief Scientist:	Eric Schulz		
Affiliation:	Bureau of Meteorology	Contact details:	eric.schulz@bom.gov.au
Principal Investigators:			
Project name:			
Affiliation:		Contact details:	

VOYAGE SUMMARY

Objectives and brief narrative of voyage

Scientific objectives

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 objective is to deploy a new SOTS mooring (SOFS-7.5). This SOTS mooring delivers to specific aspects of the atmosphere-ocean exchanges:

- 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 CO₂ 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 and underway measurements.

Voyage objectives

1. Deploy SOFS-7.5 meteorology/biogeochemistry mooring & triangulate
2. Do a CTD (1 cast to 2250m) at the SOFS-7.5 site, including collecting samples for nutrients, oxygen, dissolved inorganic carbon, alkalinity, and POC & pigments
3. Carry out underway air sensor measurement comparison between ship and SOFS-7.5 mooring

Results

1. Deploy SOFS-7.5 meteorology/biogeochemistry mooring & triangulate

Achieved

2. Do a CTD (1 cast to 2250m) at the SOFS-7.5 site, including collecting samples for nutrients, oxygen, dissolved inorganic carbon, alkalinity, and POC & pigments

Achieved

3. Carry out underway air sensor measurement comparison between ship and SOFS-7.5 mooring

Partially achieved. Due to time constraints there was no dedicated comparison period. However, the ship spent approximately 12 hours towing, performing a CTD and triangulating within a few miles of the mooring which will provide adequate comparison data.

In addition we performed a CPR tow on the return transit to Hobart.

Voyage Narrative

All times in the Voyage Narrative are in local ship time (=UTC+10h)

Monday 20 August

Departed 1200 and held inductions, mustered at 1330 and science party presentation. A test move of weights on the back deck was also performed while steaming down the river. Commenced transit to SOTS site with rough conditions encountered throughout the night.

Tuesday 21 August

A moorings operations familiarisation meeting was held at 0930. We continued our transit under moderating conditions collecting underway observations.

Wednesday 22 August

Arrived at the SOTS site around 0400 and set up 12 miles down weather from the target anchor drop site. Mooring preparation commenced 0600, with meeting and go decision made around 0700. Deployment commenced around 0745 with light wind and wave conditions from the West. Surface float deployed around 1300 and anchor at 2030.

SOFS-7.5 anchor released at 2018 08 22 10:33:26 UTC, 47 01.03' S, 142 13.60' E, -47.017165, 142.226727. Water depth under ship 4585m. Surveyed anchor position is: -47.02274, 142.2341, 4540m depth.

We moved off 1 nm and performed a CTD (12L, 36 Niskin rosette) to a depth of 2250m. 27 Niskins fired as per CTD log (see Appendix E), 24 bottles sampled for oxygen, salinity and nutrients, 12 of the 27 bottles were sampled for dissolved inorganic carbon and alkalinity. In upper the 125m: 6 samples for particulate organic carbon three extra bottles were dedicated to HPLC pigments only with a (25mm GFF) filter attached directly to the spigot and the entire 12L filtered in situ. Selected bottles for oxygen match SOFS mooring sensor depths at 30, 125, 200 and 480m.

In addition we sampled: 20 10L filtered seawater (GFF) from underway supply for sediment traps with 1 nutrient sample taken from each 10L drum; and at 0659 from the TSG underway system for nutrients at location -47.02, 142.25. We triangulated the SOFS-7.5 anchor and determined it was performing as required (releases upright, stationary and at the correct depth). Due to the lengthy time period (14.5 hours) consumed by the deployment, the dedicated ship-buoy meteorological comparison period was abandoned to enable the scheduled departure to Hobart at around midnight.

Thursday 23 August

The CPR was launched at 0045 and we then commenced transiting to Hobart under light conditions. A moorings debrief was held in the afternoon (notes are available in appendix D).

Friday 24 August

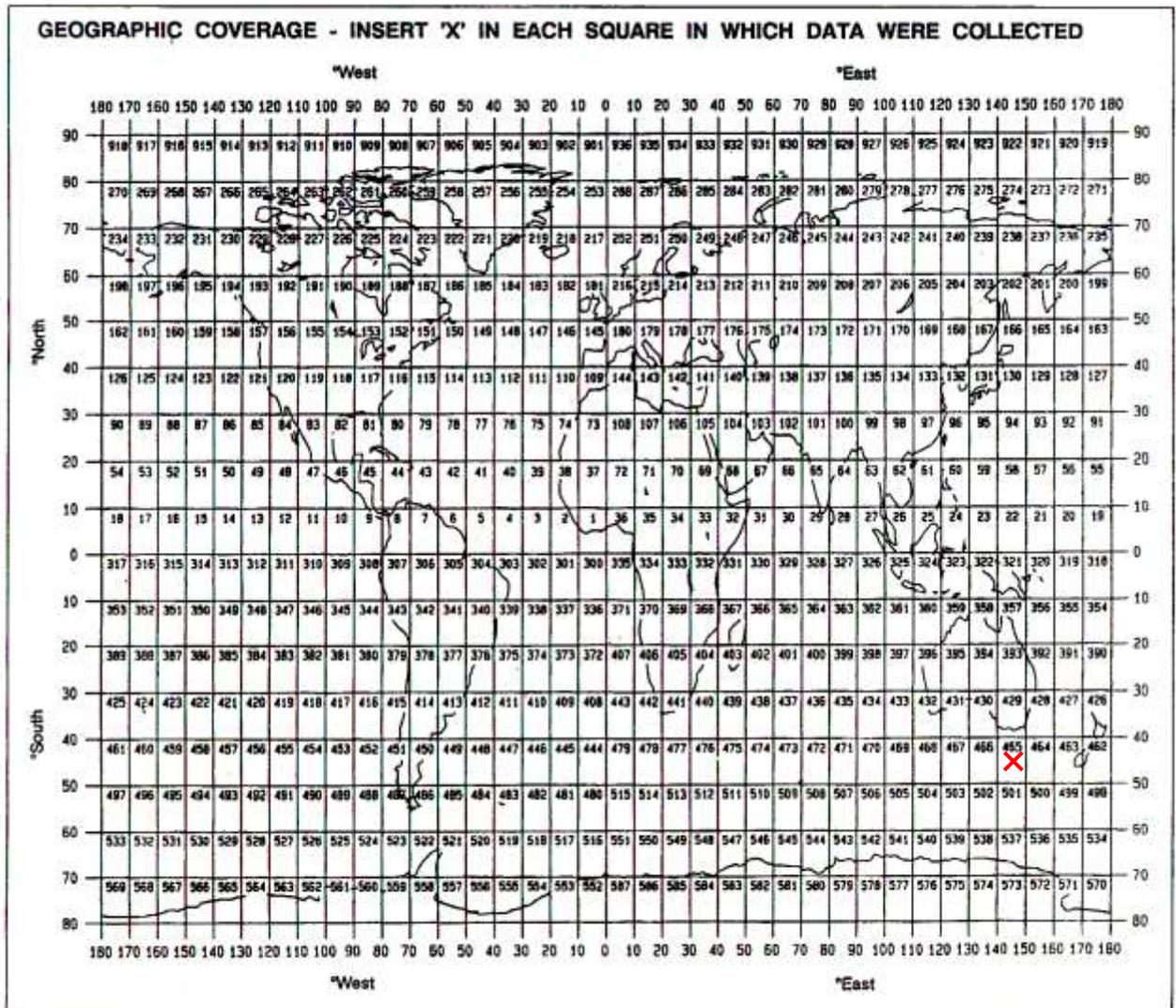
The CPR was recovered at 0400 and we arrived in the river around 0600 and docked in Hobart at 0900.

Summary

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.

Marsden Squares

× × × × ×



Moorings, bottom mounted gear and drifting systems

Item No	PI See page above	APPROXIMATE POSITION						DATA TYPE Enter code(s) from list on last page	DESCRIPTION Identify, as appropriate, the nature of the instrumentation the parameters (to be) measured, the number of instruments and their depths, whether deployed and/or recovered, dates of deployments and/or recovery, and any identifiers given to the site.
		LATITUDE			LONGITUDE				
		deg	min	N/S	deg	min	E/W		
1	Eric Schulz	47	0.6	S	142	12.81	E	MO2 M71 M90 H17 D01 D71	Southern Ocean Times Series (SOTS) site: SOFS-7.5 surface meteorological mooring deployed for recovery in March 2019 See diagram in appendix detailing instruments and depths

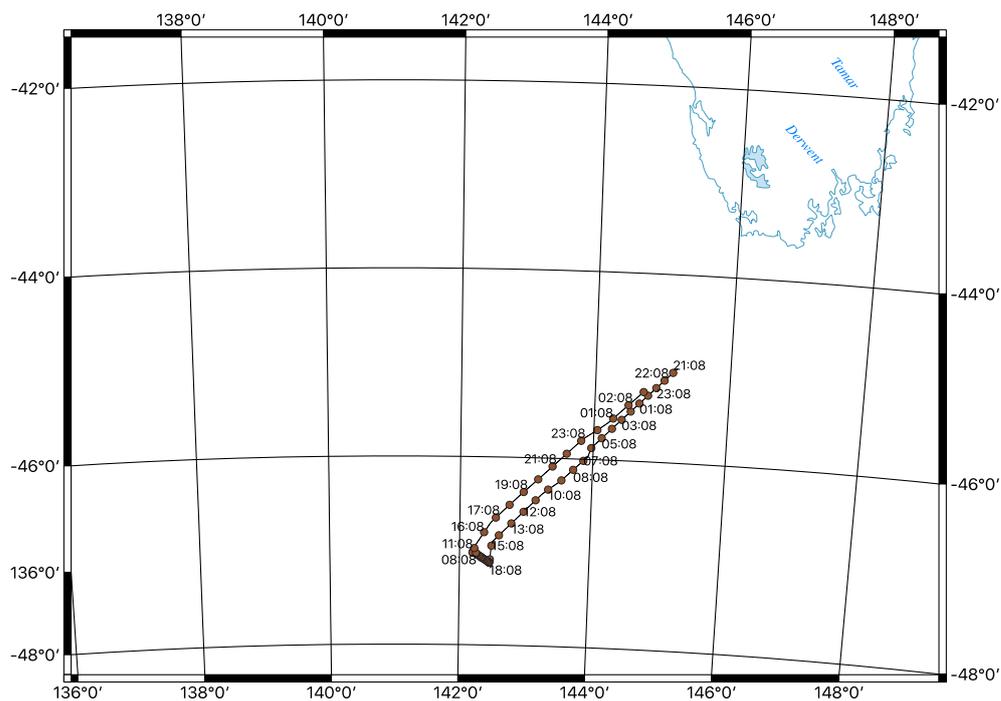
Summary of Measurements and samples taken

Item No.	PI see page above	NO see above	UNITS see above	DATA TYPE Enter code(s) from list at Appendix A	DESCRIPTION
					Identify, as appropriate, the nature of the data and of the instrumentation/sampling gear and list the parameters measured. Include any supplementary information that may be appropriate, e. g. vertical or horizontal profiles, depth horizons, continuous recording or discrete samples, etc. For samples taken for later analysis on shore, an indication should be given of the type of analysis planned, i.e. the purpose for which the samples were taken.
1	Eric Schulz	1	Casts	H10	Completed 1 CTD station for collection of discrete water and particle samples.
2	Eric Schulz	38	Hours	B08	CPR – Continuous Plankton Recorder

Curation Report

Item #	DESCRIPTION
1.	Water and particle samples collected from the CTD underway system are returned to CSIRO Marine and Atmospheric Research for chemical analyses and then discarded following quarantine protocols.

Track Chart



Ship position over the time period 21-23 August 2018

Personnel List

	Name	Organisation	Role
1.	Rod Palmer	MNF	Voyage Manager
2.	Nicole Morgan	MNF	MNF SIT support
3.	Aaron Tyndall	MNF	MNF SIT support
4.	Steve van Graas	MNF	DAP computing support
5.	Peter Shanks	MNF	DAP computing support
6.	Phil Vandenbossche	MNF	GSM support
7.	Craig Davey	MNF	GSM support
8.	Peter Hughes	MNF	Hydrochemist
9.	Eric Schulz	BOM	Chief Scientist
10.	Peter Jansen	ACE-CSIRO	Managing Engineer
11.	Jamie Derrick	CSIRO	SOTS: Mooring Supervisor
12.	Garry Curtis	CSIRO	SOTS: Mooring deck work
13.	Darren Moore	CSIRO	SOTS: Mooring deck work
14.	Diana Davies	ACE	Underway/CTD sampling
15.	Andrew Martini	CSIRO	Mooring procedural review/training
16.	Ryan Crossing	CSIRO	Mooring observer
17.	Lisa Woodward	MNF	MNF Training Officer
18.	Linda Gaskell	MNF	MNF trainee

Marine Crew

Name	Role
Mike Watson	Master
Brendan Eakin	Chief Mate
James Hokin	Second Mate
Astrid Wilson	Third Mate
Gennadiy Gervasiev	Chief Engineer
Mark Ellicott	First Engineer
Ryan Agnew	Second Engineer
Fletcher Caldwell	Third Engineer
John Curran	Electrical Engineer
Alan Martin	Chief Caterer
Cassie Rowse	Caterer
Keith Shepherd	Chief Cook
Paul Stanley	Cook
Jonathan Lumb	Chief Integrated Rating
Dean Hingston	Integrated Rating
Billy Whitaker	Integrated Rating
Murray Lord	Integrated Rating
Matt McNeill	Integrated Rating
Kel Lewis	Integrated Rating
Darren Capon	Integrated Rating

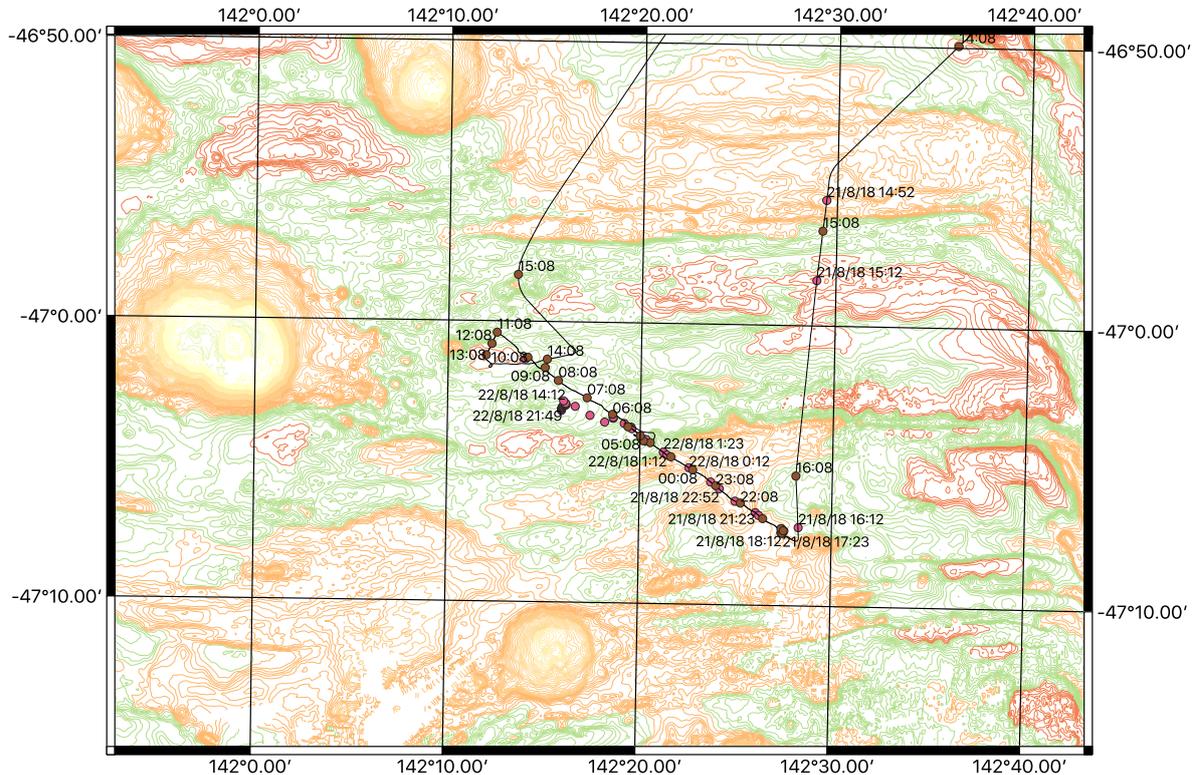
Acknowledgements

We are grateful to the MNF and ASP for excellent support at sea and flexibility in accommodating an unscheduled deployment voyage for SOFS-7.5. 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	Eric Schulz
Title	Chief Scientist
Signature	
Date:	24 August, 2018

Additional Figure



Ship track on 22 August 2018 during SOFS-7.5 mooring deployment.

- Appendix A CSR/ROSCOP Parameter Codes
- Appendix B Photographs
- Appendix C Mooring diagram
- Appendix D Moorings debrief notes
- Appendix E CTD Log

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)

	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

D01	Current meters
D71	Current profiler (eg ADCP)
D03	Currents measured from ship drift
D04	GEK
D05	Surface drifters/drifted buoys
D06	Neutrally buoyant floats
D09	Sea level (incl. Bottom pressure & inverted echosounder)
D72	Instrumented wave measurements
D90	Other physical oceanographic measurements

B26	Mammals & reptiles
B14	Pelagic fish
B19	Demersal fish
B20	Molluscs
B21	Crustaceans
B28	Acoustic reflection on marine organisms
B37	Taggings
B64	Gear research
B65	Exploratory fishing
B90	Other biological/fisheries 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

	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

H32	Isotopes
H90	Other chemical oceanographic measurements

G27	Gravity measurements
G28	Magnetic measurements
G90	Other geological/geophysical measurements

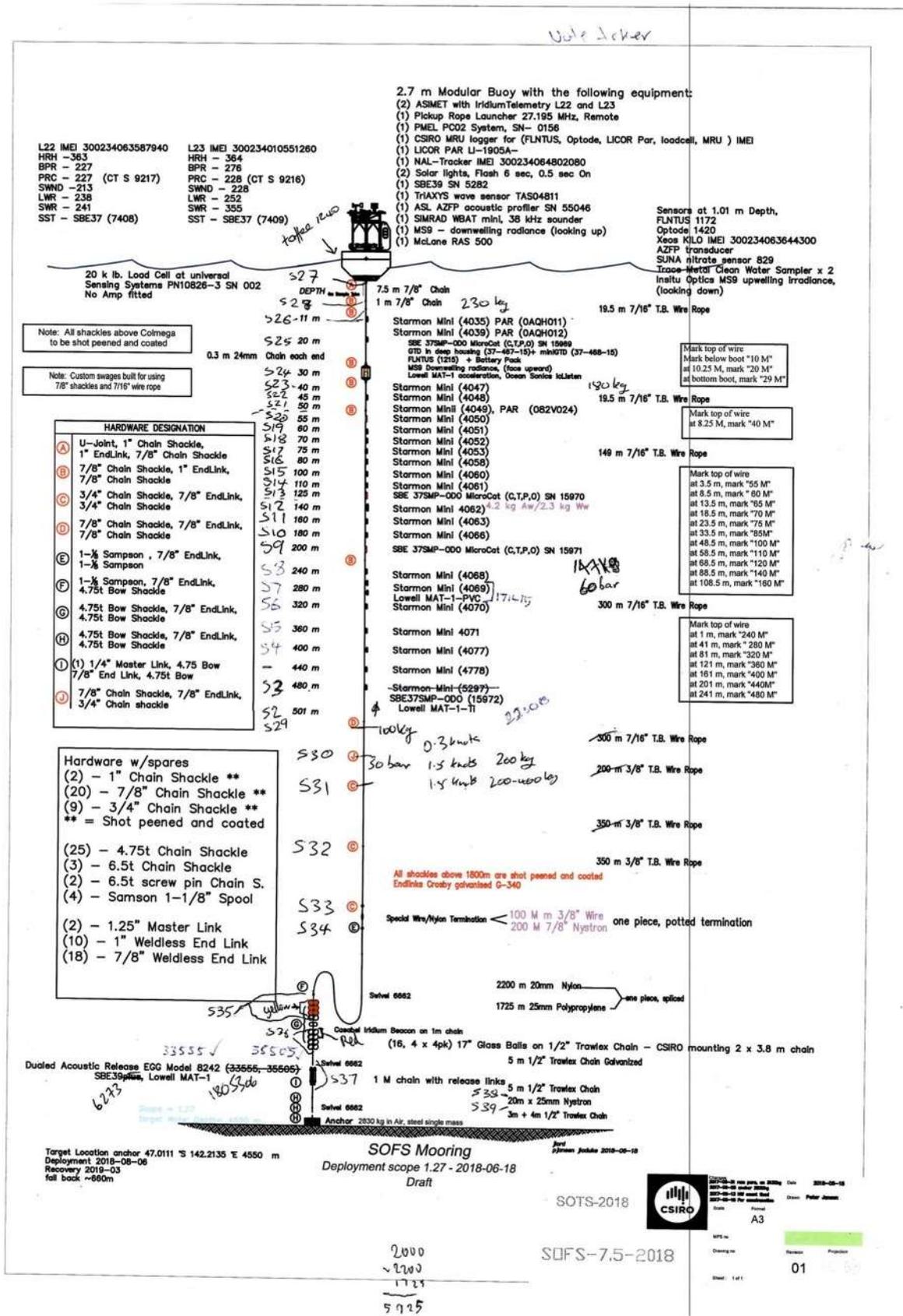
	MARINE CONTAMINANTS/POLLUTION
P01	Suspended matter
P02	Trace metals
P03	Petroleum residues
P04	Chlorinated hydrocarbons
P05	Other dissolved substances
P12	Bottom deposits
P13	Contaminants in organisms
P90	Other contaminant measurements

Appendix B - Photographs



SOFS-7.5 float (second row) and mooring deployment team (front row).

Appendix C - Mooring diagram



Appendix D – Moorings Debrief Notes

SOFS-7.5 mooring deployment debrief notes.

Meeting held: Thursday 23 August 2018

Attendees

Garry Curtis, Diana Davies, Jamie Derrick, Peter Jansen, Andrew Martini, Darren Moore, Rod Palmer, Eric Schulz, Mike Watson, Johnathon Lumb

Main discussion points

- The general feeling was that the deployment operation went smoothly, was methodical and well paced. Communication between moorings staff, deck crew and bridge was clear and well coordinated.
- During the later phase of the deployment when the load of the streamed mooring was transferred from the stopper to the anchor, the anchor was lifted off the deck and suspended between the streamed mooring and the a-frame lifting pendants. The situation was quickly rectified by bringing the a-frame further inboard and there was no dangerous loss of control. The primary cause was excessive ship speed (between 1-2 kts) due to manoeuvring. Suggested solutions were to keep the ship speed closer to 1 knot during this operation, and to have the a-frame slightly further inboard.
- The anchor was placed too far aft and near the unopened stern port gate which impeded the opening of the gate (necessary for the anchor to be deployed). The anchor was temporarily moved forward to enable the gate to be opened. It was suggested that a line describing the outer extent of the arc of the gate be painted on the deck to indicate the region.
- The anchor design could also be improved by adding three smaller support points, reducing the possibility that the long straight edges could land on someone's foot.
- The length of the operation (~15 hours) and associated heightened crew fatigue was discussed. A number of points were discussed:
 - Big time savings (i.e. deploying a stable buoy first) v. multiple smaller time savings – what is the best approach?
 - Simplified decision making to reduce risk of making poor decisions
 - Changes in the mooring design and therefore deployment procedures to reduce the length of the operation
 - Rotation of key personnel (particularly bosun and technical lead), a second shift of moorings team, changed crew shifts
 - Positioning of the buoy on the deck, reducing/eliminating the first move of the buoy.There was agreement to work more closely in future for planning the scheduling of science activities in consultation with ship's crew to minimise fatigue.

There was good usage of the harness and fall arrestors for people working near the edge when the deck was open with further discussion on codifying this in procedures and also investigating more suitable equipment. Mike agreed to request ASP purchase a number of inertia reel type fall arrestors. There was also discussion on the harness requirements.

Appendix E – CTD Log sheet

RV Investigator									Survey		in2018_v07	
CTD Log Sheet									Date		22-Aug-2018	
		Start	Bottom			End			Deployment		1	
Time (UTC)		10:52:07	11:53:47			13:09:54			CTD			
Latitude		47 00.519S	47 00.774S			47 01.279S						
Longitude		142 12.741E	142 12.277E			142 11.918E						
Bottom Depth		4590	4547			4636						
Altimeter		-1.0	-1.0			-1.0						

CTD data							Firing	Sample bottles			DIC/ATK	
Pos.	Bottle	Depth	Press.	Temp.	Sal.	Time	Ok	Sal.	POC	Nut.	DOT	Pos.
36												36
35												35
34												34
33												33
32												32
31												31
30												30
29												29
28												28
27	27	0	5.9	10.026	34.768	018-08-22T13:0	Yes		6		12	27
26	26	0	5.8	10.026	34.768	018-08-22T13:0	Yes					26
25	25	0	5.2	10.026	34.768	018-08-22T13:0	Yes	3				25
24	24	0	29.4	10.037	34.769	018-08-22T13:0	Yes		5		11	24
23	23	0	29.6	10.037	34.769	018-08-22T13:0	Yes					23
22	22	0	29.9	10.038	34.769	018-08-22T13:0	Yes	2				22
21	21	0	51.3	10.036	34.769	018-08-22T13:0	Yes		4		10	21
20	20	0	50.5	10.036	34.769	018-08-22T13:0	Yes		3			20
19	19	0	50.4	10.036	34.769	018-08-22T13:0	Yes	1				19
18	18	0	100.0	10.050	34.770	018-08-22T13:0	Yes		2			18
17	17	0	126.0	10.059	34.772	018-08-22T12:5	Yes		1		9	17
16	16	0	150.9	10.063	34.772	018-08-22T12:5	Yes					16
15	15	0	175.9	10.064	34.772	018-08-22T12:5	Yes				8	15
14	14	0	200.7	10.066	34.772	018-08-22T12:5	Yes					14
13	13	0	225.0	10.063	34.771	018-08-22T12:5	Yes				7	13
12	12	0	250.7	10.058	34.769	018-08-22T12:5	Yes					12
11	11	0	301.0	9.600	34.725	018-08-22T12:4	Yes				6	11
10	10	0	351.2	9.384	34.691	018-08-22T12:4	Yes					10
9	9	0	481.3	8.923	34.619	018-08-22T12:4	Yes				5	9
8	8	0	600.3	8.291	34.535	018-08-22T12:3	Yes					8
7	7	0	800.7	6.700	34.433	018-08-22T12:3	Yes				4	7
6	6	0	999.7	5.032	34.372	018-08-22T12:2	Yes					6
5	5	0	1200.4	3.768	34.391	018-08-22T12:2	Yes				3	5
4	4	0	1402.5	3.255	34.494	018-08-22T12:1	Yes					4
3	3	0	1599.2	2.852	34.567	018-08-22T12:1	Yes				2	3
2	2	0	1809.7	2.575	34.629	018-08-22T12:0	Yes					2
1	1	0	2002.1	2.414	34.675	018-08-22T12:0	Yes				1	1

Operator Nicole	Samplers <input type="text"/>
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Comments

DIC/ATK - Disampled, Eric Schultz poisoned.

POC - all 2L

lytic pigments - 25mm GF/F direct from Hiskin.