RV *Investigator* Voyage Plan

Voyage #:	**IN2016_V03**		
Voyage title:	Monitoring Ocean Change and Variability along 170°W from the ice edge to the equator		
Mobilisation:	Hobart, Tuesday 26 April, 2016		
Depart Leg 1:	Hobart, 0900 Wednesday 27 April, 2016		
Arrive Leg 1:	Wellington (NZ): 1100 Thursday 26 May		
Depart Leg 2:	Wellington (NZ): 1100, Friday 27 May, 2016		
Arrive Leg 2:	Lautoka (Fiji), 0900 Wednesday, 28 June, 2016		
Demobilisation:	Hobart, Thursday July 14, 2016		
Voyage Manager Leg 1:	Don McKenzie	**Contact details:**	don.mckenzie@csiro.au
Voyage Manager Leg 2:	Stephen Thomas	**Contact details:**	Stephen.thomas@csiro.au
Chief Scientist Leg 1:	Bernadette Sloyan		
Affiliation:	CSIRO Oceans and Atmosphere	**Contact details:**	Bernadette.Sloyan@csiro.au
Chief Scientist Leg 2:	Susan Wijffels		
Affiliation:	CSIRO Oceans and Atmosphere	**Contact details:**	Susan.wijffels@csiro.au
Principal Investigators:	Susan Wijffels; Bronte Tilbrook, Lev Bodrossy, Bec Cowley		
Project name:	As above		
Affiliation:	CSIRO Oceans and Atmosphere	Contact details:	Susan.Wijffels@csiro.au Bronte.Tilbrook@csiro.au Lev.Bodrossy@csiro.au Rebecca.Cowley@csiro.au
Principal Investigators:	Mark Warner, John Bullister		
Project name:	As above		
Affiliation:	University of Washington, Seattle, WA USA	**Contact details:**	warner@u.washington.edu

Supplementary Project			
Principal Investigator:	Alex Forrest, U. Tasmania.		
Project name:	Working from the other side: facing the challenges of under-ice for autonomous navigation in Antarctica		
Affiliation:	AMC, University of Tasmania	**Contact details:**	**Ph:** +61 3 6324 9744 **Email:** Alex.Forrest@amc.edu.au

Scientific objectives

Sloyan, Wijffels, Tilbrook, Warner, Bodrossy:

The full suite of key ocean parameters and the deep ocean heat and carbon reservoirs remain poorly measured. This proposal will complete full-depth, high-precision hydrographic, carbon, and tracer measurements, along 170^{o}W from the sea-ice edge to the equator, to monitor and detect ocean variability and change including changes in the carbonate chemistry associated with acidification. These data, together with other observational data and numerical models, will allow for the detection and attribution of ocean change and variability and to assess the impact of the ocean on climate variability.

This hydrographic section will monitor ocean change and variability by:

1. Directly measuring the full suite of ocean water properties (temperature, salinity, velocity, nutrients, tracers and ocean mixing) at high vertical and spatial resolution throughout the entire water column and in the deep boundary currents, contributing to the international GO-SHIP program
2. Providing high precision biogeochemical measurements to monitor changes in ocean carbon storage and oxygen concentrations, contributing to the IOCCP international program to monitor the global carbon budget.
3. Directly measure ocean mixing to improve our knowledge of the ocean Meridional Overturning Circulation.
4. Provide high precision baseline data to calibrate the Argo array, XBT program, and other autonomous observations (ocean gliders, moorings and satellites) in the vicinity of the section.
5. Deploy Argo floats for the core mission and contributions to the international SOCCOM project.
6. Obtain side-by-side CTD/XBT data for the assessment of bias errors in XBT measurements.

Voyage objectives

Sloyan, Wijffels, Tilbrook, Warner, Bodrossy:

The primary voyage objective is to obtain repeat occupations of the 155 full-depth CTD and Niskin casts along the GO-SHIP P15S section, with chemistry performed on water collected at 36 bottle levels. We will measure temperature, salinity, pressure, oxygen, fluorometry, shear and micro-scale temperature continuously, and the major nutrients, oxygen, salinity, CFC and carbon components discretely via chemical analysis on board. Small amounts of material will be filtered and stored for genomic analyses back on land. CSIRO has completed this line twice before and international groups have completed similar work along lines further east. The work plan and timings are based on these past voyages.

Argo float deployments will also be carried out – usually when just leaving a CTD station (SOCCOM floats) or during transit (we may slow the ship speed slightly). These will be over the ship’s stern (preferred).

Supplementary project

Facing the challenges of under-ice for autonomous navigation: CI Alex Forrest, University of California- Davis, AMC, U. Tasmania; On board scientist : Tobias Aldridge, UTAS / AMC - legs 1 & 2.

Accurate navigation under both drift and stationary ice is one of the key unanswered questions in polar marine science and engineering. The primary aims of this project are to (1) estimate INS drift and calibration times; and, (2) test the integration of acoustic positioning methods in an INS within a drifting and rotating frame of reference. This project will develop error propagation models at increasing latitudes and test the use of a non-stationary, ship borne acoustic positioning network on a small (<3 m) AUV. Both are critical for robust, accurate and reliable AUV operation under-ice.

The primary voyage objective is make measurements of inertial drift during vessel transit and calibration time while the *Investigator* is on station across as broad a range of latitudes as possible. The way that this will be achieved is that, while the vessel is on station, bench top tests will be conducted for alignment. Then, while moving, tests of inertial drift will be conducted. The student on board will work with the other PIs on board to coordinate timings of these tests but will not disrupt the other work taking place on board. The work plan and timing is based on methodologies established during past voyages.

Operational Risk Management

The key challenge around completion of the work program will be managing safe operations in strong wind/wave conditions and efficient ship-time management by the science and marine crew – in particular the speed at which we can arrive on station, deploy the CTD package, complete the profile, retrieve and tie down the package, get underway to the next station, complete the water sampling and set up the rosette for the next deployment

The stations are roughly 30nm apart, though they can be closer across steep topography. In the deep ocean, we expect to have around 2.5 - 2.8 hours transit time (at 11 knots) and so should have completed sampling and be ready to deploy by the time the ship arrives at the next location. Where stations are close we may be limited by water sampling time.

We do not require the ship to be exactly on location to start the cast (~within 0.1 of a nm of the target is fine) nor do we require to remain on location. Once the CTD package is deployed, the most important operational requirement is to keep the wire as vertical as possible (to reach the sea floor as fast as possible with smallest wire out) and to keep the wire away from the ships' hull. Thus drift during a cast is to be expected and is not problematic.

The stations of greatest scientific value are those at the southern end where the deep ocean warming signal is largest and the past occupations are scant due to the previous limitations of the MNF operations (50^{o} S). We hope to work as far south and as close to the ice edge as the Master deems safe. From past experience by both CSIRO and overseas teams, we expect the greatest storminess and work stoppages on leg 1, likely south of 45 ^{o} S. Weather and sea-states might limit the safe transit speed, CTD wire speed and at times require the ship to cease operations and be hove-to. We have allotted around 72 hours of time for being hove-to (if required) and also have assumed a slower transit speed south of 50 ^{o} S. Depending on the weather situation, we may work either north or south of storms and fill in the gaps after their passage, as best assessed at the time by the Master, Chief Scientist and Voyage Manager.

However, where safe to do so, we hope to maximize ship speed and our operational weather window where possible, to complete as many stations as we can before breaking the line to head into Wellington for the May 20 port visit.

Besides managing safe operations through Southern Ocean wave and wind states, we do not view our operations as high risk. The weather risk will be managed via daily assessments between the voyage leadership team (Master, Chief Scientist and Voyage Manager).

Fatigue is a key risk to manage. This has been greatly mitigated by the crew change in Wellington and fielding 3 x 8 hour CTD watches, as well as extra hands in some of the chemistry laboratories on Leg 1.

Overall activity plan including details for first 24 hours of voyage

We will steam out of Hobart to our first test station (CTD 001), targeting a 4000m or deeper site. The first 24 hours will be mostly steaming, allowing safety and orientation briefings to be carried out.

The test station likely be around 11am on the second day (April 22). The purpose is to confirm the CTD and sensor acquisition systems are all working well and that the Niskin bottles are sealing properly. If there are issues we will correct them either on board or return to Hobart if required, and plan a second test station along the transit. We will take samples for salinity analysis, and then proceed to train the science watches in water sampling techniques. Additional testing of the Inertial Navigation System (INS) for the Supplementary Project will be tested both at station and in transit. If all goes well we will then proceed along a great circle route at maximum speed to the P15S section start (68 °S and 170 °W).

Along the steam to the P15S section start, we will deploy several Argo floats – 5 from Argo Australia and 7 SOLO II floats from the Scripps Institution of Oceanography. These are targeted at set latitudes (longitudes will be dependent on the route). The CTD watch and deck crew will deploy the floats (which will be stowed in the aft instrument lab).

During the transit, we will set up the laboratories, underway logging systems and continue training the CTD watches and lab teams. Test runs of the INS will be conducted during this time to ensure that the data can be reliably collected during the testing phase. No special requirements are needed during either phase of this testing.The transit, including the test station will be around 8 days (at 10.5knts – hopefully shorter if faster average ship speeds are achieved).

As we near the ice edge at 170 °W, we will need to assess the southern most latitude for a CTD. We would like to be as far south as the Master deems safe. All CTD stations will be full-depth to within 10m of the bottom, lowering at 60m/minute where possible and with 36 Niskin bottles fired throughout the water column. On retrieval of the package, we need to tie the frame down, seal the CTD lab and get the ship underway expeditiously. During Leg 1 in particular, Argo floats will be deployed after many of the stations (see Table 2), preferably at low speeds while the ship just leaves the site. We will then work northwards completing stations as per Table 1. At 11 knots transit speeds the typical steam time is around 2.5 hours between stations, with typical cast times being 3-4 hours.

Alignment of the INS will be done at each station for 1-2 hours and then put into free inertial mode once the vessel is in motion.

Tritium/helium samples will be taken from the Niskins every 1-degree latitude spacing from 68 °S to 55 °S, then every 2-degree spacing from 55 °S to the Wellington port (about 22 stations in total).

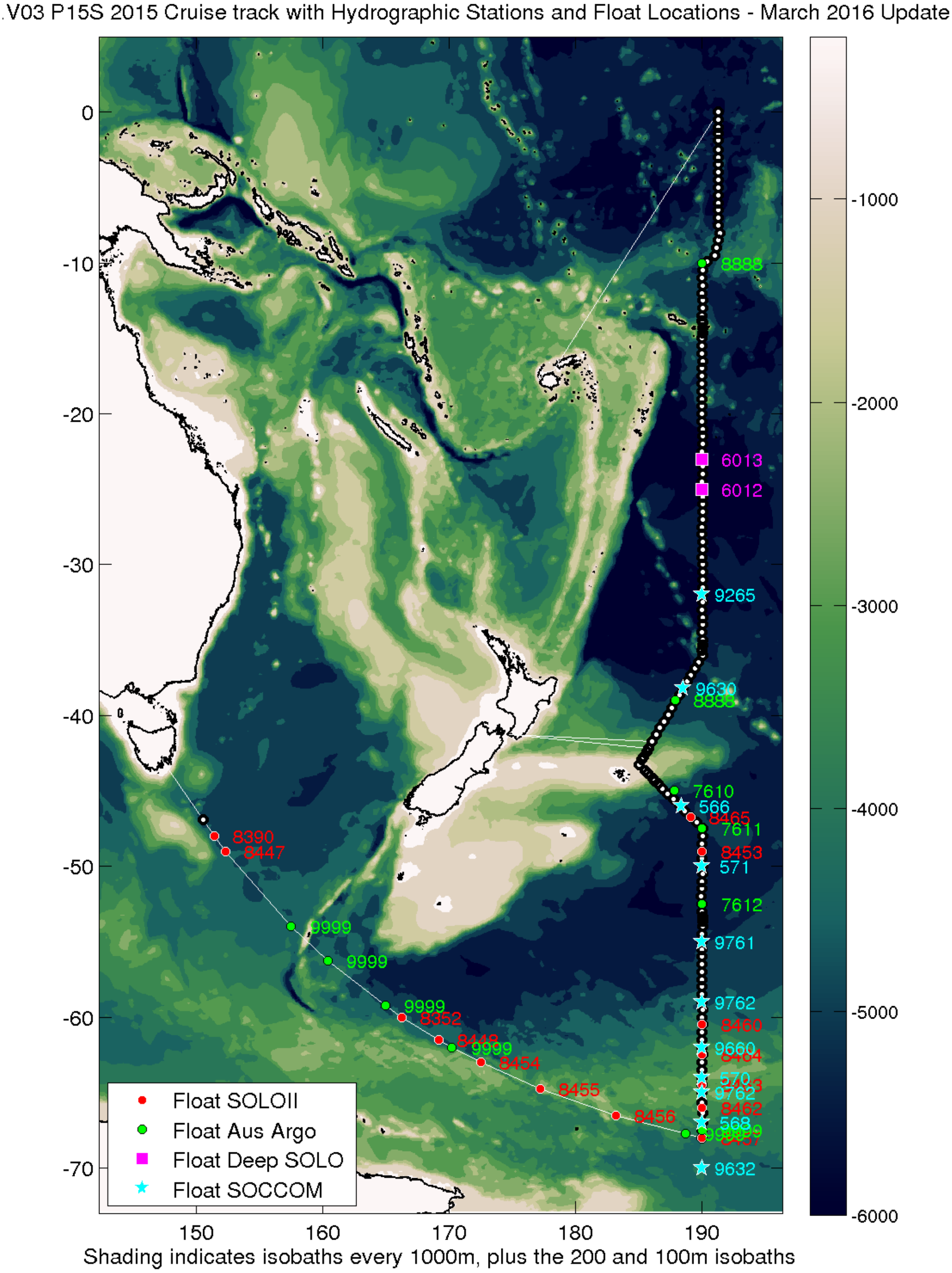
During some CTD stations, eXpendable BathyThermographs will also be deployed in the early part of the CTD cast. These will be done from the ship's stern while the CTD is in operation. Two (or three) XBT systems will be used to deploy 6 XBTs each during a CTD station. Three will be deployed while the CTD is at the surface, then three more while the CTD is descending. XBTs will be deployed every 3-5 stations, depending on how many probes are available. In addition, comparisons of modern Deep Blue XBTs and older T5 XBTs will be completed while the ship is underway.

Based on our current ship speed estimates, we anticipate completing stations 1-60 before having the break work for the 41 hour transit to Wellington to arrive May 26, 2016 in the morning. If we are ahead of schedule we will continue to complete more stations working northward before breaking the work to transit to New Zealand.

In Wellington the CTD and many of the science teams will change over. Some material will be taken off the ship for land-based analysis e.g. samples in a dry shipper, but these can be walked off. We do not anticipate any major loading or unloading of science equipment in New Zealand.

Leg 2 will comprise the remaining stations, nominally 61-155. The transit back to the line will be around 41 hours. There will be some Leg 2 float deployments. Two prototype 'deep SOLO' floats will be deployed between 20-30 °S, again after a CTD station has been completed. On finishing the last station at the equator, we have around a 4 day transit to Fiji, during which final analyses will be completed, data processed and laboratories prepared for demobilisation in Hobart. Most science crew will disembark in Fiji, though some of the underway chemistry team will remain on board.

Voyage track example



Waypoints and stations/Time estimates

Estimated waypoints, steaming and station locations and times are shown in Table 1. Assumed ship speeds for some parts are lower than 11kns, as we are uncertain that 11 knot transit speeds can be sustained by I*nvestigator* in the heavy swell and wind conditions we expect on leg 1. Past experience by CSIRO and other international teams suggests much slower transit speeds are to be expected south of 50 °S. Regardless of the plan, transits speeds should be as high as is safely possible on the day to allow the best possible chance of completing the overall work plan.

Piggy-back projects

Atmospheric underway measurements: CI Melita Keywood, CSIRO; on board scientists: Joel Alroe QUT - leg 1 & Reece Brown QUT - leg 2

The scientific objective of this work is to investigate the chemical composition, size distribution, optical properties and cloud nucleating properties of marine aerosol over the southern hemisphere with the aim of quantifying regional contributions of aerosols to radiative forcing. There is currently very large uncertainty associated with the direct, semi-direct and indirect effect of aerosols on radiative forcing. A key feature in this regard is the influence on cloud properties of cloud condensation nuclei (CCN), the very small atmospheric aerosol particles necessary for the nucleation of every single cloud droplet. A recent analysis of the 35-year CCN concentration record at Cape Grim challenges the current accepted wisdom of the role of dimethyl sulfide (DMS) on CCN formation over the Southern Ocean. In particular, it appears that DMS oxidation is only significant during the summer months at Cape Grim, and in fact other sources and processes dominate throughout the rest of the year (Gras pers com). That other sources and processes may be significant in CCN production and modulation has also recently been suggested in a review of the CLAW hypothesis. The identity of these sources remains an open question. The work proposed here will be a positive step in addressing this question.

Instrumentation will run continuously in the Aerosol and Air Chemistry Labs whilst underway with no special requirements with regards to the vessel's course or speed. On board work will involve the daily checking of instruments within the two labs and the storing of filter samples in the walk-in freezer.

In addition measurements will be taken at sea using hand held instruments outside on deck during good weather conditions.

Inorganic Nitrogen uptake: CI Anya Waite, AWI, Germany; on board scientist: Eric Raes, UWA – legs 1 & 2

The scientific objective of this work is to map, for the first time, the genomic characteristic of marine bacteria and phytoplankton along 170°W, as part of a larger set of surveys being carried out around Australia.

While we are getting better insights in the microbial community and their taxonomy, uptake and rate measurements of N and C are still very sparse throughout the wold oceans and are a high priority to accurately quantify C, N cycles and the associated primary productivity. Especially as we have to keep in mind that numerically outnumbered microbes can play a significant role in the N and C cycles of their ecosystem. Previous studies have shown that the least abundant species (in this case the anaerobic, phototropic bacteria Chromatium okenii representing ~0.3% of the total cell numbers), can contribute more than 40% of the total NH_4^+assimilation and up to 70% of the total C fixation.

We will investigate the role of microbes in the N uptake. While we may be able to get presence absence using techniques such as quantitative polymerase chain reactions (qPCR), metagenomics or high through put sequencing, isotopes (stable isotopes) are necessary to measure rates of nutrient utilization/remineralization.

We will take water from the level 02 flow through system near the Isotope Lad (Radvan). No special requirements with regards to the vessel's course or speed are required. All sampling will be aligned with the CTD stations.

<u>Tritium/Helium Measurements: CI Stephanie Downes, ACE CRC;</u> on board operations conducted by the CTD Watch Groups – legs 1 & 2. The scientific objective of this work is to obtain Tritium/Helium measurements in the Antarctic Circumpolar Current.

Helium is an inert gas naturally released at hydrothermal vents, and (as a passive tracer) is commonly used to trace deep ocean circulation. Recently, hydrothermal vents and plumes have been identified along the Australian-Antarctic Ridge and Pacific-Antarctic Ridge using observations of temperature, helium and other tracers. Only one voyage to date has been undertaken with ocean surface to floor data south of the Pacific Antarctic Ridge along 170^{o}W (67^{o}S to the Equator; 1996). However, helium data was not collected during this voyage.

The new helium dataset acquired on this voyage, will be used to fulfil the following main objectives are:

- Provide new evidence of hydrothermal activity along the western end of the Pacific Ridge, including a possible description of plume dispersion along the ocean's strongest current, Antarctic Circumpolar Current.
- Assess interconnectivity of hydrothermal systems between the Australian-Antarctic Ridge and Pacific Antarctic Ridge.
- Provide new descriptions of water mass pathways and exchange within and between the Antarctic Circumpolar Current and the Ross Gyre.

He/Tri sampling – Steph Downes and Mark Rosenberg to train watch leaders on procedures. We will aim to train watch leaders before mobilisation in Hobart with additional training occurring as equipment is setup during mobilisation. Training time should not exceed 1.5hrs in total (most of this will be pre-mobilisation). On board sampling will require nothing further than additional water samples from the CTD rosette as agreed and will be conducted by the CTD teams.

<u>Radio Carbon isotopes: CI Robert Keys, Princeton, USA</u>; on board operations conducted by the Carbon Analysis Group – legs 1 & 2.

Measure deltaC13 and deltaC14 isotopic ratios to help map the age and thus ventilation of ocean waters. On board sampling will require nothing further than additional water samples from the CTD rosette as agreed and will be conducted by the Carbon Analysis teams.

Investigator equipment (MNF)

CTD - Seabird 911 with 36 Bottle Rosette Dual sensors Oxygen Fluorometer/Back Scatter Transmissometer Altimeter	primary
CTD -Seabird 911 with 24 Bottle Rosette	backup
LADCP system	primary
XBT System	primary
Milli -Q System	primary
Light Duty Electronic Balance	Desirable
75 KHz / 150 KHz sADCP	Both
Multi Beam Acoustics	Where no interfere with sADCP
Scientific Echo Sounders	Primary
Thermosalinograph	yes
Atmospheric Underway Sensors	yes
PC02/oxygen underway	yes
MNF Clothing container	required
MNF Isotope containerised lab (RADVAN)	required
MNF Incubator container base platform	required

Name	**Essential**	**Desirable**
Aerosol Sampling Lab	x	
Air Chemistry Lab	X	
Preservation Lab		
Constant Temperature Lab	X	
Underway Seawater Analysis Laboratory	X	
GP Wet Lab (dirty)	X	
GP Wet Lab (Clean)	X	
GP Dry Lab (Clean)		
Sheltered Science Area	X	
Monkey Island		
Walk in Freezer		
Clean Freezer		
Blast Freezer		
Ultra Low Temperature Freezer		
Walk in Cool Room		

Isotope Lab (Radiation van): CI's Anya Waite, AWI, Germany; Eric Raes, UWA

Installed on the O2 deck to allow productivity incubations to be carried out using water from the underway flow system.

User Equipment

Carbon chemical analyses: CI Bronte Tilbrook, CSIRO

Carbon parameters will be measured using a coulometer, cavity ring down spectrometer, potentiometric titrator, spectrophotometer. O2/Ar measured via a quadrupole mass spectrometer, oxygen optodes. The carbon team will set up in the general purpose wet lab (clean) on the main deck.

Atmospheric underway measurements: CI: Melita Keywood, CSIRO

CCN and instrumentation utilising the Aerosol Lab air inlet – all user supplied equipment already on board from IN2016_V02.

CFC, SF_6 analysis container laboratory: CI Mark Warner, U. Washington, and John Bullister, NOAA-PMEL

CFC gas concentrations will be analysed on board in a container laboratory placed on the main deck.

He/Tri sample collection: CI Steph Downes, ACE CRC

One white fiberglass container with hydraulic crimper plus other supplies for helium sampling [40 x 24 x 24" 160 lbs]

Stack of 20 coils of copper tubing in cardboard cartons [24 x 24" x 20" ~ 260 lbs]

2 empty white fiberglass crates for copper tube samples [25 x 15 x 17" ~ 20 lbs each empty]

Crimper equipment will be set up in the CTD lab on a bench. Equipment will be bolted/clamped to the bench. Empty crates for storage of samples will be kept elsewhere (possibly stored in the wet lab (clean or dirty) or other available space.)

Note: samples should be stored at a temperature below 30 $^{\circ}$C.

Bacterial/Genomics sampling: CI Anya Waite, AWI, Germany; Eric Raes, UWA; Lev Bodrossy

- Bacterial and genomic sampling will be done using a multi head peristaltic pump (dimensions: H:30cm, W:30cm; L:60cm). Sampling will be set up in the general purpose wet lab (clean) on the main deck.
- Samples for phytoplankton pigment analysis (using HPLC back on the main land) will be done using 2 x filtration racks and vacuum pumps (dimensions filtration rack: H:60cm, W:20cm; L: 50 cm + 2 pumps H:20cm, W:20cm; L: 20cm). Sampling will be set up in the general purpose wet lab (clean) on the main deck.
- Samples for Chl a will be done using a filtration rack (dimensions: H:60cm, W:60cm; L: 60 cm). Sampling will be set up in the general purpose wet lab (clean) on the main deck.
- Sampling for picoplankton (no specific materials, we only need to take 1ml of seawater and preserve these samples with 1% paraformaldehyde).Note, I 've attached the Material Safety Data Sheet (MSDS) for 4% paraformaldehyde, we will be taking a 4 x dilution aboard). Sampling will be done in the general purpose wet lab (clean) on the main deck.
- 3 dewars with liquid nitrogen for sample storage. Dewars will be stored in the general purpose wet lab (clean) on the main deck.

- Overall I estimate to occupy 2 m in the general purpose wet lab on the main deck.
- Dissolved inorganic nitrogen uptake rates will executed in on deck incubation bins. Sample filtration will be done in the Rad van.

eXpendable BathyThermographs probes: CI Rebecca Cowley, CSIRO O&A

One or two wireless XBT systems will be brought on board. Approximately 600 XBT probes will also be on board and will require a dry storage area.

Argo/SOCCOM Floats: CI Dean Roemmich, SIO; Lynne Talley, SIO; Susan Wijffels, CSIRO O&A.

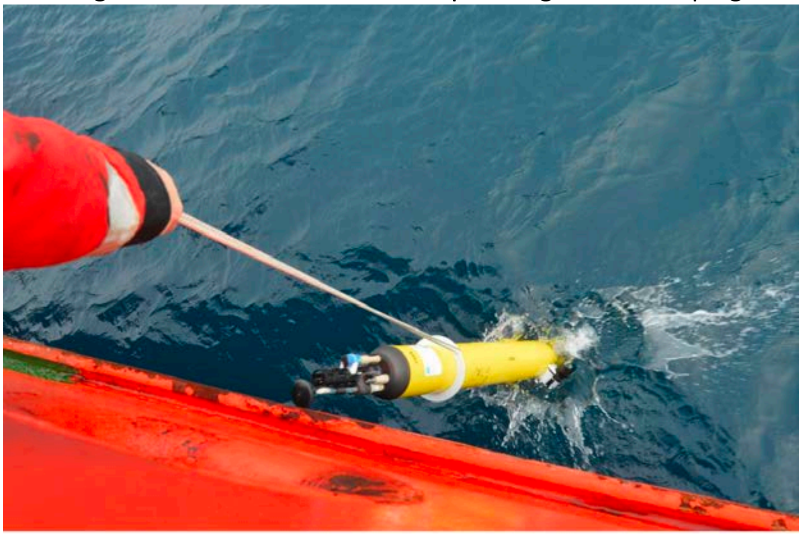
Float deployments will be carried out both during the transits and along the CTD line. Profiling floats are delicate instruments with fine seals and sensitive instrumentation. It is essential that we minimize any knocks or shocks during deployment.

Float deployment locations are shown in Table 2.

Several different float types are being deployed:

1) 'core' Argo floats – either from Argo Australia or US Argo's SOLOII. These floats will be deployed in protective biodegradable cardboard boxes via a quick release sling. These deployments can be carried out underway – preferably from the ship's stern (if weather permits). These floats should not be removed from their boxes for deployment, but be deployed with the box.

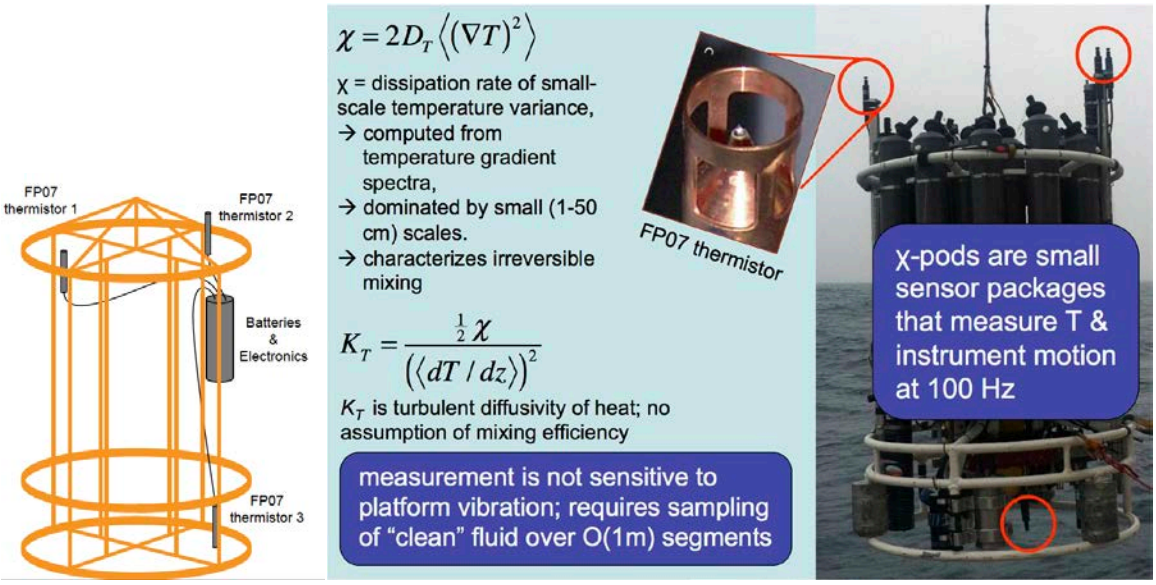
2) BGC-SOCCOM floats – these floats are heavily instrumented and 'naked' deployment is preferred to avoid entanglement of the sensors with the box edges. These are deployed via careful lowering of the floats on a line via loop through their damping disks (see picture).



These deployments can only be done at slow ship speed and on the lee side of the vessel. We will aim for these deployments to occur at low ship speed just as we leave a CTD station.

3) Deep Argo floats

Chi-Pods - high frequency temperature and package motion for mixing rates: Johnathan Nash, Oregon State University



All of instruments are internally recording, and consist of a sensor 3 cm x 12 cm cabled to an electronics pressure case (7cm x 40 cm), all rated to 6000 m. Each is powered by 2 lithium batteries, which we ship directly to the ship and install there.

Sensors will be mounted on the CTD rosette; 2 sensors pointed up, extending perhaps 30 cm above the rosette near its edges and 1-2 sensors pointing down, in the middle of biggest void at the bottom of the rosette, with their sensing element approximately 1 cm from the ship's deck when the rosette is on the deck.

Johnathan Nash to coordinate with MNF tech team lead (Steve Thomas/Rod Palmer). Installation will be done in Hobart during April 19-20. Operations instructions (data download/recharging etc) to be provided by Nash and colleagues.

Instruments will be removed from the rosette on the transit to Fiji and stored with other voyage equipment for off-loading Brisbane and be shipped back to the USA. Nash to organize.

Deep Argo test CTDs: David Murphy, SeaBird Electronics, Seattle, WA.

Install two SBE 61 Deep ARGO CTDs on the frame for stability tests against the 9plus sensors, and trying out some experimental conductivity cells. A secondary goal is to test optical oxygen and possibly pH.

SBE will send a person to help install the gear onto the frame. All gear will be internally recording. The CTD watch will be trained in how to start, stop, download and recharge (if needed) the loggers.

Permits

- Clearances for marine science and research in foreign waters
- Antarctic Treaty clearance has been granted for work and float deployments south of 60 °S.
- Isotope Lab (Radiation van).

Personnel List – Leg 1

1.	Don McKenzie	Voyage Manager	CSIRO MNF
2.	Ian McRobert	SIT Support	CSIRO MNF
3.	Rod Palmer	SIT Support	CSIRO MNF
4.	Anoosh Sarraf	DAP Support	CSIRO MNF
5.	Steven Van Graas	DAP Support	CSIRO MNF
6.	Matt Boyd	GSM Support	CSIRO MNF
7.	Christine Rees	Hydrochemist	CSIRO MNF
8.	Peter Hughes	Hydrochemist	CSIRO MNF
9.	Stephen Tibben	Hydrochemist	CSIRO MNF
10.	Kelly Brown	Hydrochemist	CSIRO O&A
11.	Lloyd Fletcher	Doctor	Aspen Medical
12.	Bernadette Sloyan	Chief Scientist	CSIRO Oceans and Atmosphere
13.	Bec Cowley	CTD watch 1 Lead	CSIRO Oceans and Atmosphere
14.	John Church	CTD watch 1	CSIRO Oceans and Atmosphere
15.	Catriona Johnson	CTD watch 2 Lead	CSIRO Oceans and Atmosphere
16.	Rodrigo Gurdeck	CTD watch 2	James Cook University
17.	Madi Rosevear	CTD watch 2	University of Tasmania
18.	Paul Sandery	CTD watch 3 Lead	CSIRO
19.	Taha Cowen	CTD watch 3	University of Tasmania
20.	Nic Pittman	CTD watch 3	University of Tasmania
21.	Melissa Miller	hydrochem/SOCCOM	Scripps Institution of Oceanography
22.	Craig Neill	Carbon Analysis	CSIRO Oceans and Atmosphere
23.	Kate Berry	Carbon Analysis	CSIRO Oceans and Atmosphere
24.	Abe Passmore	Carbon Analysis	CSIRO Oceans and Atmosphere
25.	Erik Van Ooijen	Carbon Analysis	CSIRO Oceans and Atmosphere
26.	Hayden Martin	Radio Carbon	Research School of Earth Sciences, ANU (PhD Student)
27.	Sharlynn Koh	Carbon Analysis	CSIRO
28.	Jacob Yeo	Radio Carbon	CSIRO
29.	Dave Wisegarver	CFC analysis	NOAA PMEL
30.	Bonnie Chang	CFC analysis	University of Washington, Joint Institute for the Study of the Atmosphere and Ocean or U.Washington/JISAO
31.	Joel Alroe	Atmospheric chemistry	Queensland University of Technology
32.	Eric Raes	Bacterial/Genomics	UWA
33.	Swan Sow	Bacterial/Genomics	CSIRO
34.	Nicole Hellessey	Bacterial/Genomics	University of Tasmania
35.	Tobias Aldridge	iXBlue PHINS INS	University of Tasmania, AMC

Personnel List – Leg 2

1.	Stephen Thomas	Voyage Manager	CSIRO MNF
2.	Ben Baldwinson	SIT Support	CSIRO MNF
3.	William Ponsonby	SIT Support	CSIRO MNF
4.	Hugh Barker	DAP Support	CSIRO MNF
5.	Stewart Wilde	DAP Support	CSIRO MNF
6.	Bernadette Heaney	GSM Support	CSIRO MNF
7.	Christine Rees	Hydrochemist	CSIRO MNF
8.	Cassie Schwanger	Hydrochemist	CSIRO MNF
9.	Stephen Tibben	Hydrochemist	CSIRO MNF
10.	Kelly Brown	Hydrochemist	CSIRO O&A
11.	Susan Wijffels	Chief Scientist	CSIRO Oceans and Atmosphere
12.	Esmee Van Wijk	CTD watch 1 Lead	CSIRO Oceans and Atmosphere
13.	Veronica (YueHua) Li	CTD watch 1	UNSW student
14.	Edward King	CTD watch 1	CSIRO
15.	Mark Rosenberg	CTD watch 2 Lead	ACE CRC
16.	Mainak Mondal	CTD watch 2	Australian National University
17.	Luwei Yang	CTD watch 2	University of Tasmania/IMAS
18.	Ann Thresher	CTD watch 3 Lead	CSIRO Oceans and Atmosphere
19.	Maija Kaipio	CTD watch 3	University of Auckland
20.	Asha Vijayeta	CTD watch 3	Monash University
21.	Craig Neill	Carbon Analysis	CSIRO Oceans and Atmosphere
22.	Kate Berry	Carbon Analysis	CSIRO Oceans and Atmosphere
23.	Abe Passmore	Carbon Analysis	CSIRO Oceans and Atmosphere
24.	Erik Van Ooijen	Carbon Analysis	CSIRO Oceans and Atmosphere
25.	Bronte Tilbrook	Carbon Analysis	CSIRO Oceans and Atmosphere
26.	Kate Holland	Carbon Analysis	Research School of Earth Sciences, ANU (PhD Student)
27.	Jessica Ericson	Carbon Analysis	University of Tasmania
28.	Rolf Sonnerup	CFC analysis	University of Washington, Joint Institute for the Study of the Atmosphere and Ocean or U.Washington/JISAO
29.	Bonnie Chang	CFC analysis	University of Washington, Joint Institute for the Study of the Atmosphere and Ocean or U.Washington/JISAO
30.	Reece Brown	Atmospheric chemistry	Queensland University of Technology
31.	Eric Raes	Bacterial/Genomics	University of Western Australia
32.	Gaby Paniagua Cabarrus	Bacterial/Genomics	University of Tasmania
33.	Bernhard Tschitschko	Bacterial/Genomics	University of New South Wales
34.	Tobias Aldridge	iXBlue PHINS INS	University of Tasmania/AMC

Signature

Your name	Bernadette Sloyan
Title	Chief Scientist
Date:	26 April 2018

List of additional figures and documents

Appendix A – locations where XBTs will be deployed for bias detection

Appendix A: Location map of XBT deployments – PI Bec Cowley

The map shows the CTD stations where concurrent XBTs will be dropped. The Deep Blue type probes typically terminate at 900m, while the T4 probes terminate at approximately 500m. The pink circles indicate regions of depth <2000m where T5 probes will be deployed while the ship is underway. We aim to hit the bottom with these probes, which terminate at approximately 1800 to 2000m.

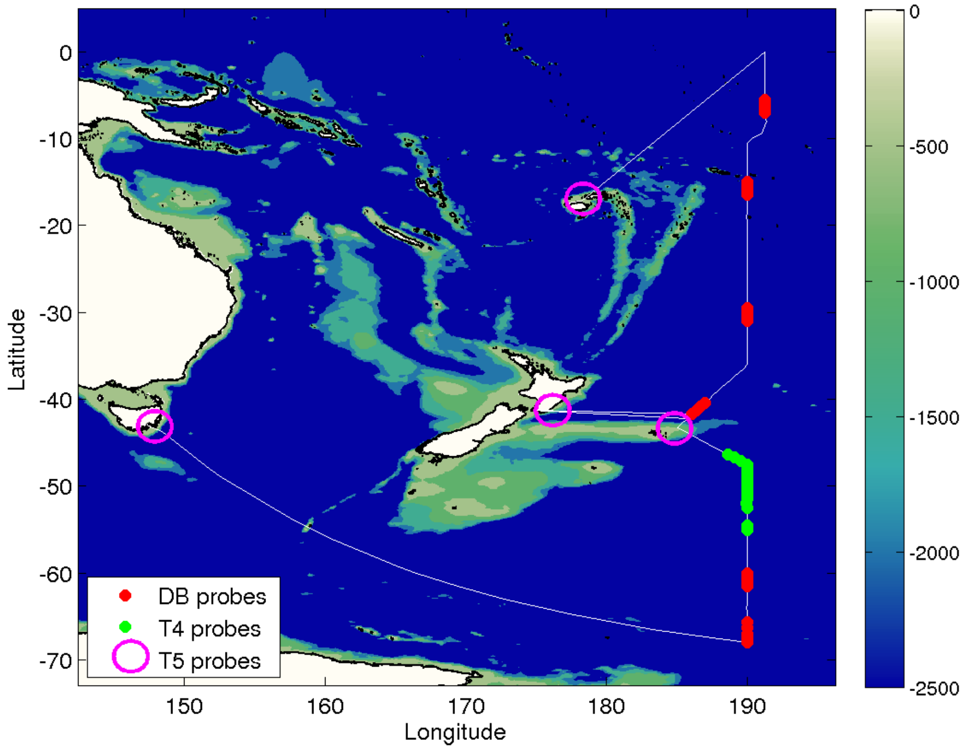


Table of deployment information

CTD stations have been selected based on the time available in the transit to the station. Stations with short transits before the CTD have been avoided in the plan.