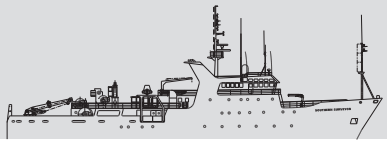

MARINE
NATIONAL FACILITY

2008 program

RV *Southern Surveyor*

voyageplan
SS09-2008

The Carbon System of Australian regional seas and the vulnerability of ecosystems to acidification.

Itinerary

Mobilise Cairns 0800hrs, July 24, 2008
Depart Cairns 1600hrs July 24, 2008
Arrive Gladstone 1300hrs, August 11, 2008 and demobilise

Principal Investigator(s)

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CSIRO

Scientific Objectives

For at least the past 800,000 years, and possibly the last 23 million years, the earth has experienced low atmospheric CO_2 conditions and many carbonate-based ecosystems have flourished. The increase in atmospheric CO_2 due to fossil fuel emissions and land use change is rapidly exposing marine ecosystems to a high CO_2 world. The immediate impact of increasing CO_2 on the ocean is to alter carbonate chemistry by a lowering of pH (increased acidity), a decrease in the surface ocean carbonate ion concentration (CO_3=), and associated declines in the calcium carbonate saturation state (Ω). Laboratory experiments have shown some species of corals and calcifying plankton [Gattuso, et al., 1998; Langdon, et al., 2000; Orr, et al., 2005; Riebesell, et al., 2000] are highly sensitive to changes in Ω. Using this empirical evidence and an ocean-only model forced with atmospheric CO_2 from the IS92a scenario, Kleypas, et al., 1999 projected up to a 30% reduction in calcification rate by 2100. They concluded that such a change would have a large negative impact on the sustainability of coral reefs.

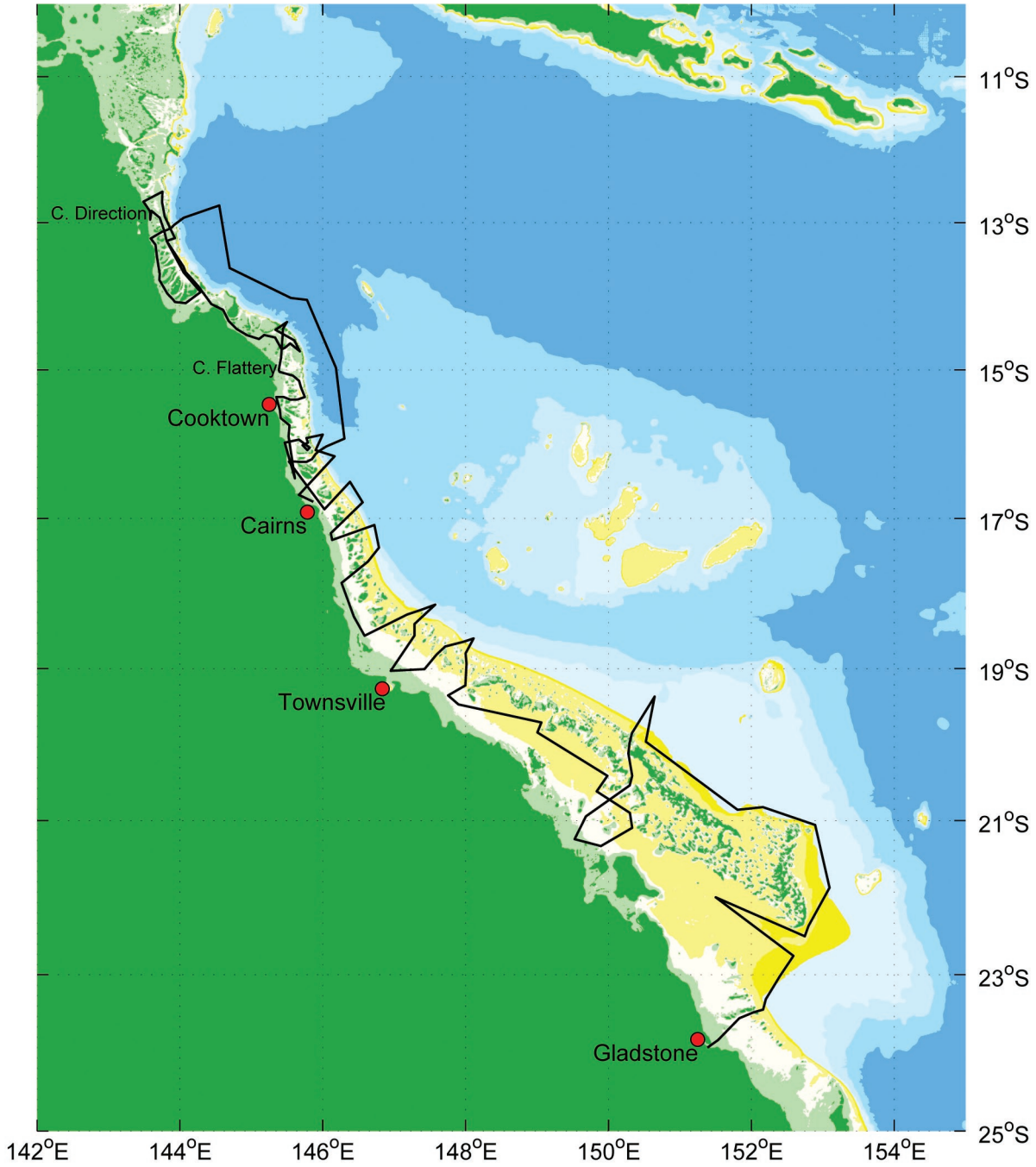
Australia contains some of the largest living carbonate platforms on earth, including the iconic Great Barrier Reef. The reef systems are likely to be impacted by acidification with potential flow-on effects to habitats, tourism and biodiversity. While the potential to disrupt ecosystems is high, there is virtually no data on ocean carbon chemistry data for the GBR region that is needed to evaluate the risk of acidification. For example, coral growth records collected from massive Porites corals at different locations on the GBR indicate about a 21% decline in calcification since the late 1980's [Cooper et al, 2008]. The changes in calcification are consistent with an acidification response, perhaps in combination with temperature related stress of the corals. However, Cooper et al concluded the lack of ocean carbon chemistry data in the region makes any firm conclusions on the cause of the decline in calcification difficult to interpret. The objective of this proposal is to obtain the first detailed measurements of the carbonate chemistry through much of the GBR system. These data will form a benchmark for determining the future progression of acidification in the region, and will provide a first assessment of how the complex reef ecosystem influences the carbonate chemistry of the region. It represents a major step in assessing the risk of acidification to the GBR in coming decades.

Voyage Objectives

Baseline carbon chemistry of the GBR. The objective of the voyage is to obtain the first detailed data on the mid to large-scale carbon chemistry of the Great Barrier Reef (GBR) system. The voyage will only cover the dry winter months and future voyages may be needed to capture the variability through other seasons. The voyage will cover the region from the Kupuntutu Passage near Cape Direction in the far North to the Capricorn Group near Gladstone and include cross-shelf and along shelf variability. The data collected will provide an understanding of how the chemistry of Coral Sea waters that exchange with the GBR lagoon are modified by calcification and primary production, and will be a benchmark for assessing the progress of acidification on the GBR in future years. Samples will be collected using a combination of underway sampling from the ship's clean seawater supply, cross-shelf CTD sections extending into the Coral Sea, and by sampling along the axis of the GBR lagoon. The samples will be analysed onboard for carbon system parameters, nutrients, oxygen and salinity. An underway system will be used to continuously measure the partial pressure of carbon dioxide in the surface waters and an equilibrator inlet mass spectrometer will be used to monitor oxygen/argon ratios to estimate net community production of the reef system.

Net primary production and calcification causes the marine biota to modify the carbon chemistry, including the saturation state of the ambient waters. The mid to large-scale sampling will provide the first data to assess how the many components of the GBR ecosystem combine to influence the carbon chemistry of the water. We will use these data along with models of exchange with offshore Coral Sea waters to determine if rate of calcification can be derived for the entire reef. If successful, this will be the first estimate of the role of the GBR system in influencing the carbon budget and alkalinity of the global ocean. Further, by relating our carbon data to the collected hydrographic data we will explore relationships that might allow us to use hydrographic data to predict alkalinity and carbon concentrations. If some skill in this prediction is apparent, we will attempt to exploit the historical hydrographic data from the major shipping passageways to quantify the temporal variability of the carbon data in the GBR and improve the temporal information on the net rate of calcification in the GBR region.

Voyage Track



July 24

Depart Cairns July 24 at 1600 hrs

The ship will transit to north of Cairns and begin a section through Trinity Opening with CTD stations at approximately 5 nm spacing. During the night the ship remain off the shelf and proceed offshore to about 15 54'S 145 51'E, located at the mouth of a passage north of Agincourt reef number 4.

July 25

On morning of July 25 the ship will head onto the shelf through a pass north of Agincourt reef 4 and enter the region behind the Agincourt reefs. The workboat will be deployed for sampling near Agincourt no 2 and 3 and 4. While the workboat is being used, the ship will do 4 CTD's in the shelf waters west of Agincourt reefs and pick up the boat in the afternoon. The ship will then complete a short CTD section Nth of Agincourt to the inner GBR lagoon, before transiting to Port Douglas to pick up four science crew late on night of July 25. The ship will then travel north along the edges of the main shipping route, stopping at 20 to 30 nm intervals for shallow CTD's.

July 26

In the early morning we will begin an across shelf section from near Cooktown towards Ribbon Reef No 5. After completion of the section the ship will move to a site off Cape Flattery and commence a northerly section past Lizard Island reaching One and Half Mile Opening in the early morning during daylight hours. The ship will pass out the opening and return via Two Mile Opening then sample on the shelf behind Yonge and Ribbon Reef 10. After completing sampling to the immediate west of Lizard Island the ship will travel along the shipping channels to the entrance for the Fairway Channel and LADS Passage.

July 27-29

In the early morning the ship will proceed up the Fairway Channel/LADS Passage with CTD's at about 20nm intervals. The primary aim is to complete E-W sections in daylight across the Kupuntutu Passage near Cape Weymouth, and a passage from near Night Island (13 11'S 143 35'E) passing out to the open sea through Second Three Mile Opening (13 04'S 143 53.5'E). While the ship is on the shelf and during night-time hours, it will travel along shipping routes of the LADS Passage and inner route providing underway and intermittent CTD samples to map the carbon chemistry through the region. If the ship does not have enough daylight hours to complete the above sections, or conditions are unsuitable, secondary targets are sections through Osborn Channel (13 00'S) and a section from near Hay Island (13 38'S 143 38.5E) and out through First Three Mile Opening (13 28'S 144 00'E). When in the LADS passage and if Halimeda mounds are identified using the Topas sub-bottom profiler some grab samples of the Halimeda will be collected. The plan is to exit through Second Three Mile Opening to the Coral Sea in the afternoon of July 29. The ship will continue offshore for about 30nm, before turning South and carrying out 1000m deep CTD's in the Coral Sea during the night.

July 30-31
Proceed south and on the morning of July 31, re-enter the reef opening near Agincourt reefs. Launch workboat and use it to sample near Agincourt No 3 in order to calibrate a moored sensor package deployed at the reef site prior to the voyage. Complete a section near Agincourt reefs and then proceed south along the shipping lane to begin a series of inshore-offshore sections.

August 1–3
Complete a series of inshore-offshore sections with high resolution CTD stations at 5-10nm spacing on transits from inshore to offshore and underway sampling and occasional CTD stations on transit from offshore to inshore using other passages through the reef. The sampling plan may shift depending on conditions and timing. The targets are sections 5-10nm station spacing at Grafton, Noggin, Palm, and Flinders Passages with underway samples and less frequent stations planned for Flora Pass, and Geranium and Magnetic Passages.

August 4-5
Transit from the southern end of Flinders Passage (about 19 25'S 145 40'E) to the vicinity of Hydrographers Passage. During this time, CTD samples will be collected at approximately 20-30nm spacing with surface underway sampling. If conditions and time permit, the ship track will be north of the regular shipping route and closer to the reefs on the outer shelf. If time permits, a section will be carried out across the GBR lagoon from Hook Reef to near Pinnacle Point, Hook Island (20 04'S 148 58'E).

August 6-7
Sample a section through Hydrographers Passage from off Mackay (21 10'S 149 25'E) and out to about 19 20'S 150 40'E in the Coral Sea. After completion of the section proceed to a region off the entrance to Hydrographers Passage (about 19 58'S 150 31.3'E) and commence swath mapping and collection of grab samples from a site sampled on Southern Surveyor in 2007.

August 8-10
Continue along the outer edge of the reef sampling at about 30nm intervals until the Capricorn Channel entrance (about 22 20'S 152 46'E), where a section will be done across the Channel to a station North of One Tree Island (23 27'S 152 05'E) in the Capricorn Group.

August 11
Complete a section with stations approximately 5nm apart from about 23 27'S 152 05'E, South of Heron Island, and ending off Gladstone (23 51'S 151 32'S).

August 11, 1300hrs, dock at Gladstone Harbour and demobilise.

Time Estimates

Sampling the GBR is a complex task given the many reefs and difficulty obtaining high quality bathymetry for some regions. The voyage track is designed to maximise coverage and may need to be modified during the voyage depending on timing and sea conditions. In the evening the ship will be in or near major shipping routes, offshore, or in well charted waters. Sections in passages north of Cairns that are not used very often will need to be completed in daylight hours, as will any use of the workboat to sample near Agincourt reef. It is unlikely the ship will always average 11 knots when underway and time for CTD's will need to be adjusted accordingly during the voyage. For an average speed of 9 knots, the transit time is 11.7 days, which allows 6 days for CTD sampling. Most CTD's will be in shallow water (<50m) and at 40min per CTD that will allow for 215 CTD's, which will be sufficient to cover the region. Sections that cross the shelf will generally have a CTD spacing of about 5nm, while sampling in or near shipping routes and during transits between sections will have CTD samples at about 20-30nm spacing and underway sampling of surface waters. If bad weather restricts sampling, the number of CTD's and cross shelf sections will be reduced to save time. Conversely, if there is time the priorities to add are: 1. A section across the Capricorn Channel between Hook Reef and Hook Island, 2. extend the section further offshore from One and Half Mile Opening to Osprey Reef and 3. extend the section from the Palm Passage to the offshore Flinders Reef.

Activity	**Distance**	**Time (days)**
Transit to stations		
Cairns-Gladstone	2530nm	9.6
Grab samples and mapping Hydrographers Passage and LADS Passage		0.3
CTD sampling		7.1

Piggy-back Projects

Biology, geology and hydrodynamics of brittle star beds in dunefields and the biota of Halimeda mounds.

Principal Investigators:
Dr J. Webster (JCU), Dr. M. Byrne (USYD) and Dr R. Beaman(JCU).

Objectives: In 2007, dense beds of brittle stars (Ophiosila sp.) were observed in underwater dune fields at Hydrographers Pass using Autonomous Underwater Vehicle imagery. These brittle star beds are likely due to favourable currents and geology, and represent a previously unknown deep habitat in the Great Barrier Reef. We propose to collect 50 to 100 specimens and limited sediment samples in order to conduct taxonomic and sedimentological analyses. We would also like to collect plankton samples at the level of the sand waves to determine what the ophiuroids might be eating. Their 'wall of arms' may be very important for pelagic-benthic coupling in the region. Our objectives are to define the biology, geology and hydrodynamics of the brittle star beds in relation to the dunefield habitat.

The second component of the piggy-back proposal is to take opportunistic grab samples from Halimeda mounds in the far North GBR, if mounds are identified during the voyage. Halimeda is known to be a recruitment habitat for invertebrates and there has been a suggestion that this is where Crown of Thorns recruits to. There are no publications on the biota associated with Halimeda on the GBR and this initial study will provide insights into whether this might be considered for future targeted research.

Voyage time: The brittle star sampling will be carried out when the ship is at the entrance to Hydrographers Passage. There is no transit time required to reach the site. A total of up to six hours is allocated to swathmapping the dunefields identified in 2007 on Southern Surveyor, and sampling the brittle stars with the grab samplers. Similarly, Halimeda mound sampling will only occur if mounds are identified during ship transits for the main voyage objectives. Occasional grab samples will be collected in time and conditions permit.

Southern Surveyor Equipment

- Communications – Voice, fax and data
- Navigation – archiving of underway data including time, ship position, bathymetric depth
- Meteorological data – air temperature, humidity, wind-speed, and direction, barometric pressure and light
- Oceanographic data – underway logging of sea surface temperature and salinity
- General computing facilities and marine charting software
- Seapath Seatex 200 – for heading pitch and roll
- Simrad EK500 sounder (12, 38, 120kHz)
- Simrad EM300 multibeam swath mapper
- ADCP
- General purpose laboratory
- Controlled temperature laboratory (3-5°C)
- Hydrochemistry laboratory
- Fish laboratory/geoscience laboratory
- Blast freezer
- Walk in freezer
- Sonardyne
- Sensors to measure: tension, winch-speed and wire out for CTD, trawl and coring winches
- Trawl winches with 5,000m of 24mm wire
- CTD/Hydro winches with 7,000m of 8mm single core conducting cable
- Hydrographic A-frame
- Stern A-frame (SWL 15 tonnes)
- 7 tonne knuckleboom crane
- Gilson winches (15 tonne, 5 tonne)
- Smith McIntyre grabs (2)
- CTD (seabird SBE 911 plus)
- Additional CTD sensors (Profiling fluorometer, DO, Light)
- Rosette (24 x 10 litre Niskin bottles)
- Underway fluorometer
- Milli-Q water supply
- Topas
- Workboat

User Equipment

Underway pCO2 measuring system
Underway equilibrator inlet mass spectrometer
SOMMA analyser and coulometer
Potentiometric titrator (2)

Special Requests

The work boat needs to be deployed near Agincourt Reefs for detailed sampling of a reef and calibration of a moored system. The moored system will be fixed to a dive pontoon, pending agreement with the pontoon owners. The samples will be collected from the workboat using a hand lowered CTD and 5 litre Niskin bottles. The ship's CTD should be tested and useable prior to the ship departing Cairns and a submersible pH electrode fitted to the CTD.

Personnel List

Bronte Tilbrook	CSIRO	Chief scientist
Richard Matear	CSIRO	Co-chief scientist, CTD watch
Kristina Paterson	CSIRO	Marine chemistry
Kate Berry	CSIRO	Marine chemistry
John Akl	CSIRO	Sampling, CTD watch
Matt Chamberlain	CSIRO	Sampling, CTD watch
Erika Woolsey	USYD	Biologist, CTD watch
Lindsay Pender	CSIRO	CTD watch
Robin Beaman	JCU	Marine Geophysicist
Tony Veness	CSIRO	EM300 MNF swath technician
Anne Kennedy	CSIRO	EM300 MNF swath technician
Pamela Brodie	CSIRO	MNF Voyage management, computing support
Lindsay MacDonald	CSIRO	MNF Electronics Support
Alicia Navidad	CSIRO	MNF Hydrochemistry
Dave Terhell	CSIRO	MNF Hydrochemistry

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.**
Pamela Brodie	AS02447
Lindsay MacDonald	AS04157
Dave Terhell	AS02843
Alicia Navidad	AS04836

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

Bronte Tilbrook
Chief Scientist