Voyage Report : Voyage 6, 2007-2008, RSV Aurora Australis

Voyage Leader : Dr Steve Rintoul, ACE CRC and CSIRO
Deputy Voyage Leader: Andrew Deep, AAD

Dates: March 22, 2008 – April 17, 2008

1. Voyage Objectives

Voyage determining projects

AAS Project	Title	POC Onboard	Chief Investigator
2793	Observing transport and water mass changes south of Australia (CLIVAR SR3): A contribution to the International Polar Year.	Steve Rintoul	Steve Rintoul
1156	Sub-Antarctic zone mooring study of interannual variability in particulate carbon export.	Thomas Remenyi	Tom Trull
2900	Ocean micronitrients (Australian sector) – IPY GEOTRACES SR3 section and associated aerosol study	Ed Butler	Ed Butler
472	Continuous plankton recorder (CPR) survey	Andrew Deep	Graham Hosie
1307	Sea ice primary production off eastern Antarctica	Jesse McIvor	Andrew McMinn

2592	Southern Ocean carbon cycle	Kristina Paterson	Bronte Tilbrook

CASO objectives:

1. To measure changes in water mass properties and inventories throughout the full ocean depth between Australia and Antarctica along 140°E (the CLIVAR/WOCE repeat section SR3), as part of a multi-national International Polar Year (IPY) program to obtain a circumpolar snapshot of the Southern Ocean in austral summer 2007-8.

2. To estimate the transport of mass, heat and other properties south of Australia, and to compare the results to previous occupations of the SR3 line and other sections in the Australian sector.

3. To deploy moorings near the Adélie Depression (142-145E) as part of a joint Australia-France-Italy program to monitor changes in the properties and flow of Adélie Land Bottom Water. (Completed during Voyage 3).

4. To identify mechanisms responsible for variability in ocean climate south of Australia.

GEOTRACES objectives :

(i) To determine full water-column distributions of key micronutrients (trace elements and relevant isotopes, TEIs: e.g. Fe, Mn, Co, Zn, Cu, Cd, Se) along the 140°E SR3 section south of Tasmania. This project forms part of a multinational International Polar Year program (IPY-GEOTRACES) to obtain a circumpolar snapshot of the Southern Ocean in austral summer 2007/08.
(ii) To assess the environmental sources, sinks and internal cycling of micronutrient TEIs in the Australian sector of the Southern Ocean and contribute further to the characterisation of their marine biogeochemistry and relationships to the global cycling of carbon and macronutrients.
(iii) To provide a baseline distribution of micronutrient TEIs in the Australian sector of the Southern Ocean as reference for assessing past and future changes.
(iv) To compare micronutrient TEI distributions with other surface-water ecosystem data (autotrophic / heterotrophic production, planktonic / microbial community structure, etc.) obtained on the SR3 section, and discern interplay between micronutrients and microscopic life-forms.
(v) To evaluate the distribution and speciation of micronutrient TEIs in different Southern Oceam water masses, relate these to the SR3 oceanographic results of AAS project #2793 (CI: Stephen Rintoul), and investigate the potential of using the micronutrient data as a proxy for individual water masses or their mode of formation.

Relationship of the research carried out on V6 to other programs:

The voyage is part of an international IPY program to obtain a circumpolar multi-disciplinary snapshot of the Southern Ocean, a key goal of three approved lead projects of the IPY: Climate of Antarctic and the Southern Ocean (CASO), Synoptic Antarctic Shelf-Slope Interactions (SASSI) and GEOTRACES.

The CASO program addresses key objectives of several other major international programs: the Climate Variability and Predictability and Climate and the Cryosphere projects of the World Climate Research Program and the Antarctica in the Global Climate System program of SCAR.

The voyage is a major field program of the Climate Variability and Change and Ocean Control of Carbon Dioxide programs of the Antarctic Climate and Ecosystems Cooperative Research Centre (ACE CRC). The voyage is also a key contribution to the Australian Climate Change Science Program funded by the Australian Greenhouse Office and to the CSIRO Wealth from Oceans National Flagship.

2. Voyage Narrative

Aurora Australis left Hobart on March 22, 2008. The vessel transited to the southern end of the WOCE/CLIVAR SR3 transect, along nominally 140E. On the way south, the continuous plankton recorder (CPR) was deployed and several test casts were carried out.

We reached the edge of the sea ice at 64 40'S, over the continental slope (water depth of 3000 m), about 6 days after leaving Hobart. We were able to make good progress through rapidly growing first year ice and reached the southernmost station on March 28, in 300 m of water over the continental shelf. We parked in the lee of some grounded icebergs to wait for strong winds to abate overnight. The winds dropped off just when we needed them to, and we were able to complete all 9 stations in the sea ice. The lack of wind meant that we could comfortably do deep CTD stations in small holes, either in the lee of icebergs or cut by steaming the ship in small circles. If there had been any wind, it would have been very difficult to complete the southern stations. Having experienced ice pilots on the bridge helped us complete the work in the sea ice very efficiently.

We then worked our way north along the transect. The weather continued to be remarkably good. We only lost time to weather once, when winds peaked at over 60 knots and we lost a total of about 36 hours. Otherwise, the section was completed with few problems. The observations collected during the voyage are summarised below. We finished the transect on the evening of March 15 without missing a station and returned to Hobart on March 17, two days early.

We completed all the voyage objectives as well as a few additional stations, including trace metal sampling near an iceberg using both the trace metal rosette and the Fast Rescue Craft (FRC).

Achievements

The voyage was a remarkable success. The major highlights are summarised here.

- One of the major goals of the CASO program was to estimate the transport of heat, freshwater and other properties by the Antarctic Circumpolar Current. The high quality CTD data and ship-board and lowered acoustic Doppler current profiler (ADCP) data will allow us to make the most accurate and complete measurements of the ocean currents between Australia and Antarctica yet obtained. The real power of these observations will be realised when results from the Australian voyages are combined with those collected by other CASO expeditions to develop a circumpolar picture of the state of the Southern Ocean.

- The measurements of water properties over the Antarctic continental shelf and slope during Voyages 3 and 6 provides further evidence that the dense water sinking near Antarctica is continuing to become less salty and less dense. The leading hypothesis to explain the freshening is increased melt of glacial ice around the margin of Antarctica, caused by warmer ocean temperatures. The samples we collected for oxygen isotope analyses will allow us to test this hypothesis.

- Chemical tracers like chlorofluorocarbons (CFCs) allow us to trace water masses, determine rates of change, and discover the processes involved in water mass formation. The CFC measurements made on V6 by US scientists (Mark Warner and Emily Limagie from the University of Washington) will be compared to measurements on earlier occupations of SR3 to detect changes in the ocean and to quantify key processes such as advection and mixing.

- We have collected the first measurements of iron and other trace elements below 1000 m depth in this sector of the Southern Ocean. Measurements of these elements on a ship is extremely difficult due to the many sources of contamination. Samples run on board suggest that the trace metal team was successful in collecting very high quality measurements with minimal contamination.

- Many of the big challenges in Southern Ocean science are interdisciplinary. To solve them requires simultaneous observations of a wide range of physical, chemical and biological variables. The range of measurements made on V6 will provide new insights into how biological productivity and carbon uptake are influenced by physical, chemical and biological processes.

- The capacity of the Southern Ocean to absorb carbon dioxide, and thereby slow the rate of climate change, is a topic of active debate at present. Some studies suggest that the Southern Ocean is less effective at absorbing CO2 than it was a few decades ago; other studies indicate the Southern Ocean "sink" of CO2 is more robust. The direct measurements of ocean CO2 uptake obtained on V6 will test the idea that the Southern Ocean's ability to store CO2 has declined.

- The CTD stations collected at the CEAMARC sites during Voyage 3 have provided new information on the nature of the circulation over the continental shelf. We found evidence that dense high salinity shelf water is escaping from the continental shelf and flowing down-slope even in summer. The high salinity shelf water was found primarily on the northern and eastern sides of the depression. Currents within the depression acted to tilt the high salinity shelf water layer such that the dense water was found at shallower depths at the sill than in the middle of the depression itself. This suggests that the regional current pattern helps facilitate the export of dense shelf water. A layer of relatively warm and salty modified Circumpolar Deep Water could be traced across the continental shelf and extending as far as the Mertz Glacier Tongue.

Problems Encountered

The entire voyage went very smoothly and few problems were encountered.

The ship's equipment all worked well, with no significant time lost to problems with the engines, thrusters, or winches.

The marine science equipment all performed well. The new CTD wire has worked extremely well all season, with none of the spooling problems, kinks, broken strands or other problems that have plagued us in previous seasons. We used a single mechanical termination on each of the two voyages (the electrical connection was reterminated early on V6).

The new ADCP worked well throughout both voyages. While we have not yet had a chance to analyse the data in detail, it appears the system is a vast improvement over the old ADCP. The range is enhanced substantially and the data look very clean. I thank everyone involved in making sure this critical piece of scientific equipment was fixed in time for V3 and V6. I would in particular like to thank Fred Stein at CSIRO for agreeing late on a Saturday afternoon to let us borrow a transducer board from Southern Surveyor.

The sea ice imagery from both the Terrascan and Sea Ice View played a big part in our being able to work effectively in the ice. After some delay, we finally began to receive images for the correct region about one day before we entered the ice.

3. Voyage Management Issues

No significant Voyage Management issues were encountered during the voyage.

4. Summary of observations made:

The sampling completed on the CTD stations occupied during V6 is summarised in the table in Attachment 1. Additional observations are described here.

The continuous plankton recorder (CPR) was towed continuously during the transit to the southern end of the transect, with the exception of a few brief stops for test casts.

We were not in the sea ice for long (just over two days), but a dedicated team of 12 volunteers made iceberg and sea ice observations hourly around the clock. Volunteer observers were briefed by the VL on the protocol for sea ice obs before we reached the ice. Relatively few sea ice observations have been made at this time of year, so even this short period of observations is likely to be useful.

A total of 73 CTD stations were completed on V6. Water samples were analysed for a range of properties, as summarised in the table. A special clean rosette for sampling of trace metals was deployed at roughly every other station. The trace metal rosette was lowered on a Kevlar rope using the stern gantry and a winch from CSIRO. The trace metal rosette could sample to depths of 1000m. To obtain trace metal samples in deep water, the regular CTD was used with some of the regular Niskin bottles replaced by special trace-metal-clean bottles at 9 stations.

At each of the trace metal stations, a Fast Repetition Rate Fluorometer (FRRF) was deployed off the stern gantry. The FRRF measures the physiological “health” of the phytoplankton (eg whether they are under stress due to a lack of iron needed for photosynthesis).

Five Argo profiling floats were deployed along the transect. Each of the five has completed a profile and reported back by satellite, indicating they are all functioning well.

At eight CTD stations, expendable bathythermographs (XBTs) were deployed while the CTD was descending. By comparing the CTD and XBT profiles, we hope to determine whether the “fall rate” of the XBTs in cold water is correctly accounted for by present algorithms. A total of 59 XBT probes were deployed.

Surface water was sampled at each CTD station for bulk particulate organic carbon (PIC) using a continuous ultra-centrifuge. Size-fractionated PIC was determined using 3 filters (200 micron, 55 micron, and 0.8 micron).

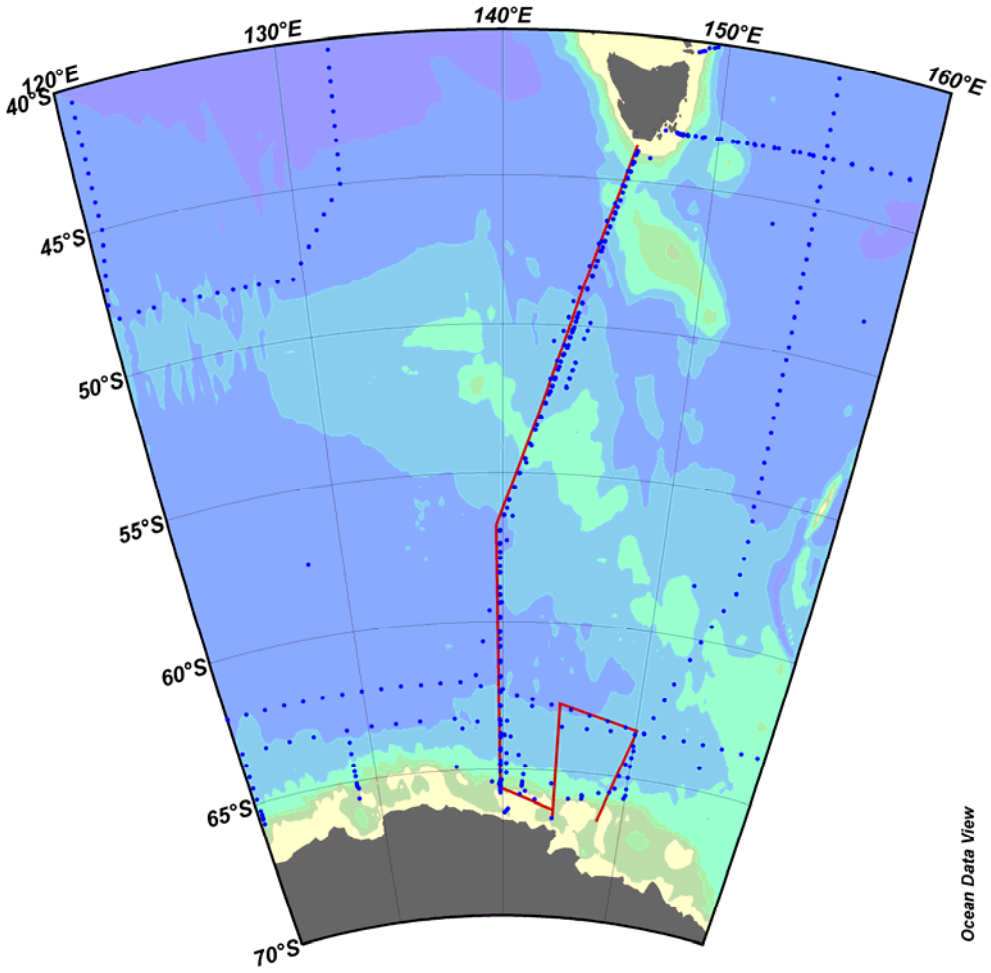
Part of the CASO program was completed on V3, and is summarised briefly here to give a complete picture of the CASO program this field season. Of the 131 CTD stations completed on V3, 45 were in support of the CASO program (the remaining 86 were primarily in support of the CEAMARC survey, although they also contribute to the goals of CASO). The CASO CTD stations were planned to sample the waters from the continental shelf to the continental rise at four locations, re-occupying stations completed in previous years where possible to allow estimates of change to be made. The lines included a transect targeted to lie along the axis of one of the large canyons down which dense bottom water cascades to the deep sea; a roughly east-west line of stations near 63S first occupied in 1994; a north-south line along 150E, repeating stations occupied in 1996 and 1971; a short section near 147E, just downstream of a second possible outflow channel; and the southern end of the SR3 line along 140E.

We deployed seven moorings and recovered three on V3. A mooring with a small surface float was deployed as part of the PULSE program at 44° 47.39'S, 145° 35.10'E. A sediment trap mooring was recovered at 53° 44' S.

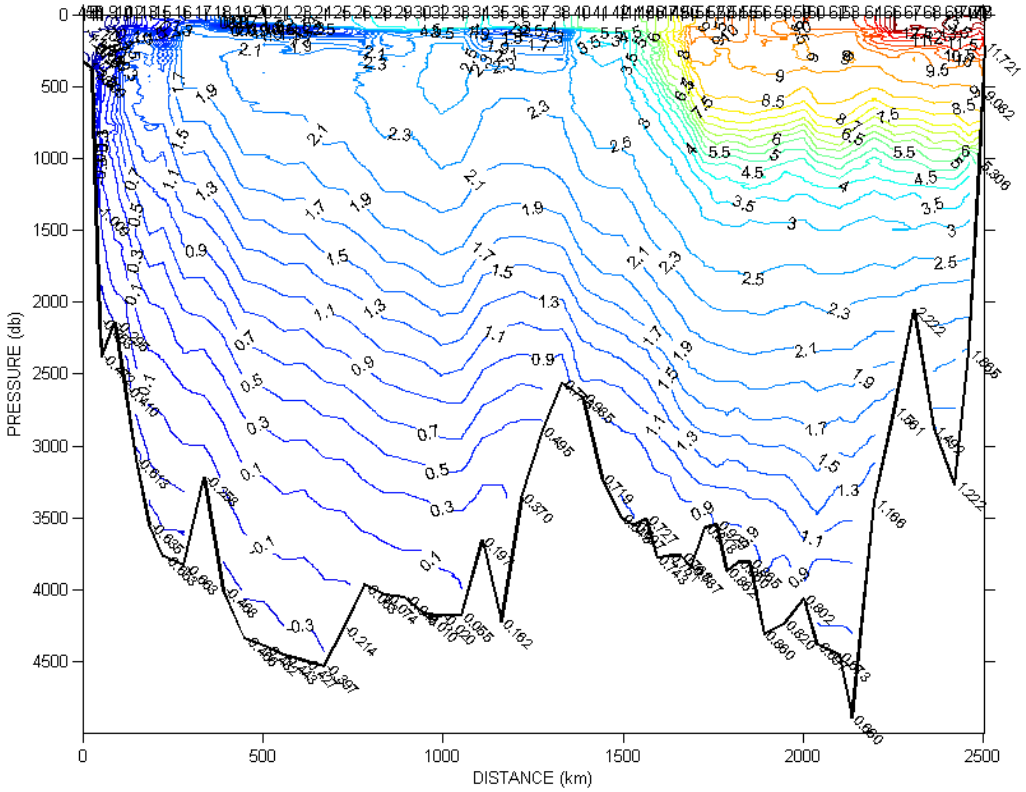
For the CASO program, moorings were deployed across a shallow sill through which dense water formed over the continental shelf escapes to the deep ocean. The problem of measuring currents in this location is made more challenging by the close proximity of the south magnetic pole (the magnetic field lines dip at 89.3°). The array consists of four moorings: two moorings with an upward-looking 75 kHz acoustic Doppler current profiler (ADCP) deployed near the sea floor beneath a string of temperature and salinity sensors; one mooring with a 75 kHz upward-looking ADCP and a special three-axis compass (Watson Strap-Down Heading Reference) capable of measuring direction even close to the pole, mounted in a streamlined housing; and a mooring of temperature and salinity sensors deployed close to the "compass mooring."

To obtain accurate direction information at all three moorings in a cost-effective manner, we took the following approach. The two moorings without a compass were designed so that the ADCP could not rotate in the horizontal plane. We are recording the currents in instrument-coordinates, from which we can determine the actual current direction if we know the orientation of the anchor package (which is assumed not to change). We deployed the compass mooring within one nautical mile of each of the two other ADCP moorings for a period of 1 week. By comparing the velocity records at the two moorings, we can determine the orientation of the ADCP instruments at the moorings without compasses. Following the deployment and recovery of the "compass mooring" at the eastern and western mooring sites, the "compass mooring" was finally deployed in the center of the array.

All of the mooring operations went very smoothly and efficiently.



The transect shown in red from Antarctica to Australia was completed during V6. The “dovetail” to the east off the coast of Antarctica was completed during V3. The blue dots show the location of stations occupied on previous expeditions.



Potential temperature measured along the SR3 transect on V6. Antarctica is on the left.

5. List of expeditioners

Transport: V6 CASO marine science - from Hobart on 22-Mar-2008								
Ticket No.	Name	Gender	Project No. (s)	Job, Affiliation	Dest. /Trip	Summary	Status	Reason
13323	Ms. Kate Berry	F	2592	Biogeochemist, CSIRO	MS	HBA-(V6)-HBA	A	AAS Project 2592 - Tilbrook
13862	Ms. Carrie Bloomfield	F	2793	Oceanographer, CSIRO	MS	HBA-(V6)-HBA	A	AAS Project 2793 - Rintoul
13320	Dr. Andrew Bowie	M	2900	Research Scientist, University of Tasmania	MS	HBA-(V6)-HBA	A	AAS Project 2900 - Butler
13461	Mr. Kim Briggs	M	2652	Marine Science Support, Australian Antarctic Division	MS	HBA-(V6)-HBA	A	AAS Project 2652 - Mr Jono Reeve
12634	Dr. Edward Butler	M	2900	Chemical oceanographer, CSIRO	MS	HBA-(V6)-HBA	A	AAS Project 2900 - Butler
13328	Mr. Wee Cheah	M	1307	Research Student, Institute for Antarctic & Southern Ocean Studies	MS	HBA-(V6)-HBA	A	AAS project 1307 - McMinn
12638	Mr. Daniel Cossa	M	2900	Chemist, CSIRO	MS	HBA-(V6)-HBA	A	AAS Project 2900 - Butler
13325	Mr. Grady Cowley	M	2592	Biogeochemist, CSIRO	MS	HBA-(V6)-HBA	A	AAS Project 2592 - Tilbrook
13409	Dr. Cath Deacon	F		Antarctic Medical Practitioner, Australian Antarctic Division	RT	HBA-(V6)-HBA	A	Voyage Doctor - J Ayton
13420	Mr. Andrew Deep	M		Deputy Leader, Australian Antarctic Division	MS	HBA-(V6)-HBA	A	Voyage Management - Dave Tonna
13321	Mr. Lars Heimburger	M	2900	Research Student, CSIRO	MS	HBA-(V6)-HBA	A	AAS Project 2900 -

								Butler
13863	Miss. Laura Herraiz Borreguero	F	2793	Oceanographer, CSIRO	MS	HBA-(V6)-HBA	A	AAS Project 2793 - Rintoul
13466	Miss. Sophie Hoft	F	2592	Biogeochemist, CSIRO	MS	HBA-(V6)-HBA	A	AAS Project 2592 - Tilbrook
13463	Mr. Peter Jansen	M	2652	Marine Science Support, Australian Antarctic Division	MS	HBA-(V6)-HBA	A	AAS Project 2652 - Mr Jono Reeve
12612	Miss. Mehera Kidston	F	2793	Oceanographer, Antarctic Climate & Ecosystem CRC	MS	HBA-(V6)-HBA	A	AAS Project 2793 - Rintoul
13485	Mr. Chris Kuplis	M	2740	Supervising Comms Technical Officer, Australian Antarctic Division	VS	HBA-(V6)-HBA	A	Voyage Management - Dave Tonna
13326	Dr. Delphine Lannuzel	F	2900	Biogeochemist, CSIRO	MS	HBA-(V6)-HBA	A	AAS Project 2900 - Butler
13308	Miss. Emily Lemagie	F	2793	Chemical oceanographer, University of Washington	MS	HBA-(V6)-HBA	A	AAS Project 2793 - Rintoul
13329	Mr. Jesse McIvor	M	1307	Institute for Antarctic & Southern Ocean Studies	MS	HBA-(V6)-HBA	A	AAS project 1307 - McMinn
13309	Miss. Alicia Navidad	F	2793	Oceanographer, CSIRO	MS	HBA-(V6)-HBA	A	AAS Project 2793 - Rintoul
13322	Ms. Kristina Paterson	F	2592	Biogeochemist, CSIRO	MS	HBA-(V6)-HBA	A	AAS Project 2592 - Tilbrook
13460	Mr. Alan Poole	M	2652	Marine Science Support, Australian Antarctic Division	MS	HBA-(V6)-HBA	A	AAS Project 2652 - Mr Jono Reeve
13312	Mr. Mark Rayner	M	2793	Hydrochemist, CSIRO	MS	HBA-(V6)-HBA	A	AAS Project 2793 - Rintoul
13316	Mr. Tank Remenyi	M	2900	Oceanographer, Australian Antarctic Division	MS	HBA-(V6)-HBA	A	AAS Project 1156 - Trull; 2900 Butler

13307	Dr. Steve Rintoul	M	2793	Voyage leader, CSIRO	MS	HBA-(V6)-HBA	A	AAS Project 2793 - Rintoul
13311	Dr. Jean-Baptiste Sallee	M	2793	Oceanographer, CSIRO	MS	HBA-(V6)-HBA	A	AAS Project 2793 - Rintoul
13327	Ms. Marie Sinoir	F	2900	Student, CSIRO	MS	HBA-(V6)-HBA	A	AAS Project 2900 - Butler
13317	Mr. Tim Smit	M	1156	Oceanographer, Australian Antarctic Division	MS	HBA-(V6)-HBA	A	AAS Project 1156 - Trull
12614	Dr. Serguei Sokolov	M	2793	Oceanographer, CSIRO	MS	HBA-(V6)-HBA	A	AAS Project 2793 - Rintoul
13462	Mr. Aaron Spurr	M	2652	Marine Science Support, Australian Antarctic Division	MS	HBA-(V6)-HBA	A	AAS Project 2652 - Mr Jono Reeve
13318	Ms. Jill Sutton	F	2900	Chemical oceanographer, CSIRO	MS	HBA-(V6)-HBA	A	AAS Project 2900 - Butler
12635	Dr. Alessandro Tagliabue	M	2900	Chemical oceanographer, CSIRO	MS	HBA-(V6)-HBA	A	AAS Project 2900 - Butler
13465	Ms. Wenneke Ten Hout	F	2592	Biogeochemist, CSIRO	MS	HBA-(V6)-HBA	A	AAS Project 2592 - Tilbrook
13324	Miss. Anais Van Ditzhuyzen	F	2592	Biogeochemist, CSIRO	MS	HBA-(V6)-HBA	A	AAS Project 2592 - Tilbrook
13310	Ms. Esmee van Wijk	F	2793	Oceanographer, CSIRO	MS	HBA-(V6)-HBA	A	AAS Project 2793 - Rintoul
13313	Mr. Mark Warner	M	2793	Oceanographer, CSIRO	MS	HBA-(V6)-HBA	A	AAS Project 2793 - Rintoul
12636	Ms. Ros Watson	F	2900	Biogeochemist, CSIRO	MS	HBA-(V6)-HBA	A	AAS Project 2900 - Butler
13549	Ms. Alice Watt	F	1156	Research Student, Australian Antarctic Division	MS	HBA-(V6)-HBA	A	AAS Project 1156 - Trull

12643	Mr. Martin Wille	M	2900	Biogeochemist, CSIRO	MS	HBA-(V6)-HBA	A	AAS Project 2900 - Butler
12617	Mr. Jan Zika	M	2793	Student, CSIRO	MS	HBA-(V6)-HBA	A	AAS Project 2793 - Rintoul
Count for Transport : 40								

6. Acknowledgements

The success of the voyage reflects the hard work of everyone involved on the voyage. I thank the Captain, Murray Doyle, and all of the crew for their professionalism and eagerness to do everything they could to get the work done. Thanks also to Andrew 'Deepy' Deep, who made my life as VL very easy by doing the DVL job so well. Each of the expeditioners made a significant contribution to the success (and fun) of the voyage and should be proud of a job well done.

CTD	latitude	longitude	maxp	hydro	CFC	CO2	C-14	DOC	O-18	density	germanium	NIWA	deep TM	chl-a	cell #	pigments	Nd	Comments	
1	-50.2	145.38	2210	X														CTD test	
2	-54.4	143.81	2811	X	X	X			X			X						CTD test	
3	-57.51	142.83	303	X	X				X									Test of TM Niskins	
4	-65.8	139.68	325	X	X	X	X	X	X		X	X		X	X	X	X		
5	-65.57	139.66	380	X	X	X	X	X	X										
6	-65.52	139.87	1343	X	X	X	X		X										
7	-65.43	139.84	2122	X	X	X			X			X		X	X	X			
8	-65.4	139.92	2376	X	X	X	X	X	X	X									
9	-65.07	139.75	2138	X	X	X			X		X								
10	-64.81	139.86	2592	X	X	X			X					X					
11	-64.88	140.21	754	X					X			X		X	X	X		near iceberg	
12	-64.55	139.85	3096	X	X	X	X	X	X										
13	-64.21	139.84	3551	X	X	X			X		X	X	X	X			X		
14	-64.21	139.84	2004	X	X	X			X		X					X			
15	-63.87	139.85	3769	X	X	X	X	X	X							X			
16	-63.35	139.83	3831	X	X	X			X	X	X	X		X				XBT	
17	-62.85	139.85	3220	X	X	X		X	X							X			
18	-62.36	139.84	3997	X	X	X			X		X								
19	-61.85	139.85	4331	X	X	X		X	X			X		X	X	X			
20	-61.35	139.84	4390	X	X	X	X	X	X	X	X								
21	-60.85	139.85	4453	X	X	X			X				X	X	X	X		XBT	
22	-60.85	139.85	4452	X	X	X			X			X							
23	-60.35	139.85	4491	X	X	X		X	X		X								
24	-59.85	139.86	4531	X	X	X			X	X		X		X	X	X			
25	-59.35	139.85	4263	X	X	X	X	X	X		X							XBT	
26	-58.85	139.84	3964	X	X	X			X				X	X	X	X			
X	-58.85	139.84	2002	X	X	X			X			X							
28	-58.35	139.85	4034	X	X	X		X	X	X	X								
29	-57.85	139.85	4049	X	X	X	X	X	X			X		X	X	X			
30	-57.35	139.87	4165	X	X	X			X		X							XBT	
31	-56.93	139.85	154										X					all bottles at 80 m for Christel Hassler	
32	-56.93	139.85	4180	X	X	X		X	X	X		X		X	X	X			
33	-56.43	140.1	4180	X	X	X		X	X									Argo 2948	
34	-55.93	140.41	3653	X	X	X			X			X		X	X	X			
35	-55.5	140.73	4225	X	X	X	X	X		X	X								
36	-55.02	141.02	3357	X	X	X						X		X	X	X			
37	-54.53	141.33	2888	X	X	X		X			X							oxy-isotope to compare with u/w; XBT	
38	-54.07	141.6	2563	X	X	X							X	X	X	X			
39	-54.07	141.61	1506	X	X	X						X						Argo 2953	
40	-53.58	141.86	2660	X	X	X	X	X		X	X								

CTD	latitude	longitude	maxp	hydro	CFC	CO2	C-14	DOC	O-18	density	germanium	NIWA	deep TM	chl-a	cell #	pigments	Nd	Comments	
41	-53.13	142.14	3218	X	X	X						X		X	X	X			
42	-52.67	142.39	3498	X	X	X							X				X		
43	-52.67	142.39	1001	X	X	X													
44	-52.37	142.53	3550	X	X	X	X	X				X		X	X	X			
45	-52.08	142.71	3506	X	X	X					X							XBT	
46	-51.81	142.84	3775	X	X	X													
47	-51.54	142.99	3763	X	X	X							X	X	X	X			
48	-51.54	143	2006	X	X	X						X							
49	-51.26	143.13	3759	X	X	X		X			X								
50	-51.01	143.27	3850	X	X	X	X	X										Argo 2944; one TM bottle for C. Hassler at chl max	
51	-50.68	143.42	3564	X	X	X						X		X	X	X			
52	-50.4	143.53	3542	X	X	X		X										XBT	
53	-50.16	143.66	3870	X	X	X				X	X								
54	-49.89	143.8	3807	X	X	X						X		X	X	X			
55	-49.61	143.93	3806	X	X	X	X	X											
56	-49.27	144.1	4309	X	X	X							X	X	X	X			
57	-49.27	144.1	1948	X	X	X						X							
58	-48.78	144.32	4234	X	X	X		X			X							Argo; XBT	
59	-48.32	144.53	4059	X	X	X						X		X	X	X			
60	-48	144.67	4380	X	X	X					X		X				X		
61	-48	144.67	1103	X	X	X					X								
62	-47.47	144.9	4452	X	X	X	X	X				X		X	X	X			
63	-47.15	144.91	4892	X	X	X												XBT	
64	-46.65	145.25	3383	X	X	X							X	X	X	X			
65	-46.65	145.25	1802	X	X	X						X							
66	-46.17	145.47	2751	X	X	X	X	X			X								
67				X	X	X						X		X	X	X			
68				X	X	X	X	X			X								
69				X	X	X		X		X		X		X	X	X		Argo 2950; TM bottle at chl max; oxy-isotope for comp u/w	
70				X	X	X	X	X		X	X								
71				X	X	X						X		X	X	X			
72				X	X	X					X								
73				X	X	X						X		X	X	X			

Aurora Australis Voyage 6 April 2008
AAD Marine Science Support
Electronic Equipment Report

Marine Science Support Personnel On Voyage: Aaron Spurr, Alan Poole, Kim Briggs, Peter Jansen.

Overall equipment problems on V6 were minimal. The voyage was blessed with very good weather most of the voyage helping to reduce the risk of equipment damage. Also most of the scientists had participated in V3 CEAMARC which meant most of the gear had already had a test run for V6. As usual, numerous items of non AAD equipment were repaired or adjusted during the course of the voyage.

Equipment not specifically mentioned can be assumed to have performed adequately.

CTD System

Seabird CTD S/N 704 was used the entire voyage. Feedback from the oceanographers suggests that the data quality was reasonable. Initially trial CTD stations suggested that there were some communications problems. The sea cable connector was replaced and the cable electrical connection reterminated which fixed the problem.The secondary temperature sensor has a problem when the temperature is below zero degrees. Although annoying, it was not replaced as only a few of the southern stations were affected. It will be returned to SeaBird for repair and recalibration. The oxygen sensor on S/N 703 is also due for return to SeaBird for calibration. One of the pins that mounts the bottles was dislodged causing some minor damage to a bottle. It was replaced with a pin from one of the disused slots and will be replaced. Overall the system worked reliably.

Acoustics System

Acoustics system worked reliably the whole voyage. The 12KHz system did not crash during the voyage but there is still no definite reason why it chooses to misbehave on some trips and not others.

ADCP

The ADCP ran without problems for the full voyage. Performance was marginal in rough conditions but otherwise gave good results. The replacement “tuned” transducer electronics board will be installed in Hobart.

Thermosalinograph, Underway Fluorescence and Oxygen

The systems ran without problems for the entire voyage. The occasional noise problem with the sea surface temperature probe has started again and the replacement of the current SBE3 sensors with fully digital items is a

priority. The flowmeter for the TSG seems noisy and should be sent back to Krohne for servicing in Hobart.

Met System

The Met System performed well the entire voyage except for the Starboard PAR sensor. This was due to a small amount of sea water finding its way into the system and will be repaired in Hobart.

XBT Tests Aurora Australis V6 April 2008
Alan Poole AAD Marine Science Support
Assistants: Kim Briggs, Aaron Spurr, Peter Jansen

A total of 8 XBT tests were performed on V6. 48 Deep Blue and 11 T7 Probes were used. Following is a very brief summary of the tests. Please refer to the Log Sheets for more details. The XBT and CTD data has been imported into Excel for preliminary comparisons.

XBT Test 1. Latitude 63S. This being the first test it took a bit of experimentation to find the best spot to launch the XBT's as the ship was effectively not moving on station. We could not launch from the starboard side as this is the windward side when on station and the XBT wire would be blown against the ship. We could not launch from the port side forward of the CTD winch as the wire was blown towards the CTD wire and we wanted to avoid a tangle of XBT wire on the CTD even though it would not cause much damage. The only place left was the port quarter. The problem here was the considerable turbulence from thrusters and the propeller, and heavy pitching when the weather was rougher. The result for Test 1 was 3 good drops out of 6 (Drops 1-6), all Deep Blues.

XBT Test 2. Latitude 61S. A much better result here due to good conditions. The result for Test 2 was 5 good drops out of 6, (Drops 7-12) all Deep Blues.

XBT Test 3. Latitude 59S. Good conditions. The result for Test 3 was 4 good drops out of 6, (Drops 13-18) for the Deep Blues and 3 good drops out of 3, (Drops 19-21), for the T7's.

XBT Test 4. Latitude 57S. Good conditions. The result for Test 4 was 6 good drops out of 6, (Drops 22-27) for the Deep Blues and 2 good drops out of 3, (Drops 28-30), for the T7's.

XBT Test 5. Latitude 54.5S. Marginal weather conditions. The result for Test 5 was 3 good drops out of 6, (Drops 31-36) all Deep Blues.

XBT Test 6. Latitude 52S. Marginal weather conditions. The result for Test 6 was 3 good drops out of 6, (Drops 37-42) all Deep Blues.

XBT Test 7. Latitude 50.5S. Poor conditions. After 4 unsuccessful drops (43-46) this test was abandoned. The constant working of the thrusters and propeller were causing the wire to be pulled against the hull or being sucked into the propellers.

XBT Test 8. Latitude 49S. With a limited number of XBT's left we decided to perform the last test whenever the next period of good weather occurred. The result for Test 8 was 6 good drops out of 8, (Drops 47-54) for the Deep Blues and 3 good drops out of 5, (Drops 55-59), for the T7's.

The final result was 48 Deep Blues used, 28 good drops. 11 T7's used 8 good drops.

General Comments

1. Devil XBT Interface S/N 42 and Toshiba Notebook CSIRO Asset No. C001406 were used for all Tests.

2. The results have been exported to Excel spreadsheets and plotted. Copies are available from Alan Poole 0419 641 729.

3. The CTD data used was derived from Seabird 911 CTD S/N 704. The dBar pressure values were converted to Depth in metres using the formula outlined in Seabird application note 69. The CTD data was thinned to every tenth scan. Calibration information is available from AAD Marine Science Support.

4. The Devil XBT Interface failed to initialise on 17 occasions and required Power Cycling to operate.

5. A test drop was performed before each test which showed system was within tolerance.

AAV60708
CASO-GEOTRACES

Project 2592

Biogeochemical Cycles of the Southern Ocean

Dr. Bronte Tilbrook. CSIRO Marine and Atmospheric Research, Hobart. (Primary Investigator).

Kristina Paterson. CSIRO Marine and Atmospheric Research, Hobart
Kate Berry. CSIRO Marine and Atmospheric Research, Hobart.

Volunteers:
Anais Van Ditzhuysen
Grady Cowley
Wenneke Ten Hout
Sophie Hoft

Operations:

- 6hrly surface water collection and analysis. Samples taken for dissolved oxygen, salinity, TotalCO_2, Alkalinity, nutrients and oxygen isotopes.

Start time (UTC): 12:05 22/03/2008
Start Position: -44.1826S 147.2447E

End Time: 11:40 15/4/2008
End Position: 43.9414 146.2423

Total number of samples: Please see associated sample log file: AA_0708V6 Underway data file.xls. Summary:
128 DO samples, 96 salinity samples, 96 TCO_2/Alk samples, 80 oxygen isotope samples and 192 nutrients samples.

- Underway pCO_2/Micro TSG/Oxygen Optode/Mass Spectrometry:

Start:
Mar 2008 05:31:30 -42.915262 147.383483

End:
15 Apr 2008 12:18:40 -43.885833 146.171167

- CTD water collection and analysis. Samples taken for dissolved organic carbon, TCO_2, Alkalinity and 14Carbon.

Please see associated file: AA_0708V6 CTD sample log.xls. Summary:
1399 TCO_2/Alk samples, 584 DOC samples and 238 Radiocarbon samples.

- Problems encountered during the voyage.

At the start of CTD stations we experienced a drop in seawater flow to our lab (lab 3) which caused changes in temperature in turn affecting measurements by our oxygen optode and mass spectrometer. The likeliest source of the problem was found to be intermittent use of the seawater line in the wetlab. Increasing overall pressure and opening tapes down-line of our lab did not solve the problem. The seawater line was inspected, including the pump and sustaining valve, and both were found to be functional and the lines intact. The exact cause of the problem on this voyage has not yet been resolved.

By leaving water running constantly in the wetlab we could minimize impacts of the flow/temperature fluctuations. However, it is likely that our dataset has been compromised due to this issue. We used an identical setup on the previous leg of CASO (AAV30708) and these problems did not occur, despite greater overall seawater usage.

To ensure adequate data quality in future voyages we would likely need to install either an independent seawater supply, or for the supply/delivery of the current system to be improved upon.

CASO (Voyage 6) Chlorofluorocarbon (CFC) Measurements
PI: Mark J. Warner, University of Washington

Samplers and Analysts: Mark J. Warner, University of Washington (warner@u.washington.edu)
Emily Lemagie, University of Washington

Samples for the analysis of dissolved CFC-11, CFC-12, and CFC-113 were drawn from 1148 of the Niskin water samples collected during the expedition. When taken, water samples for CFC analysis were the first samples drawn from the 10-liter bottles. Care was taken to co-ordinate the sampling of CFCs with other samples to minimize the time between the initial opening of each bottle and the completion of sample drawing. In most cases, dissolved oxygen, alkalinity and dissolved inorganic carbon samples were collected within several minutes of the initial opening of each bottle. To minimize contact with air, the CFC samples were drawn directly through the stopcocks of the 10-liter bottles into 100-ml precision glass syringes equipped with 3-way plastic stopcocks. The syringes were immersed in a holding bath of seawater until analyzed.

For air sampling, a ~300 meter length of 3/8" OD Dekaron tubing was run from the portable laboratory to the bow of the ship. A flow of air was drawn through this line into the CFC van using an Air Cadet pump. The air was compressed in the pump, with the downstream pressure held at ~1.5 atm. using a back-pressure regulator. A tee allowed a flow (100 ml min^{-1}) of the compressed air to be directed to the gas sample valves of the CFC analytical systems, while the bulk flow of the air (>7 l min^{-1}) was vented through the back pressure regulator. Air samples were generally analyzed when the relative wind direction was within 100 degrees of the bow of the ship to reduce the possibility of shipboard contamination. The pump was run for approximately 30 minutes prior to analysis to insure that the air inlet lines and pump were thoroughly flushed. the average atmospheric concentrations determined during the cruise (from a set of 5 measurements analyzed when possible, n=33) were 241.4 +/- 0.9 parts per trillion (ppt) for CFC-11, 536.5 +/- 2.7 ppt for CFC-12, and 77.5 +/- 1.8 ppt for CFC-113.

Concentrations of CFC-11 and CFC-12, and CFC-113 in air samples, seawater and gas standards were measured by shipboard electron capture gas chromatography (EC-GC) using techniques modified from those described by Bullister and Weiss (1988). For seawater analyses, water was transferred from a glass syringe to a fixed volume chamber (~30 ml). The contents of the chamber were then injected into a glass sparging chamber. The dissolved gases in the seawater sample were extracted by passing a supply of CFC-free purge gas through the sparging chamber for a period of 4 minutes at 80 ml min^{-1}. Water vapor was removed from the purge gas during passage through an 18 cm long, 3/8” diameter glass tube packed with the desiccant magnesium perchlorate. The sample gases were concentrated on a cold-trap consisting of a 1/8” OD stainless steel tube with a ~10 cm section packed tightly with Porapak N (60-80 mesh). A vortex cooler, using compressed air at 95 psi, was used to cool the trap, to approximately –20°C. After 4 minutes of purging, the trap was isolated, and the trap was heated electrically to ~100^{o}C. The sample gases held in the trap were then injected onto a precolumn (~25 cm of 1/8” O.D. stainless steel tubing packed with 80-100 mesh Porasil C, held at 70^{o}C) for the initial separation of CFC-12, CFC-11 and CFC-113 from other compounds. After the CFCs had passed from the pre-column into the main analytical column (~183 cm of 1/8” OD stainless steel tubing packed with Carbograph 1AC, 80-100 mesh, held at 70^{o}C) of GC1 (a HP 5890 Series II gas chromatograph with ECD), the flow through the pre-column was reversed to backflush slower eluting compounds.

The analytical system was calibrated frequently using a standard gas of known CFC composition. Gas sample loops of known volume were thoroughly flushed with standard gas and injected into the system. The temperature and pressure was recorded so that the amount of gas injected could be calculated. The procedures used to transfer the standard gas to the trap, precolumn, main chromatographic column and EC detector were similar to those used for analyzing water samples. Two sizes of gas sample loops were used. Multiple injections of these loop volumes could be made to allow the system to be calibrated over a relatively wide range of concentrations. Air samples and system blanks (injections of loops of CFC-free gas) were injected and analyzed in a similar manner. The typical analysis time for seawater samples was 11.5 min., and for gas samples was ~10.5 minutes.

Concentrations of the CFCs in air, seawater samples and gas standards are reported relative to the SIO98 calibration scale (Cunnold, et. al., 2000). Concentrations in air and standard gas are reported in units of mole fraction CFC in dry gas, and are typically in the parts per trillion (ppt) range. Dissolved CFC concentrations are given in units of picomoles per kilogram seawater (pmol kg^{-1}). CFC concentrations in air and seawater samples were determined by fitting their chromatographic peak areas to multi-point calibration curves, generated by injecting multiple sample loops of gas from a working standard (UW cylinder 45191 for CFC-11: 386.94 ppt, CFC-12: 200.92 ppt, and CFC-113: 105.4 ppt) into the analytical instrument. The response of the detector to the range of moles of CFC-12 and CFC-113 passing through the detector remained relatively constant during the cruise. The response of the detector to the upper range of CFC-11 amounts was found to slowly change during the cruise. Full-range calibration curves were run at intervals of 10 days during the cruise. These were supplemented with occasional injections of multiple aliquots of the standard gas at more frequent time intervals. Single injections of a fixed volume of standard gas at one atmosphere were run much more frequently (at intervals of ~90 minutes) to monitor short-term changes in detector sensitivity. The CFC-113 peak was often on a small bump on the baseline, resulting in a large dependence of the peak area on the choice of endpoints for integration. The height of the peak was instead used to provide better precision. The precisions of measurements of the standard gas in the fixed volume (n=450) were ± 0.61% for CFC-12, 0.89% for CFC-11, and 5.2% for CFC-113.

The efficiency of the purging process was evaluated periodically by re-stripping high concentration surface water samples and comparing the residual concentrations to initial values. These re-strip values were approximately 1% for all 3 compounds. A correction has been applied to the shipboard data.

The determination of a blank due to sampling and analysis of CFC-free waters was hampered by the lack of CFC-free waters. At several stations at the northern end of the section, CFCs in the deepest sample were measured to be less than 0.005 pmol kg^{-1} for CFC-11 and CFC-12. No sampling blank corrections have been made to this preliminary data set.

On this expedition, based on the analysis of 46 duplicate samples, we estimate precisions (1 standard deviation) of 0.75% or 0.003 pmol kg^{-1} (whichever is greater) for dissolved CFC-11, 0.30% or 0.003 pmol kg^{-1} for CFC-12 measurements, and 4.8% or 0.005 pmol kg^{-1} for CFC-113.

A very small number of water samples had anomalously high CFC concentrations relative to adjacent samples. These samples occurred sporadically during the cruise and were not clearly associated with other features in the water column (e.g. anomalous dissolved oxygen, salinity or

temperature features). This suggests that these samples were probably contaminated with CFCs during the sampling or analysis processes. Measured concentrations for these anomalous samples are included in the preliminary data, but are given a quality flag value of either 3 (questionable measurement) or 4 (bad measurement).

A small amount of water vapor made its way onto the chromatographic column on April 10th and resulted in less than optimal performance of the analytical system for a few days. During that time CFC-113 peaks were located atop a broad contaminant peak and difficult to integrate. A large amount of CFC-113 data are flagged as bad (4) during this period. As the contamination cleared up over 2-3 days, this broad peak gradually disappeared. CFC-113 values have been flagged as questionable during this interval, until the baseline was flat. Although the baseline was very noisy, the data quality for CFC-11 and CFC-12 was only slightly worse than normal and was not flagged.

Bullister, J.L., Weiss, R.F. Determination of $CC1_3F$ and $CC1_2F_2$ seawater and air. Deep-Sea Research, 25, 839-853, 1988.

Prinn, R. G., Weiss, R.F., Fraser, P.J., Simmonds, P.G., Cunnold, D.M., Alyea, F.N., O'Doherty, S., Salameh, P., Miller, B.R., Huang, J., Wang, R.H.J., Hartley, D.E., Harth, C., Steele, L.P., Sturrock, G., Midgley, P.M., McCulloch, A., 2000. A history of chemically and radiatively important gases in air deduced from ALE/GAGE/AGAGE. Journal of Geophysical Research, 105, 17,751-17,792

Estimation of Primary Production with Fast Repetition Rate Fluorometer (FRRF)

W. Cheah and A. McMinn
Institute of Antarctic and Southern Ocean Studies, University of Tasmania, Hobart, Australia

Overview of Project:

The objective of this project was to measure vertical profiles of active fluorescence of stations along the SR3 line. Photosynthetic parameters of phytoplankton under actinic light (L) as well as in darkness (D) were measured using the FRRF. The parameters included the maximum photochemical efficiency ($F_v/F_{mL,D}$), the functional absorption cross section of photosystem II ($\sigma_{PSII,L,D}$) and a turnover time of electron transfer ($\tau_{L,D}$). Depth and irradiance (PAR) were also logged with each FRRF fluorescence acquisition on each cast. Chlorophyll *a* concentration was measured by using Turner fluorometer. The photosynthetic parameters, irradiance and chlorophyll *a* concentration will then be used to estimate primary production.

Sampling strategy

FRRF was deployed to 150 m depth after every NIWA rosette cast. Chlorophyll *a* concentration was determined by filtering 2 L of seawater through 13 mm diameter Whatman GF/F filters, which were immediately added with 10 ml of methanol and stored in 4 degree Celsius refrigerator for 8 to 24 hours. Samples were taken at every NIWA station from CTD Niskin bottles (4 at mixed layer depth, 1 below the mixed layer).

Data description

Estimation of primary productivity was done following the method of Symth et al. (2004) and Melrose et al. (2006). Table 1 showed the parameters and units.

Melrose, D.C. et al. (2006). Marine Ecology Progress Series.
Smyth, T.J. et al. (2004). Journal of Plankton Research.

Table 1.

Parameter	**Units**
Minimum fluorescence, *F*o	Dimensionless
Maximum fluorescence, *F*m	Dimensionless
Variable fluorescence, *F*v	Dimensionless
Maximum photochemical efficiency, *F*v/*F*m	Dimensionless
Functional absorption cross section, σ_{PSII}	10^{-20} m^{-2} $(quanta)^{-1}$

Turnover time of electron transfer, τ	μs
Irradiance, PAR	μmol quanta m^{-2} s^{-1}
Chlorophyl *a* concentration	μg L^{-1}
Primary production	mg C mg^{-1} chl *a* h^{-1}

Metadata: Biogeochemistry of Trace Elements (Fe and Al) along the SR3 section (Antarctica to Hobart)

Andrew R. Bowie (on behalf of the ACE CRC team)
ACE CRC, University of Tasmania,
Private Bag 80, Hobart, Tasmania, Australia 7001
Andrew.Bowie@utas.edu.au
Tel: +61 3 6226 2509; Fax: +61 3 6226 2973

Overview of Project

The objective of this project was to determine dissolved Fe and Al, and different Fe species, in seawater samples collected from the full water column along the SR3 section. This project comes under AAS project #2900 and forms part of the larger International Polar Year – GEOTRACES project.

Sampling and analysis strategy

The NIWA trace metal rosette was used to collect water column profiles (down to 1000 m) of trace metals at 27 stations along SR3 at a resolution of approximately every 1 degree of latitude (9-12 depths per profile). In addition, trace metal Niskin bottles were deployed on the standard CTD rosette at 8 stations to sample from 1000 m to the bottom of the water column (six depths per profile). Full details are in contained in the NIWA sampling logbook.
Dissolved (<0.2 μm) Fe was analysed at sea by flow injection analysis with chemiluminescence following recommended GEOTRACES protocols.
Soluble (<0.02 μm) Fe, total dissolvable (unfiltered) Fe and dissolved Al will be analysed on land at the ACE CRC. A suite of trace elements will be analysed at CMAR by dynamic reaction cell ICP-QMS (see Butler metadata report for details). Samples were also collected for mercury analysis (gaseous, inorganic and methylmercury) (see Cossa metadata report for further details. Nutrients were also sampled from every bottle (nitrate, nitrite, phosphate, silicate).
Trace metal water column profile samples were also collected for the following collaborators at selected stations: Michael Ellwood, ANU (totals and speciation of Co, Cu and Zn by CLE-CSV), Eni Ibisanmi, University of Otago (Fe speciation by CLE-CSV), Tina van der Flierdt, Imperial College London (Nd isotopes), Christel Hassler, CMAR (various Fe speciation analyses and seawater for land-based biological experiments – see Butler report for more details), Willy Baeyens (trace metal speciation by DGT films). Additional details are contained in the report of Butler.

Data description

Dissolved (<0.2 μm), soluble (<0.02 μm) and total dissolvable Fe (unfiltered) by flow injection – chemiluminescence analysis (shipboard and land-based analysis)
Dissolved aluminium by flow injection – fluorescence analysis (land-based analysis)

Data file description
Data that will be submitted to the data base, and the units of these data, are given in the table below.

Parameter	Units
Dissolved, soluble & total dissolvable Fe	nmol L^{-1}
Dissolved Al	nmol L^{-1}

References
[1] Obata et al., 1993. Automated determination of iron in seawater by chelating resin concentration and chemiluminescence detection. Analytical Chemistry 65, 1524-1528.
[2] Resing, J.A., Measures, C.I., 1994. Fluorometric determination of Al in seawater by flow-injection analysis with in-line preconcentration. Analytical Chemistry 66, 4105-4111.