MARINE
NATIONAL FACILITY

2010 program

RV Southern Surveyor

CSIRO

voyagesummary SS2011_v02

SS2011_v02

GEOTRACES GP13: A collaborative international study of the marine biogeochemical cycles of trace elements and their isotopes along a zonal section of the Pacific Ocean east of Australia

Voyage period

Start: 13/05/2011
End: 05/06/2011
Port of departure: Brisbane, Australia
Port of return: Auckland, New Zealand

Responsible laboratory

Antarctic Climate and Ecosystems Cooperative Research Centre (ACE CRC)
University of Tasmania, Private Bag 80, Hobart, TAS 7001 Australia

Chief Scientist

Dr Andrew R Bowie (ACE CRC, University of Tasmania)

Scientific Objectives

The ocean plays a vital role in Earth's climate through control of atmospheric carbon dioxide concentrations. One important component of this system is the iron cycle, in which iron-rich soil dust is transported from land through atmosphere to ocean. Iron is a key micronutrient for marine plankton productivity, the scarcity of which limits essential biogeochemical processes and thus ocean fertility. This project will undertake an integrated oceanographic transect and dust monitoring program for iron, other trace elements, and their isotopes (TEIs) along the western end of the GP13 zonal section (~30ºS) east of Australia.

Our innovative measurement and analysis strategy will identify processes and quantify fluxes that control the distributions of key TEIs in the southwestern Pacific Ocean, and establish the sensitivity of these distributions to changing environmental conditions. We will use a series of novel techniques to fingerprint the sources, sinks and internal cycling of TEIs, focussing on the atmospheric delivery of iron-dust to the remote ocean. This project will provide maximum scientific reward for evaluating future global change, and has strong international collaborative activity under the auspices of the international GEOTRACES (www.geotraces.org) program.

Outcomes of this project will be an improved ability to predict climate-driven changes in the supply and biogeochemistry of trace elements in ocean waters around Australia. Our research will quantify the importance of atmospheric dust for marine ecosystem health, help inform Government policy on ocean iron fertilisation as a carbon sequestration strategy, and provide a broad basis for evaluating future climatic changes in coupled atmospheric - ocean processes.

Voyage Objectives

This voyage will undertake a zonal transect along ~30ºS east of Australia out into the South Pacific (GEOTRACES GP13 line). Three types of stations will be used to achieve our aims: (i) normal stations (every 1° of longitude), (ii) super stations (every 5º), and (iii) mega stations (every 10º) (see Voyage Track). The type of sampling and order of deployments at normal, super and mega stations are outlined below and in the Voyage Plan.

Specific aims of the project are:

(1) Undertake an integrated zonal oceanographic transect east of Australia studying the marine biogeochemical cycles of TEIs, as part of Australasia's contribution to the international GEOTRACES program;

(2) For the first time, establish the full water column, basin-scale distribution of TEIs (which a specific focus on iron, aluminium, manganese, copper, zinc, cobalt, cadmium), and investigate the role of micronutrient TEIs in the oceans surrounding Australia, and their relationship to environmental and ecosystem conditions;

(3) Determine the sources, sinks and fluxes of iron and other TEIs (focussing on atmospheric dust delivery and biomass burning), as well as their transport, solubility and chemical form in the ocean. This includes the use of quasi-conservative elemental tracers of inputs, dissolution and redox cycling;

(4) Collect subsamples for subsequent analysis of other GEOTRACES 'key parameters' (such as stable, radioactive and radiogenic isotopes; as listed in Table 2 of the GEOTRACES Science Plan) by international colleagues who are not able to participate in the field program.

Voyage activities:

The following activities will be conducted on-board the RV *Southern Surveyor* to meet our scientific objectives:

1 – CTD profile down to 1500 m at normal stations and full water column at super/mega stations to characterise physical oceanography (temperature, salinity, dissolved O2, optical transmissivity and in situ fluorescence). In addition, water will be sampled for macro-nutrient analysis (MNF hydrochemistry), particulate organic carbon (POC) and nitrogen (PON), and phytoplankton characterisation. Phytoplankton characterisation includes floristic information measured back in the laboratory using microscopy, high-performance liquid chromatography and flow cytometry. Samples will be fixed or stored in liquid N2 until analysis.

2 – Trace metal sampling down to 1500 m at normal stations and full water columns at super/mega stations using a specialised General Oceanics trace metal rosette (TMR) equipped with 12 x 10 L Niskin-X bottles. The water collected will be manipulated under laminar flow in a clean container van set up on-board. Water collected will be used to measure the following parameters:

– Dissolved trace elements (Fe, Al, Cd, Zn, Co, Mn, Pb, etc, using FIA and ICP-MS techniques).

– Iron chemical speciation using an electrochemical approach

– Iron bioavailability

– Large sample volumes (1-2 L) for iron, zinc, cadmium and copper isotopes (for MC-ICP-MS analysis)

– Large sample volumes (5-10 L) for radiogenic isotopes of Pa, Th, Nd (ICP-MS analysis)

– Nutrients at the nanomolar levels (segmented flow colorimetric analysis with a liquid waveguide capillary cell)

3 – Deployment of in situ McLane pumps (at 4 depths) at super/mega stations to measure parameters that require the filtration of large volumes (up to 100 L). The filters collected will be used to measure particulate materials – including trace metals, carbon, biogenic silicic acid and DNA.

4 – Dust collection using a high-volume sampler set up on the monkey island. Filters will be analysed by ICP-MS to assess metal solubility and fluxes associated with dust deposition.

The procedure associated with the deployments of the trace metal clean rosette and in situ pumps are outlined in Appendixes 1 and 2 of the Voyage Plan). All procedures will be discussed at toolboxes with personnel at sea prior to deployment. Most shipboard participants have experience in deploying such equipment. For more details about the measurements associated with this oceanographic voyage please refer to the original proposal.

All these operations are required for the success of this project. The most critical one is sampling trace metal clean water using the trace metal rosette (TMR). The use of the McLane pumps will allow the measurement of the in-situ stochiometric ratios of particles (including phytoplankton) and are thus important to understand the dynamics of this marine system. Both the trace metal rosette and in situ pumps deployments have been successfully undertaken during SSv01/2010. Deployment of the standard CTD is essential to characterise the physical oceanography of the region and place our GEOTRACES measurements in a hydrographic context. Finally, the sampling of atmospheric dust should also be regarded as a priority as it has been demonstrated that dust supply is important in that region and it could induce phytoplankton blooms; yet little is known on the trace elements that can potentially be released and the subsequent biological effect associated with the dust deposition in the South Pacific.

The trace metal rosette will be deployed off the stern using the towed body winch fitted with 6 km of 6 mm Dynex rope and using a specialised trace metal block suspended on the trawl deck 'A'-frame. The McLane pumps will be deployed off the stern using the net drum winch fitted with 4 km of 9 mm (7 mm wire with 1 mm thick PVC coating) sheathed mooring wire and through a block on the trawl deck 'A'-frame. Each will used independent winches and lines to rapidly switch between deployments.

Results

Deployment of all equipment required for the GEOTRACES GP13 voyage was successful. The trace metal rosette (TMR), the McLane pumps, CTD and aerosol sampler all performed well. Three types of stations were used to achieve our aims: (i) 29 normal stations (every 1o of longitude), (ii) 3 super stations (every 5o), and (iii) 4 mega stations (every 10o). Deployments at normal stations were typically down to 1500 m, with deployments at super- and mega- stations to the full water column. We also collected samples and data from the TMR and CTD down to 6000 m at station 31 (32.5ºS, 177ºW) to characterise for the first time trace elements and isotopes in the deep waters passing through the Kermadec Trench.

Over 3000 dissolved water samples were collected from the TMR, over 400 particulate filter samples from the McLane pumps, over 2000 water samples from the CTD, and 9 filter samples from the aerosol sampler. Samples will be analysed in the 6-18 month period following the voyage in the laboratories of the respective Principal Investigator for the following parameters:

- Dissolved trace elements (Fe, Al, Cd, Zn, Co, Mn, Pb, Ba, etc, using FIA and ICP-MS techniques).
- Abundance and isotopic composition of trace elements in suspended marine particles
- Particulate organic carbon (POC) and nitrogen (PON)
- Iron and copper chemical speciation using an electrochemical approach
- Iron bioavailability
- Large sample volumes (1-2 L) for iron, zinc, cadmium and copper isotopes
- Large sample volumes (5-10 L) for radiogenic isotopes of Pa, Th, Nd
- Trace elements in atmospheric dusts collected on filters from an aerosol sampler
- Trace elements in collected rain samples
- Nutrients at the nanomolar levels
- Phytoplankton characterisation using microscopy, high-performance liquid chromatography and flow cytommetry
- Photosynthetic health
- Genomics and metagenomics
- Nitrogen fixation genes

A number of analyses were carried out on-board including dissolved Fe by flow injection analyses, iron chemical speciation by competitive ligand equilibration – cathodic stripping voltammetry, phytoplankton photophysiology and hydrography (major nutrients, salinity, oxygen) by standard techniques. Shipboard data indicate that the TMR was non-contaminating for dissolved Fe, one of the most contamination-prone elements. At station #3, a typical micronutrient-type and oceanographically-consistent profile for dissolved Fe was observed (Figure 1). We were unable to carry-out all our planned analytical tasks on board due to contaminated Milli-Q pure water supply (flow injection analyser), and unstable power supply and ship's vibrations (cathodic stripping voltammeter) in the ANU 20' clean container. These samples will now be analysed in the home laboratories after the voyage. Surface subsamples for nanonutrients were collected from the TMR at all stations, and were analysed on the next leg of the GP13 section by New Zealand colleagues. Unfortunately, preliminary data indicate low level contamination for nanonutrients collected from the TMR. The PIs are investigating the source of this problem. Ocean colour satellite data (8 day MODIS image, 4 km resolution) and aerosol dust data and forecasts (NAAPS, hysplit forward trajectories) was relayed to the ship by colleagues at University of Technology Sydney (Dr Mark Baird) and Griffith University (Prof. Grant McTainsh and the Australian dustwatch network), respectively, in order to help with sampling strategies during the voyage.

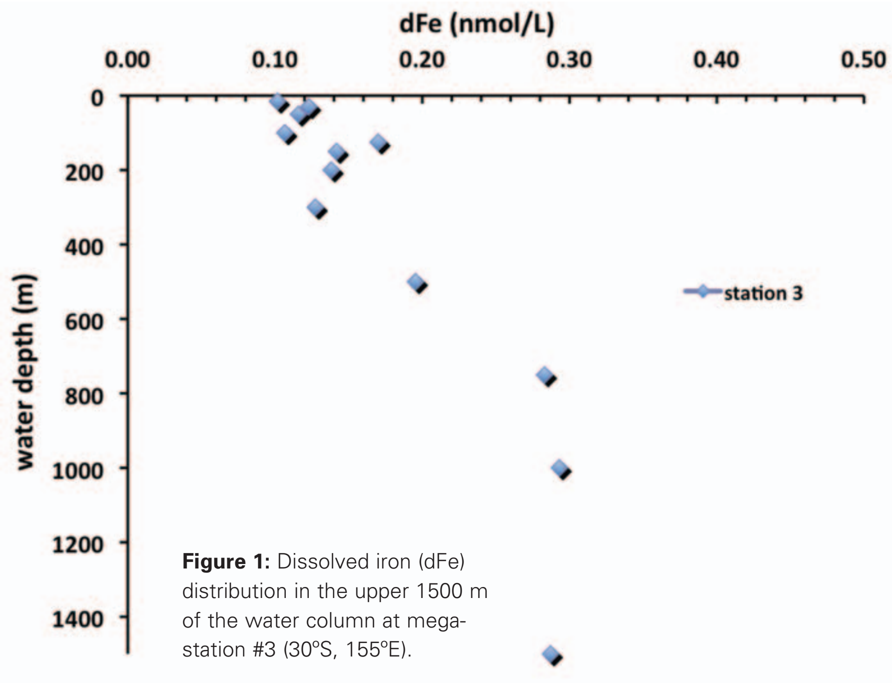
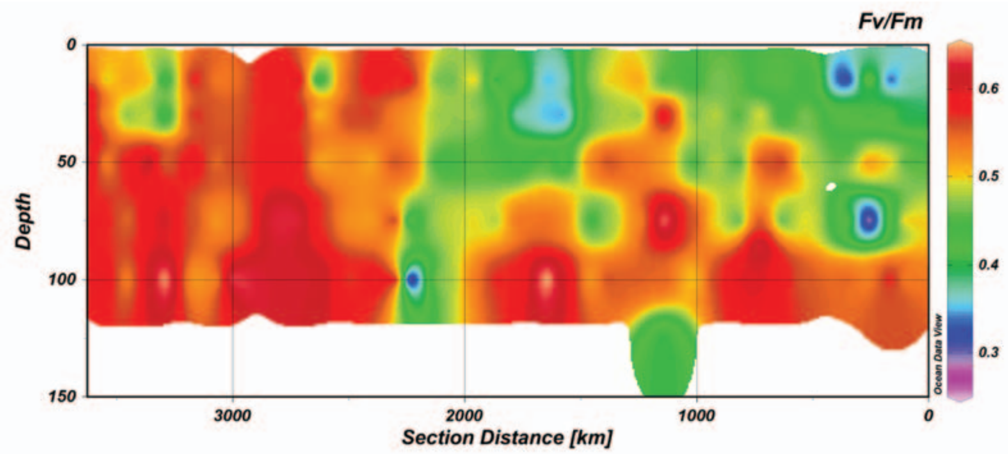


Figure 1: Dissolved iron (dFe) distribution in the upper 1500 m of the water column at mega-station #3 (30ºS, 155ºE).

Two stations were not carried out due to inclement weather (stations 09, and 25 CTD only deployed). Two deployments (station 03 cast 2, and station 04 cast 1) of the TMR were unsuccessful due to a software problem. This was resolved by reverting to an earlier version of the software, which was successfully tested at station 04 cast 2. An intermittent problem was identified with the one of the McLane pumps. This was believed to be due to a faulty communications cable between the electronics housing and the pump head, and the Chief Scientist is in consultation with the pump manufacturer to resolve this problem.

Operations were carried out in an efficient manner, which resulted in many deployments taking less time than that allocated. This allowed us to add an extra 2 normal stations at the end of the Australian leg of the GP13 section and finish our science at 32.5ºS 170ºW.

This project is the first time that data on the distribution of many trace elements and their isotopes (TEIs) along the GP13 section in the Tasman Sea and southwest Pacific has been collected, and the 8 deep water deployments (including a 6000 m deployment of the TMR in the Kermadec Trench at 32.5ºS 177ºW) represent some of the few deep profiles that presently exist in any ocean worldwide. Preliminary results from shipboard analysis of dissolved Fe indicate that the western end of the transect had extremely low concentrations of dissolved Fe, despite the proximity of sampling to the continental shelf and possible dust deposition sources. Upper mixed layer nutrient concentrations were below micromolar detection limits at all stations along section GP13, with typical increases below the mixed layer. These preliminary hydrography results demonstrate low NOx concentrations in the top 100 m. Based on the maximum quantum yield (Fv/Fm), phytoplankton east of 170ºE were nutrient limited. Complementary studies on the voyage will indicate the degree of iron and nitrogen co-limitation in these waters. The photosynthetic competency along the GP13 section is shown in Figure 2. In addition, new EM300 swath bathymetric data was collected along the ocean section from 153º30'E to 170ºW along 30ºS (diverting to 32.5ºS at 177ºE), an area of significant topography including ocean ridges and trenches, submerged reefs and seamounts. This data is archived and can be processed and quality controlled after the voyage.



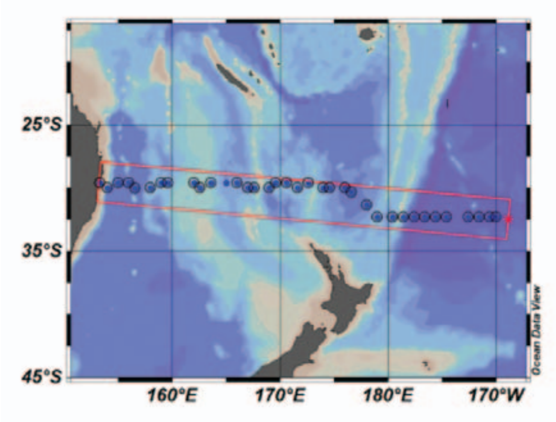


Figure 2: Average Fv/Fm in the upper 150 m along the GP13 section (~30ºS) in the Tasman Sea and southwest Pacific Ocean.

In summary, voyage ss2011_v02 successfully achieved the following objectives:

(1) We carried out an integrated zonal oceanographic transect east of Australia studying the marine biogeochemical cycles of TEIs, as part of Australasia's contribution to the international GEOTRACES program;

(2) Samples were collected to establish the full water column, basin-scale distribution of trace elements and isotopes along GP13 for the first time;

(3) Data from subsequent laboratory analyses will determine the sources, sinks and fluxes of TEIs (focussing on atmospheric dust delivery), as well as their transport, solubility and chemical form in the ocean;

(4) A number of subsamples were collected for later analysis of other GEOTRACES (such as stable, radioactive and radiogenic isotopes) and bioGEOTRACES (marine microbial biogeography and biogeochemistry; i.e., 'omics') key parameters by international colleagues who are not able to participate in the field program.

Voyage Narrative

Voyage ss2011_v02 departed Brisbane at 16:40 on Friday 13 May, 2011. The RV *Southern Surveyor* headed out into the Tasman Sea in calm conditions, with dolphins swimming ahead of the bow and into a wonderful sunset. The scientific party, which included participants from 7 different nations, quickly became accustomed to life at sea, and prepared instruments and equipment for the test stations and toolboxes scheduled for early the following morning.

The voyage plan consisted of 'normal' station spaced every degree 1° of longitude and 'super' or 'mega' stations at every 5o of longitude. Normal stations included deployment of the trace metal rosette (TMR) and CTD with sampling to 1500 m, and large volume in situ pumps were also deployed at the 'super' or 'mega' stations, which sampled the full water column.

After a 6 hour passage to open water, we woke up to the sight of Gold Coast skyscraper hotels and the headland of Byron Bay along the coastline. Toolboxes were held on the bridge for deployments of the TMR off the stern and the CTD off port midships. Several scientists took ginger and sea-sickness tablets to overcome the effects of an increasing sea-swell. After successful deployments, we headed for an evening normal station #1 at 30ºS 153º30'E, with scientists settling into the 12-hour working shifts. Trace metal analysis systems were tested in the ANU 20' container on the forecastle deck.

The first 'mega-station' soon arrived at 30ºS 155oE, where all equipment was deployed to the full ocean depth of 4700 m: CTD, TMR twice, and McLane large-volume in situ pumps twice (after toolbox and test dip). A number of biological parameters were sampled at this station off both the TMR and CTD. The deep cast of the TMR was not successful, with the Niskin bottles returning to the surface empty. Since we were already behind schedule, the winds were increasing and we needed time to diagnose the problem, we decided to continue slowly to the next station. At station 4, and another failed deployment of the TMR, we diagnosed the problem to be related to the 'Rosesoft' software used to program the TMR, and reverted to an earlier version of the firmware that had been used successfully on ss2010_v01. No more problems with the TMR software were encountered for the rest of the GP13 voyage.

Our normal stations continued to proceed well, with typically 1 hour for the CTD and 2 hours for the TMR deployments. At station #7, we encountered Elisabeth Reef nearby which rose to 200 m below the surface of the ocean, which was now a deep blue colour. We experienced mostly clear sunny days with 15-20 knot winds, which allowed for smooth operations. A number of albatross were sighted following the ship. On the evening of 19 May, clocks were advanced 1 hour. The super-station at 30ºS 160ºE proceeded well, except for the failure of one of the McLane pumps. The long duration of the station meant that both teams of scientists had to work longer shifts than normal and rest up between operations where possible. We deployed the Benthos deep-sea 'pinger' on the TMR for the first time at this station, which allowed us to target the bottom depth of 1667 m.

Station #9 was cancelled due to bad weather and increasing sea-swell. The next 3 normal stations were carried out efficiently, with all equipment (TMR and CTD) working well. We also continued to collect aerosol dust samples on the ship's monkey island when the winds were favourable (sector and strength). We arrived at the 30ºS 165ºE mega-station on Friday 19th May. This station was a re-occupation of the PINTS (ss2010_v01) process station P1. A full suite of parameters were collected, together with samples for an international GEOTRACES intercalibration exercise. This station also coincided with Pier's birthday, and the stewards baked a cake for the occasion as a reward for staying up all night!

The next 5º of longitude were covered in just under 2 days, and we were soon approaching our next super-station (#18) at 170ºE. A group photo of the scientific team was taken on the aft deck in sunny conditions prior to the station, which was carried out smoothly over the next 11 hours. Efficient sampling operations and smooth seas allowed us to catch up on time lost at the beginning of the voyage and after the next 4 normal stations, we were back on schedule. Colleagues at Griffith University informed us that conditions over the continent were suitable for large-scale dust entrainment, and therefore we continued to monitor our aerosol sampling equipment carefully as we passed just south of Norfolk Island, where ship's time advanced 1 hour to NZST.

We passed the half-way mark ('hump day') of the voyage as we approached mega-station #23 again, which again meant another long working day for the scientific party. All equipment performed well. Weather conditions were dominated by northerly winds, bringing relatively humid air (~85% humidity) southwards, 25 knots of winds and a fairly confused, choppy sea. After station #24 (30ºS 176ºE), the voyage track diverted in a south-easterly direction toward the 32o30'S line of latitude. The TMR at station #25 was aborted due to rapidly worsening weather conditions, and difficulty in spooling the Dynex rope through the General Oceanics block on the stern 'A'-frame. After a weather delay of 10.5 hours, the next few normal stations proceeded well as we crossed the South Fiji Basin. Here, the topography of the surrounding seafloor was very interesting, with a number of seamounts and ridges observed as we approached the boundary between the Indo-Australian and the Pacific plates. This region was mapped using the EM300 swath bathymetric data system on board the ship. Rain sampling was also carried out in this region from the ship's monkey island.

Super-station #28 took place on the international date-line, where east meets west and tomorrow became yesterday! However, the ship remained on NZST time for the rest of the voyage, to aid logging of activities. We marked the occasion with a lunchtime photo on the bow of the ship, and continued to proceed with deployment of our TMR, CTD and McLane pumps. One of the McLane pumps failed on both deployments at this station, and at this station we were able to diagnose that this was due to a faulty communications cable between the electronics housing and the pump head. Unfortunately, we did not have a spare cable on-board, but informed our NZ colleagues to arrange for a new one for their leg of the GP13 section, which followed ours.

We were about 6 hours ahead of schedule as we approached normal station #31, which was situated over the Kermadec Trench, where the ocean depths reached 8850 m. Both the CTD and TMR were deployed to 6000 m depth at station #31, their maximum rated deployment depths. We believe that the TMR operation was the deepest TMR deployed ever throughout the world's oceans. Our last mega-station (#33) was located at 32º30'S 175ºW. The seas were exceptionally calm here. Scientific equipment again worked well, except one of the McLane pumps. The ship's crew demonstrated a number of safety equipment at this station, including distress beacons (or 'flares'), rocket line-throwing equipment and emergency position indicating radio beacons (EPIRBs).

Our goal of the Australian leg of GP13 was to complete our final station at the 170ºW line of longitude, which intersected the CLIVAR P15S line, and was a region of important scientific value due to the mixing of a number of water masses from the Pacific and Antarctic Oceans. The Captain and Chief Scientist therefore decided to steam directly to station #38 at 170ºW, with the plan to pick up the intermediate normal stations on the return leg to Auckland. We successfully deployed the CTD and TMR to 4000 m at station #38, and took extra samples including radionuclides, and those for NZ and international GEOTRACES intercalibration exercises. The second leg of GP13 on the New Zealand RV Tangaroa will start at 32º30'S 170ºW. Normal stations #37 to #35 were carried out efficiently and we were also able to deploy the TMR (no CTD) at station #34, before diverting to a south-westerly course for the transit to New Zealand. A fair north-easterly wind pushed RV *Southern Surveyor* into port, and voyage ss2011_v02 arrived in Auckland at 08:00 on Sunday 5 June, 2011.

The success of the Australian leg of GEOTRACES GP13 was due to the very efficient and professional execution of station activities, good teamwork by scientists, ship's crew and officers, and effective communications between all parties. A blog of the voyage is posted at www.obs-vlfr.fr/GEOTRACES/index.php/outreach/cruise-blogs/gp13-blog, as part of GEOTRACES Outreach activities. A scientist from a developing nation (Dr Thato Mtshali from CSIR, South Africa) was a member of the scientific contingent as part of the GEOTRACES Education and Training activities.

Summary

Voyage ss2011_v02 was a huge success. Over 5000 samples were collected over the 23 days of ship time, many of them for parameters that have not been measured in this region of the ocean before, and never in the deep-sea (>1000 m) waters that we sampled. These samples will be analysed in the laboratories of the Principal Investigators in the 6-18 month period following the voyage. Good sea conditions, and efficient operations by both the scientific party and crew allowed us to deploy all scientific equipment and instruments, and achieve our overall scientific objectives. The multidisciplinary background and experience of the PIs benefitted the collaborations at sea, and made for an enjoyable and productive atmosphere during the voyage.

Project name

GEOTRACES: An International Study of the Marine Biogeochemical Cycles of Trace Elements and Their Isotopes (www.geotraces.org)

Coordinating body

GEOTRACES International Project Office, 14, av. Edouard Belin, 31400 Toulouse cédex 9, France

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

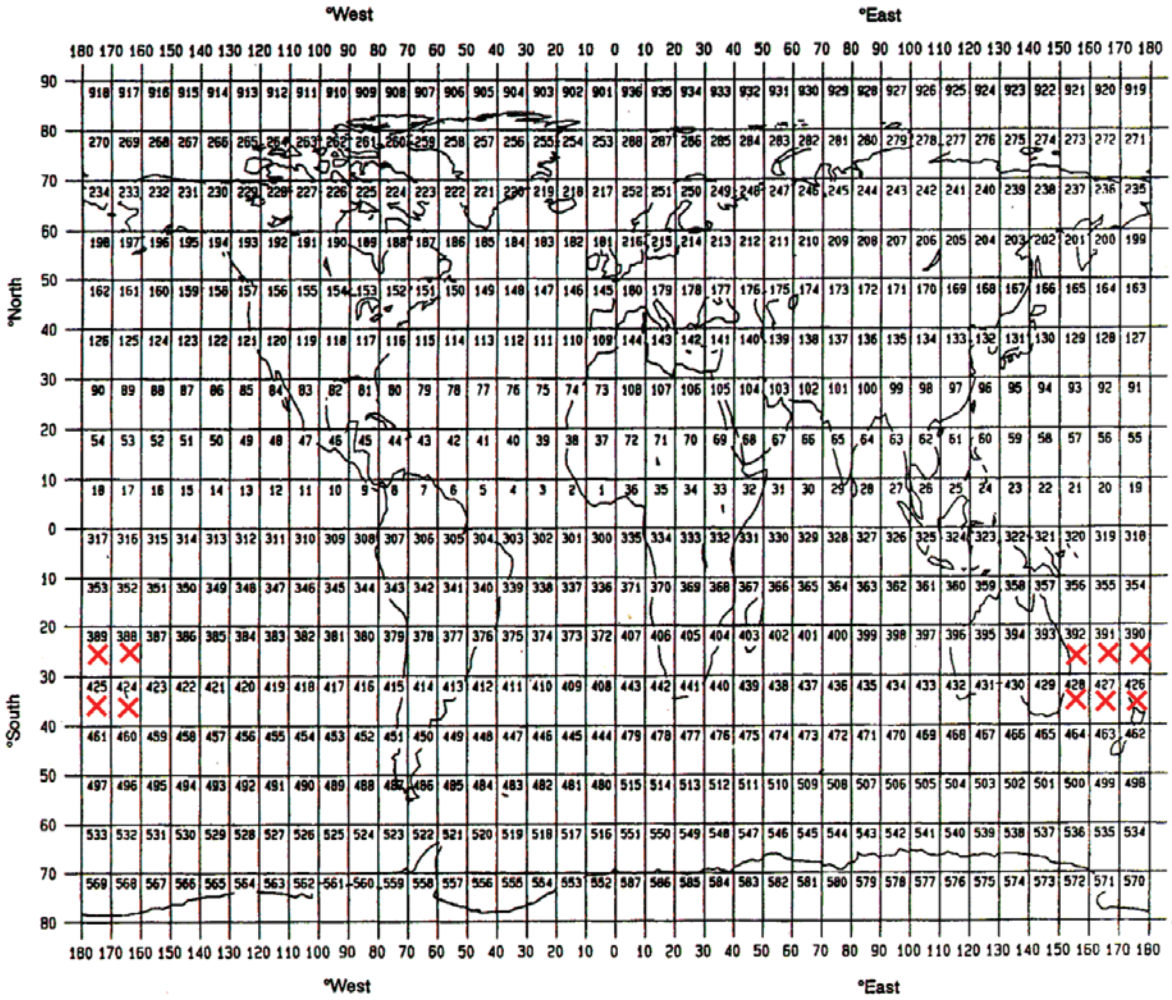

Figure 3: Geographic coverage

SUMMARY OF MEASUREMENTS AND SAMPLES TAKEN					
Item No.	**PI**	**NO**	**UNITS**	**DATA TYPE**	**DESCRIPTION**
1	MNF	76	oC	H10	Temperature, measurement at the top and bottom of each CTD
2	MNF	114	N/A	H10	Salinity, used to calibrate the sensor of the seabird 911, 2-3 samples per cast (depending on depth of CTD)
3	MNF	114	mmol/L	H21	Dissolved oxygen, used to calibrate the sensor of the seabird 911, 2-3 samples per cast (depending on depth of CTD)
4	MNF	760	µmol/L	H22 H75 H26	Major nutrients (NOx, Si and PO4) taken at each CTD deployment.
5	MNF	190	µmol/L	H22 H75 H26	Nanonutrients (NOx, Si and PO4) taken at each TMR deployment. These need further analysis by flow injection and will complement analysis that were below detection limit from the MNF Hydrochemists
6	A	540	nmol/L	H30	Dissolved and total dissolvable iron from the TMR. These samples will be analysed in the lab using flow injection technique.
7	A	540	nmol/L	H30	Total dissolved trace metals (Cu, Mn, Fe) from the TMR. Sample will be analysed using isotope dilution ICP-MS.
8	D	168	nmol/L	H30	Total dissolved trace metals (Cu, Zn, Cd, Pb) from the TMR. Sample will be analysed using ICP-MS.
9	E	168	nmol/L	H30	Fe chemical speciation from the TMR. Sample will be analysed using electrochemical techniques.
10	D	168	nmol/L	H30	Cu chemical speciation from the TMR. Sample will be analysed using electrochemical techniques.
11	D	150	nmol/L	H30	Dissolved trace metal stable (Fe, Zn and Cu) isotopic signature from the TMR. Sample will require further analysis using MC-ICP-MS technique.
12	B	150	nmol/L	H30	Dissolved trace metal stable (Cd) isotopic signature from the TMR. Sample will require further analysis using MC-ICP-MS technique.
13	B	48	nmol/L	H30	Dissolved trace metals for GEOTRACES and AUS-NZ intercalibration exercises from the TMR. Analaysis using various techniques.
14	E	100	µmol/L	H90	Suwannee River fulvic acid (SRFA)-like compounds from the TMR.
15	E	228	µg/L	B02	Pigments and Chl a from the CTD. Analysis by HPLC technique back in the laboratory. These will be use to infer the biomass and the composition of the phytoplankton community.
16	E	228	cell/mL	B07	Picoplankton and bacterial abundance from the CTD using flow cytometry.
17	E	228	Relative units	B90	Photosynthetic health (Fv/Fm) of the phytoplankton community from the CTD. These samples are used to infer nutrient limitation. These samples were analysed on-board using the Water-PAM.
18	B	112	N/A	B90	Nifh from the CTD. A gene that controls the expression of nitrogenase, the primary enzyme used during nitrogen fixation.
19	I	112	nmol/L	H90	Dissolved barium from the CTD. These samples will require further analysis using ICP-MS.
20	A	21	µmol/L	B71	Particulate organic carbon and nitrogen from 3 depths on the CTD used to complement McLane pump samples. Samples collected for land-based mass spectrometry analysis.
21	H	70	cell/mL	B90	Flow cytometry (glutaraldehyde preserved samples) (bioGEOTRACES).
22	H	70	N/A	B90	Single cell genomics (glycerol preserved samples) (bioGEOTRACES).
23	H	70	N/A	B90	qPCR and Metagenomics (bioGEOTRACES).

Item No.	PI	NO	UNITS	DATA TYPE	DESCRIPTION
24	G	114	nmol/L	H32	Dissolved radiogenic (Pa, Th, Nd) isotopes from the CTD. These samples will require further analysis using ICP-MS.
25	A	28	nmol/L	H30	Particulate trace metals from the McLane pumps. These samples were collected on QMA filters and will require further analysis using ICP-MS.
26	A	28	µmol/L	B71	Particulate organic carbon and nitrogen from the McLane pumps. These samples were collected on QMA filters and will require further analysis using mass spectrometry techniques.
27	A	28	µmol/L	H30	Particulate iron mineralogy from the McLane pumps. These samples were collected on QMA filters and will require further analysis using X-ray synchrotron techniques. Collected for Dr Thato Mtshali (CSIR, South Africa)
28	E	28	N/A	B90	Metagenomics and ferredoxin/flavodxin index from the McLane pumps. These samples were collected on QMA filters.
29	D	28	µmol/L	H32	Particulate trace metal stable isotopes from the McLane pumps. These samples were collected on polycarbonate filters and will require further analysis using MC-ICP-MS.
30	G	28	µmol/L	H32	Particulate trace metal radiogenic (Pa, Th) isotopes from the McLane pumps. These samples were collected on polycarbonate filters and will require further analysis using MC-ICP-MS.
31	C	9	nmol/L	M70	Atmospheric dust collection. These samples will require further analysis for trace metals using ICP-MS. Collected by Dr Ed Butler for analysis by lab A and Dr Alex Baker (UEA, UK)
32	A	2	nmol/L	M71	Rain collection. These samples will require further analysis for black carbon and trace metals using ICP-MS. Collected by Dr Laurie Burn-Nunes (Curtin Uni.)

Curation Report

Item No.	DESCRIPTION
1	The organisational unit is the Marine National Facility. Data will also be made available (after the 2-year delay) on the GEOTRACES Data Assembly Centre (GDAC) database.
2	The organisational unit is the Marine National Facility. Data will also be made available (after the 2-year delay) on the GEOTRACES Data Assembly Centre (GDAC) database.
3	The organisational unit is the Marine National Facility. Data will also be made available (after the 2-year delay) on the GEOTRACES Data Assembly Centre (GDAC) database.
4	The organisational unit is the Marine National Facility. Data will also be made available (after the 2-year delay) on the GEOTRACES Data Assembly Centre (GDAC) database.
5	The organisational unit is the Plymouth Marine Laboratory (United Kingdom). Data will be made available on the national MarLIN and international GDAC database. A timeframe of 2 years is expected to analyse the samples and publish the results.
6	The organisational unit is the Antarctic Climate & Ecosystems CRC. Data will be made available on the national MarLIN and international GDAC database. A timeframe of 2 years is expected to analyse the samples and publish the results.
7	The organisational unit is the Antarctic Climate & Ecosystems CRC. Data will be made available on the national MarLIN and international GDAC database. A timeframe of 2 years is expected to analyse the samples and publish the results.
8	The organisational unit is the Australian National University. Data will be made available on the national MarLIN and international GDAC database. A timeframe of 2 years is expected to analyse the samples and publish the results.
9	The organisational unit is the University of Technology Sydney. Data will be made available on the national MarLIN and international GDAC database. A timeframe of 2 years is expected to analyse the samples and publish the results.
10	The organisational unit is the Australian National University. Data will be made available on the national MarLIN and international GDAC database. A timeframe of 2 years is expected to analyse the samples and publish the results.
11	The organisational unit is the Australian National University. Data will be made available on the national MarLIN and international GDAC database. A timeframe of 3 years is expected to analyse the samples and publish the results.
12	The organisational unit is the National Institute for Water and Atmospheric Research (New Zealand). Data will be made available on the national MarLIN and international GDAC database. A timeframe of 3 years is expected to analyse the samples and publish the results.
13	The organisational unit is the National Institute for Water and Atmospheric Research (New Zealand). Data will be made available on the national MarLIN and international GDAC database. A timeframe of 2 years is expected to analyse the samples and publish the results.
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18	The organisational unit is the National Institute for Water and Atmospheric Research (New Zealand). Data will be made available on the national MarLIN database. A timeframe of 2 years is expected to analyse the samples and publish the results.
19	The organisational unit is the Vrije Universiteit Brussel (Belgium). Data will be made available on the national MarLIN and international GDAC database. A timeframe of 2 years is expected to analyse the samples and publish the results.
20	The organisational unit is the Antarctic Climate & Ecosystems CRC. Data will be made available on the national MarLIN and international GDAC database. A timeframe of 2 years is expected to analyse the samples and publish the results.
21	The organisational unit is the Massachusetts Institute of Technology (USA). Data will be made available on the national MarLIN and international GDAC database. A timeframe of 2 years is expected to analyse the samples and publish the results.

Item No.	DESCRIPTION
22	The organisational unit is the Massachusetts Institute of Technology (USA). Data will be made available on the national MarLIN and international GDAC database. A timeframe of 2 years is expected to analyse the samples and publish the results.
23	The organisational unit is the Massachusetts Institute of Technology (USA). Data will be made available on the national MarLIN and international GDAC database. A timeframe of 2 years is expected to analyse the samples and publish the results.
24	The organisational unit is the University of Tasmania. Data will be made available on the national MarLIN and international GDAC database. A timeframe of 2 years is expected to analyse the samples and publish the results.
25	The organisational unit is the Antarctic Climate & Ecosystems CRC. Data will be made available on the national MarLIN and international GDAC database. A timeframe of 2 years is expected to analyse the samples and publish the results.
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29	The organisational unit is the Australian National University. Data will be made available on the national MarLIN and international GDAC database. A timeframe of 2 years is expected to analyse the samples and publish the results.
30	The organisational unit is the University of Tasmania. Data will be made available on the national MarLIN and international GDAC database. A timeframe of 2 years is expected to analyse the samples and publish the results.
31	The organisational unit is the Antarctic Climate & Ecosystems CRC. Data will be made available on the national MarLIN and international GDAC database. A timeframe of 2 years is expected to analyse the samples and publish the results.
32	The organisational unit is the Antarctic Climate & Ecosystems CRC. Data will be made available on the national MarLIN and international GDAC database. A timeframe of 2 years is expected to analyse the samples and publish the results.

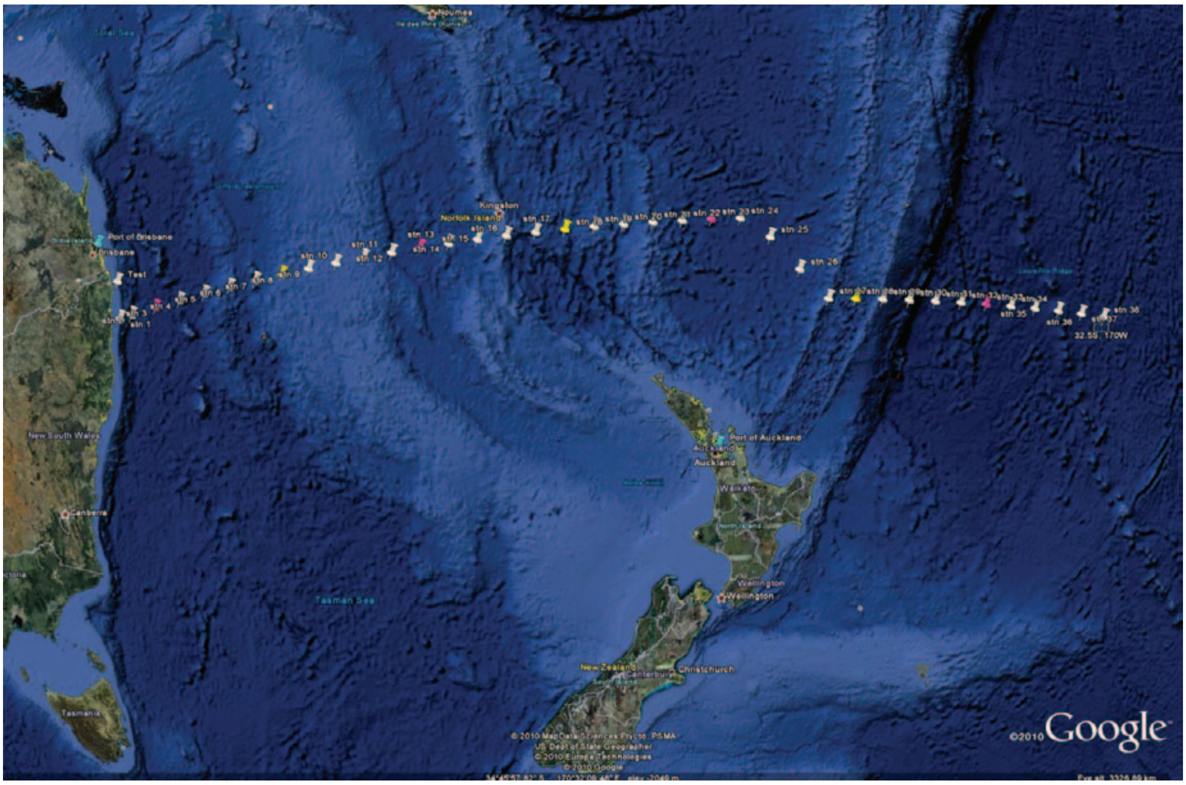

Figure 4: Station locations along the Australian leg of the GEOTRACES GP13 voyage track (voyage ss2011_v02) overlain on Google Earth bathymetry of the study region. Normal stations (1o longitude spacing) are shown in white, super stations (every 5o) in yellow and mega stations (every 10o) in pink. Start (Brisbane, 13 May 2011) and finish (Auckland, 05 June 2011) ports are shown as blue markers. Stations 9 and 25 were cancelled due to bad weather.

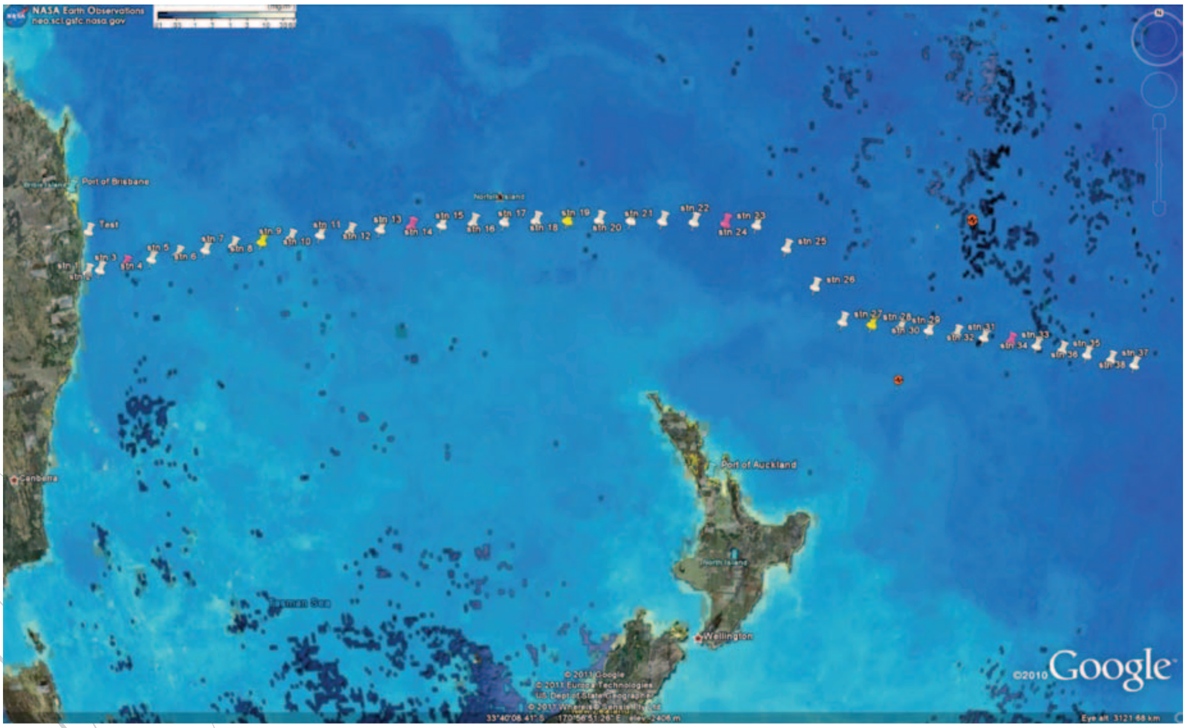

Figure 5: Station locations along the Australian leg of the GEOTRACES GP13 voyage track (voyage ss2011_v02) overlain on May 2011 composite Chlorophyll Concentration (1 month - Aqua/MODIS).

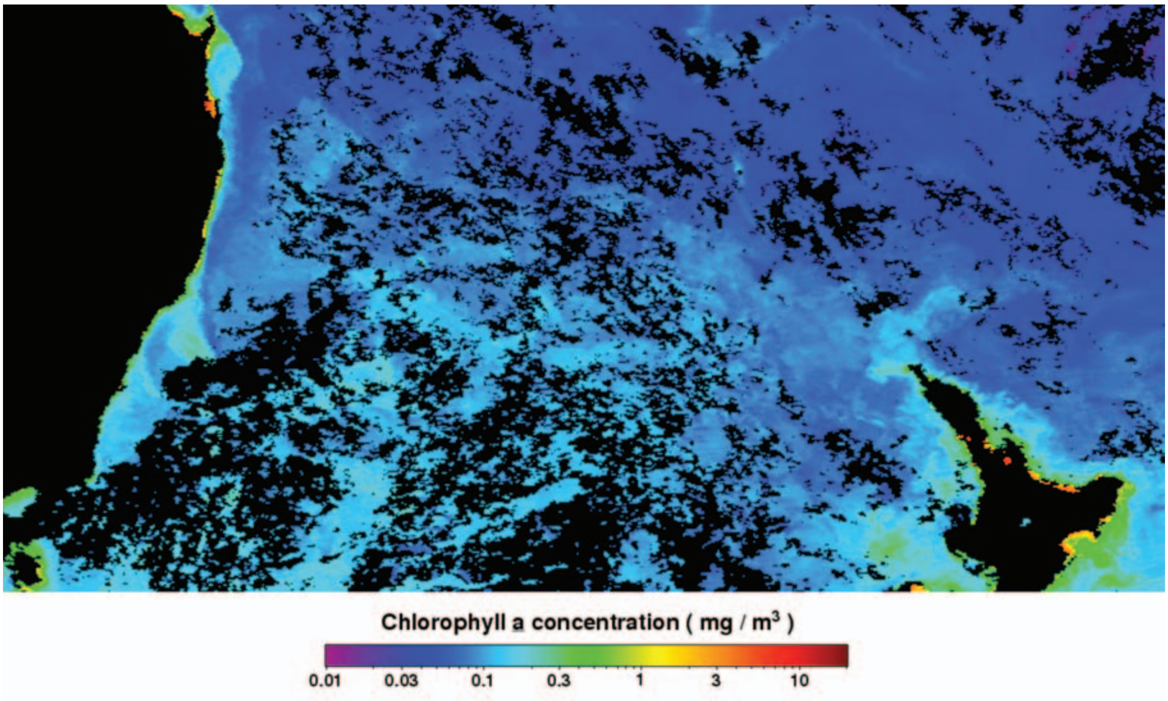

Figure 6: 8 day MODIS image of Tasman Sea (4 km resolution) taken on 30 May 2011 with colour bar of chlorophyll a concentration along the bottom (courtesy of Dr Mark Baird, UTS).

General ocean area

Tasman Sea
Southwest Pacific Ocean

SPECIFIC AREAS

Voyage ss2011_v02 undertook a zonal ocean section along the 30oS line of latitude (from 153o30'E to 176oE) and then diverting to 32o30'S and continuing eastwards (from 179oE to 170oW) (Figure 4). This constituted the GEOTRACES GP13 line, with stations re-occupying the CLIVAR P06 line. A full station and event log can be found in Appendix 2.

Scientific Participants

Name	Affiliation	Role
Andrew Bowie	ACE CRC	Chief Scientist, Chemical oceanographer (trace metal rosette chief)
Christel Hassler	UTS	Alternative Chief Scientist, Biological oceanographer (CTD chief)
Pier van der Merwe	ACE CRC	Marine chemist (McLane pumps chief)
Delphine Lannuzel	UTAS	Sea-ice marine chemist
Claire Thompson	ANU	Chemical oceanographer
Louiza Norman	UTS	Marine biologist
Laurie Burn-Nunes	Curtin Uni.	Trace chemist
Taryn Noble	UTAS	Marine paleoceanographer
Fabien Queroue	UTAS	Marine chemist
Thato Mtshali	CSIR, Stellenbosh (South Africa)	Marine chemist
Ed Butler	UTAS	Chemical oceanographer
Pamela Brodie	CMAR	MNF Computing Support, Voyage Manager,
Karl Forcey	CMAR	MNF Electronics Support, Deputy VM
Sue Reynolds	CMAR	MNF Hydrochemistry support
Peter Hughes	CMAR	MNF Hydrochemistry support

Marine Crew

Name	Role
John Barr	Master
Mike Tuck	Chief Mate
Tom Watson	Second Mate/Cadet
Upendra Kapugeekiyena	Chief Engineer
Mike Yorke-Barber	First Engineer
Graham Perkins	Second Engineer
Robert Dittko	Chief Cook
Cassandra Rowse	Chief Steward
Brooke Seal	Second Steward
John Howard	Boatswain/CIR
Graham McDougal	Integrated Rating
Nathan Arahunga	Integrated Rating
Ellen Smith	Integrated Rating
Gareth Gunn	Integrated Rating

Acknowledgements

We acknowledge the Master, officers and crew of the RV *Southern Surveyor* for excellent and professional work at sea, and for helping to create a friendly atmosphere on board the vessel. This project benefitted from the generous loan of major scientific equipment from ANU, ACE CRC, NIWA, UTAS and CSIRO. Dedicated and efficient collaboration by the sea-going scientific team and Marine National Facility participants, and other land-based Principal Investigators, was instrumental to the success of this voyage. Taryn Noble is thanked for writing the voyage blog (posted at: www.obs-vlfr.fr/GEOTRACES/index.php/outreach/cruise-blogs/gp13-blog), Laurie Burn-Nunes for preparing the Event Log, Claire Thompson for collating the Metadata, Christel Hassler for preparing the CTD Log, Mark Baird for provision of MODIS satellite images, and Craig Strong and Grant McTainsh for sending HYSPLIT and NAAPDS aerosol data to the ship.

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Dr Andrew Bowie, 11 July 2011
Chief Scientist