



voyagesummaryss2013\_v06

# SS2013\_v06

**Voyage:** Integrated Marine Observing System (IMOS) Facility 3. Southern Ocean Time Series (SOTS) moorings for climate and carbon cycle studies southwest of Tasmania (47°S, 140°E)

## Voyage period

Start: 6/10/2013 End: 17/10/2013 Port of departure: Hobart, Australia Port of return: Hobart, Australia

### **Responsible laboratory**

ACE CRC PB 80, Hobart, Tas 7001, Australia

## **Chief Scientist**

Dr Eric Schulz Bureau of Meteorology

### **Executive Summary**

This voyage was carried out as part of an ongoing effort to service the IMOS Southern Ocean Time Series Facility. The Facility will be operating with a reduced number of moorings at the site for the next 18 months. Three moorings were recovered (SOFS-4 air-sea flux mooring, SAZ-15 sediment trap mooring, and Pulse-10 biogeochemistry mooring). One mooring (SAZ-16) that was deployed on the last voyage in May 2013 (ss2013\_v03) was left in the water for later recovery – either in around June 2014, or April 2015. Additional ancillary work included CTD casts and underway water samples.

### **Scientific Objectives**

The overall scientific objective is to obtain frequent measurements of surface and deep ocean properties that control the transfer of  $CO_2$  from the atmosphere to the upper ocean, and then onwards to the ocean interior in the form of sinking particles. This "biological pump" drives carbon sequestration from the atmosphere, and writes the sedimentary record. The controls on its intensity are complex and involve processes that vary on daily, weekly, seasonal, and inter-annual timescales. Obtaining observations with the necessary frequency is not possible from ships. For this reason the IMOS Southern Ocean Time Series Facility seeks to obtain this information using automated sensor measurements and sample collections.

## **Voyage Objectives**

This voyage was an early recovery mission, made necessary when the planned April 2014 service voyage became unavailable. The moorings recovered were:

#### SOFS-4 mooring

To make meteorological and upper ocean measurements of physical and chemical properties important to air-sea exchange of heat, water, momentum, and dissolved gases (oxygen and  $CO_2$ ).

### • Pulse-10 mooring

To make upper ocean measurements of properties that control carbon uptake and export to the ocean interior, including temperature, salinity, mixed layer depth, light, oxygen, total dissolved gases, phytoplankton fluorescence, particle backscatter, and dissolved nitrate, and collect 24 paired water samples later study of nutrients and phytoplankton identification.

### • SAZ-15 mooring

To collect sediment trap samples in the deep sea (below 1000m) to quantify the transfer of particulate carbon and other materials to the ocean interior.

SAZ-16 mooring was left in the ocean to complete it's program, for recovery in 2014 or 2015.

Ancillary measurements carried out included underway and CTD sensor and sample collections. No ancillary zooplankton net drops or CPR tows were performed as this equipment was not provided prior to departure.

### **Voyage Narrative**

#### Friday 4 October 2013

Mobilisation day. Loading of equipment

#### Monday 7 October

Departed at 0800 in pleasant conditions. While in sheltered waters we practiced SOFS buoy recovery operation with winches and A-frame on the aft deck. A test CTD was performed to 90m. We commenced transit to SOTS site at around 1500.

#### **Tuesday 8 October**

We continued to transit in moderate conditions with 30kt Westerlies. Recovery procedure meetings for each mooring were held throughout the day. We arrived at the site around 2100 and stationed the ship off the SOFS-4 mooring to collect meteorological comparison observations over night.

#### Wednesday 9 October

0600 dawn at the SAZ-15 site revealed good conditions with winds around 20kts and seas 2-3m. After 0630 JHA/Toolbox and aft deck toolbox meetings, the ship took up position 0.5Nm NW of the anchor site ant the releases triggered at 0800. Floats were spotted on the surface shortly after and grappling commenced around 0900. The mooring recovery was completed by 1730, debrief by 1830, craning and unspooling completed by 2200.

#### **Thursday 10 October**

Weather was inclement (30-40kts) and expected to deteriorate further. 0615 communicated with Pulse-10 acoustic release (to confirm it would respond when triggered later) and morning spent unspooling remainder of SAZ-15 wire. Overnight conditions deteriorated further with wind gusting to 60kts.

#### Friday 11 October

Rough conditions. Ship on most comfortable heading for the day with a slow upwind course. Brief 2-hour lull in winds at 1800, but soon back up to full strength again.

#### Saturday 12 October

Conditions still unsuitable for mooring operations with 40kt westerlies. Communicated with SAZ-16 acoustic release and received response that system is working as planned.

#### Sunday 13 October

Conditions eased somewhat overnight. Toolbox meeting held on bridge at 0800, but conditions still not settled enough for mooring operations. Squalls, snow, hail and very cold southerly blowing (air temperature around 3 Deg C).

#### Monday 14 October

0600 Conditions moderate with 20kt winds. Toolbox held. Pulse-10 release triggered 0700 and float sighted 0750. Floats on board 0820 and mooring recovery completed 1400. Craning and unspooling completed 2130. CTD some miles to the east of Pulse site performed at 1700. Profiled to 1250m, samples 1000m-surface, 10 depths with doubles: DO, DIC, Salts, Nutrients, large volumes near surface for plankton and at 1000m for reference.

#### **Tuesday 15 October**

0600 Conditions good with 25kt winds and moderate seas from the west. Overcast with fog, light rain and snow flakes. Toolbox held. The SOFS-4 release was triggered at 0700 and floats spotted 0815. The floats were successfully grappled on the first go and on board by 0850. The buoy was recovered by 1330 and mooring operations completed by 1420. A CTD some miles to the north east of the SOFS site was performed at 1600. Profiled to 1250m, samples 1000m-surface, 10 depths with doubles: DO, DIC, Salts, Nutrients and large volume near surface for plankton. Transit to Hobart commenced 1630.

Three points relating to this recovery were:

- A 4-pack and 8-pack of glass ball flotation had imploded (12 out of 40), but still sufficient floatation to lift releases to the surface. The strategy of creating smaller (4 ball) packs and increasing spacing between packs appears to have been successful with the spread of damage isolated to individual packs. The two packs destroyed were not adjacent.
- The auto-recovery line launcher has been under development for some time and deployed on the last three SOFS moorings. This recovery saw the first successful activation and deployment of the recovery line. The light messenger line was grappled with little trouble. The heavier recovery line was easily extracted by tugging on the messenger line. The recovery line is 18m long (messenger ~26m, 2Ton breaking load). The messenger line was pulled in by hand and cleated on the bulwark. There was some difficulty and lengthy delays in securing the recovery line to the ship's lifting line
- A SOFS float landing & securing structure, consisting of two parallel landing rails running fore and aft and designed to provide a simple cradle in which to land the buoy was trialled. The equipment worked well, allowing for immediate securing of the buoy and longer-term strapping down to be achieved simply and quickly.

#### Wednesday 16 October

Continued transit to Hobart under rough conditions with strong 40kt (gusting 70kt) westerlies and 7-8m seas on the beam. Heavy rolling. Galley closed – spag boll for breakfast, lunch & tea.

### Thursday 17 October

Arrived in Hobart for pilot at 0800. Alongside dock at 0900 and demobilisation commenced.

#### Nearby mooring that will not be recovered until 2014 or 2015

SAZ-16 Deployed 4 May 2013			
Anchor Target Site	46° 47.400'S	141° 49.500'E	4530 m
Anchor Drop Site:	46° 47.7516' S	141° 48.8316'E	4496 m
Anchor Triangulated Site:	46° 47.603′S	141° 49.392′E	4531 m
Distance from Drop to Triangulated site: 0.41 nmiles			
Distance from Drop to Target site: 0.58 nmiles			
Subsurface mooring – no surface expression			

### **CTD Deployments**

CTD deployments 02 and 03 were carried out to 1250m depth. Niskin bottle samples were collected at 10 depths (1000, 800, 600, 400, 200, 150, 120,70, 30, 5m; paired Niskins with both sampled each depth) for dissolved oxygen, DIC, alkalinity, salinity and nutrients. Mounted sensors measured temperature, conductivity, dissolved oxygen, photo synthetically available radiation, phytoplankton fluorescence, and beam transmission.

Water was collected at 1000 and 800m from deployment 02 and 03 for the CMAR Calibration facility.

Water was collected at 5m from deployment 02 and 03 for Phil Boyd for phytoplankton work.

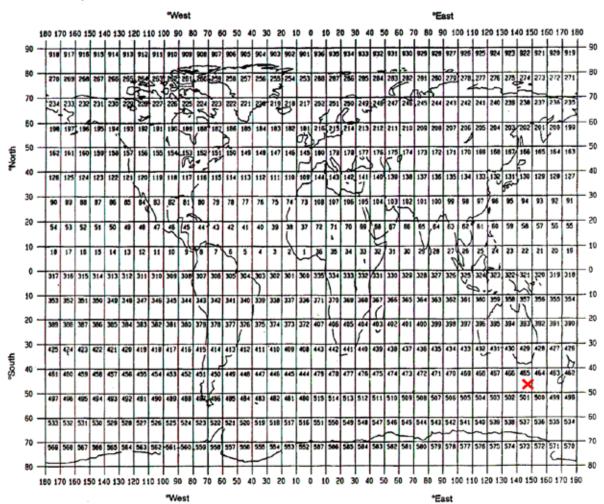
## **Summary**

The voyage was successful in achieving all scientific goals. Mooring operational procedures had been revised prior to the voyage to provide a more structured approach to the recoveries. The use of smaller recovery teams, supported by fresh teams for follow-on work (craning and spooling) worked well with improved on-deck control and coordination.

The crew and science party performed superbly despite prolonged rough and tedious seas.

## **PRINCIPAL INVESTIGATORS**

- A. Eric Schulz, BOM-CAWCR, E.Schulz@bom.gov.au
- B. Tom Trull, ACE CRC UTAS CMAR-CAWCR, Tom.Trull@utas.edu.au



### GEOGRAPHIC COVERAGE - INSERT 'X' IN EACH SQUARE IN WHICH DATA WERE COLLECTED

7 VOYAGE SUMMARY - SS2013\_v06

	MOORINGS, BOTTOM MOUNTED GEAR AND DRIFTING SYSTEMS									
			App Latitude	oroxima	te pos	ition Logitude		Data		
ltem No.	PI	deg	min	N/S	deg	min	E/W	Data Type	DESCRIPTION	
1	A	46	46.6	S	141	59.6	E	M02, M06, M90, H71, D01, H90, H17, H21	Recovered SOFS-4 (deployed 1 May 2013)	
2	В	46	56.3	S	142	17.1	E	H90	Recovered Pulse-10 (deployed 7 May 2013)	
3	В	46	50.3	S	141	40.7	E	H90	Recovered SAZ-15 (deployed 18 July 2012)	

SUMMARY OF MEASUREMENTS AND SAMPLES TAKEN								
Item No.	PI	No.	Units	Data Type	DESCRIPTION			
1	В	1	cast	H10	2 CTD casts to 1200m, sampled at 10 depths for analyses of nutrients, salinity, DIC, alkalinity, dissolved oxygen			
2	А	700	miles	H71	Continuous monitoring of underway seawater supply for temperature, salinity for study of physical heat and mass flux			
3	А	700	miles	M02	Continuous monitoring of incoming short and long-wave radiation for heat fluxes			
4	А	700	miles	M06	Continuous monitoring of routine meteorological observations (wind, ait temperature, humidity and pressure) for heat, mass and momentum fluxes			
5	А	700	miles	M90	Continuous monitoring of precipitation for mass fluxes			
6	В	4ß	samples	H71, H11	Underway Water Samples			

## **Curation Report**

ltem No.	DESCRIPTION	
1	Water samples collected from the CTD and underway system are returned to CSIRO Marine and Atmospheric Research for gas and salinity measurements and then discarded following quarantine protocols.	

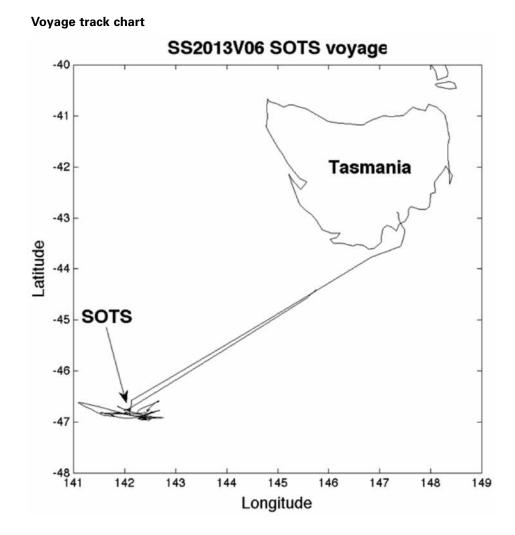


Figure 1: Ship track SS2013\_v06

**General ocean area(s):** Southern Ocean – Indian Sector **Specific areas:** Subantarctic Zone southwest of Tasmania

## **Personnel list**

## **Scientific Participants**

Name	Affiliation	Role
1. Eric Schulz	BOM	Chief Scientist, Met OBS, moorings
2. Stephen Bray	ACE CRC	Moorings, sedtraps, CTDs
3. Peter Jansen	IMOS-UTAS	Moorings, Toolbox briefings
4. Mark Lewis	CMAR	Moorings, Technical Supervisor
5. James LaDuke	CMAR	Moorings
6, Don McKenzie	MNF-CMAR	MNF Voyage Manager
7. Tegan Sime	MNF-CMAR	Voyage Manager Understudy
8. Max McGuire	MNF-CMAR	Voyage Manager Understudy
9. Nicole Morgan	MNF-CMAR	MNF Electronics Support
10. Peter Dunne	MNF-CMAR	MNF Electronics Support
11. Pamela Brodie	MNF-CMAR	MNF Computing Support,
		Deputy Voyage Manager

## Marine Crew

Name	Role
John Barr	Master
Mike Tuck	Chief Mate
Tom Watson	2nd Mate
Mike Yorke-Barber	Chief Engineer
Seamus Elder	1st Engineer
Graeme Perkins	2nd Engineer
Cassandra Rowse	Chief Steward
Warren Leary	Chief Cook
Serena Pearson	2nd Cook
Jonathon Lumb	CIR
Ron Johnston	IR
Dave Jephson	IR
Michael Chalk	IR
Nathan Arahanga	IR

# Acknowledgements

Thanks to the Master, Crew, MNF staff, and the onboard Science Team the voyage went very smoothly which is testament to the skill and professionalism of all aboard.

## Eric Schulz Chief Scientist 16 October 2013

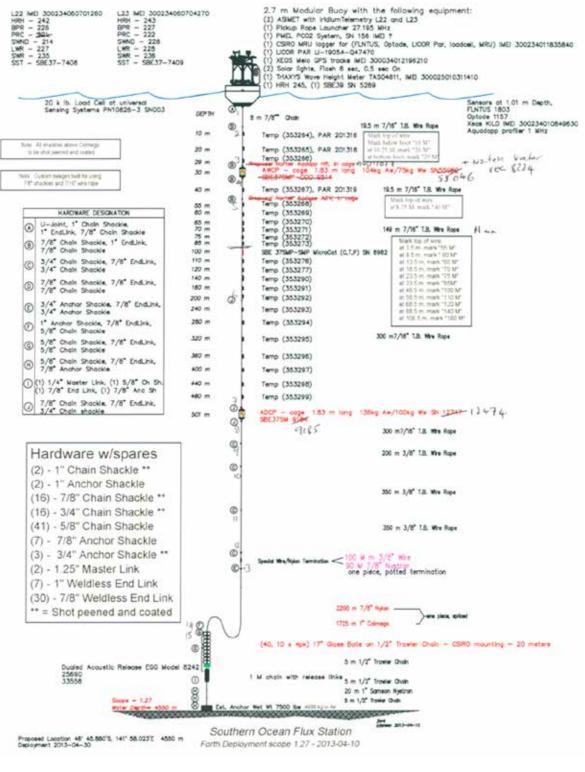


Figure 2: SOFS-4 mooring diagram

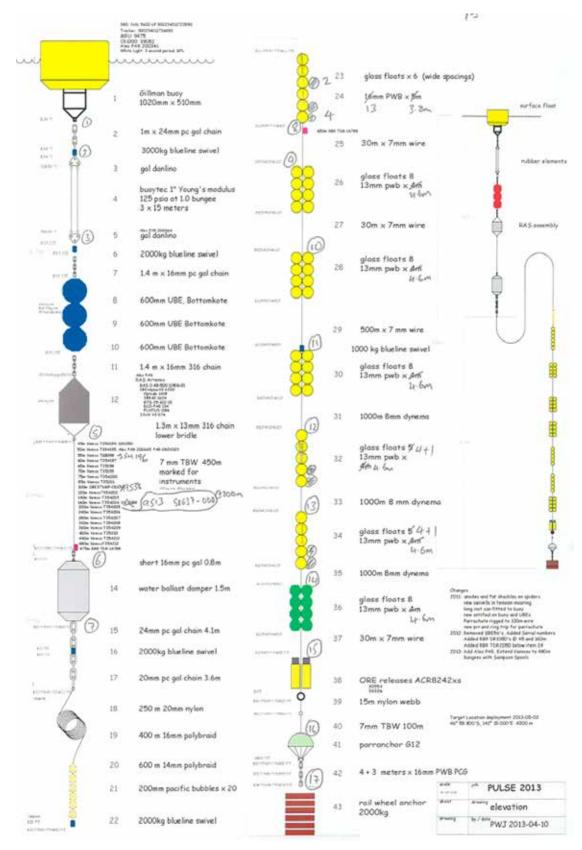


Figure 3: Pulse-10 mooring diagram

ດ SAZ 15	\$	# floats	Length		Description
SAZ 15 SAZ 2012 - 2013		0	2		pickup floats, 4 x 200mm, white
47S, 142E		Q 🔪	/ 60	m	pickup line,polypro, floating 16mm, green
Version			<b>5</b> 1.9		mast, galv steel, glass floats, 17"
Revised: 19 July 2012, as deployed			<mark>&gt; 3</mark>		chain 13mm
Deployed: 18 July 2012 S.Surveyor		4 fits	30	m	wire 7mm
Recover:2013, Apr SS OR Sept. Inv Drawn: S. Bray, ACE CRC (5Dec20			0.5	m	transponder CART, inline SS cage,F=75kg
		16 flts	8 6		floats, glass 17" on chain 13mm
	nominal	Y	<u> </u>		wire 7mm
	depth		50 4		wire 7mm as tether
radio 160.785MHz T=~2s, strobe, xeos T=3s dbi white burst	below	Insulate	1		tripod SS316
Aroos PACIA 24771 pick floo	sealevel	Insulate	7 2		sed trap Ti frame, McLane
McLane sn 11741-01, tilt	1000m	Insulate	1		chain bridle, mild steel
Cups G 500 x21		mounte	40		wire 7mm
Star-Oddi sn1010 T,P,pitch,roll			4		wire 7mm as tether
100 and a 114 had a 10		Insulate	1		tripod SS316
now hollon, plugg v0	1050m		2.1	m	sed trap SS316 frame, IRS (TS mode)
E new battery plugs x2		Insulate 🖌	1 1		chain bridle, mild steel
Nortek Aquadopp		E ALA	110		wire 7mm
Nortek Aquadopp sn AQD 6622		5 flts 😽	<u> </u>	m	floats, glass 17" on chain 13mm
	-		50	m	wire 7mm
Details Wire: torque balanced (TBW)			1 1	m	current meter, SS cage, vaneless
7mm wire terminations swaged					
& proof tested			200		wire 7mm
9mm wire terminations swaged		5 flts	3		floats, glass 17" on chain 13mm
& proof tested (1st CSIRO batch!)		Swiver	500	m	wire 7mm
Chain: proof coil galv (PCG) Swivels: Blueline pn (A402), SWL 2ton		5 flts 🖯	<mark>2</mark> 3	m	floats, glass 17" on chain 13mm
greased			50		wire 7mm
greased		Insulate	4		wire 7mm as tether
		Insulate 🧲	1		tripod SS316
McLane sn 11649-01, short	2000m	Insulate	2		sed trap Ti frame, McLane
Cups T250 x21	2000111		Z 1 350		chain bridle, mild steel
		8 fits 8			wire 7mm
Triped detail			× 3 500		floats, glass,17" on chain 13mm wire 7mm
Tripod detail wire, ms, ~4m long		I	500		wie / min
wire termination, ms		I	500	m	wire 7mm
shackle ms 2t		a 111	<b>9</b> 3		floats, glass,17" on chain 13mm
shackle, pin up, ss : insulate pin		6 flts Swivel			wire 7mm
ring, ss, with 12-14mm lift rope			500		
shackle, pin down, ss tripod top hole, ss		6 flts 😽	8 3	m	floats, glass,17" on chain 13mm
tripod top hole, ss			50	m	wire 7mm
McLane sn 11640-01, tilt		Insulate	4	m	wire 7mm as tether
Cups A 500x21		Insulate	→ 1		tripod SS316
RBR TDR-2050, sn 016371	3900m	Insulate	2		sed trap Ti frame, McLane
and the state of the second stands			2 1	m	chain bridle, mild steel
Landing site (triangulated) Degrees & minutes			300	m	wire 7mm
46° 50.229'S 141°40.710'E		7 0	<mark>o</mark> 5		floats, glass,17" on chain 13mm
Decimal degrees		7 flts of Swivel	<mark>ඊ</mark> 200		wire 7mm
-46.8371, 141.6785		Swiver	L _	m	SBE microcat 37, clamped, sn 8597 ,P,T,
	colour	ed 8 flts 🛛	<mark>२</mark> 5	m	floats, glass,17" on chain 13mm
		<u> </u>	<u> </u>	m	wire 9mm
2x releases 8242xs sn 34060, 3406	1		1.4	m	releases
12 min. 30 sec. for pickup fits to sur			0.5		release chain + big ring
13 min. 24 sec. for mast to surface			15	m	nylon snatch strap, 65mm wide
77 min. for bottom floats to surface			100	m	wire 9mm
Seafloor: nominal 4600 m,			4		chain 16mm (rub-while-u-wait chain)
triangulated 4591 m single stack anchor 2 ms plates, 5ms	a uda entre		3 1.2	m	chain 16mm anchor, ~1800kg in air,~1565kg wet
	s wheels		1.2	m	anchor, ~touuko in air.~1565ko wet

Figure 4: SAZ-15 mooring diagram

ຼັ SAZ 15		# floats	Length		Description
SAZ 15 SAZ 2012 - 201	3	0	2		pickup floats, 4 x 200mm, white
47S, 142E		Q 🔪	/ 60		pickup line,polypro, floating 16mm, green
Version			5 1.9		mast, galv steel, glass floats, 17"
Revised: 19 July 2012, as deploy		4 fits	P 3		chain 13mm
Deployed: 18 July 2012 S.Survey Recover:2013, Apr SS OR Sept. I			30	m	wire 7mm
Drawn: S. Bray, ACE CRC (5Dec.			0.5	m	transponder CART, inline SS cage,F=75kg
CART sn 34038		16 flts 🖯	K 6		floats, glass 17" on chain 13mm
	nominal		50		wire 7mm
Mast detail radio 160.785MHz T=~2s.	depth	I	4		wire 7mm as tether
strobe, xeos T=3s dbl white burst	below	Insulate	1		tripod SS316
Argos BASM 24771, pink flag	sealevel	Insulate	7 2		sed trap Ti frame, McLane
McLane sn 11741-01, tilt	- 1000111	Insulate 🖓	9 1		chain bridle, mild steel
Cups G 500 x21		1	40	m	wire 7mm
Star-Oddi sn1010 T,P,pitch,roll		1	4		wire 7mm as tether
IRS controller #1, body #2	1050m	Insulate	$1^{1}$		tripod SS316
nous hollons aluga uD	105011	Insulate Y	2.1	m	sed trap SS316 frame, IRS (TS mode) chain bridle, mild steel
E new battery plugs x2		insulate	_ 110		wire 7mm
Nortek Aquadopp		5 flts 🛛	8 5		floats, glass 17" on chain 13mm
sn AQD 6622			50	m	wire 7mm
Details			1 4		
Wire: torque balanced (TBW)		T	1	m	current meter, SS cage, vaneless
7mm wire terminations swaged & proof tested		_	_ 200	m	wire 7mm
9mm wire terminations swaged		5 flts	3	m	floats, glass 17" on chain 13mm
& proof tested (1st CSIRO batch!)		Swivel	500		wire 7mm
Chain: proof coil galv (PCG)		5 fits 🛛	2 3	m	floats, glass 17" on chain 13mm
Swivels:Blueline pn (A402), SWL 2to	on,	0 m 0	- 50	m	wire 7mm
greased		Insulate	4		wire 7mm as tether
		Insulate	> 1	m	tripod SS316
McLane sn 11649-01, short			/ 2	m	sed trap Ti frame, McLane
Cups T250 x21	2000m	Insulate 🖓	7 1		chain bridle, mild steel
			350		wire 7mm
		8 flts 😽	<mark>5 _3</mark>		floats, glass,17" on chain 13mm
Tripod detail			500	m	wire 7mm
wire, ms, ~4m long		I	500		
wire termination, ms shackle ms 2t			500		wire 7mm
shackle, pin up, ss : insulate pin		6 flts	3		floats, glass,17" on chain 13mm
ring, ss, with 12-14mm lift rope		Swivel	500		wire 7mm
shackle, pin down, ss		6 flts 🖯	<mark>२</mark> 3	m	floats, glass,17" on chain 13mm
tripod top hole, ss			50	m	wire 7mm
McLane sn 11640-01, tilt			4	m	wire 7mm as tether
Cups A 500x21		Insulate	→ 1	m	tripod SS316
RBR TDR-2050, sn 016371	3900m	Insulate	2	m	sed trap Ti frame, McLane
		insulate H	7 1	m	
Landing site (triangulated) Degrees & minutes			300	m	wire 7mm
Degrees & minutes 46° 50.229'S 141°40.710'E			5		floats, glass,17" on chain 13mm
Decimal degrees		7 flts	<mark>5</mark> 200		wire 7mm
-46.8371, 141.6785		Swivel	L		SBE microcat 37, clamped, sn 8597 ,P,T,s
	colour	red 8 fits 🛛	<mark>२</mark> 5	m	floats, glass,17" on chain 13mm
		<u> </u>	50	m	wire 9mm
2x releases 8242xs sn 34060, 340	)61		1.4	m	releases
12 min. 30 sec. for pickup fits to s			0.5		release chain + big ring
13 min. 24 sec. for mast to surfac			15		nylon snatch strap, 65mm wide
77 min. for bottom floats to surfac	e		100	m	wire 9mm
Seafloor: nominal 4600 m,			4		chain 16mm (rub-while-u-wait chain)
triangulated 4591 m single stack anchor 2 ms plates, 5			3 1.2	m	10001 1 1 10001 1
	man uch only		1 2	m	anchor ~1800kg in air ~1565kg wet

Figure 5: SAZ-16 mooring diagram

## **CSR/ROSCOP PARAMETER CODES**

### METEOROLOGY

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

#### PHYSICAL OCEANOGRAPHY

- H71 Surface measurements underway (T,S)
- H13 Bathythermograph
- H09 Water bottle stations
- H10 CTD stations
- H11 Subsurface measurements underway (T,S)
- H72 Thermistor chain
- H16 Transparency (eg transmissometer)
- H17 Optics (eg underwater light levels)
- H73 Geochemical tracers (eg freons)
- D01 Current meters
- D71 Current profiler (eg ADCP)
- D03 Currents measured from ship drift
- D04 GEK
- D05 Surface drifters/drifting buoys
- D06 Neutrally buoyant floats
- 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

## 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
- B01 Primary productivity
- B02 Phytoplankton pigments (eg chlorophyll, fluorescence)
- B71 Particulate organic matter (inc POC, PON)
- B06 Dissolved organic matter (inc DOC)
- B72 Biochemical measurements (eg lipids, amino acids)
- B73 Sediment traps
- B08 Phytoplankton
- B09 Zooplankton
- B03 Seston
- B10 Neuston
- B11 Nekton
- B13 Eggs & larvae
- B07 Pelagic bacteria/micro-organisms
- B16 Benthic bacteria/micro-organisms
- B17 Phytobenthos
- B18 Zoobenthos
- B25 Birds
- B26 Mammals & reptiles
- B14 Pelagic fish
- B19 Demersal fish
- B20 Molluscs
- B21 Crustaceans
- B28 Acoustic reflection on marine organisms
- 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