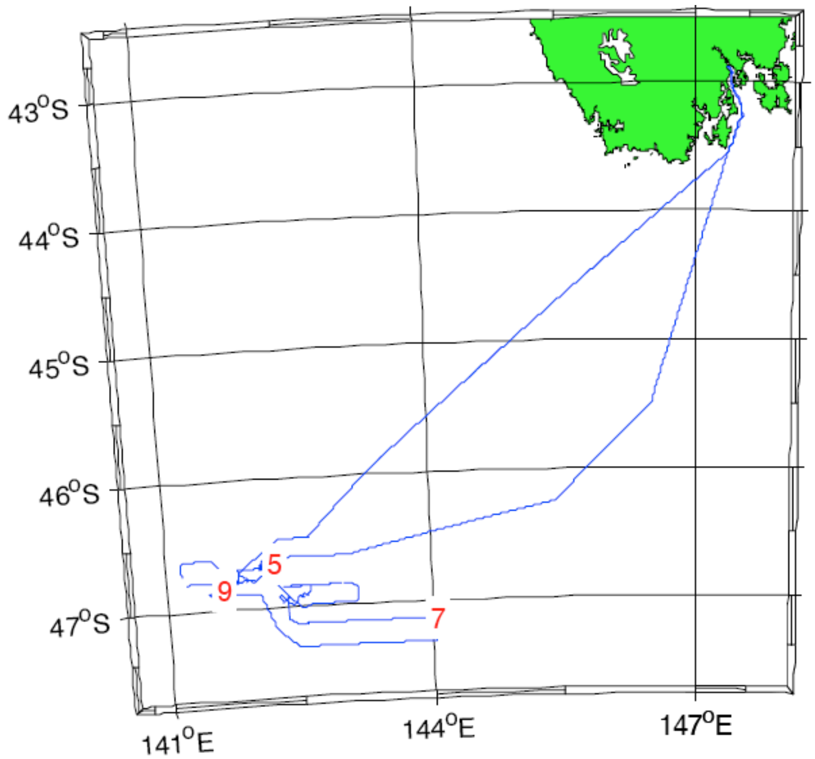
CRUISE REPORT: IN2015_V01

(Updated AUG 2016)



Highlights

Cruise Summary Information

Section Designation	**IN2015_V01 (SOTS)**
Expedition designation (ExpoCodes)	**096U20150321**
Chief Scientists	**Dr Tom Trull / CSIRO, Eric Schulz /BOM**
Dates	2015-03-21 - 2015-03-30
Ship	*R/V Investigator*
Ports of call	Hobart
Geographic Boundaries	46° 40' 1.2" S 141° 34' 7" E 144° 1' 12" E 47° 9' 5" S
Stations	4 ctd stations
Floats and drifters deployed	2 autonomous profiling floats,
Moorings deployed or recovered	3 moorings deployed, 1 recovered

Contact Information:

Professor Thomas Trull Antarctic Climate & Ecosystems Cooperative Research Centre Hobart, Tasmania Phone: (03) 6226 2988 Email: tom.trull@csiro.au	Eric Werner Schulz Australian Bureau of Meteorology Oceanography, Meteorology E.Schulz@bom.gov.au

Links To Select Topics

Shaded sections are not relevant to this cruise or were not available when this report was compiled.

Cruise Summary Information	Hydrographic Measurements
Description of Scientific Program	**CTD Data:**
Geographic Boundaries	Acquisition
Cruise Track (Figure): PI CCHDO	Processing
Description of Stations	Calibration
Description of Parameters Sampled	Temperature Pressure
Bottle Depth Distributions (Figure)	Salinities Oxygens
Floats and Drifters Deployed	**Bottle Data**
Moorings Deployed or Recovered	Salinity
	Oxygen
Principal Investigators	Nutrients
Cruise Participants	Carbon System Parameters
	CFCs
Problems and Goals Not Achieved	Helium / Tritium
Other Incidents of Note	Radiocarbon
Underway Data Information	**References**
Navigation Bathymetry	
Acoustic Doppler Current Profiler (ADCP)	
Thermosalinograph	
XBT and/or XCTD	
Meteorological Observations	**Acknowledgments**
Atmospheric Chemistry Data	
Data Processing Notes	

TABLE OF CONTENTS

Marine
National Facility

RV Investigator

Voyage Summary

Voyage #	IN2015_VO1	
Voyage title:	IMOS Southern Ocean Time Series automated moorings for climate and carbon cycle studies southwest of Tasmania	
Mobilisation:	Hobart, Friday, 20 March 2015	
Depart:	0900, Hobart, Saturday, 21 March 2015	
Return:	0900, Hobart, Monday, 30 March 2015	
Demobilisation:	Hobart, Monday, 30 March 2015	

Voyage Manager:	Max McGuire	Contact details: max.mcguire@csiro.au
Chief Scientist:	Tom Trull	
Affiliation:	CSIRO O&A	Contact details: tom.trull@csiro.au
Co-PI:	Eric Schulz	
Affiliation:	Bureau of Meteorology	Contact details: E.Schulz@bom.gov.au

OBJECTIVES AND BRIEF NARRATIVE OF VOYAGE

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. The Southern Ocean Time Series observatory (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 was 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:

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

- the Pulse biogeochemistry mooring focuses on processes important to biological CO2 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.

- 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 provided quality control and spatial context, which was further augmented by Bio-Argo float and Triaxus towed body deployments, and satellite remote sensing.

The voyage also supported several ancillary projects:

1. Composition of phytoplankton, Philip Heraud, Monash University

The scientific objectives were to explore the use of spectroscopic techniques characterize phytoplankton elemental and molecular compositions to understand their variability, links to environmental conditions, and roles in biogeochemical cycles. The voyage objective was 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 were 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, and the SOCCOM consortium
(www.soccom.org)

The overall 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 was 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 were to deploy 2 autonomous profiling floats, each accompanied by a CTD cast to 2250m.

4. Continuous Plankton Recorder Survey, Anthony Richardson, CSIRO/UQ

The voyage objective was to tow a CPR on one leg to provide plankton samples for microscopic identification, as part of the broader collection of samples and characterization of plankton communities in the waters of Australian coastal and regional seas.

Priority-ranked list of tasks to achieve the overall objectives (from Voyage Plan):

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 clean and trace-clean underway water supply sampling and sensor measurements, meteorological observations, and 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

Results

Amazingly, essentially all planned tasks were fully achieved for the core project and all ancillary projects. This is a huge achievement, made possible by the weather, the capabilities of the ship, and the professionalism of MNF, ASP, and the science project teams. The ability to include ancillary project teams also led to new collaborations, including one featured in our Science Highlights below.

There were only two exceptions:

1. commitment to supporting the ancillary cloud radar observations meant that a planned final tow of the Triaxus on the return leg to Hobart could not be fit in ahead of the MNF operational need to dock early in the morning on Monday 30 March 2015. This outcome emphasizes the new challenges that come with the advantages of larger science parties.
2. evaluation of the fidelity of the underway seawater supply for dissolved oxygen sampling by comparison to CTD-Niskin samples was compromised by a blocked intake. There is a need to make intake cleaning a standard procedure, supported by intake pressure measurements being available to the ship crew.

Counterbalancing these shortfalls were the completion of activities beyond those in the initial Voyage plan, including:

1. an additional Argo float was deployed for the IMOS Argo facility
2. an additional CTDs was completed to 1500m to collect deep seawater for use by the MNF Hydrochemistry and CSIRO Calibration Facility teams.
3. collection of cloud radar data during a satellite overpass for ancillary project 3.

Voyage Narrative

Saturday 21 March 2015 Calm water procedures practice

After a final lift to re-load the towed body winch following re-certifying it for ancillary use with mooring work, we departed at 0900. We adjusted the compass off Battery Point and proceeded to Adventure Bay for equipment testing and procedure practice. The CTD deployment from the coring boom was difficult but ultimately successful, although sensor logging was not fully successful. Mooring practice work focused on familiarization of crew and project teams with user and ship equipment and procedures for lift of the SOFS float. The practice was very beneficial and revealed the advantages of remote control of the A-frame and winches, but also some limitations. The remote control box is not intuitive, responds slowly, and can easily lead to unwanted and unexpected actuations of the hydraulics. This is an important safety issue and needs attention to resolve it - with a dedicated box for just the winches and A-frame as used in high risk work.

Sunday 22 March 2015 Transit and Triaxus Tow

During this transit day the mooring deployment procedures were reviewed by the crew, MNF, and science teams. We carried out a very successful first tow of 6 hours of the Triaxus, with successful data collection from all instruments including the newly mounted SUNA nitrate and FIRe variable fluorescence instruments. There remains some work to do to implement logging of all data streams in a uniform way, rather than on an instrument by instrument basis. Late in the tow, one CTD channel was lost, which appears to have resulted from clogging by a salp (as the Triaxus was coated with the remains of many salps when recovered). Development of a shield for the intakes or their reorientation may be required. Some data loss also occurred for the FIRe instrument owing to problems with the project supplied laptop used for its logging. During the Triaxus tow we collected a suite of particle samples from the underway science seawater supply for chemical and biological characterization.

Monday 23 March 2015 Deployment of SOFS-5

We made the decision to proceed with deployment of the drogued top end of the mooring at our "Go/No-go" meeting at 0630, but reserved the right to cancel launch of the SOFS-5 surface float if the weather worsened. It lightened and we launched the float at 1200 and recovered its trailing end about 1300. The ship approach to the float was initially on the starboard side, but had to switch to the port side as we came into range for grappling. Reconnection of the line to the ship is difficult on this side because the electrical box on the stern is a severe hindrance and should be relocated (as previously recommended in our IN2014_E04 report). We proceeded to deploy the mooring and released the anchor about 22:20 after a long day on deck. We ran 3-mile repeat weather legs through the night for sensor comparisons between the ship and SOFS-5 mooring instruments.

Tuesday 24 March 2015 Spooling on of Pulse-11

We began work at 0800 to spool on the Pulse-11 mooring, while carrying out a CTD cast to 2250m. Sensor display during the downcast was problematic, but correct during the upcast. 22 of 24 Niskins properly closed and were sampled by MNF hydrochemists and the project team for O2, DIC, ALK, salinity, nutrients, pigments, particulate organic carbon, and coccolithophores. Worsening weather precluded the planned tow of the Triaxus, and we carried out triangulation of the SOFS-5 anchor position, and then swath mapping of the Pulse-11 deployment target site and a survey of oceanographic properties to the southeast of SOTS using the underway sensors.

We experienced flooding of the main CTD room, Underway laboratory, and Hydrochem laboratory on the northerly leg of this survey when the ship was tilted to starboard, from water upwelling from the scuppers.

This presents both safety hazards (slipping in the labs) and science quality issues (dirty conditions in the labs) and needs attention.

We held a well-attended SOFS-5 post-deployment discussion which revealed several issues that need attention to improve the safety of the mooring deployment operation. These issues and others raised in the post-deployment meetings held after each deployment and recovery are presented in Appendix 3.

Weds 25 March 2015 Deployment of Pulse-11 and overnight Triaxus tow 2

Deck preparations began at 0600, ahead of the Go/No-Go decision meeting and mooring Toolbox held on the bridge at 730. This approach provides experience with working on deck prior to making the decision, as well as an early start on the preparation work. We agreed to proceed in light southeasterly winds and remnant 4m westerly swell, working slowing into the swell in anticipation of a westerly wind change later in the day. Deployment went smoothly, but strengthening south-east winds forced us to head south of the initial deployment target, and into water depths greater than that acceptable for the mooring design. With the mooring streaming astern we then towed back towards the alternate Pulse-11 site and deployed in acceptable water depth. Overnight we mapped bathymetry while moving east to cross into a warm-core eddy feature in preparation for deployment of and sampling by the Triaxus the next day.

Thurs 26 March 2015 Spooling on of SAZ-17

We began spooling at 0800 and simultaneously carried out CTD-7, followed by deployment of the Argo float Hull 6381i and SOCCOM Float 8514 while underway at 1 knot. We then lined up 1 hour south of the CTD for our Triaxus tow to the west, but electrical faults precluded deployment and we carried out another CTD cast to collect water for the hydrochemistry and calibration labs. After tracing the fault to high current draw by the FIRe instrument in unusual start-up configuration, we proceeded with the Triaxus tow overnight with ancillary underway sampling. We held the Pulse-11 post-deployment debriefing (the main outcome was to note that operations for deployment of the 'string-of-pearls' floats at the top of the s-tether would be much easier with the netd rum winch relocated to the deck).

Friday 27 March 2015 Deployment of SAZ-17 mooring

We recovered the Triaxus just before 0600. The left lower tail cone was missing on recovery and appears to have vibrated free owing to failure of the adhesive connection between its mounting tangs and the main fuselage. The failure was disappointing but not crucial as data collection was not interrupted and control and operation of the Triaxus unchanged. Salps had again affected CTD channels to some extent during the tow (loss of secondary oxygen). We then deployed the SAZ-17 mooring. This went very smoothly and was completed by mid-afternoon, allowing us to hold a post-deployment briefing (no issues arose), complete another CTD to 2250m, and launch the second and final SOCCOM float. We then proceeded to triangulate the SAZ-17 mooring and successfully verify acoustic communication with the SAZ-16 mooring. We spent the night swath mapping, before setting up 1 mile downstream of the SAZ-16 anchor to be ready for recovery.

Saturday 28 March 2015 Recovery of SAZ-16 mooring

After our formal Go decision at 0630, we released the mooring at 0710 (first light). The mast was sighted approximately 20 minutes later, and was grappled on the port stern quarter. The mast and first pack of 16 glass floats had tangled and were recovered together. All equipment was recovered in good condition, with full sample returns from all four sediment traps. The final two float packs had also tangled and were again recovered together. We held a post-deployment discussion with all involved, which raised no concerns and emphasized that things went particularly smoothly as a result of increased familiarity with ship systems and mooring procedures by the crew. We remained in the SOTS region until 2100 in anticipation of an arriving storm front with clouds that could be simultaneously surveyed from the ship cloud radar and from above by a satellite overpass. We then departed towards Hobart towing the CPR.

Sunday 29 March 2015 Triaxus survey of persistent anti-cyclonic eddy

The planned survey was cancelled to meet MNF operational needs. The CPR tow was continued until retrieval at the Tasmanian shelf edge.

Summary

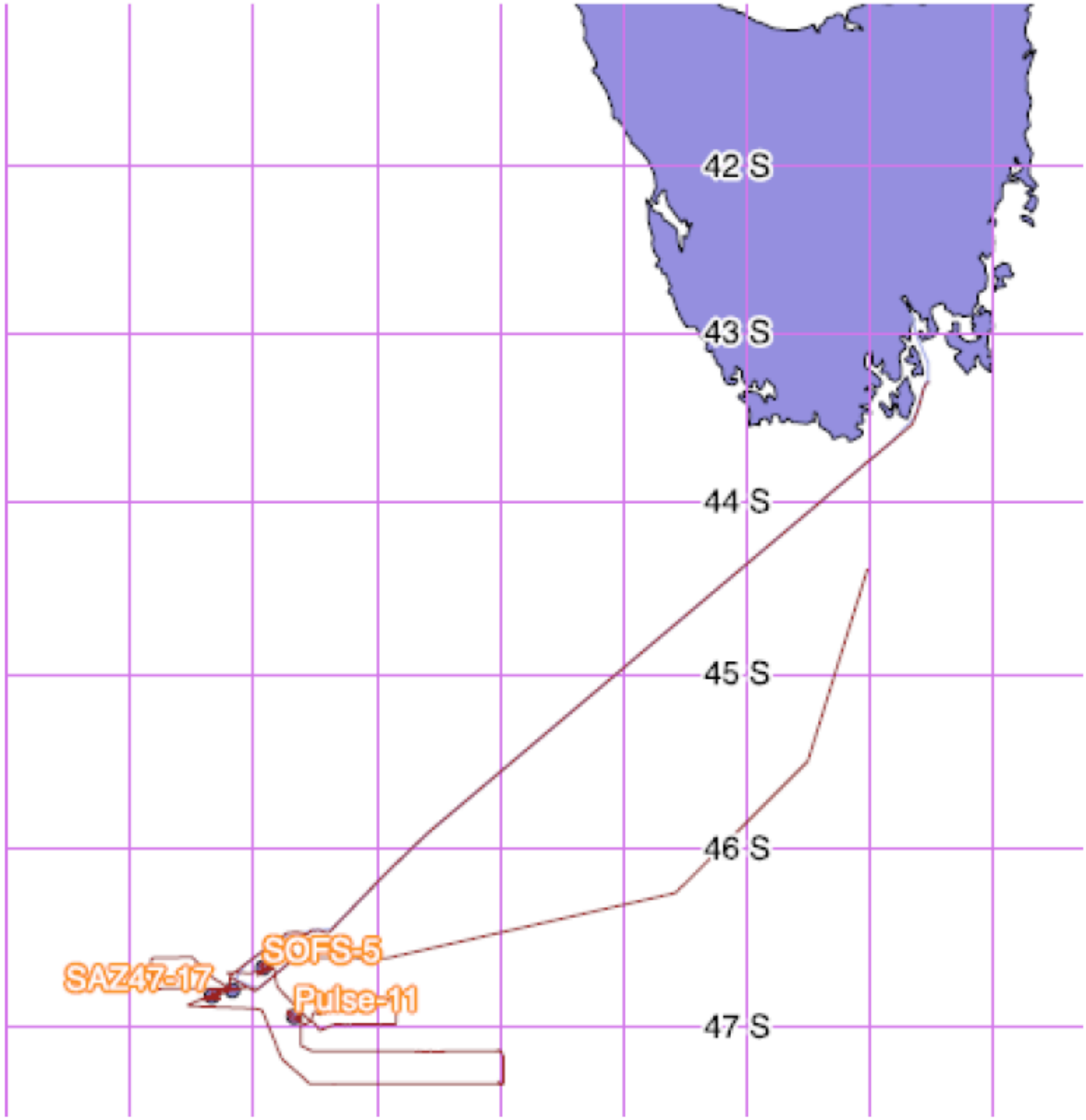
The main success of the voyage was the re-establishment of the Southern Ocean Time Series observatory, via the deployment of the SOFS-5, Pulse-11, and SAZ-17 moorings, along with the recovery of the SAZ-16 mooring. Sample analyses for the recovered SAZ-16 sediment traps will be performed throughout 2015. Tele-metered observations are already live to the internet from the Southern Ocean Flux Station mooring. Observations from the Pulse biogeochemistry and SAZ sediment trap moorings will be available 1-year after their recovery in April 2015. The work was done safely, efficiently, and with 100% completion using new procedures, new personnel, and the new *RV Investigator.*

Triangulated anchor depths and positions for the SOTS moorings:

SOFS-5:	4664m	46.6670S	142.0732 E
Pulse-11:	4240m	46.9405S	142.3261 E
SAZ-17:	4502m	46.8249S	141.6559 E

While these mooring deployments were the main focus, the voyage also achieved an amazing variety of additional scientific results, including via new collaborations with the ancillary projects. A selection of these are presented in the Scientific Highlights section.

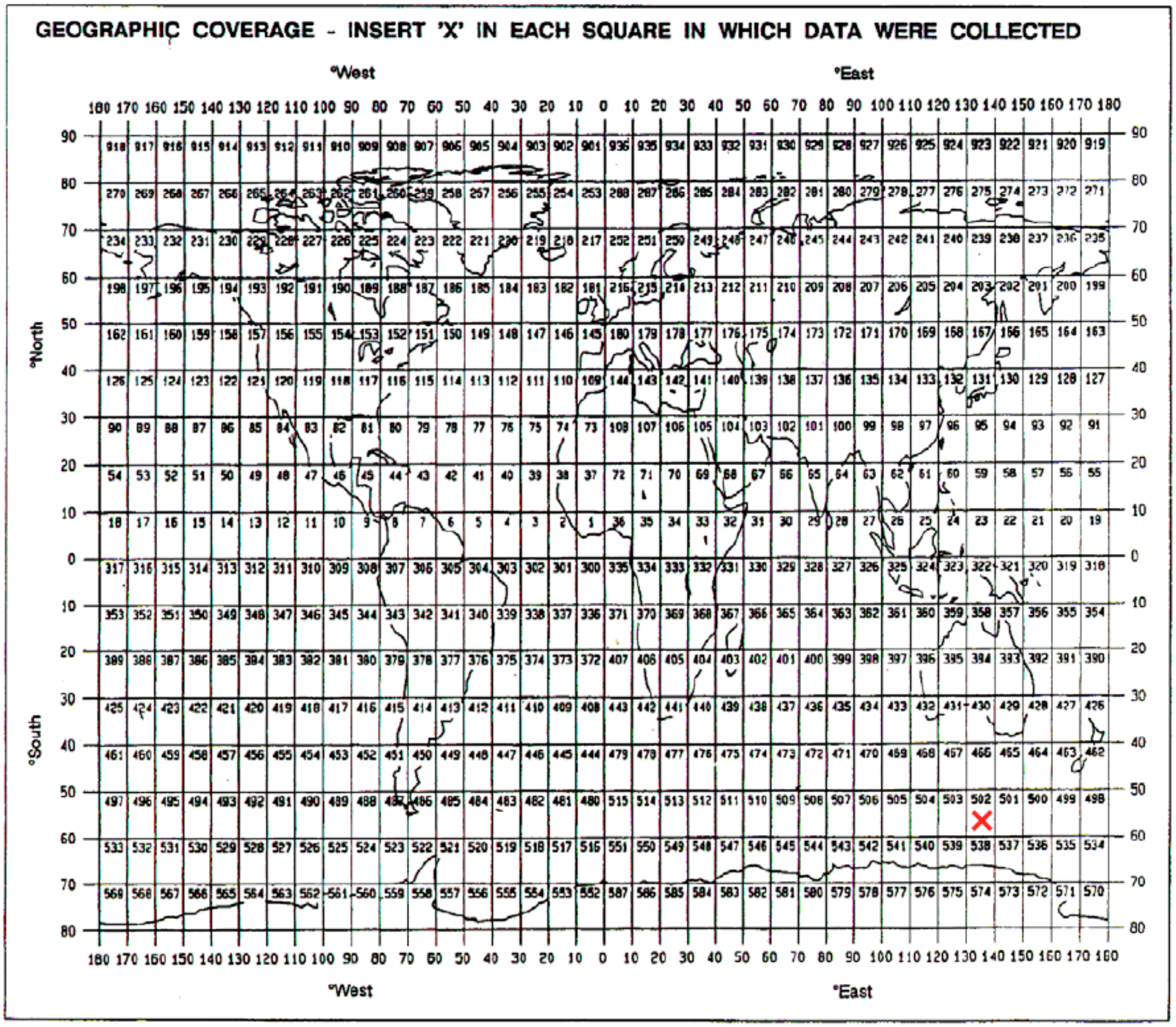
Voyage Track



Marsden Squares

Move a red “x” into squares in which data were collected

× × × × × ×



Principal Investigators

A. Eric Schulz, BOM, E.Schu lz@bom.gov.au
B. Tom Trull, ACECRC/CSIRO, Tom.Trull@csiro.au
C. Melita Keywood, CSIRO, Melita.Keywood@csiro.au
D. Alain Protat, BOM, A.Protat@bom.gov.au
E. Philip Heraud Monash, phil.heraud@monash.edu

Moorings, Bottom Mounted Gear And Drifting Systems

Item No	PI	APPROXIMATE POSITION LATITUDE deg min N/S	LONGITUDE deg min E/W	DATA TYPE	DESCRIPTION
1	A	46 40.02 S	142 4.38 E	M02, M06, M90,H71, DOl, H90, H17, H21	Deployed SOFS-5 air-sea flux mooring, for recovery in April 2016
2	B	46 56.43 S	142 19.566 E	H90	Deployed Pulse-11 biogeochemistry mooring, for recovery in April 2016
3	B	46 49.494 S	141 39.354 E	H90	Deployed SAZ-17 sediment trap mooring, for recovery in April 2016
4	B	46 47.603 S	141 49.392 E	H90	Recovered SAZ-16 sediment trap mooring, deployed inMay 2013
5	B	47 09.5 S	144 01.12 E	H90	Argo profiling float Hull 6381i
6	B	47 8.58 S	144 0.56 E	H90	SOCCOM profiling float ID 8514
6	B	46 50.66 S	141 34.007 E	H90	SOCCOM profiling float ID 9315

Summary Of Measurements And Samples Taken

Item No.	PI	NO	UNITS	DATA TYPE	DESCRIPTION
1	B	1	cast	H10	3 CTD casts to 2250m with T,S,O2,phytoplankton fluorescence, particle backscatter, and beam attenuation sensors, sampled at 24 depths for analyses of nutrients, salinity, DIC, alkalinity, dissolved oxygen ; and particulate organic carbon and pigments at the top 6 depths
2	A	700	miles	H71	Continuous monitoring of underway seawater supply for temperature salinity for study of physical heat and mass flux
3	A	700	miles	M02	Continuous monitoring of incoming short and long-wave radiation for heat fluxes
4	A	700	miles	M06	Continuous monitoring of routine meteorological observations (wind, ait temperature, humidity and pressure) for heat, mass and momentum fluxes
5	A	700	miles	M90	Continuous monitoring of precipitation for mass fluxes
6	B	50	samples	H10	Underway Water Samples for particulate organic carbon, biogenic silica, spectroscopic and pigment analyses

Curation Report

Item No. DESCRIPTION

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

TRACK CHART
See figure below
GENERAL OCEAN AREA(S)
Southern Ocean - Indian Sector
SPECIFIC AREAS
Subantarctic Zone southwest of Tasmania

Personnel List

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 Graase	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.	Abe Passmore	ACE-UTAS	Sediment traps
16.	Rob Newham	UTAS	Honours student
17.	Alice della Penna	UTAS-Uparis	PhD student
18.	Phillip Heraud	Monash Univ	Phytoplankton composition
19.	Olivia Sackett	Monash Univ	Phytoplankton composition
20.	Katerina Petrou	Monash/UTS	Phytoplankton composition
21.	Alain Protat	BOM	Clouds study leader
22.	Ken Glasson	BOM	Radar instrument specialist
23.	Melita Keywood	CSIRO	Aerosol measurements
24.	Jason Ward	CSIRO	Aerosol measurements
25.	Natasha Henschke	UNSW	LOPC instrument specialist
26.	Henrique RapizoGomes	Swinburne	SOFS wave/turbulence
27.	Phil De Boer	CSIRO	Mooring Technical Supervisor
28.	Brandon Beneford	EEC	Weather radar
29.	Emily O'Brien	AMC	FRMS fatigue management study

Marine Crew

Name	Role
Mike Watson	Master
Gurmukh Ngra	Chief Mate
Adrian Koolhof	Second Mate
Andrew Roebuck	Third Mate
Ian Mortimer	Chief Engineer
Mark Ellicott	First Engineer
Michael Sinclair	Second Engineer
Damian Wright	Third Engineer
John Curran	Electrical Engineer
Cassandra Rowse	Chief Caterer

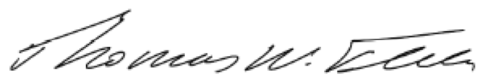
Name	Role
Emma Lade	Caterer
Rebecca Lee	Chief Cook
Matthew Gardiner	Cook
Graham McDougall	Chief Integrated Rating
Jarod Ellis	Integrated Rating
Christopher Dorling	Integrated Rating
Paul Langford	Integrated Rating
Peter Taylor	Integrated Rating
Matthew McNeill	Integrated Rating
Darren Capon	Integrated Rating

Acknowledgements

We are grateful to the MNF and ASP for ship access prior to the mobilization day, and for excellent support at sea. Superb preparation of our mooring equipment included major contributions from shoreside team members Danny McLaughlin, Darren Moore, Stephen Bray, Diana Davies, and Andreas Marouchos. We thank the directors of the MNF, IMOS, and the ACE CRC (Ron Plaschke, Tim Moltmann, and Tony Worby, respectively) for support of SOTS.

Signature

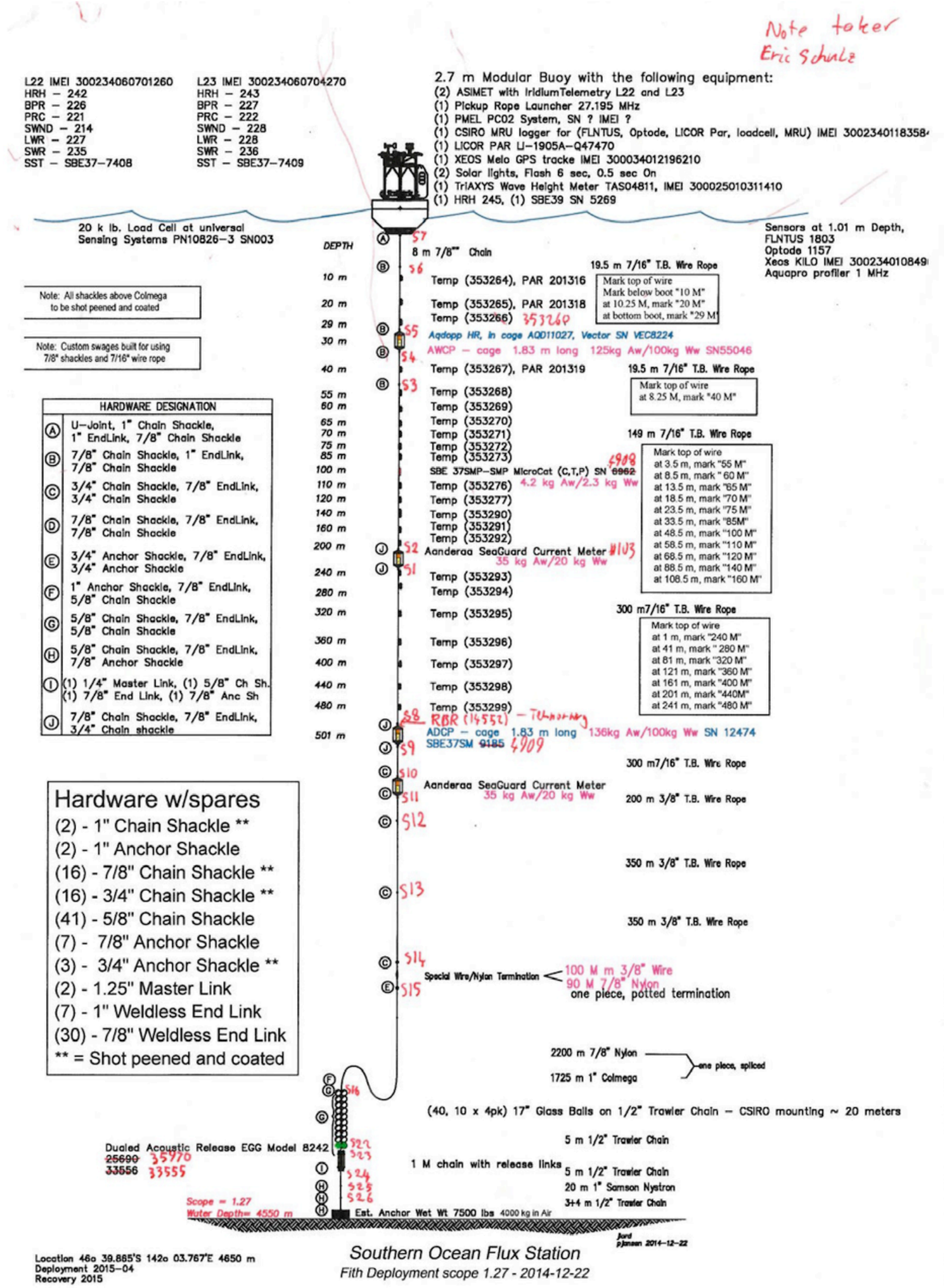
Your name Thomas W Trull
Title Chief Scientist
Signature

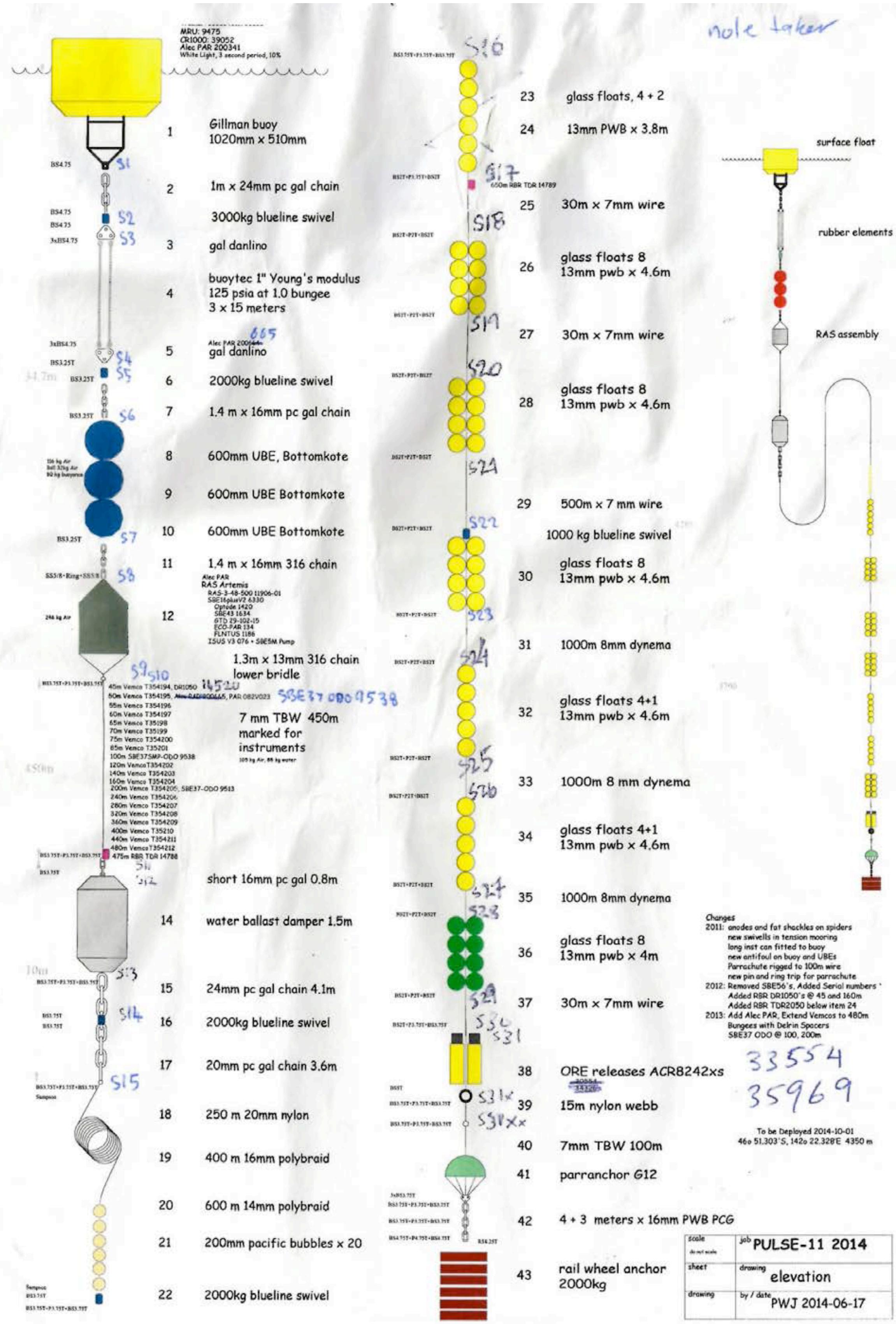


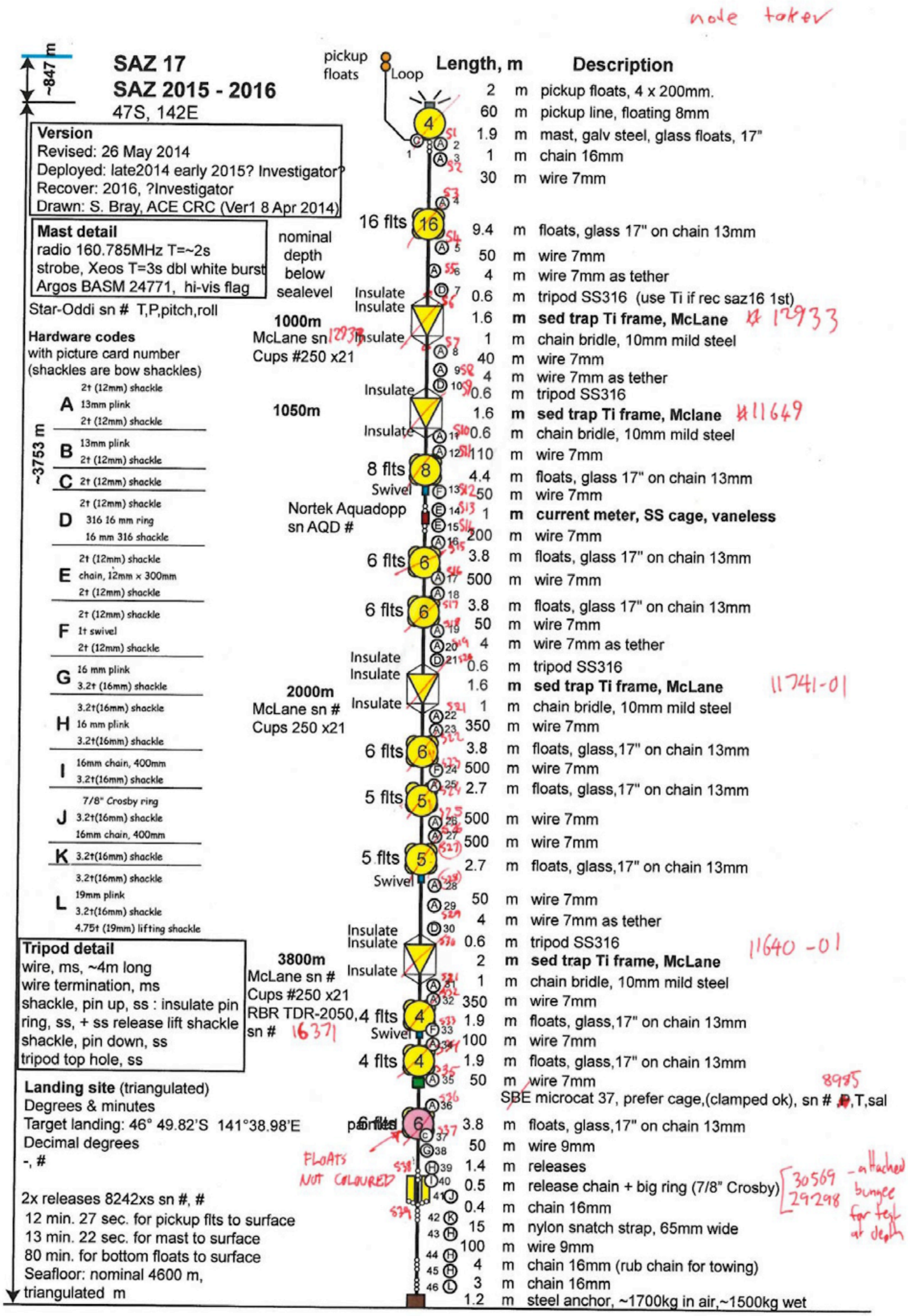
Date: 30 March 2015

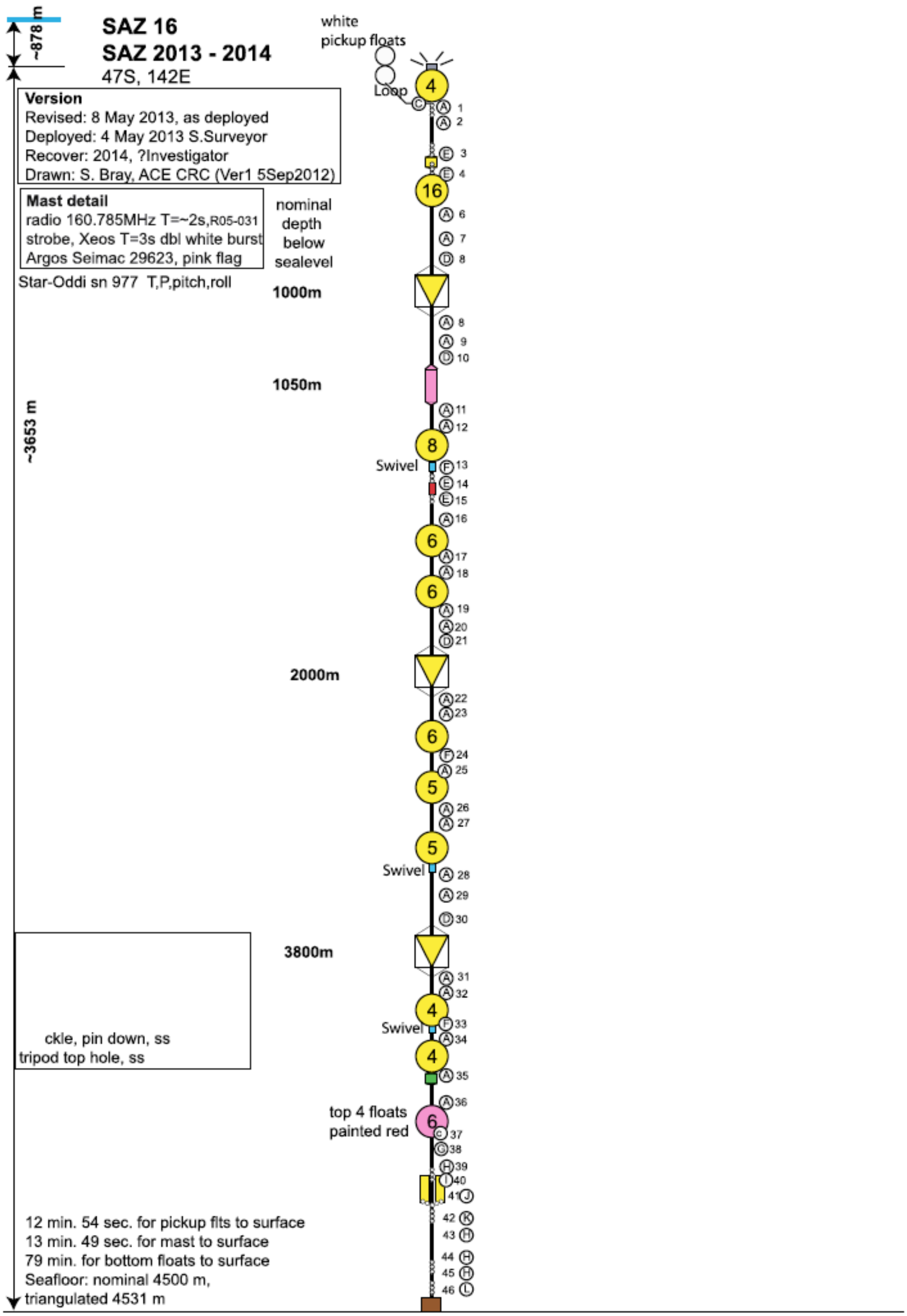
Appendix 1 SOTS Mooring Diagrams
Appendix 2 Post Mooring Deployment De-briefing Notes
Appendix 3 Photos

Appendix 1 SOTS Mooring Diagrams




note taker
MRU: 9475
CR1000: 39052
Alec PAR 200341
White Light, 3 second period, 10%
1 Gillman buoy 1020mm x 510mm
2 1m x 24mm pc gal chain
3000kg blueline swivel
3 gal danlino
4 buoytec 1" Young's modulus 125 psia at 1.0 bungee 3 x 15 meters
Alec PAR 200665
5 gal danlino
6 2000kg blueline swivel
7 1.4 m x 16mm pc gal chain
8 600mm UBE, Bottomkote
9 600mm UBE Bottomkote
10 600mm UBE Bottomkote
11 1.4 m x 16mm 316 chain
Alec PAR
RAS Artemis
RAS-3-48-500 11906-01
SBE16plusV2 6330
Optode 1420
SBE43 1634
GTD 29-102-15
ECO-PAR 134
FLNTUS 1186
ISUS V3 076 + SBE5M Pump
12
244 kg Air
1.3m x 13mm 316 chain lower bridle
45m Vemco T354194, DR1050 14520
50m Vemco T354195, PAR 082V023 SBE37 ODO 9538
55m Vemco T354196
60m Vemco T354197
65m Vemco T35198
70m Vemco T35199
75m Vemco T354200
85m Vemco T35201
100m SBE37SMP-ODO 9538
120m Vemco T354202
140m Vemco T354203
160m Vemco T354204
200m Vemco T354205, SBE37-ODO 9513
240m Vemco T354206
280m Vemco T354207
320m Vemco T354208
360m Vemco T354209
400m Vemco T35210
440m Vemco T354211
480m Vemco T354212
475m RBR TDR 14788
7 mm TBW 450m marked for instruments
105 kg Air, 88 kg water
short 16mm pc gal 0.8m
14 water ballast damper 1.5m
15 24mm pc gal chain 4.1m
16 2000kg blueline swivel
17 20mm pc gal chain 3.6m
18 250 m 20mm nylon
19 400 m 16mm polybraid
20 600 m 14mm polybraid
21 200mm pacific bubbles x 20
22 2000kg blueline swivel
23 glass floats, 4 + 2
24 13mm PWB x 3.8m
650m RBR TDR 14789
25 30m x 7mm wire
26 glass floats 8 13mm pwb x 4.6m
27 30m x 7mm wire
28 glass floats 8 13mm pwb x 4.6m
29 500m x 7 mm wire
1000 kg blueline swivel
30 glass floats 8 13mm pwb x 4.6m
31 1000m 8mm dynema
32 glass floats 4+1 13mm pwb x 4.6m
33 1000m 8 mm dynema
34 glass floats 4+1 13mm pwb x 4.6m
35 1000m 8mm dynema
36 glass floats 8 13mm pwb x 4m
37 30m x 7mm wire
38 ORE releases ACR8242xs
39 15m nylon webb
40 7mm TBW 100m
41 parranchor G12
42 4 + 3 meters x 16mm PWB PCG
43 rail wheel anchor 2000kg
surface float
rubber elements
RAS assembly
Changes
2011: anodes and fat shackles on spiders
new swivells in tension mooring
long inst can fitted to buoy
new antifoul on buoy and UBEs
Parrachute rigged to 100m wire
new pin and ring trip for parrachute
2012: Removed SBE56's, Added Serial numbers
Added RBR DR1050's @ 45 and 160m
Added RBR TDR2050 below item 24
2013: Add Alec PAR, Extend Vemcos to 480m
Bungees with Delrin Spacers
SBE37 ODO @ 100, 200m
33554
35969
To be Deployed 2014-10-01
46o 51.303'S, 142o 22.328'E 4350 m
scale do not scale
job PULSE-11 2014
sheet
drawing elevation
drawing
by / date PWJ 2014-06-17


note taker
SAZ 17
SAZ 2015 - 2016
47S, 142E
~847 m
Version
Revised: 26 May 2014
Deployed: late2014 early 2015? Investigator?
Recover: 2016, ?Investigator
Drawn: S. Bray, ACE CRC (Ver1 8 Apr 2014)
Mast detail
radio 160.785MHz T=~2s
strobe, Xeos T=3s dbl white burst
Argos BASM 24771, hi-vis flag
Star-Oddi sn # T,P,pitch,roll
Hardware codes
with picture card number
(shackles are bow shackles)
A 2t (12mm) shackle, 13mm plink, 2t (12mm) shackle
B 13mm plink, 2t (12mm) shackle
C 2t (12mm) shackle
D 2t (12mm) shackle, 316 16 mm ring, 16 mm 316 shackle
E 2t (12mm) shackle, chain, 12mm x 300mm, 2t (12mm) shackle
F 2t (12mm) shackle, 1t swivel, 2t (12mm) shackle
G 16 mm plink, 3.2t (16mm) shackle
H 3.2t(16mm) shackle, 16 mm plink, 3.2t(16mm) shackle
I 16mm chain, 400mm, 3.2t(16mm) shackle
J 7/8" Crosby ring, 3.2t(16mm) shackle, 16mm chain, 400mm
K 3.2t(16mm) shackle
L 3.2t(16mm) shackle, 19mm plink, 3.2t(16mm) shackle, 4.75t (19mm) lifting shackle
~3753 m
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
Landing site (triangulated)
Degrees & minutes
Target landing: 46° 49.82'S 141°38.98'E
Decimal degrees
-, #
2x releases 8242xs sn #, #
12 min. 27 sec. for pickup flts to surface
13 min. 22 sec. for mast to surface
80 min. for bottom floats to surface
Seafloor: nominal 4600 m,
triangulated m
pickup floats
Loop
nominal depth below sealevel
16 flts
Insulate
Insulate
1000m
McLane sn 12933 Insulate
Cups #250 x21
Insulate
1050m
Insulate
8 flts
Swivel
Nortek Aquadopp
sn AQD #
6 flts
6 flts
Insulate
Insulate
2000m
McLane sn #
Cups 250 x21
Insulate
6 flts
5 flts
5 flts
Swivel
Insulate
Insulate
3800m
McLane sn #
Cups #250 x21
Insulate
RBR TDR-2050, 4 flts
sn # 16371
Swivel
4 flts
painted flts 6
FLOATS NOT COLOURED
Length, m | Description
2 m pickup floats, 4 x 200mm.
60 m pickup line, floating 8mm
1.9 m mast, galv steel, glass floats, 17"
1 m chain 16mm
30 m wire 7mm
9.4 m floats, glass 17" on chain 13mm
50 m wire 7mm
4 m wire 7mm as tether
0.6 m tripod SS316 (use Ti if rec saz16 1st)
1.6 m sed trap Ti frame, McLane # 12933
1 m chain bridle, 10mm mild steel
40 m wire 7mm
4 m wire 7mm as tether
0.6 m tripod SS316
1.6 m sed trap Ti frame, Mclane # 11649
0.6 m chain bridle, 10mm mild steel
110 m wire 7mm
4.4 m floats, glass 17" on chain 13mm
250 m wire 7mm
1 m current meter, SS cage, vaneless
200 m wire 7mm
3.8 m floats, glass 17" on chain 13mm
500 m wire 7mm
3.8 m floats, glass 17" on chain 13mm
50 m wire 7mm
4 m wire 7mm as tether
0.6 m tripod SS316
1.6 m sed trap Ti frame, McLane 11741-01
1 m chain bridle, 10mm mild steel
350 m wire 7mm
3.8 m floats, glass,17" on chain 13mm
500 m wire 7mm
2.7 m floats, glass,17" on chain 13mm
500 m wire 7mm
500 m wire 7mm
2.7 m floats, glass,17" on chain 13mm
50 m wire 7mm
4 m wire 7mm as tether
0.6 m tripod SS316 11640-01
2 m sed trap Ti frame, McLane
1 m chain bridle, 10mm mild steel
350 m wire 7mm
1.9 m floats, glass,17" on chain 13mm
100 m wire 7mm
1.9 m floats, glass,17" on chain 13mm
50 m wire 7mm
SBE microcat 37, prefer cage,(clamped ok), sn # 8985 P,T,sal
3.8 m floats, glass,17" on chain 13mm
50 m wire 9mm
1.4 m releases
0.5 m release chain + big ring (7/8" Crosby) 30569 29298 - attached bungee for test at depth
0.4 m chain 16mm
15 m nylon snatch strap, 65mm wide
100 m wire 9mm
4 m chain 16mm (rub chain for towing)
3 m chain 16mm
1.2 m steel anchor, ~1700kg in air,~1500kg wet


SAZ 16
SAZ 2013 - 2014
47S, 142E
~878 m
~3653 m
Version
Revised: 8 May 2013, as deployed
Deployed: 4 May 2013 S.Surveyor
Recover: 2014, ?Investigator
Drawn: S. Bray, ACE CRC (Ver1 5Sep2012)
Mast detail
radio 160.785MHz T=~2s,R05-031
strobe, Xeos T=3s dbl white burst
Argos Seimac 29623, pink flag
Star-Oddi sn 977 T,P,pitch,roll
nominal depth below sealevel
white pickup floats
Loop
1000m
1050m
Swivel
2000m
Swivel
3800m
Swivel
ckle, pin down, ss
tripod top hole, ss
top 4 floats painted red
12 min. 54 sec. for pickup flts to surface
13 min. 49 sec. for mast to surface
79 min. for bottom floats to surface
Seafloor: nominal 4500 m,
triangulated 4531 m

Appendix 2 Recommendations from mooring de-briefings

Recommendations requiring MNF and ASP actions

The hand-held control box for the winches and A-frame is difficult to use. Serious mistakes were made such as operating the wrong winches and operating them in the wrong direction. A simpler control box is needed.

Lighting on deck is insufficient - winch drivers struggled to see hand signals from the Bosun and the positions of mooring lines and components. Gimballed down lights on the A-frame to illuminate the mooring, and more deck lights to eliminate shadowing, (including under the overhanging Gilson winch platform) are needed.

Relocation of the electrical box on the port stern rail is needed, to allow for clear lines of site and clear passage of mooring pick-up and tagging lines.

Relocation of the netdrum winch from the O2 deck to a portable mount on the main deck is needed to allow it to be used for mooring work.

A charting tool is needed that can add waypoints in the operations room that can be viewed on the bridge, preferably with bathymetry available as an overlay for targeting anchor locations.

Access to the port side of the a-frame is congested by the a-frame hydraulics blocking the escape route from the rear of the vessel; they should be relocated.

Recommendations for project team for 2016 SOTS voyage

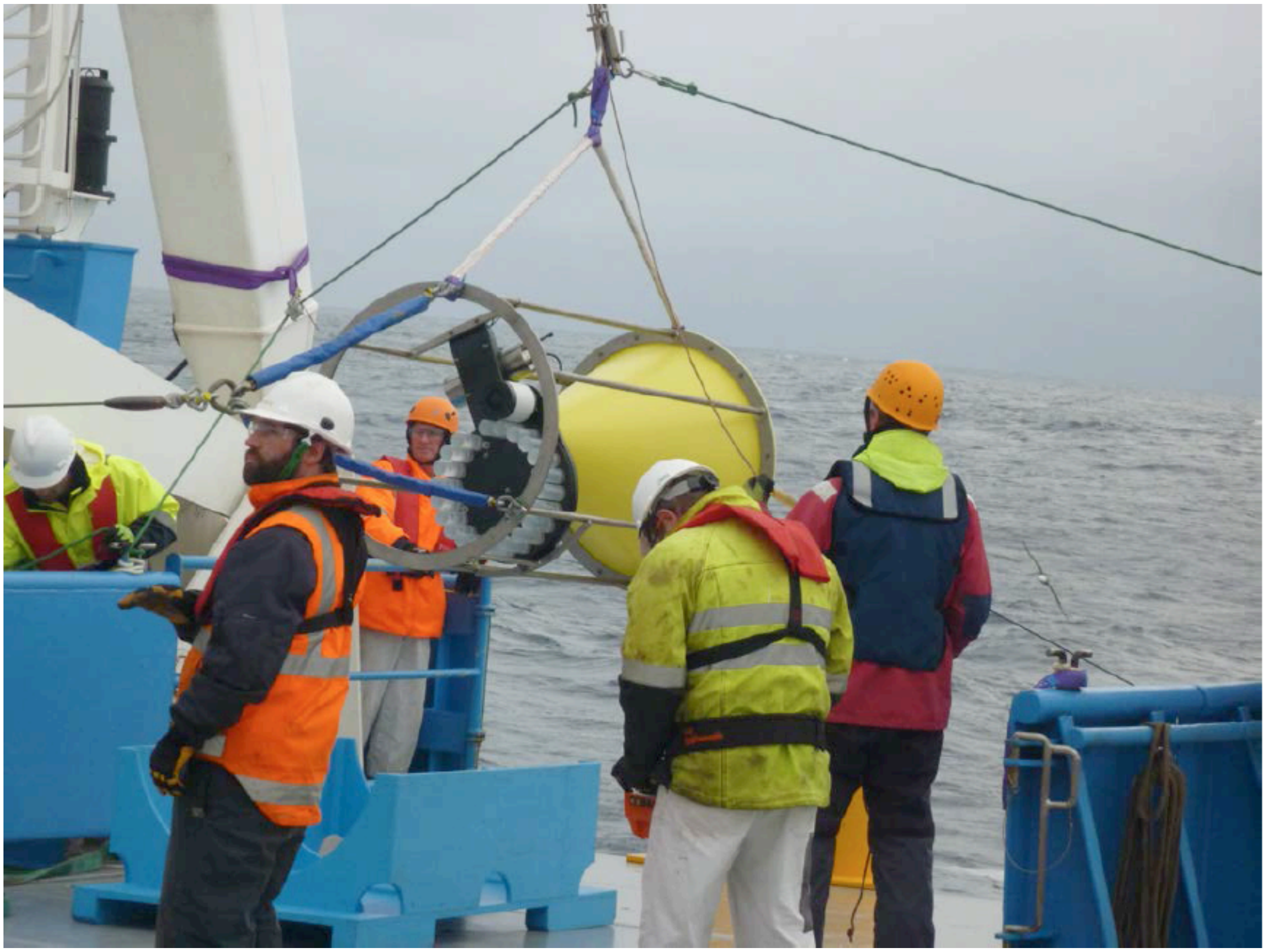
SOFS-5 Anchor (and preferably all anchors) needs to be loaded on port side - to avoid having to move it past the mooring wire.

SOFS-5 Deck Rails should be mounted further to port.

Pulse mooring small instruments should be provided with tear-away tags to speed up on−deck recording of serial numbers as they are mounted.

Provide water proof paper for note taker

Appendix 3 Photos



New procedure for controlled sediment trap launch. The trap is held in-line between the winch (line to left) and mooring (line to right entering the sea), and lifted out of its deckcradle via a bridle using the new hoist mounted on the A-frame. Two tag lines to pullies on the A-frame allow it to be controlled until it is aft of the ship and released via the quickrelease trigger line (held by hand). The Technical Supervisor (white helmet in left foreground) is providing a hand signal to the deck winch driver (out of photo to left). The Bosun (orange helmet facing camera) is overseeing the operation. The crewman in the the foreground (in white helmet with back to camera) is an IR operating the waist-belt mounted portable controls for the the A-frame and the A-frame mounted hoist. A simpler control box would allow this to be done while still keeping an eye on the equipment and associated risks. Photo by Eric Schulz, BOM.

SOTS team: Jamie, Phil, James, Max, Pete, Paul, Peter, Chris, Abe, Graeme, Tom

Not in Photo: deck crew: Jarod, Darren, Matt; Bridge officer: Mike, Adrian, Gurmukh, Andrew

Operations Cameras and Event Logging: Emily, Natasha, Steve

Marine
National Facility

RV Investigator

CTD Processing Report

Voyage #: IN2015_V01
Voyage title: IMOS Moorings
Depart: Hobart, 0910 Saturday, 21 March 2015
Return: Hobart 0900 Tuesday, 30 March 2015
Report compiled by: Steven Van Graas & Pamela Brodie

1 SUMMARY

These notes relate to the production of quality controlled, calibrated CTD data from RV Investigator voyage 1N2015_V01, from 21 Mar 2015 - 30 Mar 2015.

Data for 3 deployments were acquired using the Seabird SBE911 CTD 21, fitted with 24 ten litre bottles on the rosette sampler. Sea-Bird-supplied calibration factors were used to compute the pressures and preliminary conductivity values. CSIRO -supplied calibrations were applied to the temperature data. The data were subjected to automated OC to remove spikes and out-of-range values.

The final conductivity calibration was based on a single deployment grouping. The final calibration from the primary sensor had a standard deviation (S.D) of 0.0015 PSU, within our target of 'better than 0.002 PSU'. The standard product of ldbar binned averaged were produced using data from the primary sensors.

The dissolved oxygen data calibration fit had a S.D. of 0.45uM. The agreement between the CTD and bottle data was good.

The Fluorometer, the Wet Labs Transmissometer, and the Biospherical Photosynthetically Active Radiation (PAR) sensor were also installed on the auxiliary A/D channels of the CTD.

Complications regarding the acquisition software caused the deployment numbers recorded with the casts to be different to the actual cast being recorded. Cast 1 was recorded as deployment 5, cast 2 recorded as deployment 7, and cast 3 recorded as deployment 9. To avoid ambiguity the deployment numbers recorded by the acquisition software, not the actual cast, will be referred to throughout the report.

2 VOYAGE DETAILS

2.1 Title

IMOS Southern Ocean time series automated moorings for climate and carbon cycle studies southwest of Tasmania.

2.2 Principal Investigators

Dr Tom Trull and Dr Eric Schulz.

2.3 Voyage Objectives

The scientific objectives for 1N2015_V01 were outlined in the Voyage Plan.

For further details, refer to the Voyage Plan and/or summary which can be viewed on the CSIRO Marine and Atmospheric Research web site.

2.4 Area of Operation

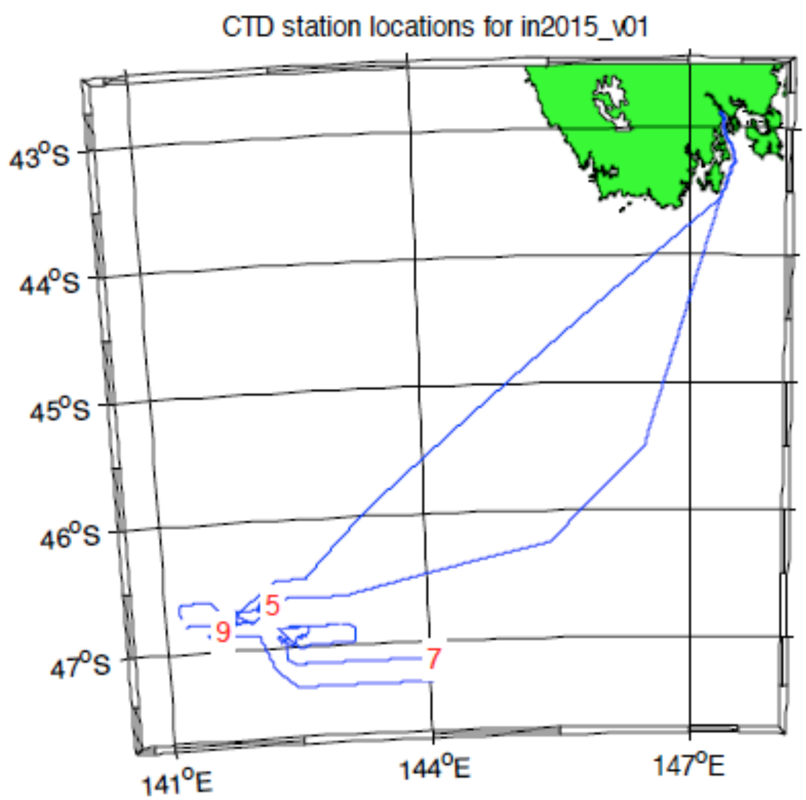


Figure 1: Area of operation for IN2015_V01

3 PROCESSING NOTES

3.1 Background Information

The data for this voyage were acquired with the CSIRO CTD unit 21, a Seabird SBE911 with dual conductivity and temperature sensors.

The CTD was additionally fitted with SBE43 dissolved oxygen sensors, Fluorometer, Transmissometer and PAR sensors. These sensors are described in Table 1 below.

Table 1: CTD Sensor configuration on IN2015_VO1

Description	Sensor	Serial No.	A/D	Calibration Date	Calibration Source
Pressure	Digiquartz 410K-134	858/P380	P	17/3/2015	P - dbar
Primary Temperature	Seabird SBE3plus	4722	TO	27/2/2015	CSIRO 3109T
Secondary Temperature	Seabird SBE3plus	4522	T1	27/2/2015	CSIRO 3106T
Primary Conductivity	Seabird SBE4C	3868	CO	26/2/2015	CSIRO 3102C
Secondary Conductivity	Seabird SBE4C	3168	C1	26/2/2015	CSIRO 3098C
Primary Dissolved Oxygen	SBE43	1794	A0	11/2/2015	CSIRO 3055D0
Transmissometer	C-Star25cm	CST1421	A1	18/6/2014	Wet Labs
PAR	QCP2300	70111	A2	23/8/2013	Manuf. Cal.
Fluorometer	FLBBRTD	3698	A4	23/9/2014	
Scattering	FLBBRTD	3698	A5	23/9/2014	

Water samples were collected using a Seabird SBE32, 24-bottle rosette sampler. Sampling was from 24 ten litre bottles which were fitted to the frame. There were 3 deployments.

The raw CTD data were converted to scientific units and written to netCDF format files for processing using the Matlab-based, procCTD package. This procCTD application is described in the *procCTD Procedures Manual* (Beattie, 2010).

The procCTD software was used to apply automated OC and preliminary processing to the data. This included spike removal, identification of water entry and exit times, conductivity sensor lag corrections and the determination of the pressure offsets. It also loaded the hydrology data and computed the matching CTD sample burst data. The automatically determined pressure offsets and in-water points were inspected.

The bottle sample data were used to compute final conductivity and dissolved oxygen calibrations. These were applied to the data, after which files of binned 1dB averaged data were produced.

3.2 Pressure and temperature calibration

The pressure offsets are plotted in Figure 2 below. The 'crosses' refer to initial out-of-water values and the 'diamonds' the final out-of-water values. Due to software issues there were no out-of-water values captured for the start of deployment 5.

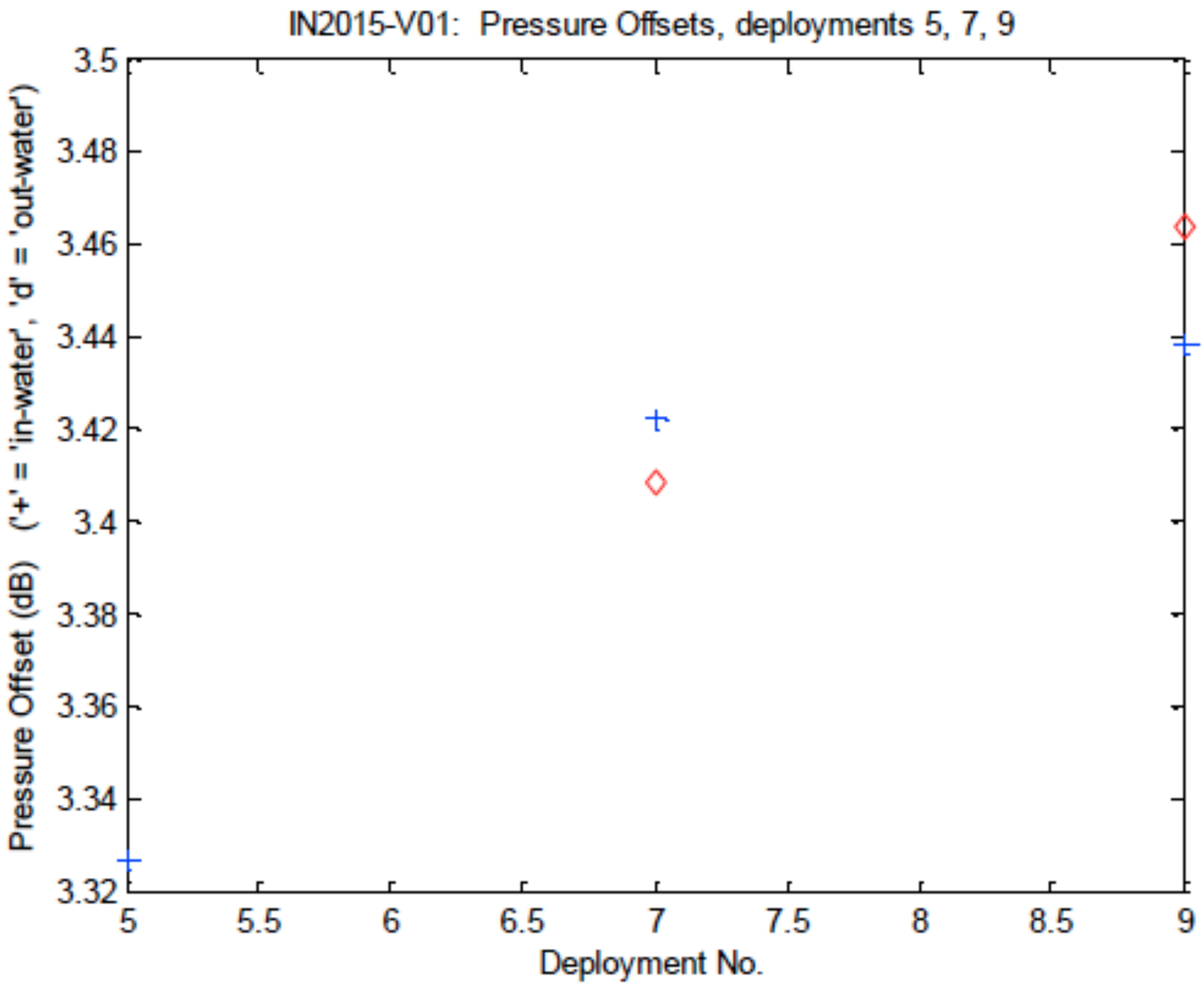


Figure 2: CTD pressure offsets

The difference between the primary and secondary temperature sensors at the bottle sampling depths is plotted below. Most deployments plot within ±1 m°C of zero - outliers result from sampling in regions of high vertical temperature gradient as supported by the similarity between the temperature and conductivity difference shown in figure 5. This indicates neither sensor has drifted significantly from its calibration.

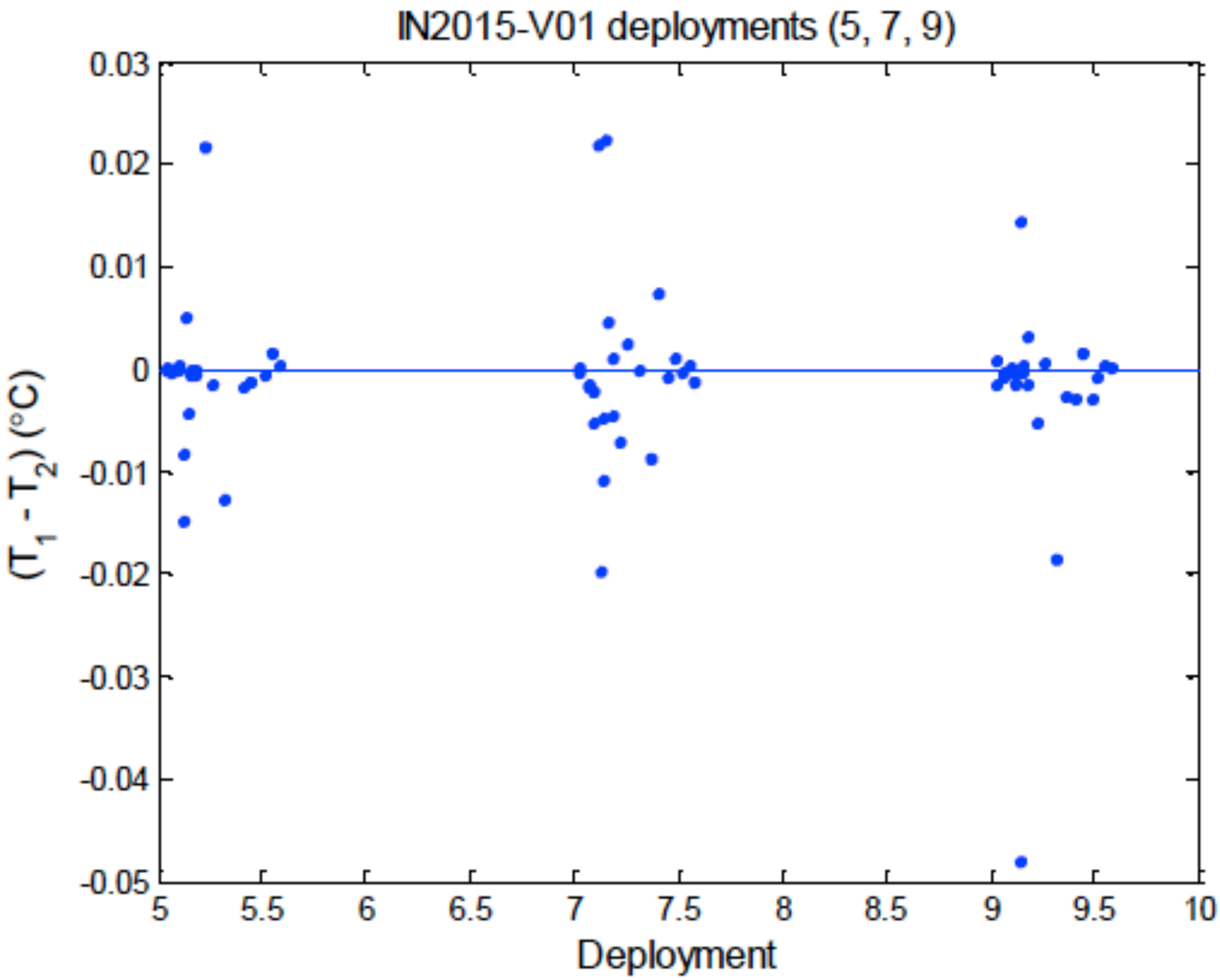


FIGURE 3: Mean difference between primary and secondary temperature sensors

3.3 Conductivity Calibration

Discrepancies and possible sampling problems between bottle and CTD salinities for the primary conductivity sensor would show in Figure 4, the plot of calibrated (CTD - Bottle) salinity below. The calibration was based upon the sample data for 59 of the total of 70 samples taken during deployments (the outliers marked in Figure 4 below with the red and magenta diamonds are excluded from the calibration).

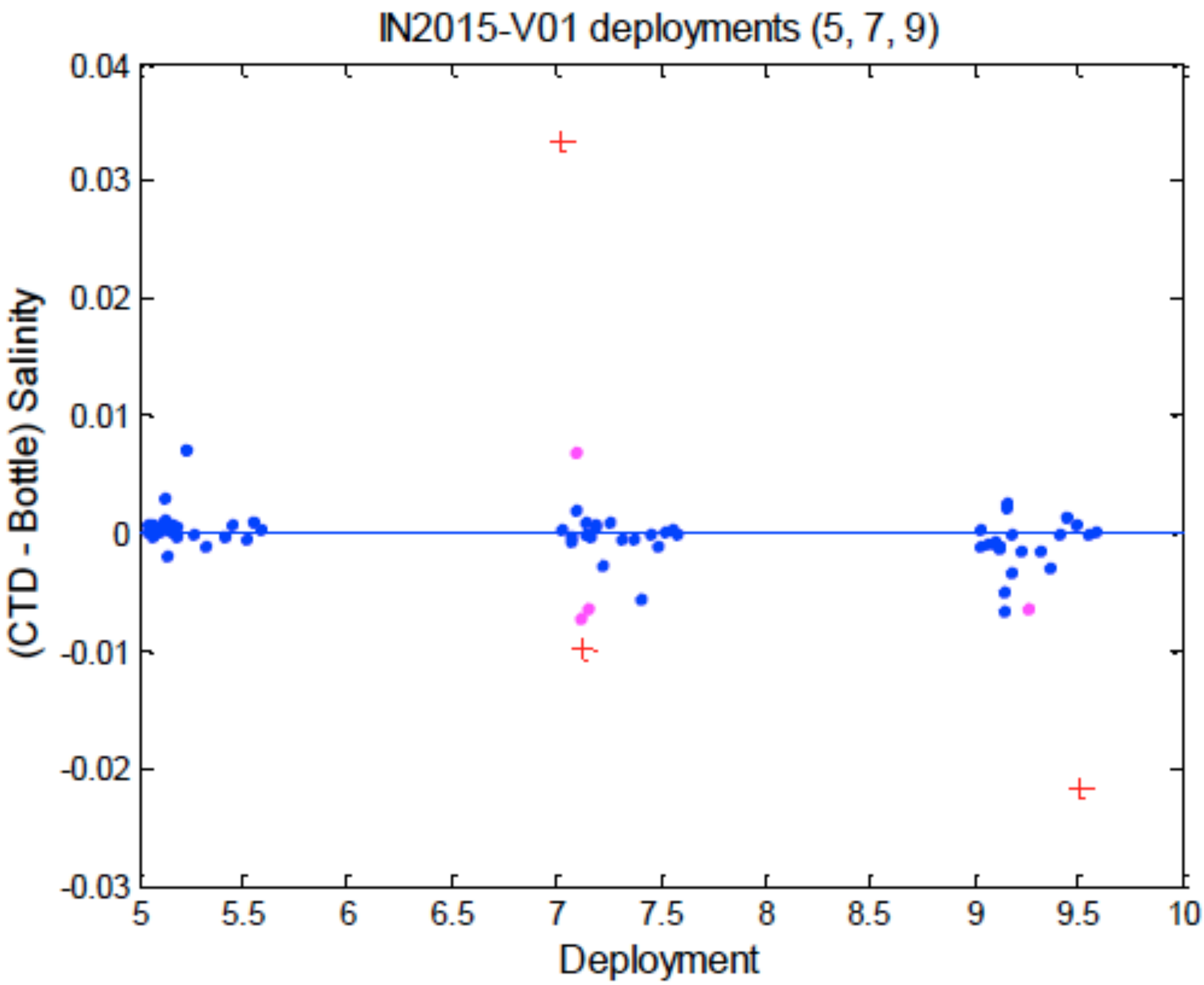


Figure 4: CTD -bottle salinity plot.

The plot of calibrated mean (primary - secondary) downcast conductivities at the bottle sampling depths for all deployments in Figure 5 shows that the calibrated conductivity cell responses corresponded well.

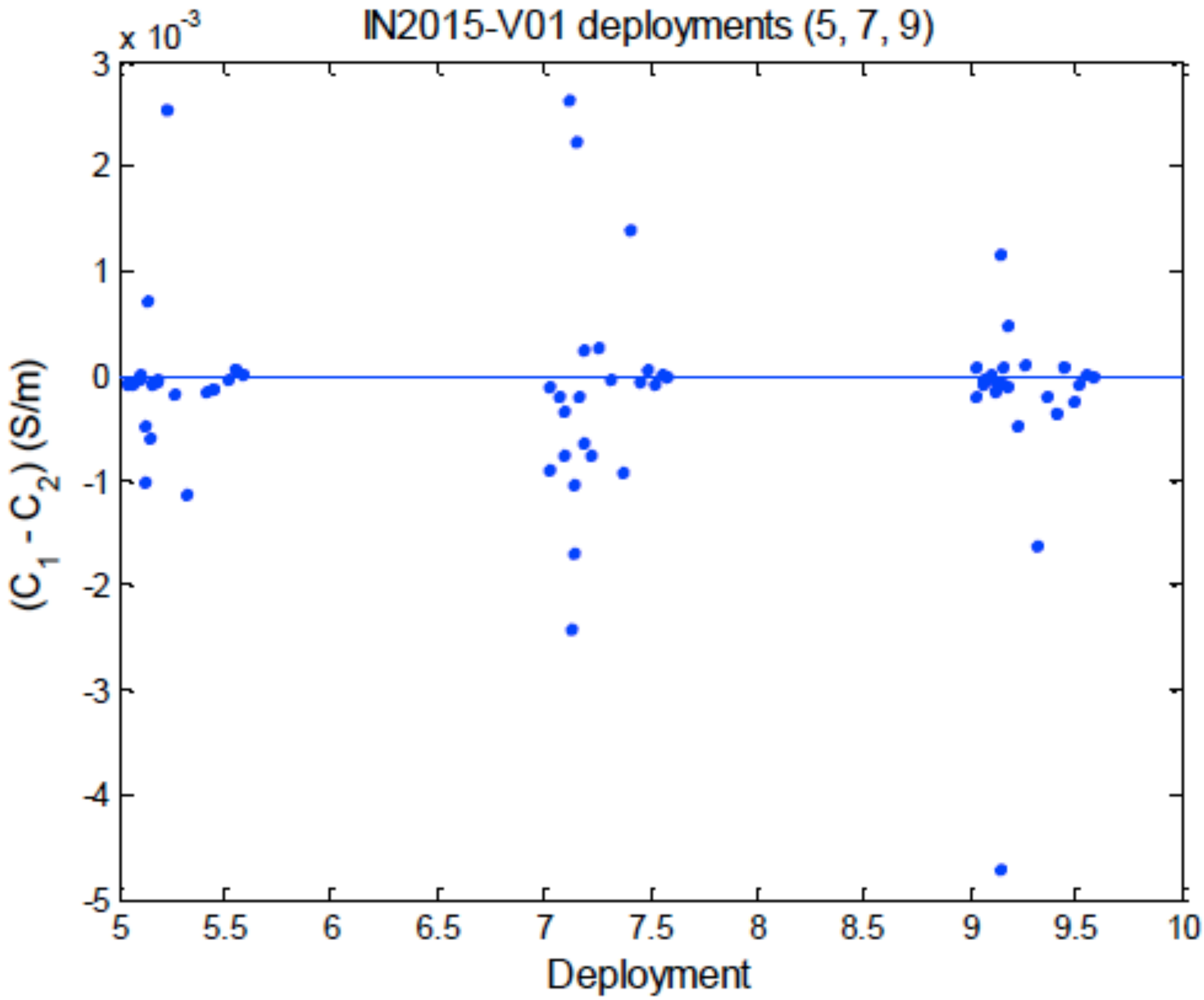


Figure 5: Mean difference between primary and secondary conductivity sensors

The final result for the primary conductivity sensor was -

Scale Factor (a1)	0.99939667	wrt. Manufacturer's calibration
Offset (a0)	0.0010603624	ditto
Calibration S.D. (Sal)	0.001494 PSU	

The calibration using the secondary conductivity sensor was -

Scale Factor (a1)	0.99950285	wrt. Manufacturer's calibration
Offset (a0)	0.0010507233	ditto
Calibration S.D. (Sal)	0.0021734 PSU	

This is a good calibration. We normally aim for a S.D. of 0.002 psu for 'typical' oceanographic voyages. The above calibration factors were applied to all deployments.

Data from the primary conductivity and temperature sensors were used to produce the averaged salinities.

3.4 Dissolved Oxygen Sensor Calibration

3.4.1 SBE calibration procedure

Sea-Bird (2010a) describes the SBE43 as "a polarographic membrane oxygen sensor having a single output signal of 0 to +5 volts, which is proportional to the temperature-compensated current flow occurring when oxygen is reacted inside the membrane. A Sea-Bird CTD that is equipped with an SBE43 oxygen sensor records this voltage for later conversion to oxygen concentration, using a modified version of the algorithm by Owens and Millard (1985)".

Calibration involves performing a linear regression, as per Sea-Bird (2010b) to produce new estimates of the calibration coefficients Soc and Voffset. These new coefficients are used, along with the other, manufacturer-supplied coefficients, to derive oxygen concentrations from the sensor voltages.

Results

Deeper casts (>1000m) are known to be affected by pressure-induced hysteresis with this sensor. This is corrected automatically within procCTD using the method discussed by SeaBird (2010c).

There is a small mismatch between downcast and upcast dissolved oxygen due to the response time of the sensor. No correction for the sensor lag effect has been applied.

A single calibration group was used with the associated 5BE43 up-cast data to compute the new Soc and Voffset coefficients. The plot below is of CTD - bottle oxygen differences for both upcast and downcast data (red indicates 'bad' data; + for upcast and square for downcast).

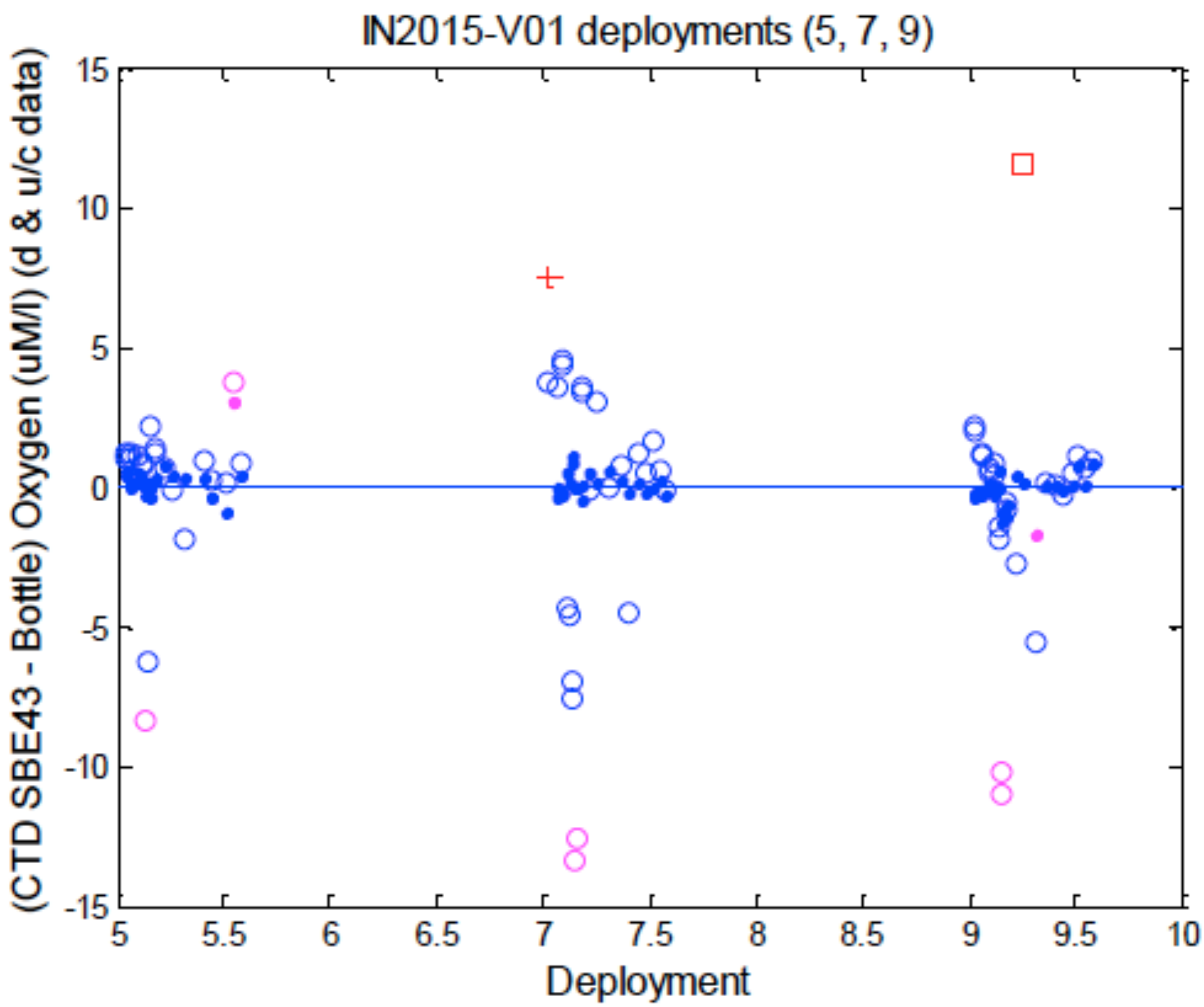


Figure 7: (SBE43 - Bottle) Oxygen Difference with upcast CTD data

The old and new Soc and Voffset values for DO sensors are listed in Table 2 below. The Soc value is a linear slope scaling coefficient; Voffset is the fixed sensor voltage at zero oxygen. As expected, over time, the increasing Soc scale factors show the 5BE43 sensor is losing sensitivity.

The calibrations were applied for each sensor and the averaged files were created using the result from the primary sensor, as there was no secondary Oxygen sensor present.

Table 2: Dissolved oxygen calibrations

	Manufacturer's calibration of primary sensor	Primary sensor calibration	Manufacturer's calibration of secondary sensor	Secondary sensor calibration
Voffset	-0.49151738	-0.46500549	N/A	N/A
Soc	0.50939087	0.51282073	N/A	N/A
Fit SD (uM)		0.4474	N/A	N/A

3.5 Other sensors

The Biospherical PAR sensor was also used for all deployments. The output is a nominal O-5 volts. This data channel has been included in the output files for all deployments. Clearly, time of day and environmental factors such as sea state and cloud cover impact on these readings. If most or all of the values for a deployment are near zero it indicates a night-time cast. In deployments where the PAR profiles have sub-surface maxima the CTD may have been shaded by the ship.

3.6 Bad data detection

The limits for each sensor are configured in the CAP the CTD acquisition software and are written to the netCDF scan file. Typical limits used for the sensor range and maximum second difference are in Table 3 below. The rejection rate is recorded in the procCTD processing log file.

Table 3: Sensor limits for bad data detection

Sensor	Range min	Range max	Max Second Duff
temperature	-2	40	0.05
conductivity	-0.01	7	0.01
oxygen	-1	500	0.5
fluorometer	0	100	0.5

3.7 Averaging

The calibrated data were 'filtered' to remove pressure reversals and binned into the standard product of 1 dbar averaged netCDF files. The binned values were calculated by applying a linear, least-squares fit as a function of pressure to the sensor data for each bin, using this to interpolate the value for the bin mid-point. This method is used to avoid possible biases which would result from averaging with respect to time.

Each binned parameter is assigned a QC flag. Our quality control flagging scheme is described in Pender (2000).

The QC Flag for each bin is estimated from the values for the bin components. The QC Flag for derived quantities, such as Salinity and Dissolved Oxygen are taken to be the worst of the estimates for the parameters from which they are derived.

4 References

Beattie, R.D., 2010: procCTD CTD Processing Procedures Manual.
http://www.marine.csiro.au/~dpg/opsDocs/procCTD.pdf

Trull, T., 2015: The RV Investigator. Voyage Plan 1N2015_V01
http://www.cmar.csiro.au/datacentre/process/data_files/cruise_docs/Investigator/in2015_v01_plan.pdf

Pender, L., 2000: Data Quality Control Flags.
http://www.cmar.csiro.au/datacentre/ext_docs/DataQualityControlFlags.pdf

Sea-Bird Electronics Inc., 2010a: Application Note No 64: SBE 43 Dissolved Oxygen Sensor -- Background Information, Deployment Recommendations, and Cleaning and Storage. http://www.seabird.comlpdf_documents/ApplicationNotes/appnote64Feb10.pdf

Sea-Bird Electronics Inc., 2010b: Application Note No 64-2: SBE 43 Dissolved Oxygen Sensor Calibration and data Corrections using Winkler Titrations. http://www.seabird.comlpdf_documents/ApplicationNotes/Appnote64-2Feb10.pdf

Sea-Bird Electronics Inc., 2010c: Application Note No 64-3: SBE 43 Dissolved Oxygen (DO) Sensor - Hysteresis Corrections. http://www.seabird.comlpdf_documents/ApplicationNotes/Appnote64-3Feb10.pdf

Marine
National Facility

RV Investigator

Hydrochemistry Processing Report

Voyage:	1N2015_V01
Chief Scientist:	Dr Tom Trull
Voyage title:	IMOS Southern ocean times series
Report compiled by:	Rayner and Rees

1 ITINERARY

Mobilise	Date	
Hobart	19-20 March 2015	
Depart	Date	Depart
Hobart	21 March 2015	Hobart
Arrive	Date	Arrive
Hobart	30 March 2015	Hobart
Demobilise	Date	
Hobart	30-31 March 2015	

2 KEY PERSONNEL LIST

Name	Role	Organisation
Dr Tom Trull	Chief Scientist	SIMS - UNSW
Max McGuire	Voyage Manager	CSIRO
Christine Rees	Hydrochemist	CSIRO
Mark Rayner	Hydrochemist	CSIRO

3 SUMMARY

3.1 Hydrochemistry

Analysis	Sampled
Salinity (Guildline Salinometer)	86
Dissolved Oxygen (automated titration)	73
Nutrients (AA3)	70

3.2 Rosette and CTD

• 4 CTD stations were completed with a 24 bottle rosette (10 L).

3.3 Nutrients

Details					
HyPro Vrsion	3.20				
Instrument	AA3				
Software	Seal AACE 6.10				
Methods	AA3 Analysis Methods internal manual				
Nutrients anaylsed	Silicate	Phosphate	NOx	Nitrite	Ammonia
Concentration range	140 µmol/L	3 µmol/L	35.0 µmol/L	1.4 µmol/L	2 µmol/L
Method Detection Limit (MDL)	0.2 µmol/L	0.02 µmol/L	0.02 µmol/L	0.02 µmol/L	0.02 µmol/L
Matrix Corrections	N	N	N		
Analyst(s)	Christine Rees & Mark Rayner				
Lab Temperature (±1°C)	Variable, 19.0 - 24.0°C				
Reference Material	RMNS - BW (Appendix 5.1)				
Sampling Container type	Sample tube: polypropylene, lid: High density polyethylene				
Sample Storage	≤2 hrs at room temperature				
Pre-processing of Samples	None				
Comments	The temperature was logged using a temperature/humidity logger QP6013 (Jaycar) placed on the deck of the chemistry module. See appendix 5.4				

3.4 Salinities

Details	
HyPro Version	3.20
Instrument	Guildline Autosal Laboratory Salinometer 8400(B) - SN 71613
Software	Osil
Methods	Hydrochemistry Operations Manual + Quick Reference Manual
Accuracy	± 0.001 salinity units
Analyst(s)	Mark Rayner,
Lab Temperature (±0.5°C)	21.0 -23.8°C
Reference Material	Osil IAPSO - Batch P157
Sampling Container type	Old sample bottles, duplicate sample taken in new salt bottles
Sample Storage	Samples held in Salt Room for 24 hrs before analysis within ~48 hrs

Comments	Salinometer was set-up and worked well. The Osil software was used to collect data. Files were exported into excel and uploaded into HyPro for processing. The cast number is posted edited into the data file under the Sample ID column.

3.5 Dissolved oxygen

Details

HyPro Version	3.20
Instrument	Automated Photometric Oxygen system
Software	SCRIPPS
Methods	SCRIPPS
Accuracy	0.01 ml/L + 0.5%
Analyst(s)	Christine Rees
Lab Temperature (±1°C)	Variable, 19.0 - 24.0°C
Sample Container type	Glass Erlenmeyer flask with glass stopper.
Sample Storage	Samples analysed within ~48 hrs
Comments	There were some issues with communication between the dosimat and computer, software freezing, and the software picking the incorrect file to obtain the Thiosulphate Normality as well as the calibrated flask volumes. Further work is required to sort this file issue out. There was also issues with obtaining a good blank during the second analyses

4 DETAILED PROCESSING

Oxygen and salinity data where imported into Hypro. There was no evidence of any outliers or bad data points required to be flagged in Hypro.

All nutrient data was processed starting from Aace and Hypro version 3.20.

4.1 Procedure

The procedure for data processing is outline in Figure 1.

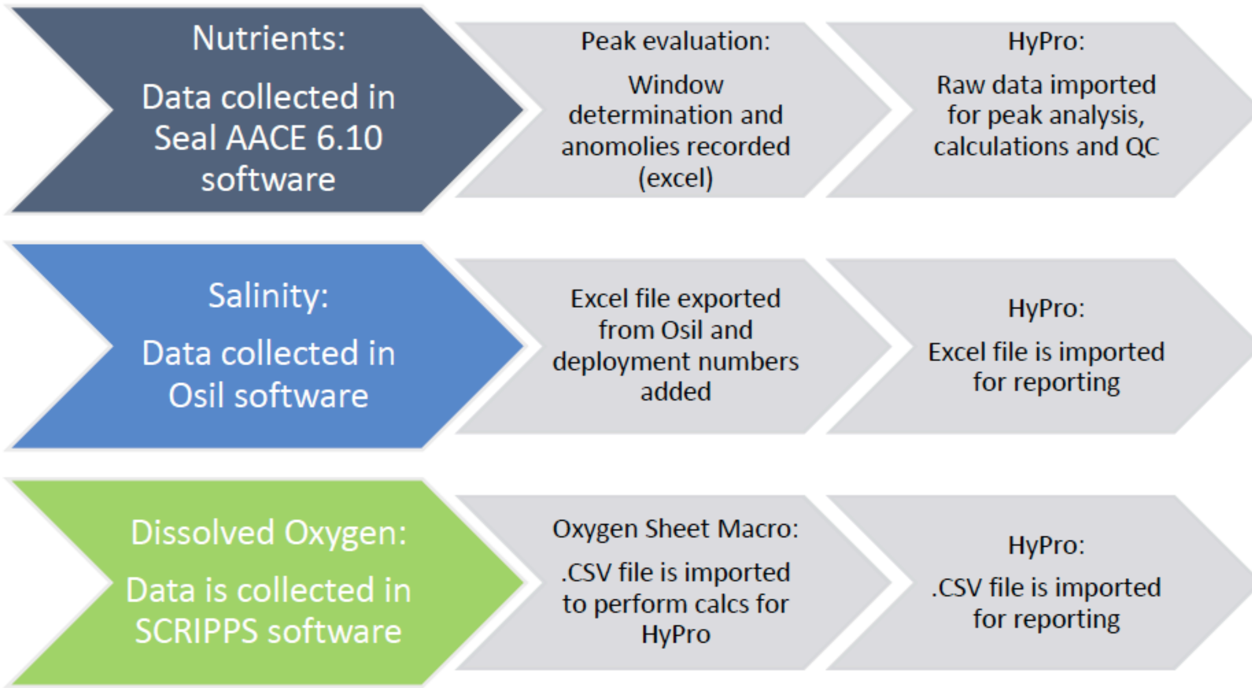


Figure 1: The process above shows the data trail procedure from the initial data generated to output via HyPro for reporting.

4.2 Nutrients

- Silicate, phosphate and Nitrate + Nitrite analysis was carried out during the voyage. The AA3 was set up with a master file lN2015_V01 (24 sample tray protocol) the AA3 worked well producing high quality data. AACE files were sent directly to the lN2015_V01 current directory where they were then copied into the SEAL program file directory on the processing computer.
- All runs have a corresponding AA3 Run_ Analysis _Worksheet file & AA3_Processing_Worksheet file to assist in characterising data.
- The final slk and chd file produced from AACE were copied into Hypro directory for calculation of nutrient concentrations. Hypro uses the median of the peak window to calculate the concentration of each peak.
- During the voyage analysis run nut004 had a high MDL for silicate and phosphate. Further processing determined that the high MDL is most likely an artefact of the baseline shifting during the analysis of the MDL's. Phosphate RMNS at the end of the run also changed from 2% to 3%. Comparison of the surface silicate samples with the other analysis runs indicated they were also higher. The silicate samples were repeated from refrigerated samples the next day. Comparison of phosphate samples indicated that the results from nut004 were OK. The repeated run nut005 results had an improved MDL for silicate and the surface samples were of similar concentrations to the other analyses. The silicate results from nut005 were the reported concentrations to the chief scientist on board. Further investigation is required into why analysis run nutOO4 had a lower than normal precision.

- Files for this voyage – nut001 - 006.

Details	Silicate	Phosphate	Nitrate + Nitrite	Nitrite	Ammonia
Data Reported as	µM l^-1	µM 1^{-1}	µM 1^{-1}	N/A	N/A
Calibration Curve degree	>0.9995	>0.9995	>0.9995		
Forced through zero?	N	N	N		
# of points in Calibration	5 or 6	5	5		
Matrix Correction	Y	Y	Y		
Blank Correction	N	N	N		
Carryover Correction	Y	Y	Y		
Baseline Correction	Y	Y	Y		
Drift Correction	Y	Y	Y		
Data Adj for RMNS	N	N	N		
Medium of Standards	LNSW				
Medium of Blank	18.2 Ω MQ				
Proportion of samples in duplicate?	10%				

Table 1: Nutrient data processing details

File	Silicate	Phosphate	Nitrate + Nitrite	Nitrite	Ammonia	Run Type
IN2015_v01nut001	x	x	x			Set-up Char.
Peak window	50-105	50-100	60-105			
RMNS	≤2%	≤2%	≤2%			
Comments	Peak Period Moved in AACE					
IN2015_v01nut002	x	x	x			Testing file exporting, Cd column & sample needle position
Peak window	50-105	50-100	60-105			
RMNS	≤1%	≤2%	≤2%			
Comments	Peak Period Moved in AACE, Baseline noisy forced					
IN2015_v01nut003	x	x	x			CTD5 3 samples ran in duplicate
Peak window	50-105	50-100	60-105			
RMNS	≤1%	≤1%	≤1%			
Comments	Baseline noisy forced	Peak Period Moved in AACE				
IN2015_v01nut004	x	x	x			CTD7 3 samples ran in duplicate
Peak window	50-105	50-100	60-105			
RMNS	≤1%	≤2%	≤1%			
Comments	New pump tubes, very high MDL.	New pump tubes	New pump tubes			
IN2015_v01nut005	x					CTD-Silicate repeat of deployment 7
Peak window	50-105					
RMNS	≤1%					
Comments	Peak Period Moved in AACE					

IN2015_v01nut006	x					CTD9 3 samples ran in duplicate
Peak window	50-105	50-100	60-105			
RMNS	≤1%	≤2%	≤1%			
Comments	Baseline slight noise, New reagents except tartaric acid					

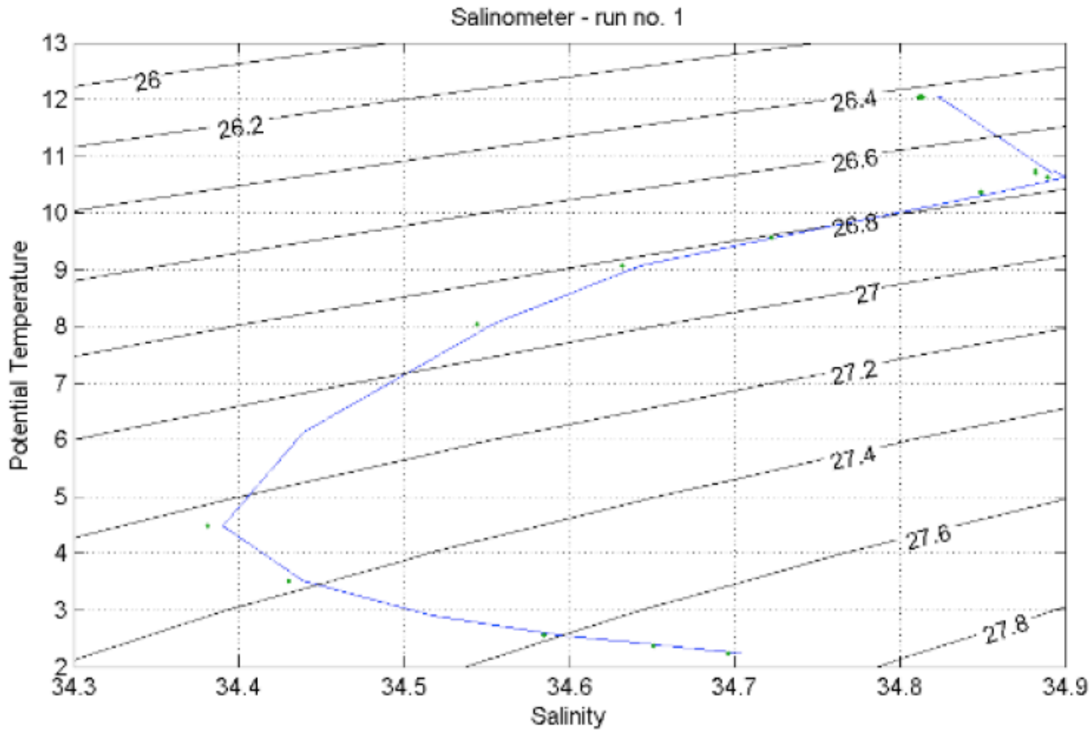
4.3 Salinities

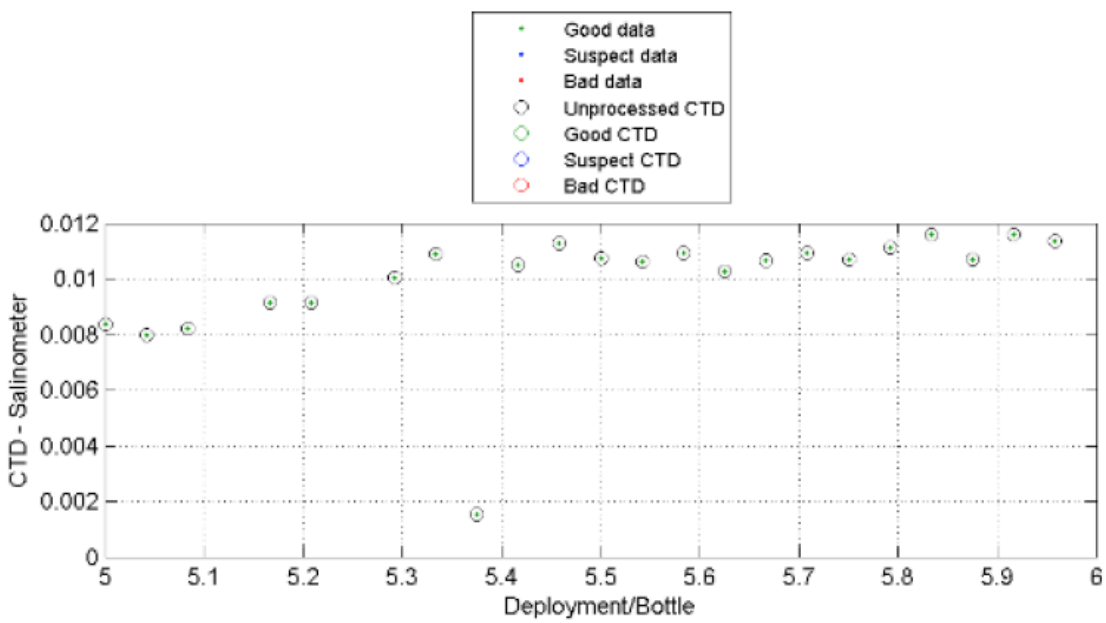
- Files for this voyage - sal00l, sal003 sal004; in addition; samples for a storage experiment T-0 were also analysed (16).
- Salinity data was collected using Osil software.
- Lab temperature stable. Bath set at 24°C. Lab temperature and bath temperature was measured before both analyses, both temperature were suitable for analyses to proceed.

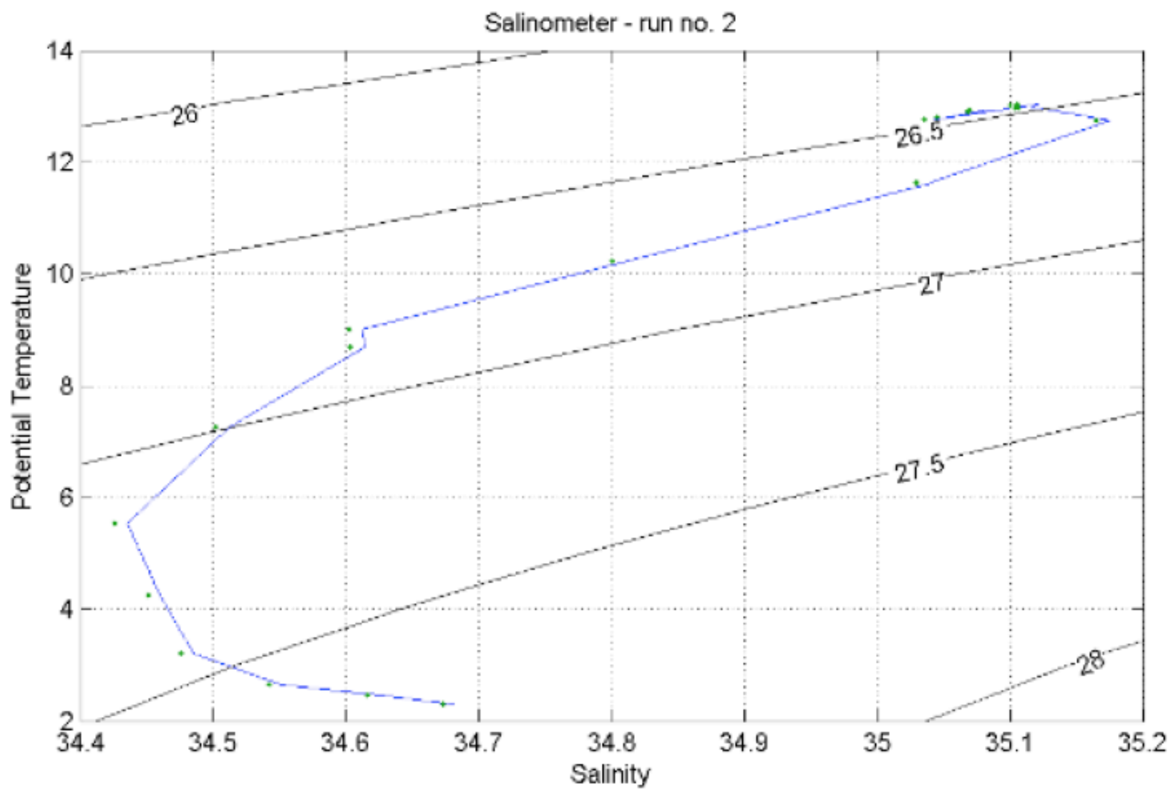
4.4 Dissolved oxygen

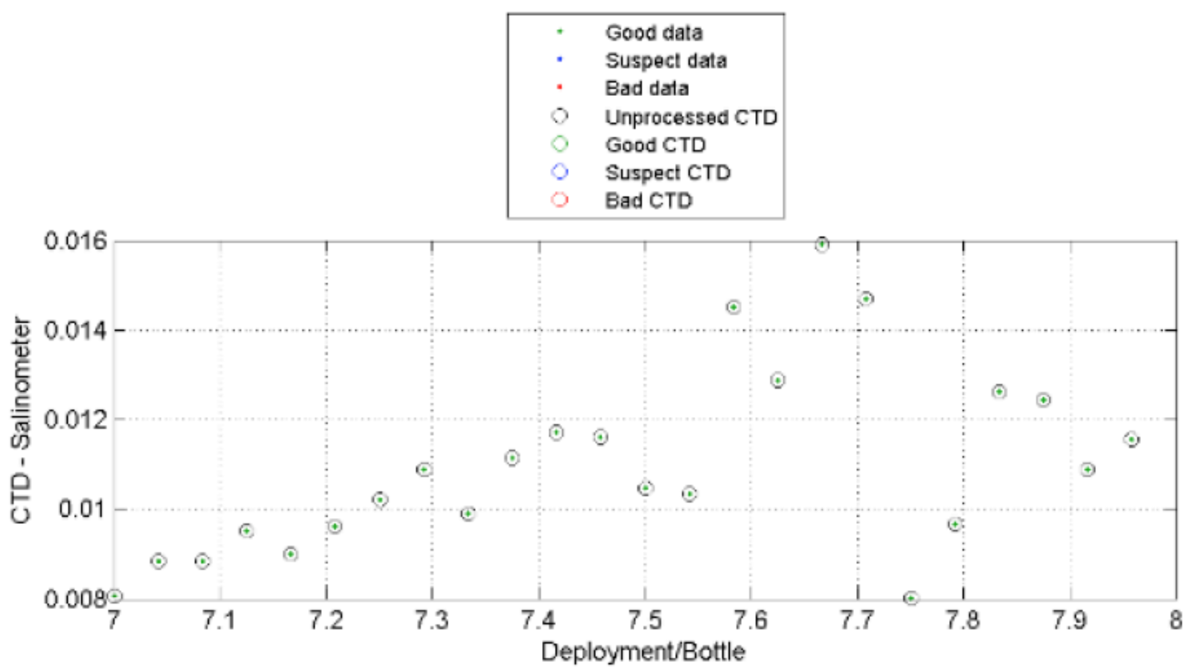
- The DO system was problematic with a number of issues; com port identification, software freezing, communication with the dosimats, the program picking the incorrect thiosulphate normality and difficulties in obtaining a good blank reading (during second calibration). To try and correct the blank readings the following was performed; both burettes flushed, detector windows cleaned, bath cleaned, thiosulphate dispensing tip re-orientated and only one flask #225 was used. To correct the program from picking the incorrect thiosulphate normality was difficult to resolve, as we are not sure which file it was reading. We managed to get it to select the right concentration (not sure how) in the end. Communication between the dosimats and computer were resolved by following the written protocol.
- Comparison between the underway samples and the CTD surface samples indicated there was a problem with the dissolved oxygen results for the oxy00l-003 files. Further investigation by plotting the dissolved oxygen results against the CTD results indicated there was an offset between these results, with the filesoxy00l-003 having incorrect oxygen concentrations. Investigation found that the programme was using the incorrect volumes for calculating the concentration of dissolved oxygen. This problem has been resolved by placing a new copy of the volume file into the directory. The oxygen data was re-calculated using the correct flask volumes in Hypro.
- Files for this voyage - oxy00l - 003. Plus oxy099 for 3 underway samples.

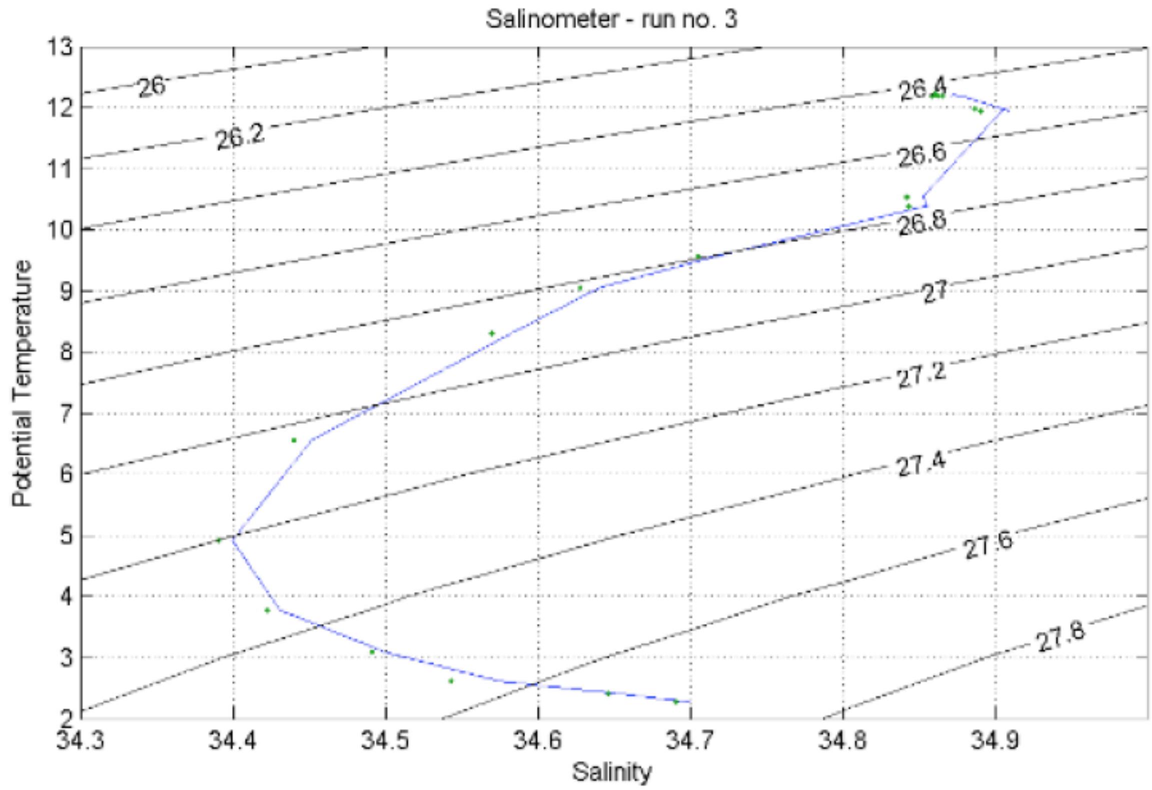
4.5 CTD vs Hydro Salinities

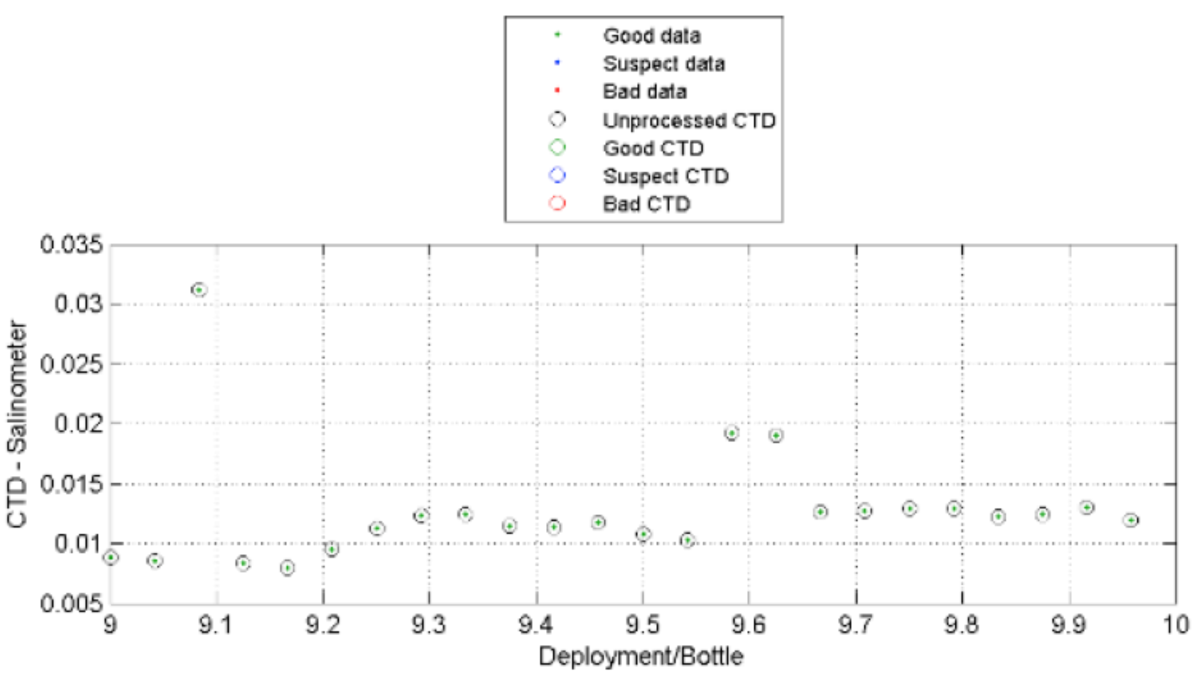




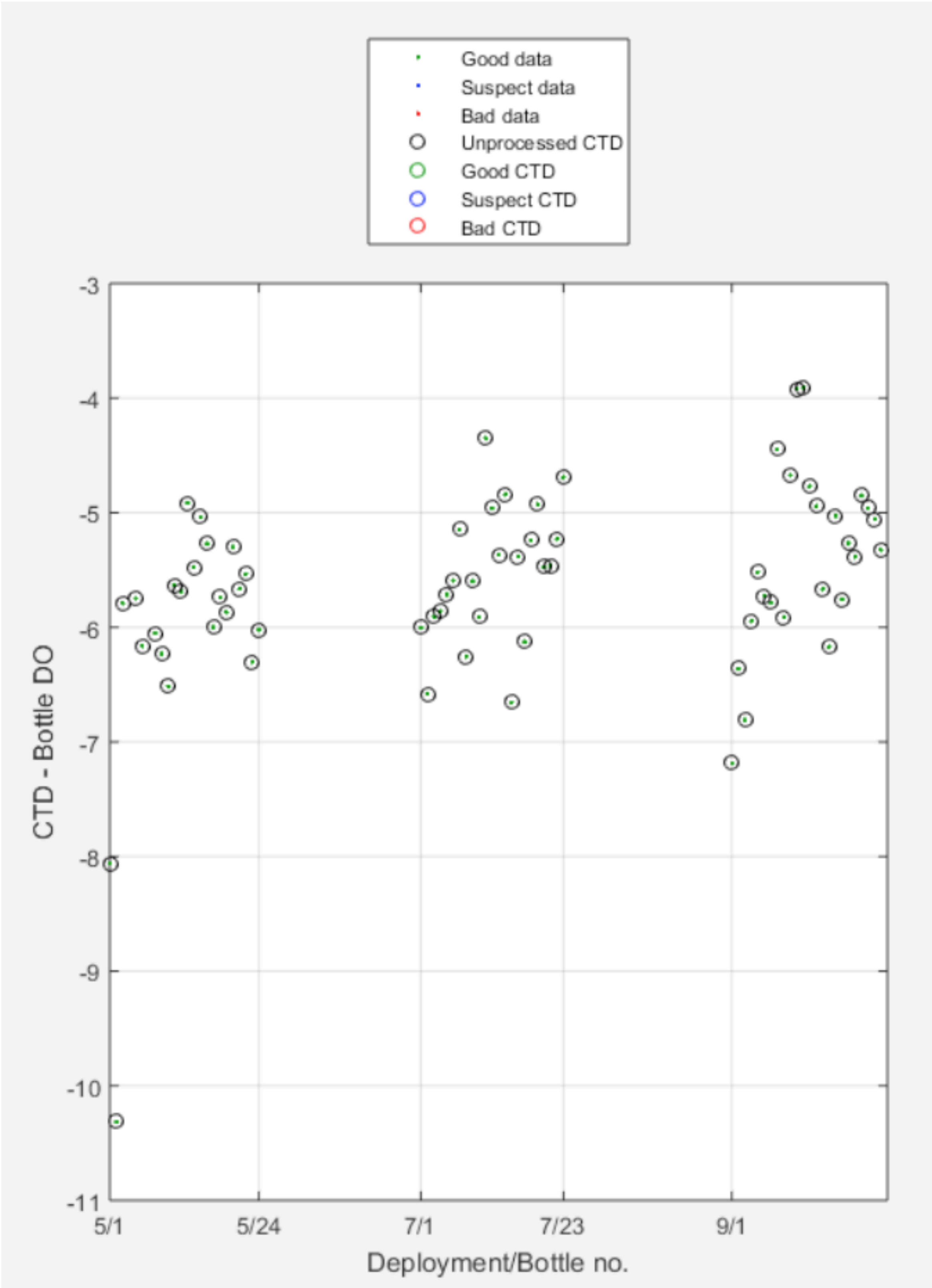

Salinometer - run no. 2
Potential Temperature
Salinity
26
26.5
27
27.5
28


Good data
Suspect data
Bad data
Unprocessed CTD
Good CTD
Suspect CTD
Bad CTD
CTD - Salinometer
Deployment/Bottle

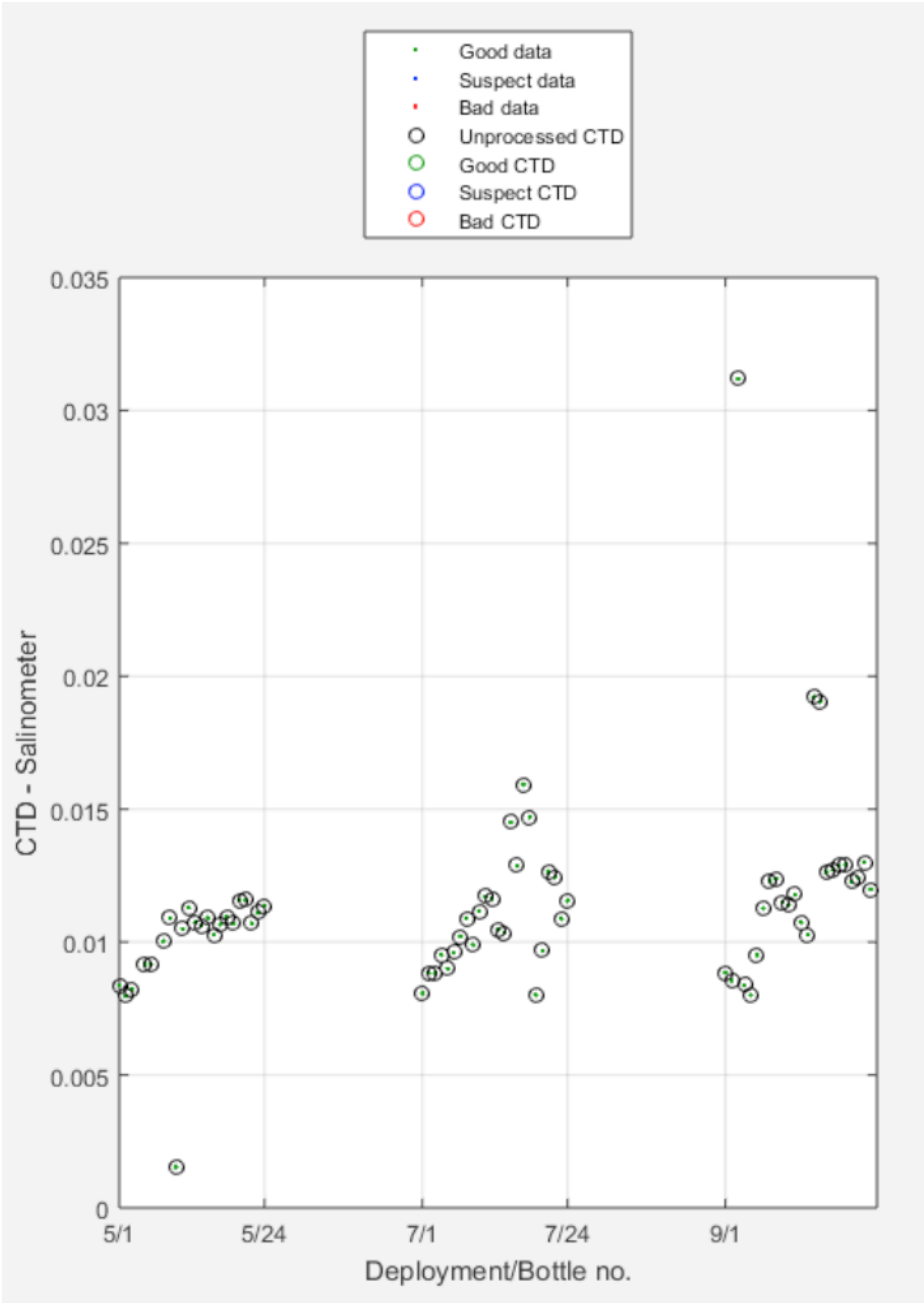

Salinometer - run no. 3
Potential Temperature
Salinity
26
26.2
26.4
26.6
26.8
27
27.2
27.4
27.6
27.8


Good data
Suspect data
Bad data
Unprocessed CTD
Good CTD
Suspect CTD
Bad CTD
CTD - Salinometer
Deployment/Bottle

4.6 CTD vs Hydro **Oxygens**



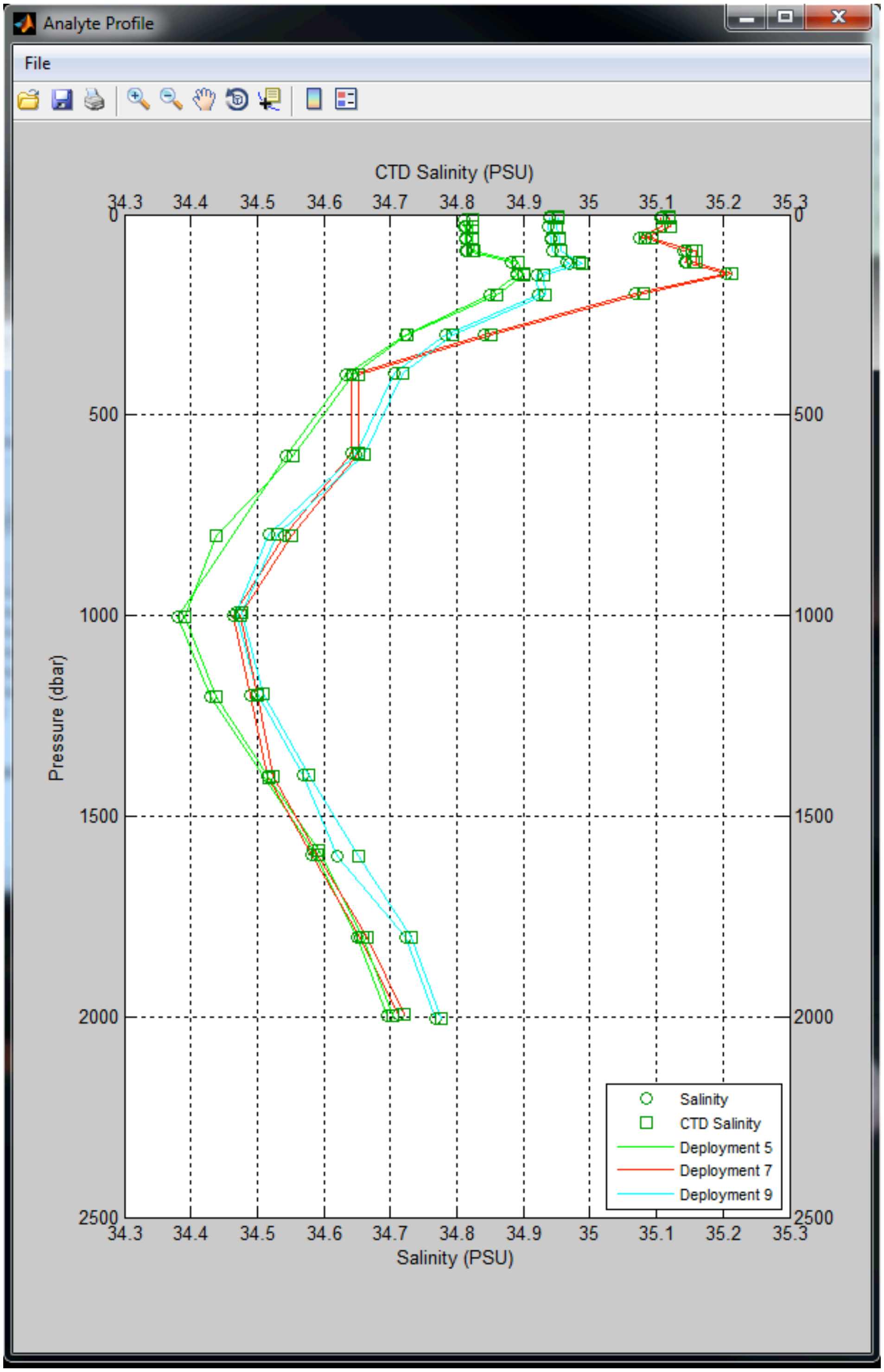
CTD vs Hydro **Salinities**



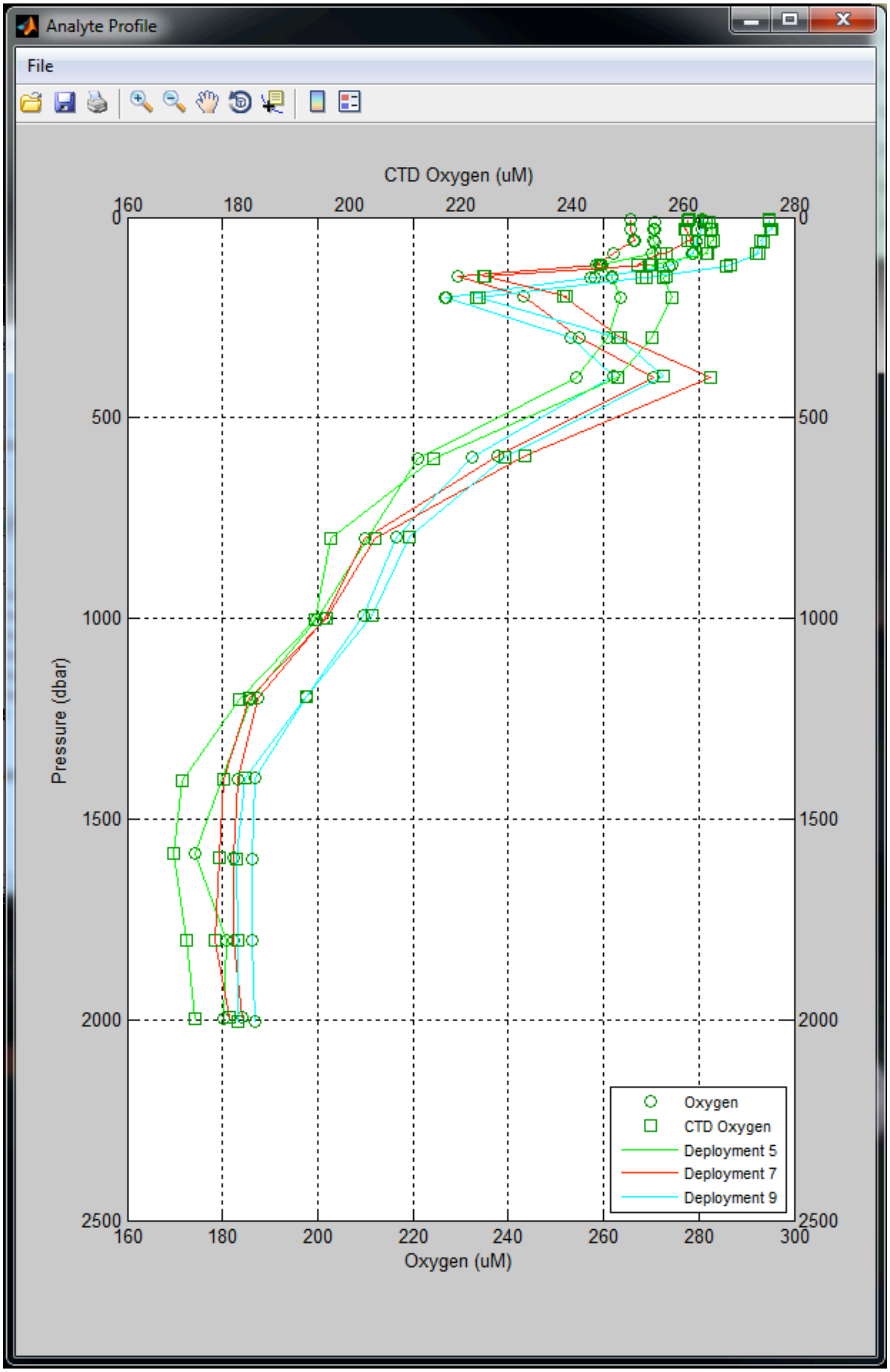
4.7 Plots

All waterfall plots consist of good data, without any outliers. This indicates there wasn't any leakage from the Niskin bottles.

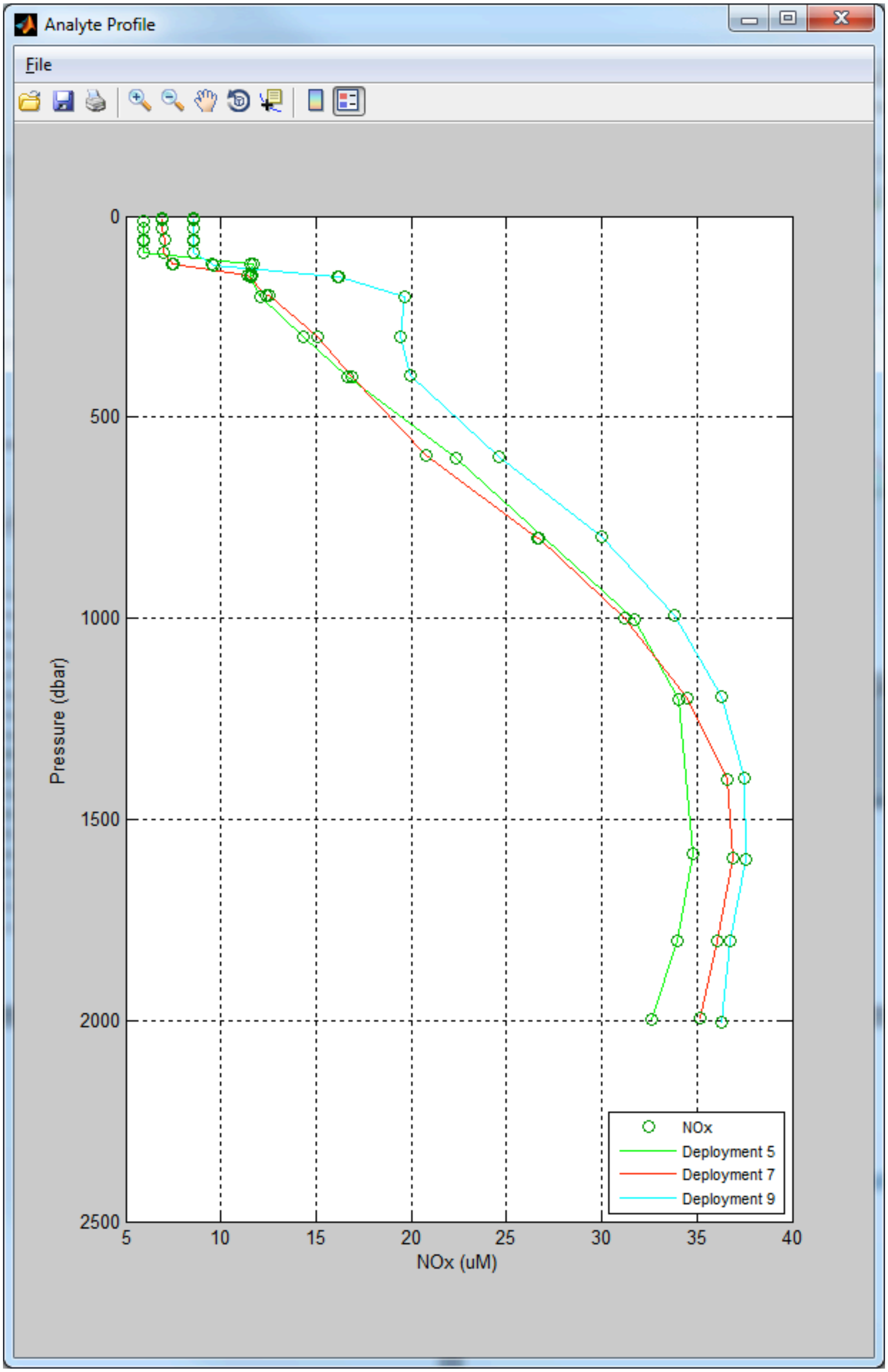
4.7.1 Salinity vs pressure waterfall plot



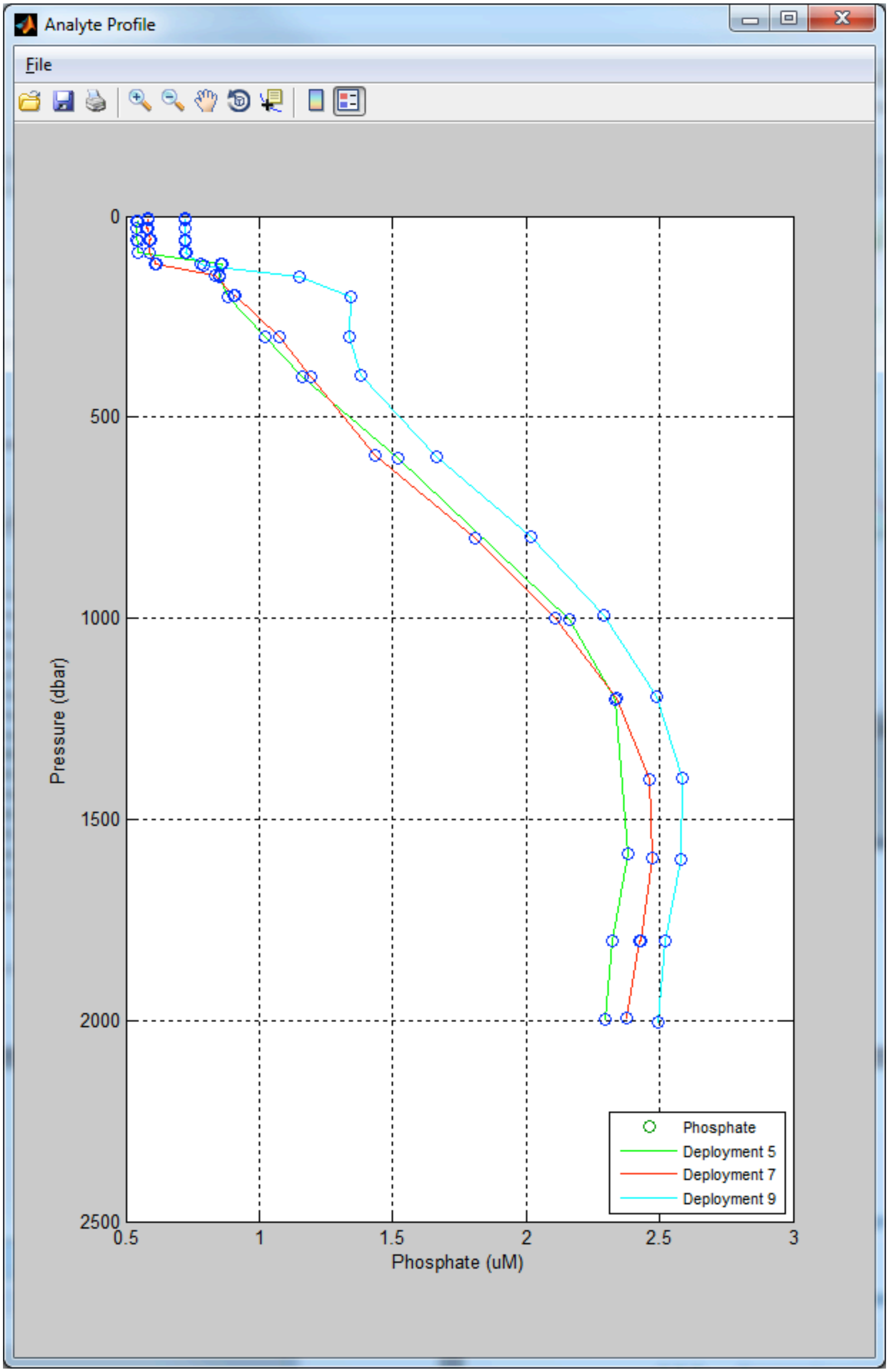
4.7.2 Oxygen vs pressure waterfall plot



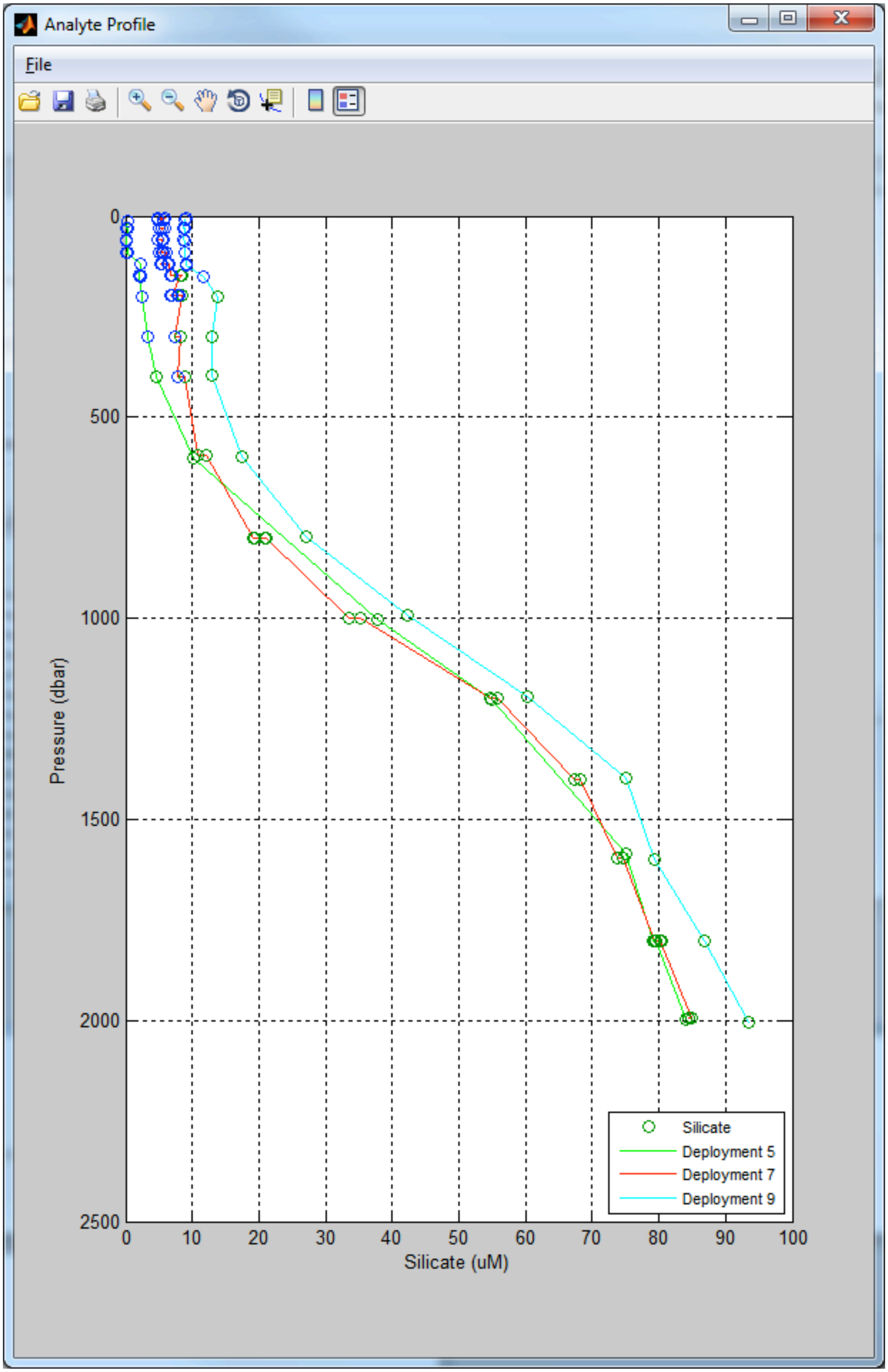
4.7.3 NOx vos pressure waterfall plot



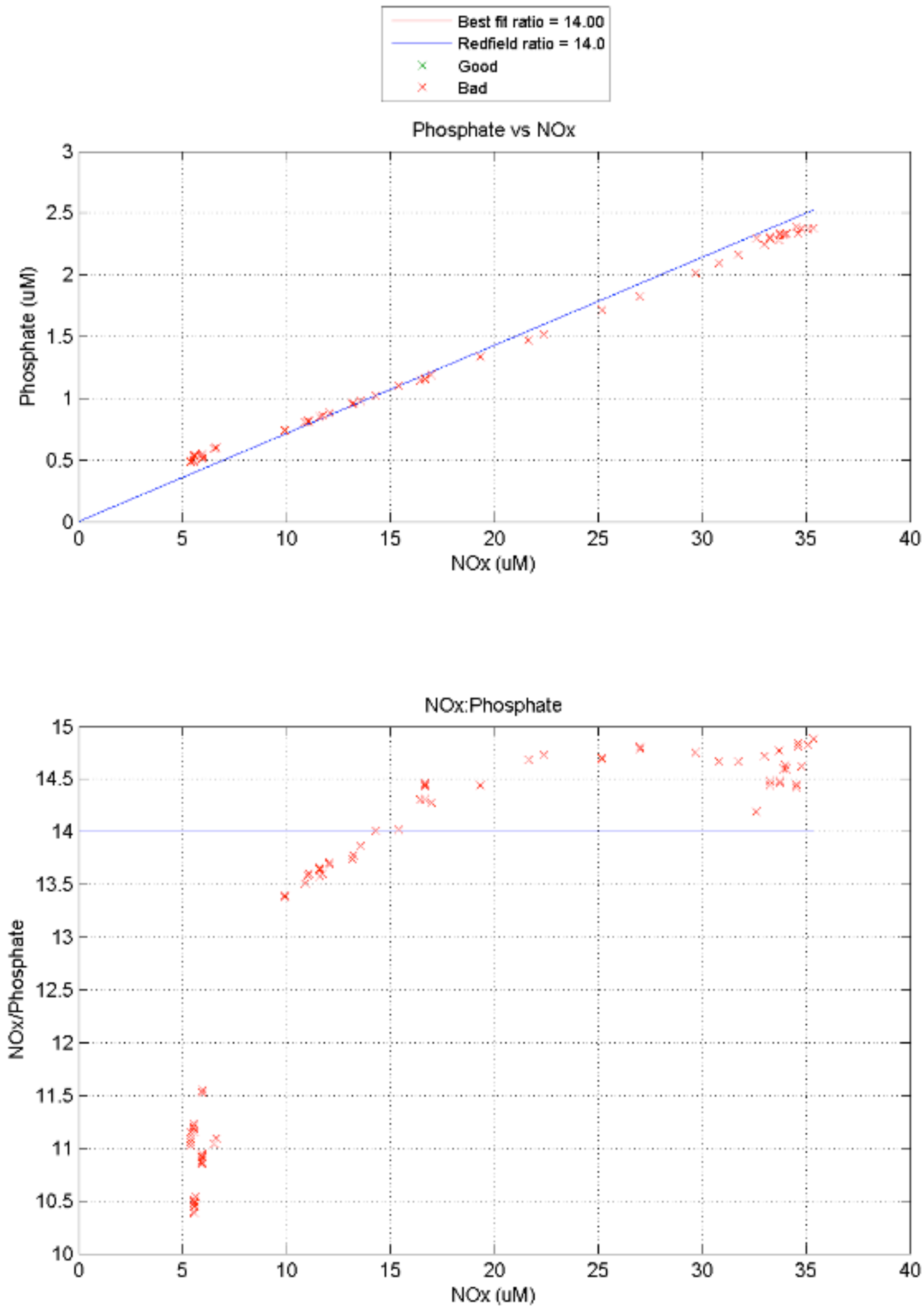
4.7.4 Phosphate vs pressure waterfall plot



4.7.5 Silicate vs pressure waterfall plot

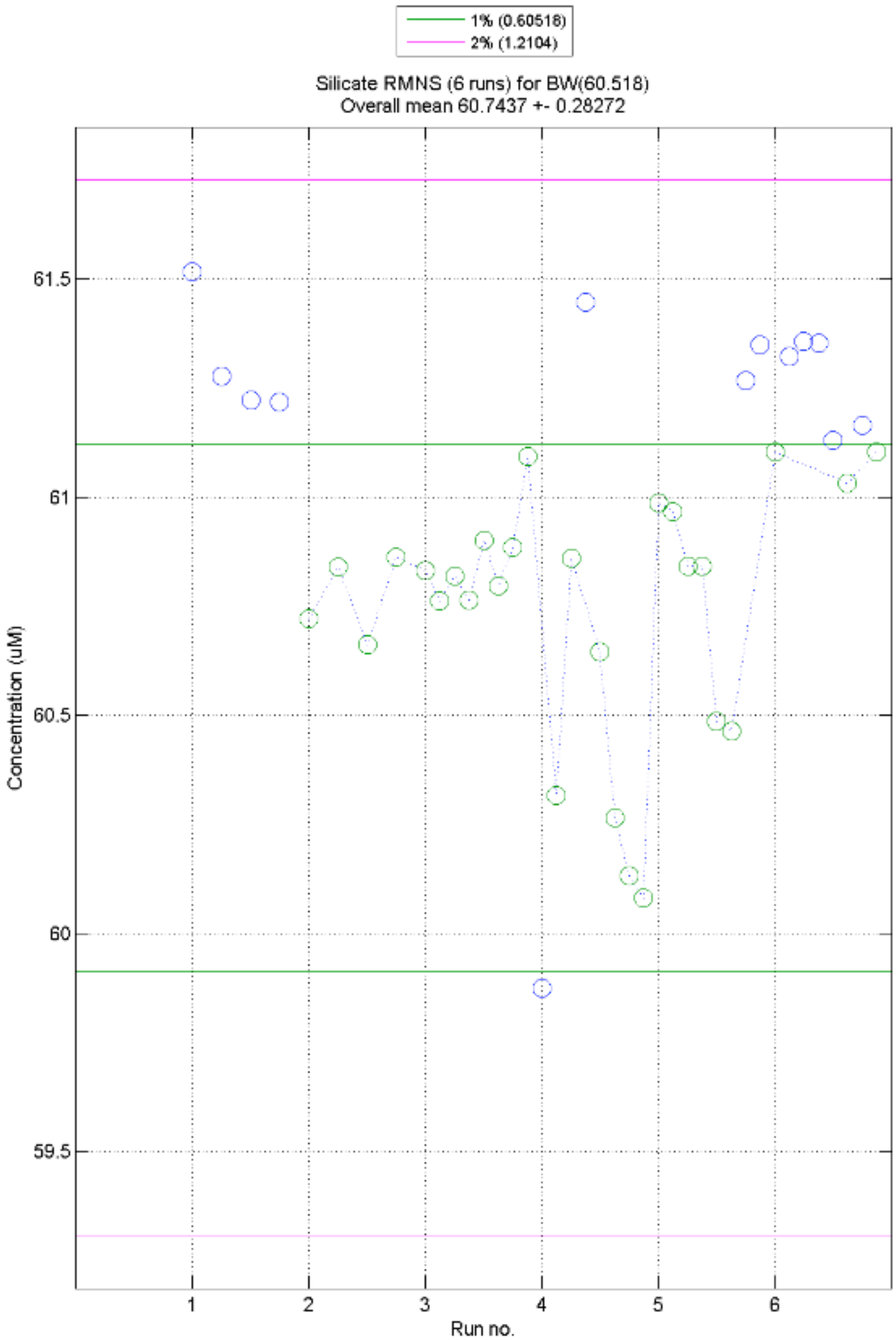


4.7.6 Redfield ratio plot

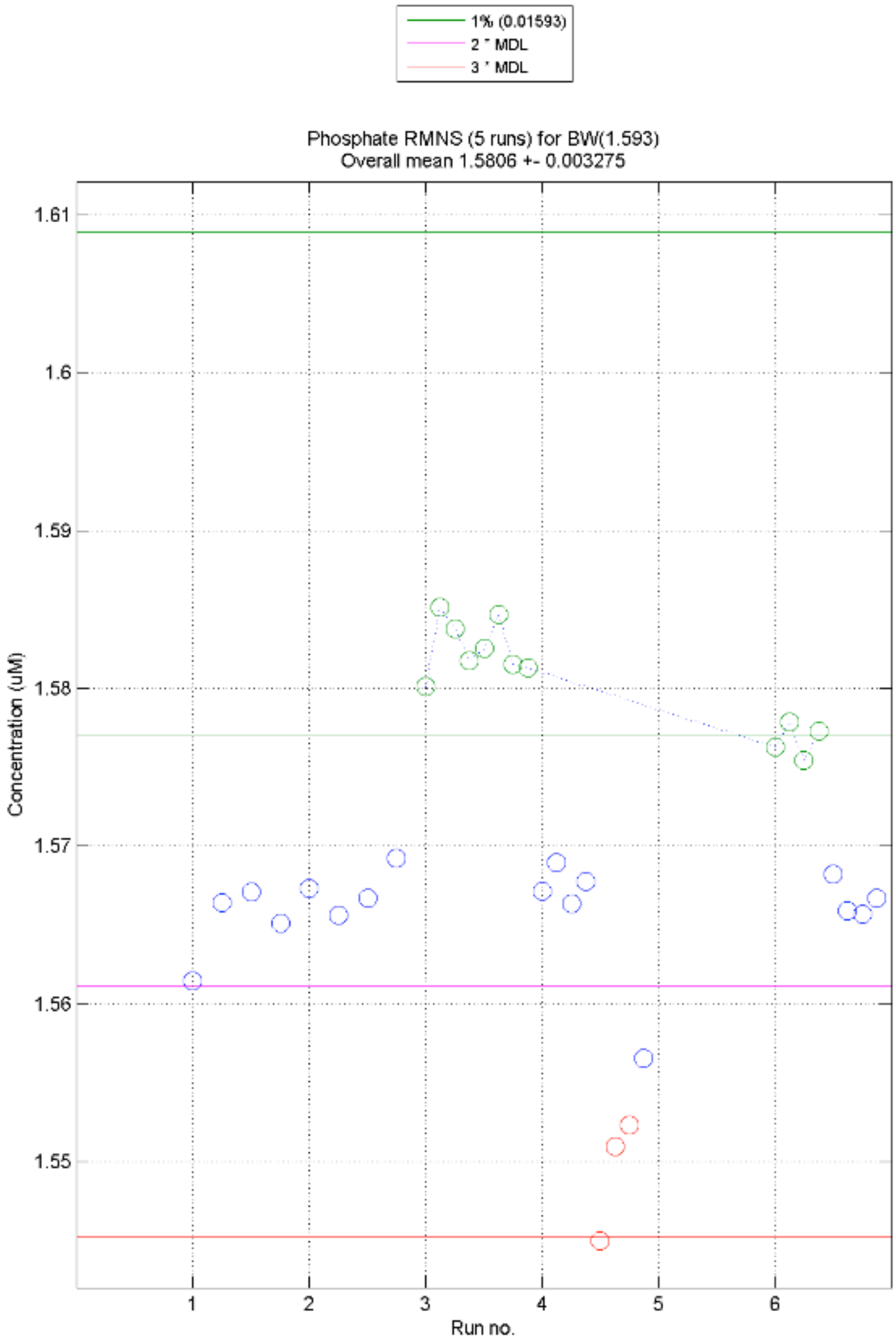


4.8 Quality Control

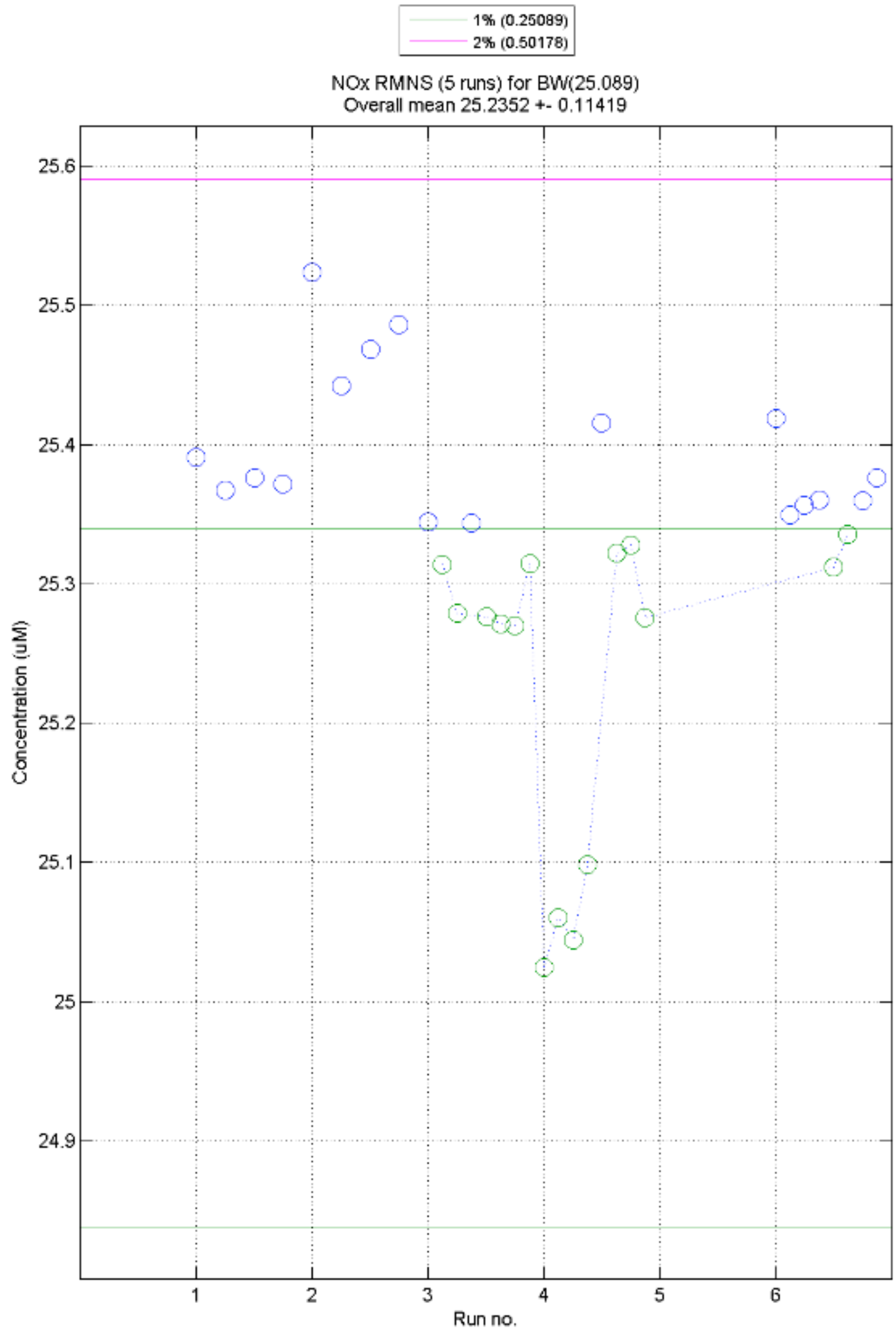
4.8.1 Silicate RMNS Chart



4.8.2 Phosphate RMNS Chart



4.8.3 NOx RMNS Chart



4.8.4 Duplicates

File	Silicate	Phosphate	Nitrate + Nitrite	Nitrite	Ammonia
Duplicates within limit	0.70 µM	0.02 µM	0.175 µM	N/A	N/A
1N2015_v0lnut00l	x	x	x		
1N2015_v0lnut002	x	x	x		
1N2015_v0lnut003	x	x	x		
1N2015_v0lnut004	x	x	x		
1N2015_v0lnut00S	x	x	x		
1N2015_v0lnut006	x	x	x		

4.9 Investigation of missing data and actions required

Deployment	RP	Analysis	Reason for removal	Action taken
#5	4	N/A	Niskin bottle did not close	Samples not collected
#5	7	N/A	Leaking Niskin bottle	Samples not collected

5 APPENDIX

5.1 Nutrient Reference Materials

RMNS	NOx	NO2	PO4	SiO4
BT	19.069	0.482	1.327	43.03
BF	41.388	0.02	3.114	157.932
CA	20.552	0.072	1.434	36.864
BU	4.052	0.07	0.381	21.517
BV	36.234	0.055	2.574	103.835
BW	25.089	0.052	1.593	60.518
BY	0.022	0.008	0.04	1.833

5.2 Salinity Reference Material

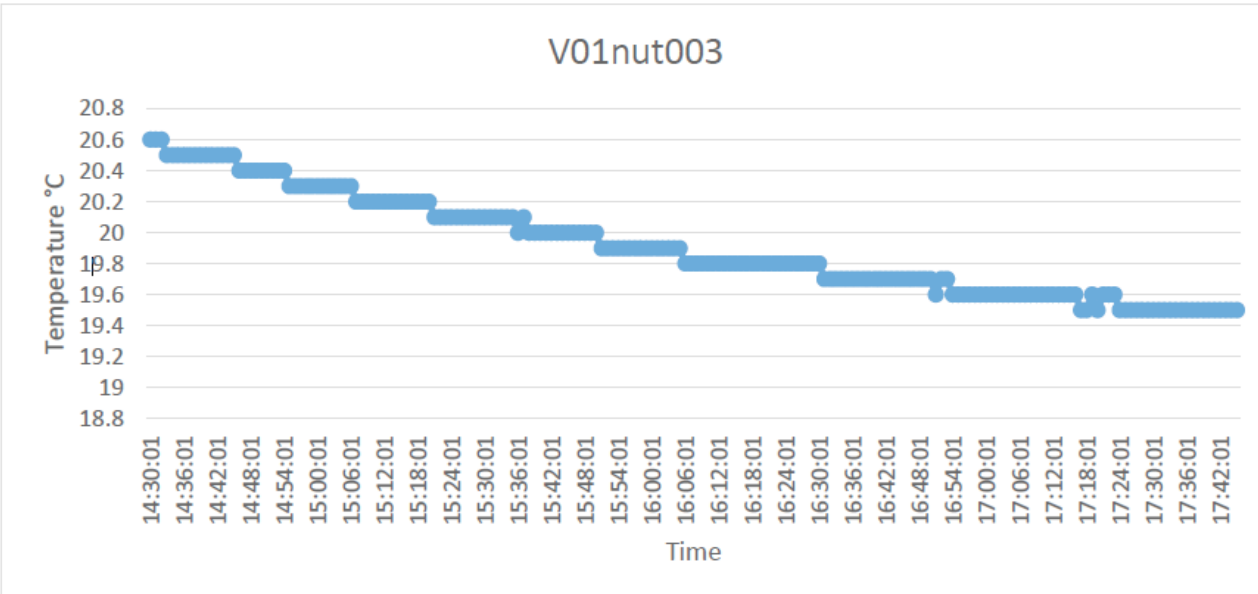
Batch No: P 157 K15 = 0.99985, use by date 15th May 2017.

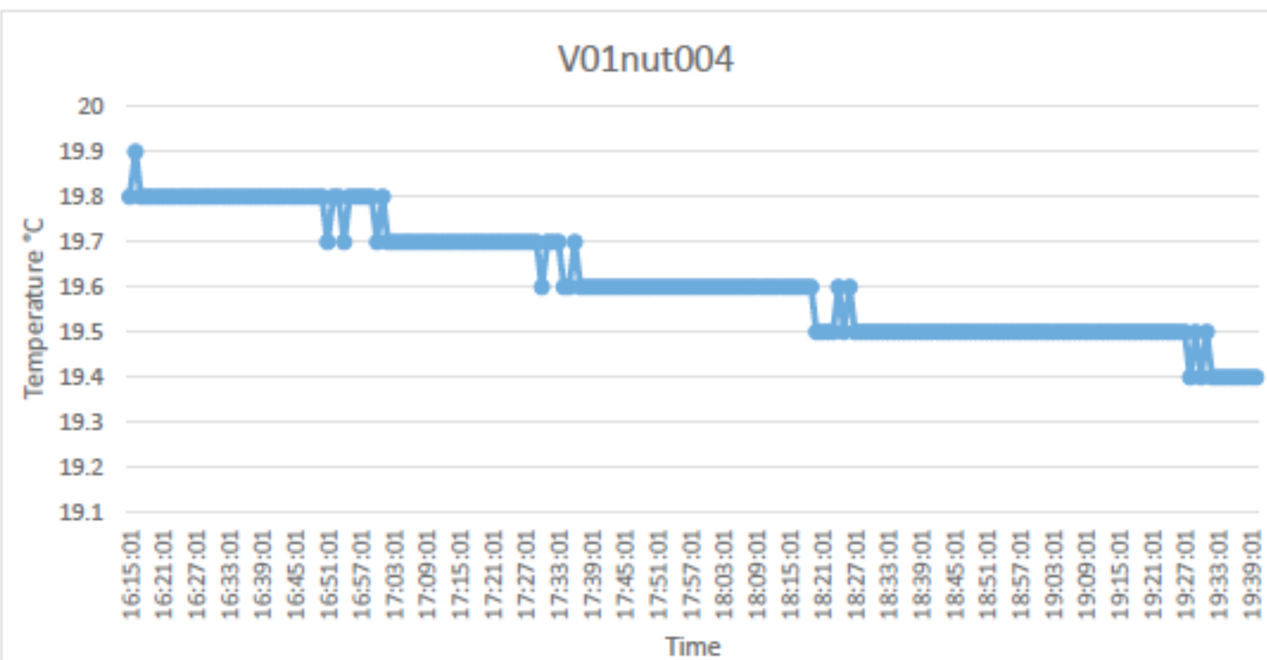
5.3 Go-Ship Specifications

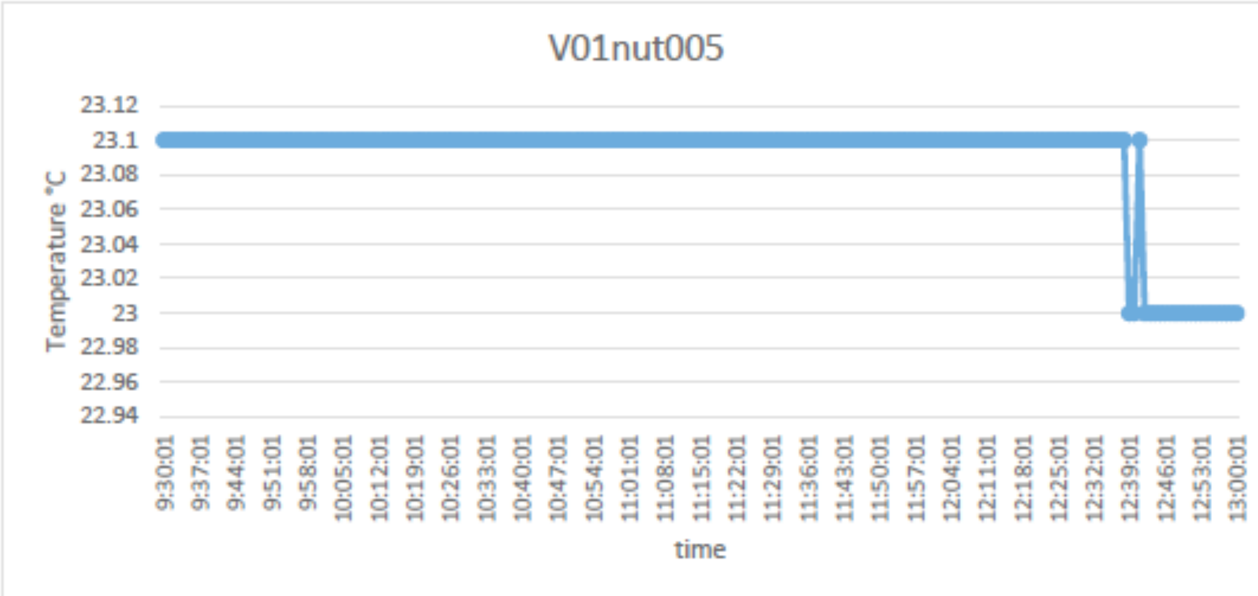
Salinity	Accuracy of 0.001 is possible with AutosalTM salinometers and concomitant attention to methodology, e.g., monitoring Standard Sea Water. Accuracy with respect to one particular batch of Standard Sea Water can be achieved at better than 0.001 PSS-78. Autosal precision is better than 0.001 PSS-78. High precision of approximately 0.0002 PSS-78 is possible following the methods of Kawano (this manual) with great care and experience. Air

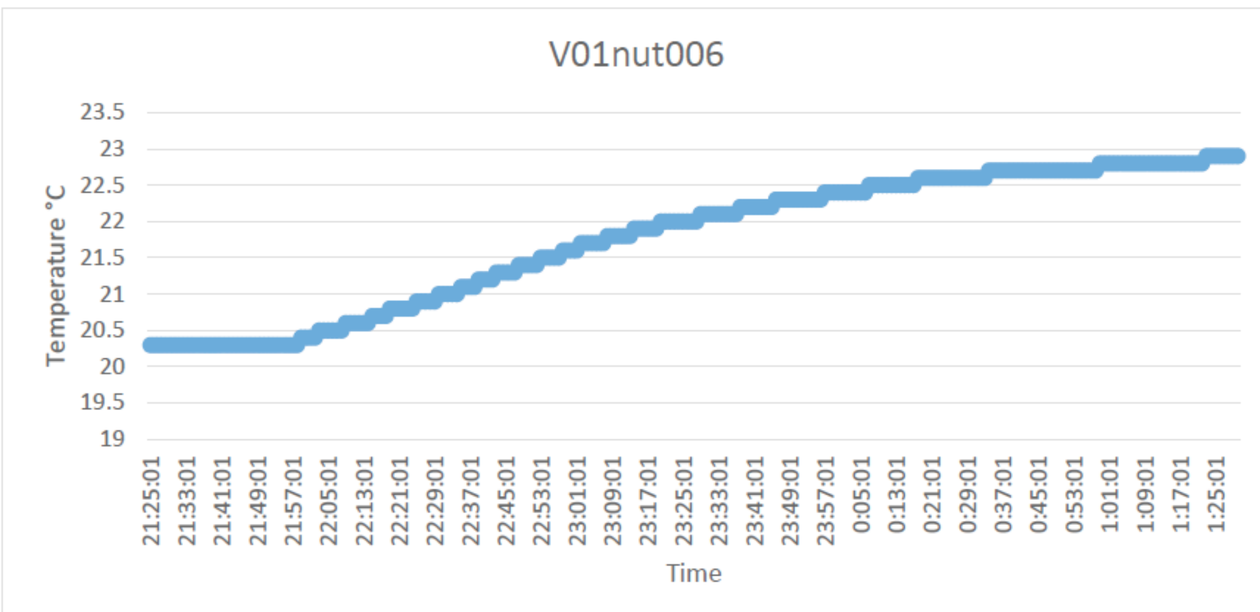
	temperature stability of ± 1°C is very important and should be recorded.1
O2	Target accuracy is that 2 sigma should be less than 0.5% of the highest concentration found in the ocean. Precision or reproducibility (2 sigma) is 0.08% of the highest concentration found in the ocean.
SiO2	Approximately 1-3% accuracy†, 2 and 0.2% precision, full-scale.
PO4	Approximately 1-2% accuracy†, 2 and 0.4% precision, full scale.
NO3	Approximately 1% accuracy† 2 and 0.2% precision full scale

5.4 Temperature change over nutrient analyses






V01nut005
Temperature °C
23.12
23.1
23.08
23.06
23.04
23.02
23
22.98
22.96
22.94
9:30:01
9:37:01
9:44:01
9:51:01
9:58:01
10:05:01
10:12:01
10:19:01
10:26:01
10:33:01
10:40:01
10:47:01
10:54:01
11:01:01
11:08:01
11:15:01
11:22:01
11:29:01
11:36:01
11:43:01
11:50:01
11:57:01
12:04:01
12:11:01
12:18:01
12:25:01
12:32:01
12:39:01
12:46:01
12:53:01
13:00:01
time


V01nut006
Temperature °C
23.5
23
22.5
22
21.5
21
20.5
20
19.5
19
21:25:01
21:33:01
21:41:01
21:49:01
21:57:01
22:05:01
22:13:01
22:21:01
22:29:01
22:37:01
22:45:01
22:53:01
23:01:01
23:09:01
23:17:01
23:25:01
23:33:01
23:41:01
23:49:01
23:57:01
0:05:01
0:13:01
0:21:01
0:29:01
0:37:01
0:45:01
0:53:01
1:01:01
1:09:01
1:17:01
1:25:01
Time

CCHDO DATA HISTORY NOTES:

File Online
Carolina Berys

IN2015_v01_Voyage Summary_FINAL 20150407.pdf (download)
<http://cchdo.ucsd.edu/data/12234/IN2015_v01_Voyage%20Summary_FINAL%2020150407.pdf>
#997e4
Date: 2016-06-15
Current Status: unprocessed

File Online Carolina Berys

096U20150321.exc.csv (download)
<http://cchdo.ucsd.edu/data/12236/096U20150321.exc.csv> #3f8e4
Date: 2016-06-15
Current Status: unprocessed

File Merge SEE

09IN20150321_ct1.zip (download)
<http://cchdo.ucsd.edu/data/12218/09IN20150321_ct1.zip> #d7328
Date: 2016-06-15
Current Status: merged

File Merge SEE

09IN20150321_nc_ctd.zip (download)
<http://cchdo.ucsd.edu/data/12219/09IN20150321_nc_ctd.zip> #1c127
Date: 2016-06-15
Current Status: merged

Updated CTD exchange and netcdf formats SEE

Date: 2016-06-15
Data Type: CTD
Action: Website Update
Note:

SOTS 2015 096U20150321 processing - CTD/update -
CTDPRS,CTDTMP,CTDSAL,CTDOXY,XMISS,PAR,FLUOR

2016-06-16

SEE

Submission

```
filename    submitted by            date        id
-------------------- ------------- ---------- -----
09IN20150321_ct1.zip    update      2016-06-15 12218
```

Changes

```
09IN20150321_ct1.zip
  - Changed ship code from IN to 6U.
  - Added cruise information to the header comments:
  # Changed Ship code from IN to 6U for the R/V Investigator
  # Data source: Tom Trull 9/17/15
  # DATES: 20150321 - 20150330
  # SHIP: R/V Investigator
  # Cruise: Southern Ocean Time Series - SOTS; IN2015_V01
  # Region: SE Indian
  # DATES: 20150321 - 20150330
  # Chief Scientist: Tom Trull
  # Supported by the Australian Commonwealth Cooperative Research Centre
    Program (T. Trull ACE Carbon RP2.1) and the Australian Marine
    National Facility (T. Trull, IN2015_V01 voyage award)
  # 3 stations with 24 place 10L Rosette
  # SOCCOM Biogeochemical floats deployed by Tom Trull
  #      Sta    WMO_ID     Lat       Lon      Date    U.W.ID
  #       7   5904470  -47.1284  143.9814  20150325   8514
  #       9   Deployed, but never responded           9315
  # Supported by NSF Award PLR-1425989 to J.L. Sarmiento et al.
  # Hydro/CTD: Who - Tom Trull; Status - final
```

Conversion
----

file	converted from	software
096U20150321_nc_ctd.zip	096U20150321_ct1.zip	hydro 0.8.2-47-g3c55cd3

Updated Files Manifest
----

file	stamp
096U20150321_ct1.zip	20160616CCHSIOSEE
096U20150321_nc_ctd.zip	20160616CCHSIOSEE

:Updated parameters: no parameters updated

opened in JOA with no apparent problems:
096U20150321_ct1.zip
096U20150321_nc_ctd.zip

opened in ODV with no apparent problems:
096U20150321_ct1.zip

File Submission Robert Key

096U20150321.exc.csv (download)
<http://cchdo.ucsd.edu/data/12236/096U20150321.exc.csv> #3f8e4
Date: 2016-06-09
Current Status: unprocessed
Notes

Robert Key
Ship code changed from IN to 6U in all instances of EXPOCODE. Old name added as alias in header

File Submission Robert Key

IN2015_v01_Voyage Summary_FINAL 20150407.pdf (download)
<http://cchdo.ucsd.edu/data/12234/IN2015_v01_Voyage%20Summary_FINAL%2020150407.pdf>
#997e4
Date: 2016-06-06
Current Status: unprocessed
Notes

Originator's summary cruise report. Downloaded from
http://mnf.csiro.au/~/media/Files/Voyage-plans-and-summaries/Investigator/Voyage%20Plans%20summaries/2015/IN2015_v01_Voyage%20Summary_FINAL%2020150407.ashx

File Merge SEE

09IN20150321_ct1.zip (download)
<http://cchdo.ucsd.edu/data/12096/09IN20150321_ct1.zip> #bf181
Date: 2016-05-10
Current Status: merged

File Merge SEE

09IN20150321_nc_ctd.zip (download)
<http://cchdo.ucsd.edu/data/12097/09IN20150321_nc_ctd.zip> #baf04
Date: 2016-05-10
Current Status: merged

Updated CTD exchange and netcdf formats SEE

Date: 2016-05-10
Data Type: CTD
Action: Website Update
Note:

SOTS 2015 09IN20150321 processing - CTD/merge - CTDPRS,CTDTMP,CTDSAL,CTDOXY,XMISS,PAR,FLUOR

2016-05-10

SEE

Submission

Filename	submitted by	date	id
09IN20150321_ct1.zip			12096

Changes

09IN20150321_ct1.zip
  - removed SCATT and SCATT_FLAG_W from files, as data are bad.

Conversion
----

file	converted from	software
09IN20150321_nc_ctd.zip	09IN20150321_ct1.zip	hydro 0.8.2-47-g3c55cd3

Updated Files Manifest
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file	stamp
09IN20150321_ct1.zip	20160510CCHSIOSEE
09IN20150321_nc_ctd.zip	20160510CCHSIOSEE

:Updated parameters: CTDPRS,CTDTMP,CTDSAL,CTDOXY,XMISS,PAR,FLUOR

opened in JOA with no apparent problems:
    09IN20150321_ct1.zip
    09IN20150321_nc_ctd.zip

opened in ODV with no apparent problems:
    09IN20150321_ct1.zip

File Online Carolina Berys

in2015_v01CTD_nc.zip (download)
<http://cchdo.ucsd.edu/data/12095/in2015_v01CTD_nc.zip> #a1a46
Date: 2016-02-11
Current Status: merged

File Merge SEE

in2015_v01CTD_nc.zip (download)
<http://cchdo.ucsd.edu/data/12095/in2015_v01CTD_nc.zip> #a1a46
Date: 2016-02-08
Current Status: merged

CTD exchange and netcdf formats online SEE

Date: 2016-02-08
Data Type: CTD
Action: Website Update
Note:

SOTS 2015 09IN20150321 processing - CTD/merge -
CTDPRS,CTDTMP,CTDSAL,CTDOXY,XMISS,PAR,FLUOR,SCATT

2016-02-08

SEE

Submission

Filename	submitted by	date	id
in2015_v01CTD_nc.zip	CSIRO via SEE	2016-02-08	12095

Changes
----

in2015_v01CTD_nc.zip
- reformatted CSIRO netcdf format to Exchange format
- CTDSAL: changed Parameter units from 1e-3 to PSS-78
- XMISS: changed Parameter name transmissometer to XMISS, and changed units from % to %TRANS
- CTDOXY: converted values from UMOL/L to UMOL/KG
- ALL CASTNO assigned to 1 by CCHDO
- added comments

Conversion
----

file	converted from	software
09IN20150321_nc_ctd.zip	09IN20150321_ct1.zip	hydro 0.8.2-47-g3c55cd3

Updated Files Manifest
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file	stamp
09IN20150321_ct1.zip	20160208CCHSIOSEE
09IN20150321_nc_ctd.zip	20160208CCHSIOSEE

:Updated parameters: CTDPRS,CTDTMP,CTDSAL,CTDOXY,XMISS,PAR,FLUOR,SCATT

opened in JOA with no apparent problems:

            09IN20150321_ct1.zip
            09IN20150321_nc_ctd.zip

opened in ODV with no apparent problems:
            09IN20150321_ct1.zip

File Submission SEE

in2015_v01CTD_nc.zip (download)
<http://cchdo.ucsd.edu/data/12095/in2015_v01CTD_nc.zip> #a1a46
Date: 2016-02-05
Current Status: merged
Notes

SOTS cruise
EXPOCODE 09IN20150321
from CSIRO Marine Research, via SEE
files created July 23, 2015

File Submission Robert M. Key

IN2015_v0_CTD_ProcessingReport.pdf (download)
<http://cchdo.ucsd.edu/data/12049/IN2015_v0_CTD_ProcessingReport.pdf> #ccc77
Date: 2015-12-16
Current Status: unprocessed
Notes

09IN20150321
SOCCOM cruise
Note this file has 3 new pigments. New names alert was sent in separate e-mail

File Submission Robert M. Key

IN2015_v01_HYDROCHEM_ProcessingReport_v1.0.pdf (download)
<http://cchdo.ucsd.edu/data/12048/IN2015_v01_HYDROCHEM_ProcessingReport_v1.0.pdf>
#8b3d5
Date: 2015-12-16
Current Status: unprocessed
Notes

09IN20150321
SOCCOM cruise
Note this file has 3 new pigments. New names alert was sent in separate e-mail