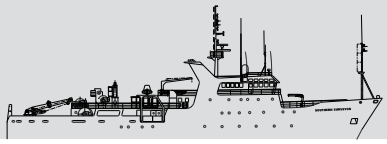

MARINE
NATIONAL FACILITY

2013 program

RV *Southern Surveyor*

voyageplan
ss2013_t03

1. **Microbial oceanography of northern Australia**
2. **Global Drifter Program**
3. **Geographic limits of the Great Barrier Reef submerged reefs/Upper-slope swath mapping**
4. **Transect Measurements of Greenhouse Gases and Ozone in the Marine Atmosphere**

Itinerary
Saturday 27 July, 2013: 1600 – Depart Broome
Saturday 10 August, 2013: 1200 – Arrive Brisbane

1: Principal Investigators
Dr. Martina Doblin (Chief Scientist)
University of Technology, Sydney
Email: martina.doblin@uts.edu.au
Phone: 02 9514 8307

Dr. Justin Seymour (non-voyage participant)
University of Technology, Sydney

Dr Mark Brown (non-voyage participant)
The University of New South Wales

2: Principal Investigator
Dr. Kiki Dethmers, (NAMRA-AIMS)

3: Principal Investigators
Principal Investigators: Dr Robin Beaman (JCU)
Dr Gordon Keith (CSIRO)

4: Principal Investigators
Dagmar Kubistin
(University of Wollongong)

Clare Murphy (Paton-Walsh)
(University of Wollongong

Professor David Griffith
(University of Wollongong)

CSIRO

Scientific Objectives

Ship time on this transit voyage was allocated to four programs:

1. Microbial oceanography of northern Australia – primary program (36 hours), lead by UTS
2. Global drifter program – lead by Dr Kiki Dethmers at NAMRA-AIMS, requiring minimal station time
3. Swath mapping around the GBR, lead by Dr Robin Beaman (JCU) and Dr Gordon Keith (CSIRO) (12 hours)
4. Greenhouse gas measurement, lead by Dagmar Kubistin at UoW

Details about the programs are found below:

1. Microbial oceanography of northern Australia

Principal Invetigators:

Dr. Martina Doblin (Chief Scientist)
University of Technology, Sydney
Plant Functional Biology and Climate Change Cluster
PO Box 123 Broadway, NSW 2007
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Dr Mark Brown (non-voyage participant)
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Kensington, NSW 2052
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Scientific Objectives

The specific objectives of the proposed research are:

1-1. To determine the significance, diversity and seasonality of nitrogen fixation by microorganisms in the nitrogen limited waters of NW and NE Australia (Lauren Messer).

1-2. To examine the expression of light harvesting genes in phototrophic bacteria in different optical climates in the northern coastal and oceanic region of Australia (Jaume Biblioni).

1-3. To understand the biogeochemical role of eukaryotes with respect to N and Si uptake processes.

1-4. To understand the diversity and biogeochemical role of eukaryotes with respect to N uptake processes.

1-5. To reveal the species composition, photophysiology and carbon fixation of phytoplankton in optically complex coastal and ocean waters surrounding Northern Australia.

1-6. To obtain a new understanding of the processes involved in marine snow formation at different depths within the pristine waters of Northern Australia.

2. Global Drifter Program

Principal Investigator: Dr. Kiki Dethmers (NAMRA-AIMS)

Scientific Objectives

The specific objectives of the proposed research are:

2-1. To determine the direction and velocity of subsurface currents across the Timor and Arafura Seas

2-2. To obtain baseline parameters for developing a dispersal prediction model of derelict fishing gear

2-3. To observe (and potentially retrieve) derelict fishing gear, in particular 'ghost nets'

2-4. To record and identify marine wildlife sightings across the Arafura and Timor Seas

Methods: 1) Deploy a series of SVP drifters to track mean currents at a fixed depth (20 m) beneath the ocean surface. The key elements of the drifter include the drogue, the surface float and the connecting tether. Drifter positions are calculated with an installed GPS receiver and provide the information necessary to calculate mean water currents. **2)** If the weather permits, take position on the deck outside the wheelhouse with binoculars and camera to conduct visual observations for marine animals and derelict fishing gear during 3 2-hour sessions per day.

3. Geographic limits of the Great Barrier Reef submerged reefs/Upper-slope swath mapping

Principal Investigators: Dr Robin Beaman (JCU) and Dr Gordon Keith (CSIRO)

Scientific Objectives

1. To determine the full spatial distribution of the Great Barrier Reef (GBR) shelf edge submerged reefs, i.e. can we identify their northern and southern limits?

2. To understand the detailed geomorphology of the submerged reefs and shelf edge features at these northern and southern limits.

3. To collect swath data in those parts of the upper-slope that currently have no swath data.

Methods: Swath mapping will use the RV *Southern Surveyor's* Simrad EM300 multibeam system, in addition to acquiring shallow seismic data using the hull-mounted Topas PS18 subbottom profiler. Sound velocity profiles for the swath system will be generated from the CTD dips undertaken by the microbial oceanography team.

Time estimates: Swath mapping will be undertaken at the standard transit speed with no requirement for stopping. Up to 12 hours has been allocated during the voyage transit to undertake some exploratory surveying at some priority sites along the GBR shelf edge, subject to safe navigation.

4. Transect Measurements of Greenhouse Gases and Ozone in the Marine Atmosphere

Principal Investigators: Dagmar Kubistin (University of Wollongong), Clare Murphy (Paton-Walsh) (University of Wollongong), Professor David Griffith (University of Wollongong)

Scientific Objectives:

The project aims to improve our understanding of the sources, sinks and background concentrations of key greenhouse gases in the Southern Hemisphere.

1. Make continuous measurements of carbon dioxide, methane, nitrous oxide, carbon monoxide and ozone as the RV *Southern Surveyor* travels along the chosen transect;

2. Assimilate measured data into a variety of atmospheric chemical transport, inverse and statistical models to improve our knowledge and understanding of atmospheric greenhouse gases and their sources and sinks.

Methods: The main measurement technique will be a continuous flow gas analyser. The instrument incorporates a pump, a Fourier transform spectrometer and a White cell. It is a fully automated system that is capable of making simultaneous measurements of carbon dioxide, methane, nitrous oxide and water vapour.

A commercial UV absorption instrument will be used for in-situ ozone measurements with a time resolution of 1 min. An additional pump will be required for the sample line. A commercial NOx monitor will be used for distinguishing ship exhaust influenced air.

Time estimates: Continuous gas samples will be taken enroute with no impact on transit voyage time.

Voyage Objectives

1-1) Deploy CTD-rosette to obtain vertical profiles of water column structure (temperature, salinity, dissolved oxygen, Photosynthetically Active Radiation, chlorophyll-a fluorescence, CDOM fluorescence), as well as photosynthetic rates and collect water samples for molecular biological assessment of the microbial community composition and fucntion.

1-2) Undertake deck-board biogeochemical process studies, focusing on nitrogen and carbon fixation.

1-3) Undertake manipulative experiments to alter the quantity and quality of light available for photosynthesis and carbon fixation.

2-1) Release 5-12 drifters at targeted locations along the voyage track. The exact number of drifters is dependent upon how many will be allocated to this project by the NOAA-AOML Global Drifter Program – to be confirmed.

2-2) Routinely conduct visual observations for marine animals and derelict fishing gear.

3-1) Map the submerged reefs along the GBR shelf edge, which lie adjacent to and just landward of the shelf break at approximately the 100 m contour, from the northern GBR in the Torres Strait then southwards following the 100 m contour along the shelf break towards the Swains Reefs.

3-2) Within the northern and central GBR sections, there are some priority sites along the shelf edge for exploratory (at continual transit speed) swath surveys within the 12 hours allocated, subject to safe navigation. These sites are (north to south):

Mantis Reef	143° 55.5'E	12° 16.3'S	
Tydeman Channel	144° 34.0'E	13° 58.0'S	
Ribbon 10/9 Channel	145° 41.9'E	14° 56.0'S	
Ribbon 8/7 Channel	145° 43.9'E	15° 07.5'S	
Ribbon 6/5 Channel	145° 44.9'E	15° 14.7'S	
Myrmidon Reef*	147° 22.6'E	18°15.0'S	*highest priority

3-3) Having followed the submerged reefs along the shelf break at the 100 m contour to about 21°S (the eastern limit of the Swains Reefs) or wherever the submerged reefs disappear, head out to the approximate 300 m contour and cross the Capricorn Channel at 400 m.

The microbial ecologists would like to do a CTD station in the deep water of the Coral Sea (CTD 23; 20°39'42.73"S, 154°29'56.59"E) if there is time.

Finally, should time permit, we'd like to return to the 100 m contour along the shelf break for the remaining transit to Brisbane.

4-1) Undertake continuous underway measurements of greenhouse gases.

Voyage significance

Despite their overwhelming abundance in the oceans, very little is known about the microbial processes occurring in Australian waters, particularly in the north, nor the impact of environmental change on microbe diversity and biogeochemical function. This region includes the pristine but environmentally sensitive Torres Strait and Great Barrier Reef Marine Park, as well as Indonesian through-flow (ITF) and Coral Sea waters associated with the source of the Leeuwin and East Australian Currents respectively. Our research will provide important new data on the drivers of ecosystem productivity and biogeochemistry in this region, which will have immediate relevance for predictions of chemical fluxes and system productivity within Australian waters.

The format of the proposed research is well suited to a Transit Voyage, because sampling procedures are relatively rapid and followed by substantial on-board processing and manipulation, which can take place while the vessel is steaming, allowing for short interruptions to the transit schedule. Our proposed research also has general significance to Australian oceanographic research, as it will incorporate a substantial training element, which will include providing scientific, logistical and leadership experience to students and Early Career Researchers (ECR).

Voyage track

The proposed voyage track is presented in Fig. 1. Dates and approximate times for arrival and departure are based on an average speed of 19 Km/ hour (10 knots) (Table 1). Start times are flexible and can be adjusted.

This part of the science program will involve stopping at regular intervals along the transit to undertake CTD deployments. The goal is to characterise the microbial communities in different water types and examine their activity. Because physiology of marine photosynthetic organisms is affected by the time of day, we want to undertake operations at the same time each day if at all possible. Each day we wish to sample at one pre-dawn station starting at 05:00 and one afternoon station at 15:00.

Note that during the early morning station will require two CTD operations. The first will involve a water column profile to 300 m (or less, depending on water depth), with samples captured at the surface. The operation will then switch to a light sensor deployment (with vessel facing the sun). We will then do a second CTD cast to capture water at the subsurface fluorescence maximum. We will adjust this schedule depending on time availability in consultation with the voyage manager and Master of the vessel.

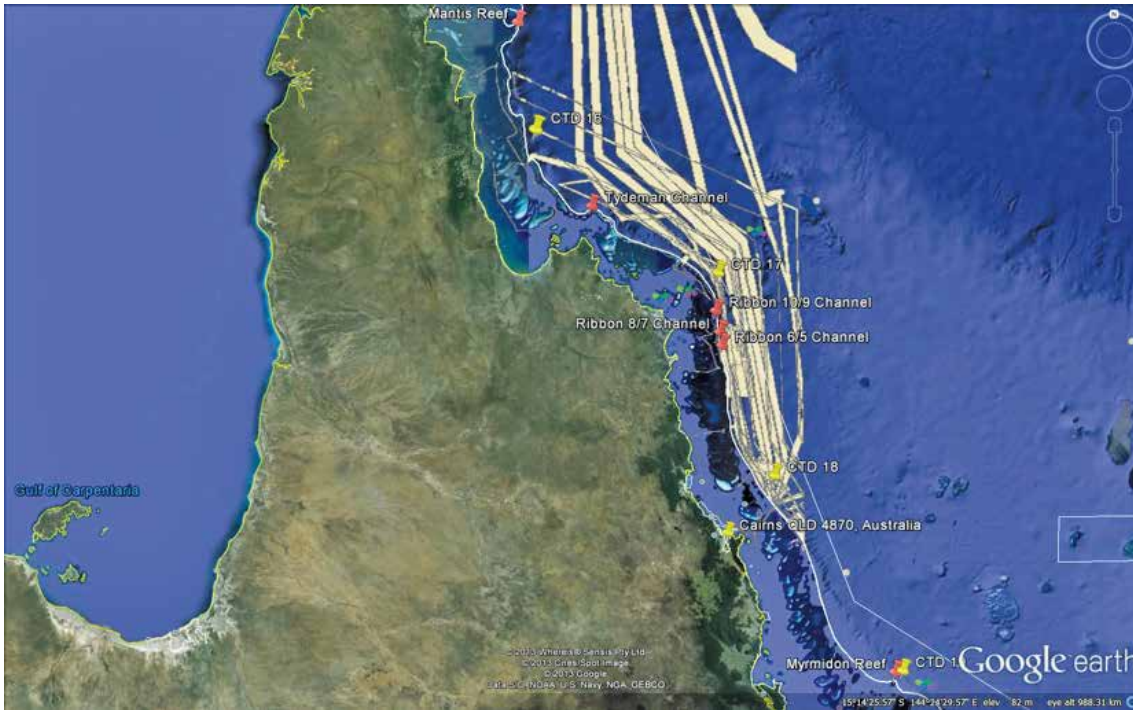
The complete sequence of tasks and the voyage schedule is shown below. Station locations and timing are indicative, and would be relocated depending on weather or time constraints.

The station locations in the Great Barrier Reef World Heritage Area have been designed to run along the 100 m contour. Priority areas for reef mapping are shown in red (a more detailed figure is shown overleaf).

Figure 1

	Time	Station Number	Latitude (°S)	Longitude (°E)	Location	Cumulative Time (h)
27/07/13	1600	Start	18° 2’ 31.59”	122° 14’ 42.06”	Broome	
28/07/13	0500	1	16° 28’ 38.58”	122° 0’ 27.15”	Kimberley	1
28/07/13	1500	2	15° 11’ 50.35”	122° 51’ 42.14”		2
29/07/13	0500	3	13° 50’ 47.49”	124° 38’ 50.67”		3
29/07/13	1500	4	13° 0’ 52.89”	125° 59’ 16.63”		4
30/07/13	0500	5	12° 1’ 21.84”	127° 58’ 35.36”	Timor Sea	5
30/07/13	1500	6	11° 22’ 37.37”	129° 23’ 11.76”		6
31/07/13	0500	7	10° 47’ 11.69”	131° 30’ 0.39”	Arafura Sea	7
31/07/13	1500	8	10° 35’ 1.73”	133° 2’ 38.56”		8
1/08/13	0500	9	10° 39’ 46.73”	135° 14’ 30.44”		9
1/08/13	1500	10	10° 41’ 39.91”	136° 47’ 54.76”	Gulf	10
2/08/13	0500	11	10° 45’ 32.33”	139° 0’ 42.22”		11
2/08/13	1500	12	10° 49’ 9.29”	140° 33’ 48.58”		12
3/08/13	0500	13	10° 15’ 26.73”	142° 41’ 1.71”		13
3/08/13	1500	14	9° 46’ 30.66”	144° 7’ 30.07”		14
4/08/13	0500	15	11°49'11.36"S	143°58'46.77"E		15
		Mantis Reef	12° 16.3’S	143° 55.5’E		
4/08/13	1500	16	13°16'22.02"S	144° 3'32.29"E		16
		Tydeman Channel	13° 58.0’S	144° 34.0’E		
5/08/13	0500	17	14°35'25.43"S	145°43'32.43"E		17
		Ribbon 10/9	14° 56.0’S	145° 41.9’E		
		Ribbon 8/7	15° 07.5’S	145° 43.9’E		
		Ribbon 6/5	15° 14.7’S	145° 44.9’E		
5/08/13	1500	18	16° 25’ 27.17”	146° 13’ 15.87”		18
		Myrmidon Reef	18° 15.0’S	147° 22.6’E		
6/08/13	0500	19	18° 14’ 12.35”	147° 27’ 0.72”		19
6/08/13	1500	20	18° 56’ 15.09”	148° 51’ 17.71”		20
7/08/13	0500	21	19°52'27.80"S	150°36'35.52"E		21
7/08/13	1500	22	20° 47’ 37.65”	152° 10’ 6.25”		22
8/08/13	0500	23	20° 39’ 42.73”	154° 29’ 56.59”		23
8/08/13	1500	24	21°39'47.76"S	153°13'26.71"E		24
9/08/13	0500	25	23°59'13.40"S	152°49'5.19"E		25
9/08/13	1500	26	25°22'45.20"S	153°29'55.35"E		26
10/08/13	0500	27	26°57'24.88"S	153°19'33.83"E		27
10/08/13	1000	End			Brisbane	

Table 1: Station locations and timings for CTD casts during ss2013_t03 based upon the vessel departing Broome at 1600 Saturday 27th July and reaching Brisbane at 1200 Saturday 10th August traveling at an average speed of 19km/hr (10 knots).



Mantis Reef	143° 55.5′E	12° 16.3′S	
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Ribbon 8/7 Channel	145° 43.9′E	15° 07.5′S	
Ribbon 6/5 Channel	145° 44.9′E	15° 14.7′S	
Myrmidon Reef*	147° 22.6′E	18°15.0′S	*highest priority

Summary of scientific operations during voyage:

CTD operations will be carried out during the day only (0500 and 1530).

There will be periodic sampling from the in-line water system (no halt to ship operations required)
27 CTD rosette samplings
14 Biogeochemical N-fix and C-fix stations
Total = 27 operations x 1 hour operations

Daily optical casts (one per afternoon)
14 x 0.5 h = 7 h
Total of 34 h with 2 h to spare

Release of drifters (minor deviation from voyage track).

Continuous day and night swath mapping of shelf edge and upper-slope areas along the GBR.

Weather contingency for program 1 is to conduct the major 0500 stations each day and not do the afternoon casts.

Schedule

27/07/2013
0800 Load equipment
1600 Depart Broome
1700-1800 Dinner
1900 Tool box

28/07/2013
0500 CTD+Rosette for surface microbial sampling/ setup N2 fixation/13C incubation
Optical cast
CTD+Rosette for fluorescence max sampling
0700-0745 Breakfast
1130-1230 Lunch
1530 CTD+Rosette
1700-1800 Dinner

29/07/2013 – 09/08/13
Same schedule as 28/07/13 (above)

10/08/2013
0700-0745 Breakfast
1200 Arrival Brisbane
1130-1230 Lunch
1700 Finish unloading

Experimental design and sample collection

Samples will be acquired from 27 stations along the transit route, weather and time depending. At each station, CTD deployments will be used to obtain samples from 3-6 depths (nominally surface, chlorophyll maximum and below chlorophyll maximum, with other depths in between). Following each CTD cast, sample filtration and preparation for incubation experiments can occur while the ship is steaming. Incubation experiments will be established following collection of samples from the 0500 CTD deployment (14 in total). During the entire voyage, samples will periodically be taken (at approximately 2 hour intervals) from the ships in-line water system. These samples will be filtered for microbial DNA and fixed for flow cytometric analysis.

The voyage track proposed does not deviate substantially from the shortest route and we are flexible to accommodate changes to our proposed route. Our priority is a high resolution of sample frequency in these northern waters (i.e. high number of stations), rather than a specific or convoluted voyage track.

Sample processing and analysis

AIM 1: Rates of nitrogen fixation will be assessed from on-deck incubation experiments (24 hr) where seawater samples will be spiked with the stable isoptope $^{15}N_2$. Samples will be filtered and the $^{15}N_2$ content will be measured using isotope ratio mass spectrometry post-voyage. We will use this approach to determine net nitrogen fixation rates at the surface and chlorophyll maximum. Water samples from the surface and chlorophyll maximum will be filtered on to 0.2 µm membrane filters for nucleic acid extraction (DNA and RNA) post-voyage. The gene encoding the enzyme nitrogenase will be used to assess the taxonomy and activity of nitrogen fixing microorganisms through pyrosequencing and quantitative PCR.

AIM 2: To investigate light controls on proteorhodopsin and bacteriochlorophyll-a, water samples from the surface, selected depths within the euphotic zone and the chlorophyll maximum will be filtered onto 0.2 µm membrane filters. Post-voyage nucleic acid extraction (DNA and RNA) will target the genes responsible for encoding proteorhodopsin and bacteriochlorophyll-a.

AIM 3: Rates of silicate incorporation will be assessed using the fluorescent stain PDMPO. Water samples will be incubated on deck and filtered onto membranes after 24 h incubation. Rates of Si incorporation will be measured on samples using quantitative fluorescence approaches in the laboratory at UTS.

AIM 4: Labelled nitrate (e.g.^{15}N-potassium nitrate) will be added to natural phytoplankton assemblages and incubated on deck. Samples will be filtered onto precombusted glass fibre (GF/F) filters and analysed using isotope ratio mass spectrometry post-voyage. We will use this approach to determine net nitrate uptake rates at the surface and chlorophyll maximum. Water samples from the surface and chlorophyll maximum will also be filtered on to 0.2 µm membrane filters for nucleic acid extraction (DNA and RNA) post-voyage.

AIM 5: To reveal the photophysiology and carbon fixation of phytoplankton in different optical climates, water samples will be spiked with ^{14}C-bicarbonate and incubated in a photosynthetron in the laboratory for 1-24 hrs. Rates of ^{14}C incorporation will be calculated after liquid scintillation counting, yielding estimates of phytoplankton primary production. A profiling irradiance sensor will characterise multispectral light availability within the water column. Phytoplankton species composition and photosynthetic traits will be characterized using flow cytometry and active fluorescence of live samples. Samples filtered onto 0.7 µm GF/F filters will be analysed for photopigments (using high performance liquid chromatography), C:N, C:P elemental ratios and particulate organic carbon (isotope ratio mass spectrometry).

AIM 6: To determine the abundance of transparent exopolymeric particles (TEP) water samples will be collected from multiple depths and preserved in formalin for post-voyage filtration through 0.4 µm membrane filters and analysis of TEP using a dye-binding assay.

Scientific outcomes

The proposed research will provide a new understanding of the ecology and biogeochemistry of Australia's northern waters and will answer the following important questions:

- How do rates of nitrogen fixation vary temporally in northern Australian waters; how does nitrogen fixation support primary production in this region in times of nutrient limitation?
- How do abiotic and biotic processes influence the occurrence and expression of genes encoding proteorhodopsin and bacteriochlorophyll a indicative of photoheterotrophy?
- What role do different eukaryotic phytoplankton play in the N cycle?
- Do rates of Si incorporation into diatoms vary with temperature and species?
- How important are nutrients for phytoplankton photoacclimation and carbon fixation in different optical climates?
- How important is TEP production for the aggregation of carbon exports in the N Australian waters?

International Collaboration

The proposed research will involve collaboration with leading international scientists, who will add capacity to oceanographic research in Australia. Dr Claire Mahaffey (University of Liverpool, UK), will provide expertise in the nitrogen fixation techniques, and optical expert Dr David Suggett will provide bio-optics expertise that will be employed during the voyage.

Student/ECR training

A major feature of the proposed research involves the excellent opportunities for involvement by students and early career researchers (ECRs). This research will provide a platform for training the next generation of biological oceanographers at several levels. Four PhD students will participate in this voyage, which will provide them with an opportunity to gain ship-board research experience and collect data for their research projects. This will provide a timely boost to Australia's future oceanographic capacity, with the imminent commissioning of a new major research vessel.

Southern Surveyor Equipment

- HYDROCHEMIST will be required
- 24 bottle carousel and frame (10 L Niskins)
- Ecotriplet sensor to occupy one position on the rosette sampler
- CTD instruments / rosette deployment and recovery (winch, wire and deployment system)
- ADCP (both low and high frequency)
- Labs various
- Laboratory fresh water
- Ultra-pure fresh water
- Authorisation to use 14C – application submitted to Philip Pennington
- Scintillation counter
- Masthead PAR measurements
- -80 °C freezer
- Walk in -20 °C freezer
- Refrigerator
- Fume cupboards & Hazardous Materials lockers.
- Thermosalinograph
- TSG SST, oxygen and flow rate (intake temperature, Aanderaa Optode oxygen sensor and EM flow meter)
- Underway water analysis instruments (pCO2; O2 for TSG; chlorophyll & bio-optical sensors)
- Nutrient analyser
- Data processing IT
- Data processing lab computers, printers, scanners, photocopiers etc.

Program 3. Swath mapping around the GBR

- Simrad EM300 multibeam swath system
- Topas PS18 subbottom profiler
- Post-processing computer with Caris HIPS/SIPS software.

User Equipment

1. Downwelling irradiance sensor on the masthead (CSIRO Land and Water)
2. Bio-optics cage with Ramses multi-spectral irradiance sensors (SIMS owned)
3. Fast-tracker fluorometer (to be used in lab mode; SIMS owned)
4. Photosynthetron (CMAR WA)
5. Vacuum pumps, peristaltic pumps, filters for chlorophyll, stable isotopes, molecular analyses
6. HPLC filtration unit (UTS)
7. Molecular filtration units (UTS/UNSW/MacU)
8. 47mm filtration units for TSS/POC (UTS)
9. 47mm glass filtration units for DOC (UTS)
10. Liquid Nitrogen dewars, filled
11. Formalin, alcohol, Lugols solution, glutaraldehyde, Paraformaldehyde, Sodium Azide, Phosphoric acid
12. deckboard incubators
13. Temperature and light loggers for deckboard incubators
14. PAM fluorometer
15. Gear from Bronte Tilbrook to sample DIC and alkalinity – to be confirmed

Special Requests

We aim to conduct incubation experiments during the transit. With no weather contingency, we may still require access to deck incubators and labs on arrival into Brisbane on the final day of the voyage (Saturday 10 August).

We'd like pCO_2 measurements made while underway and would like to request ammonia measurements.

Personnel List

Participant	Affiliation	Position	Shift
1. Dr. Martina Doblin	UTS	Chief Scientist	Day (0500 to 1700)
2. Ms Lauren Messer	UTS	PhD Student	Day (0500 to 1700)
3. Ms Charlotte Robinson	UTS	PhD Student	Day (0500 to 1700)
4. Mr Jaume Bibiloni Isaksson	UTS	PhD Student	Day (0500 to 1700)
5. Ms Kirralee Baker	UTS	PhD Student	Day (0500 to 1700)
6. Dr Shalin Seebah	UTS	Post-doc	Day (0500 to 1700)
7. Mr James McLaughlin	CMAR	Research fellow / Alternate Chief Scientist	Day (1000 to 2200)
8. Ms Kiki Dethmers	AIMS	Chief Investigator	
9. Dr Robin Beaman	JCU	Chief Investigator/Swath	Midnight to midday
10. Mr Gustavo Hinestrosa	USydney	PhD Student/Swath	Midday to midnight
11. Lisa Woodward	CMAR	MNF Voyage Manager	
12. Rod Palmer	CMAR	MNF Electronics Support	
13. Rick Smith	CMAR	MNF Swath Support	
14. Anoosh Sarraf	CMAR	MNF Computing Support	
15. Sue Reynolds	CMAR	MNF Hydrochemistry Support	

UTS – University of Technology Sydney; **MNF** – Marine National Facility; **CMAR** – CSIRO Marine and Atmospheric Research; **JCU** – James Cook University; **USydney** – University of Sydney

As per AMSA requirements for additional berths on Southern Surveyor, the following personnel are designated as System Support Technicians and are required to carry their original AMSA medical and AMSA Certificate of Safety Training on the voyage:

Name	AMSA Certificate of Safety Training No.
Lisa Woodward	BB01145
Rod Palmer	BB05328
Anoosh Sarraf	BB02298
Sue Reynolds	BB03210

This voyage plan is in accordance with the directions of the Marine National Facility Steering Committee for the Research Vessel Southern Surveyor.

Hydrochemistry sample calculations:

CTD stations (27 x 6 depths) = 162

Salinity – 2 per cast = 54 samples (conductivity minimum and maximum)

Oxygen – 3 per cast = 81 samples (oxygen minimum, oxygen maximum and somewhere in the middle)

Nutrients – 6 per cast = 162 samples

Plus additional samples from experiments – 14 x 2 depths x 2 time points x duplicates = 112

Require: NOx, NH4, PO4, Si

Dr Martina Doblin
Chief Scientist