Voyage Plan **IN2015_V01**

Title

IMOS SOUTHERN OCEAN TIME SERIES AUTOMATED MOORINGS FOR CLIMATE AND CARBON CYCLE STUDIES SOUTHWEST OF TASMANIA

Itinerary

20-21 March 2015 Hobart mobilisation
depart as soon as possible on 21 March

31 March 2015 Hobart return
1 April 2015 Hobart demobilisation

Principal Investigator
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Scientific objectives

The Southern Ocean has a predominant role in the movement of heat and carbon dioxide into the ocean interior moderating Earth's average surface climate. SOTS uses a set of three automated mooring 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.

Voyage objectives

The primary objective is to deploy a full set of SOTS moorings (SOFS, Pulse, and SAZ) and to obtain ancillary information of the oceanographic conditions at the time of deployment using CTD casts, underway measurements, the Triaxus towed body, and deployment of autonomous profiling "Bio-Argo" floats.

Each of the SOTS moorings delivers to specific aspects of the atmosphere-ocean exchanges, with some redundancy:

i) the Southern Ocean Flux Station (SOFS) focuses on air properties, ocean stratification, waves, and currents.

ii) the Pulse biogeochemistry mooring focuses on processes important to biological CO_2 consumption, including net community production from oxygen measurements and nitrate depletion, biomass concentrations from bio-optics and bio-acoustics, and collection of water samples for nutrient and plankton quantification.

iii) the SAZ sediment trap mooring focuses on quantifying the transfer of carbon and other nutrients to the ocean interior by sinking particles, and collecting samples to investigate their ecological controls.

Additional water sampling and sensor comparisons against shipboard systems provide quality control and spatial context, which is further augmented by Bio-Argo float and Triaxus towed body deployments, and satellite remote sensing.

Priority-ranked list of tasks to achieve the overall objectives:

1. Deploy SOFS-5 meteorology mooring
2. Deploy Pulse-11 biogeochemistry mooring
3. Deploy SAZ-17 sediment trap mooring
4. Recover SAZ-16 sediment trap mooring
5. Do CTDs (2 casts to 2250m) at the SOTS site, including collecting samples for nutrient, oxygen, dissolved inorganic carbon, alkalinity, and particulate matter analyses.
6. Do ancillary underway measurements, including:
    a) Clean and trace-clean underway water supply sampling and sensor measurements
    b) meteorological observations
    c) bio-acoustics using shipboard multi-beam/multi-frequency system
7. Deploy 2 SOCCOM autonomous profiling floats – 1 at SOTS site, one during transit to or from Hobart to SOTS site. Do a CTD cast to 2250m prior to each deployment
8. Tow MacArtney Triaxus to and/or from SOTS site, and one or more nights while at SOTS site.
9. Tow CPR to and/or from SOTS site

Overall activity plan including details for first 24 hours of voyage
(Approximate timings, subject to weather and operational revision)

2015-03-20/21: mobilise – load all equipment and spool on SOFS-5 mooring
Depart as soon on 21 March as possible.

2015-03-21: test CTD, Triaxus, and mooring deck procedures in Storm Bay, begin transit

2015-03-22/23: continue transit to SOTS mooring site towing Triaxus, and doing underway sensor observations, possibly with one stop to do 1 CTD cast and deploy 1 SOCCOM Argo float.

2015-03-23: In day deploy SOFS-5 mooring; at night pump water to fill incubation bags and collect underway data (seawater and air sensors, mooring triangulation).

2015-03-24: in day spool on Pulse-11 mooring and set up deck for Pulse and SAZ mooring work while mapping with Triaxus near SOTS site; at night continue Triaxus mapping and underway data collection.

2015-03-25: in day deploy Pulse-11 mooring; at night underway data collection.

2015-03-26: in day spool on SAZ-17 mooring at set up deck for its deployment; at night collect underway data.

2015-03-27: in day deploy SAZ-17 mooring; at night collect underway data

2015-03-28: recover SAZ-16 sediment trap mooring; at night do two CTD casts and deploy remaining SOCCOM Argo float.

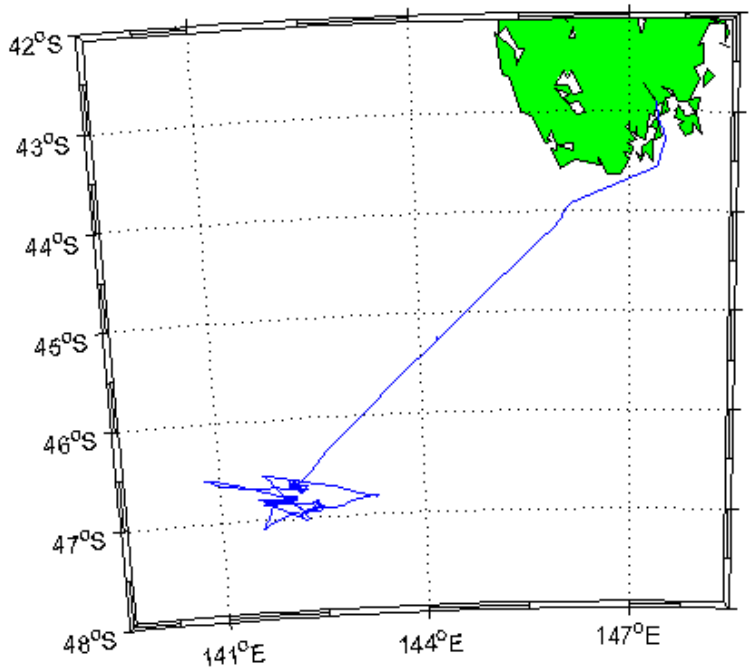
2015-03-29: *weather day*

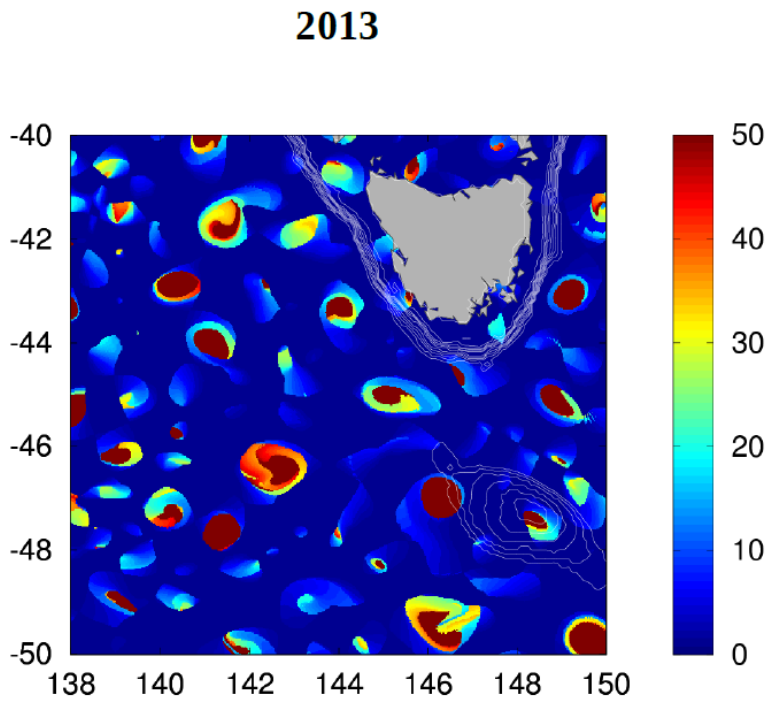
2015-03-30: *half weather day,* depart ~16:00 for Hobart

2015-03-31: return to Hobart, towing Triaxus or CPR, collecting underway data, (possibly with one stop to do 1 CTD cast and deploy 1 SOCCOM Argo float if not done on southbound transit)

2015-04-01: 08:00 arrive Hobart, demobilise

Voyage track example: the exact path to and from Hobart at the SOTS site will depend on eddy features as identified by near real time satellite altimetry (e.g. as present in 2013 and coloured by their water retention times in days). The goal is to cross eddy centres during the transit and map them more extensively near the site.





Waypoints and stations

Transit time estimates at 11 knots (total 3 days), but note that transit will be slower ~8 knots while towing Triaxus oscillating body.

	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

Individual Mooring Locations:

SOFS-5 Target:	46^{o} 39.865'S	142^{o} 03.767'E	4650 m depth
Pulse-11Target:	46^{o} 51.303'S	142^{o} 22.328'E	4350 m depth
SAZ-17 Target:	46^{o} 49.824'S	141^{o} 38.981'E	4600 m depth
SAZ-16 Current:	46° 47.603’S	141° 49.392’E	4531 m depth

Piggy-back projects

1. Composition of phytoplankton

Philip Heraud, Monash University

The scientific objectives are to characterize phytoplankton elemental and molecular compositions to understand their variability, links to environmental conditions, and roles in biogeochemical cycles.

The voyage objective is to obtain samples by filtering the ship's underway seawater supply and Niskin bottle samples collected with the CTD-Rosette system.

2. Properties of Southern Ocean Clouds and Aerosols

Alain Protat, BOM
Melita Keywood, CSIRO

The scientific objectives are to characterize cloud and aerosol properties using physical and chemical sensor measurements and sample collections.

The voyage objectives are to install and operate cloud radar and aerosol sampling systems.

3. Southern Ocean Carbon Cycling Observations and Modeling (SOCCOM)

Lynne Talley, Scripps Institution of Oceanography
Jorge Sarmiento, Princeton University
and the SOCCOM consortium (www.soccom.org)

The scientific objectives are to determine the interactions between changing Southern Ocean circulation and stratification and the physical and biological uptake of carbon dioxide and associated ecosystem impacts. The approach is to deploy autonomous profiling floats with new generation sensors in bio-optical sensors for microbial biomass, oxygen sensors to determine ocean ventilation, pH sensors to examine ocean acidification, and nitrate sensors to track biological productivity.

The voyage objectives are to deploy 2 autonomous profiling floats, each accompanied by a CTD cast to 2250m.

Investigator equipment

Trawl Deck Equipment and Support:

1. Stern-ramp cover ("dance-floor***")*** without overhanging lip on aft surface installed with gap protectors and mounts for user-supplied Bulls Horns fairlead.
2. A-frame utility winches refitted with non-elastic polymer cables and light weight heads and lifting hooks for safe working conditions.
3. Tagging line cleat attachment points fitted.
4. 2 container slots free for installation of user-supplied containers and deck clear for installation of a third container on starboard aft quarter

O2 Deck Equipment and Support

1. Netdrum winch in working order, with non-elastic polymer working line fitted

CTD Equipment and Support

1. minimum 24-bottle CTD-rosette with 10L Niskin bottles and O_2, PAR, US SOCCOM special fluorometer, and transmissometer sensors mounted.
2. CTD voltage inputs calibrated to correctly log sensor inputs
3. MNF supplied hydrochemist to carry out oxygen sensor calibrations on land and analyses at sea (priority), as well as salinity and nutrient analyses.
4. WOCE/Go-Ship compliant CTD data processing and output files to be provided, including error estimates for oxygen and nutrient parameters

Underway Equipment and Support

1. Triaxus towed body and towed body winch, with user-supplied SUNA and FIRE sensors mounted, and MNF supplied electronics, computing, and piloting support
2. Multibeam/Multifrequency bio-acoustic system, with MNF supplied electronics, computing, and piloting support
3. Working and logging underway echosounder with bottom detection and real-time display
4. Working and logging underway ADCP, with real-time display
5. Working and logging underway thermosalinograph and fluorometer and real-time display
6. Working hull mounted 12 kHz transducer for use with acoustic release deck unit
7. Working drop keel for thermosalinograph and ADCP data gathering
8. Working and logging meteorological instruments including ISAR SST radiometer

User Equipment

* Items for piggy back project 1, ** Items for piggy back project 2, *** Items for piggy back project 3

For Installation on Trawl Deck (see deck loading plan):

1. CSIRO mooring winch - requires hydraulic leads to power supply installed in shelter
2. 2xhalf-height open-top containers to hold mooring equipment
3. Full height container for storing and working on sediment traps, RAS instrument package, and SOCCOM Argo floats*** – requires monophase 240V 15-30 amp power supply
4. SOFS float and recovery cradle
5. Pulse float and recovery cradle
6. Pulse damper and UBE 3-float pack
7. Pulse RAS instrument package
8. three mooring anchors
9. up to ~10 cage pallets of mooring equipment
10. pneumatic line thrower ("grappling cannon") – requires welding or other mounting arrangements on aft port and starboard rails.
11. Video cameras

For installation elsewhere:

1. acoustic release deck unit to be mounted in the Ops room (and spare unit stored)
2. radio-direction-finder and Argos antennae to be mounted on the monkey island, and the associated receiving units on the ship's bridge.
3. **BOM-Protat Basta Radar unit for clear-sky deck installation
4. **CSIRO-Keywood multiple instruments in Air Chemistry Laboratory (installed during IN2015_E01)
5. **CSIRO-Keywood multiple instruments in Aerosol Laboratory (installed during IN2015_E01)

For installation in the General Purpose (Clean) Laboratory:

1. Trull filtration system for collection of particulate matter samples from underway supply and CTD casts
2. * Heraud filtration system for collection of particulate matter samples from underway supply and CTD casts
3. * Heraud Laser Raman instrument for measurement of phytoplankton compositions
4. * Heraud Fourier Transform Infra-Red Spectrometer for measurement of phytoplankton compositions

For installation on the Triaxus towed body:

1. SUNA nitrate sensor
2. FIRE fluorescence induction and relaxation sensor

Special Requests

Please see the above ***Investigator Equipment*** and ***User Equipment*** lists for installation support requests.

Separate documents provide detailed procedures and risk management for:

1. Mooring deployments
2. Triaxus deployments
3. Argo float deployments

Permits

Collection of seawater and sediment trap samples for return to Hobart under ACE CRC Quarantine permit #IP115003079.

Transfer of seawater and sediment samples from Hobart under Quarantine Permits Monash#IP13020876

Mooring locations and buoy marking details will be provided to AMSA for notice to mariners.

Personnel List

List all scientific participants, their affiliation and role on the voyage

1	Max McGuire	MNF	Voyage Manager
2	Steve Thomas	MNF	SIT electronics support
3	Will Ponsonby	MNF	SIT electronics support
4	Pamela Brodie	MNF	DAP computing support
5	Steve Van Grasse	MNF	DAP computing support
6	Bernadette Heaney	MNF	GSM support
7	Mark Rayner	MNF	Hydrochemist
8	Christine Rees	MNF	Hydrochemist
9	Brett Muir	MNF	Triaxus support
10	Tom Trull	CSIRO-ACE	Chief Scientist
11	Eric Schulz	BOM	Co-Chief Scientist
12	Peter Jansen	IMOS-UTAS	Mooring Managing Engineer
13	Jim LaDuke	CSIRO	Mooring deck work
14	Jamie Derrick	CSIRO	Mooring Technical Supervisor
15	Mark Rosenberg	ACE-UTAS	Mooring Technical Supervisor
16	Abe Passmore	ACE-UTAS	sediment traps
17	Rob Newham	UTAS	Honours student
18	Alice della Penna	UTAS-UParis	PhD student
19	Phillip Heraud	Monash Univ	Phytoplankton composition
20	Olivia Sackett	Monash Univ	Phytoplankton composition
21	Katerina Petrou	Monash/UTS	Phytoplankton composition
22	Alain Protat	BOM	Clouds study leader
23	Ken Glasson	BOM	Radar instrument specialist
24	Melita Keywood	CSIRO	Aerosol measurements
25	Jason Ward	CSIRO	Aerosol measurements
26	Natasha Henschke	UNSW	LOPC instrument specialist
27	Henrique RapizoGomes	Swinburne	SOFS wave/turbulence
28	Phil De Boer	CSIRO	Mooring Technical Supervisor
29	Brandon Beneford	EEC	Weather radar
30	Emily O'Brien	AMC	FRMS

Certification

Thomas W Trull
IN2015_V01Chief Scientist
ACE CRC Carbon Program Leader
CSIRO Oceans & Atmosphere Senior Scientist

5 March 2015

List of additional figures and documents:

Figures:

Figure 1. SOFS-5 mooring

Figure 2. Pulse-11 mooring

Figure 3. SAZ-17 mooring

Figure 4. SAZ-16 mooring

Documents Provided Separately:

SOFS Mooring Deployment Procedure

Pulse Mooring Deployment Procedure

SAZ Mooring Deployment Procedure

SAZ Mooring Recovery Procedure

Argo float deployment procedure (provided by CSIRO Argo Facility)

Triaxus deployment procedure (provided by MNF)