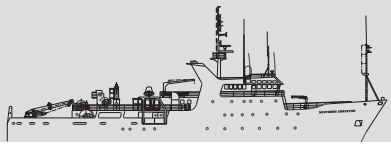

MARINE
NATIONAL FACILITY

RV *Southern Surveyor*

2007
program

CSIRO

voyage summary SS07/2007

SS07/2007

Evolution of drowned shelf edge reefs in the GBR; implications for understanding abrupt climate change, coral reef response and modern deep water benthic habitats.

Itinerary

Mobilise and depart Cairns 1700hrs, Wednesday 26th Sep, 2007
Arrive Mackay 0800hrs, Tuesday 16th Oct, 2007 and demobilise

Principal Investigators

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Professor Maria Byrne (not on board) – Department of Anatomy and Histology, University of Sydney, Sydney, NSW 2006 Australia
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Scientific Objectives

Drowned reefs on the edge of continental shelves or drop off zones of oceanic islands have been recognised from many different areas of the world. Investigations off Barbados (Fairbanks, 1989), Hawaii (Webster et al., 2004a), Papua New Guinea (Webster et al., 2004b) and more recently Tahiti (Camoin et al., 2005) have confirmed the significance of these reefs as unique archives of abrupt global sea level rise and climate change. Similar structures occur in the GBR; indeed, in the region of Hydrographers Passage east of Mackay, a series of drowned barrier reefs have been identified at depths between -35 and -100m, while off Ribbon Reef 5 east of Cooktown, two drowned structures have been identified at -50 and -70m (Beaman et al., In Press; Davies and Montaggioni, 1985; Harris and Davies, 1989; Hopley, 2006; Hopley et al., 1997) More recent information has recognised similar structures off Escape Reef, Grafton Passage, Flora Passage (Beaman et al., In Press) and east of the outer reefs (Bowl to Viper) off Townsville. Also significant are Davies' unpublished observations and video imagery from ten submersible dives, confirming that the structures east of Ribbon Reef 5 and east of Bowl Reef are indeed drowned reefs, and also bottom camera observations by Hopley et al. (1997) in the central GBR.

It is clear therefore that a succession of barrier reefs occupy the outer shelf between 40 and 100 m. None of these structures have been adequately investigated; yet they have the potential to provide unique and critical information on the course of sea level and climatic history off eastern Australia, and equally important information about their role as habitats and substrates for present day biological communities. Data collected previously includes intermittent bathymetric profiling, sidescan imaging, single channel seismic profiling and reconnaissance sampling (Beaman et al., In Press; Harris and Davies, 1989; Hopley et al., 1997, Davies, unpubl). No systematic high-resolution mapping, imaging or sampling has ever been attempted; such tasks form the principal field objectives of our program. The scientific objectives are:

- To define the ages of the succession of the shelf edge reefs.
- To define the spatial extent and biological composition of such structures.
- To understand their relationship to past sea levels, how they grew and the cause of their demise.
- To define the composition of the biological communities currently using the dead reefs as growth substrates and habitats.
- To establish a complete data set that will encourage international scientific drilling of the reefs.

Voyage Objectives

Our first voyage objective was to map four study sites along the Queensland margin where the approximate location (Ribbon Reef, Noggin Pass, Viper Reef, and Hydrographers Passage) of submerged reefs were known (Fig. 1). Each planned study area was about 20 square nautical miles. Depths for surveys ranged from shoal areas marked on charts to 200 metres on the upper slope. For each survey box, we aimed for 100% multibeam swath coverage, and then required several lines of sub-bottom profiles (Topas PS-18 and Sparker) through each survey box. Detailed multibeam bathymetric and backscatter surveys using the Simrad EM300 determined the spatial distribution, depth and morphology of the reefs. These data established if the submerged reefs were regionally significant geomorphic features with consistent depths, and their relationship with shelf width and slope angle and finer-scale geomorphologic details. The Topas PS-18 and Sparker sub-bottom profilers provided information about the acoustic reflection and geometric characteristics of the drowned reefs and associated sediments.

A second voyage objective was to conduct optical groundtruthing of the seabed using high-resolution underwater stereoscopic images, as well as high-resolution multibeam bathymetry, mounted on a state-of-the-art Autonomous Underwater Vehicle (AUV). The AUV surveyed transects across the drowned reefs and inter-reef areas to assess the substrate morphology and character of the modern epibenthic assemblages associated with the shelf edge reefs. The AUV's onboard Seabird CTD also took continuous measurements establishing the present day oceanographic conditions on the shelf edge.

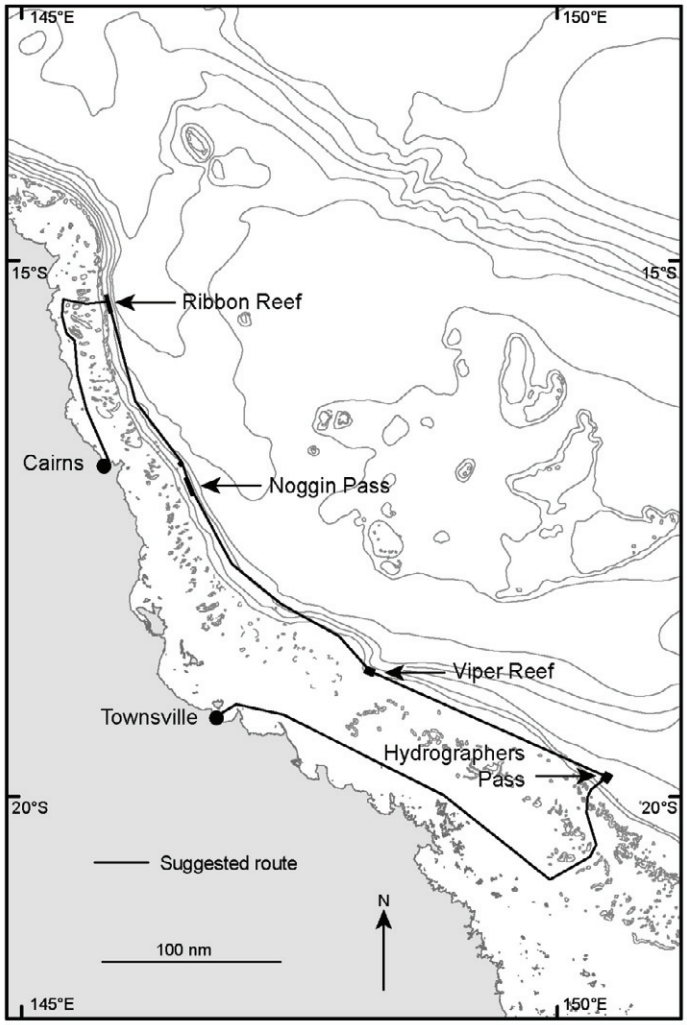

Figure 1: Planned voyage track and survey boxes

A third voyage objective was to collect dredged rock samples from the tops of the shelf edge reefs. The detailed bathymetric and AUV surveys provided targeted site locations in each study area to obtain rock samples using a standard rock dredge and a Smith-McIntyre sediment grab to recover sediments between the reefs. Rock dredges were towed parallel to contours and along the features in order to collect samples of similar age and composition from the last phase of reef growth. To ensure the fidelity of post-voyage geochemical analyses, CTD and water sampling were collected at each site.

Results

All survey statistics and sample locations are presented in Tables 1 to 5. The highlights of the data collected from each of the four survey areas are summarised below, with a detailed description of the daily operations in the Voyage Narrative section.

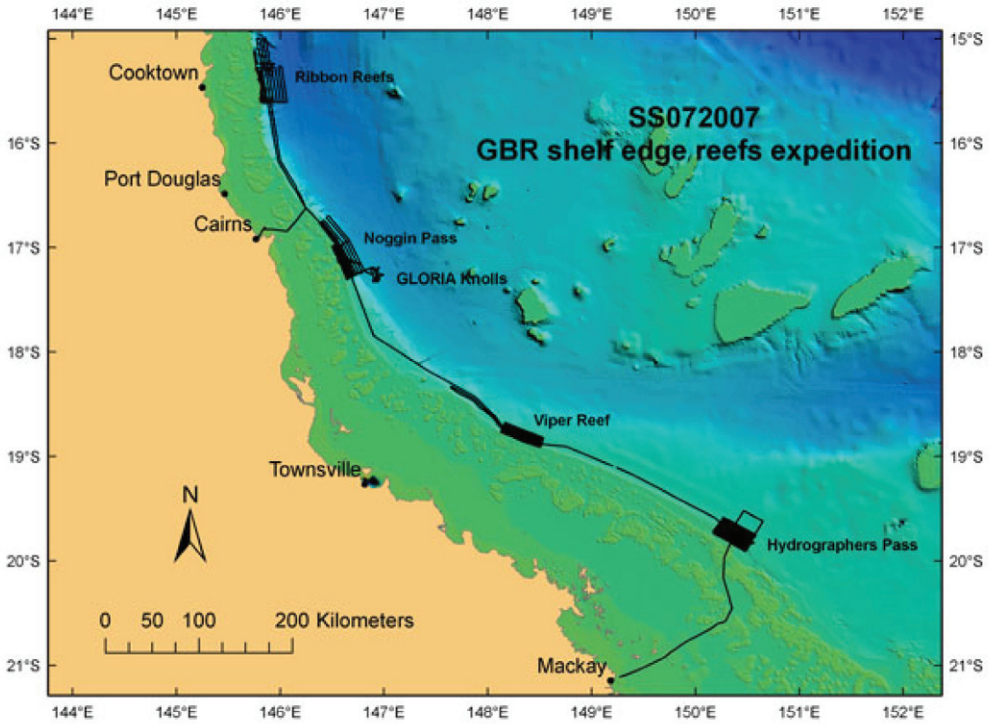

Figure 2: Voyage track of the RV *Southern Surveyor* during voyage SS07/2007 to investigate the shelf edge reefs along the margin of the Great Barrier Reef. The total voyage track covered roughly 3000 nm from Cairns to Mackay.

Ribbon Reefs survey area

EM300 swath mapping of the Ribbon Reefs survey area covered 1609.87 km2. This area is characterised by a fossil reef feature at 50 m and a terrace feature at 70 m that marks the edge of the shelf (Fig. 3). Below the shelf edge, the upper slope is incised by well-developed canyons that extend down into the Queensland Trough in water depths greater than 2 km.

The Topas sub-bottom profiler was also run at all times during swath mapping operations. The Topas system yielded little sub-bottom information directly beneath the fossil reefs but did perform well on soft sediments adjacent to the reefs. Similarly, the towed Sparker system revealed little subsurface information directly beneath the fossil reefs but did achieve deeper penetration, albeit at lower resolution than the Topas, in the adjacent soft sediments. In the Ribbon Reefs survey area,, both the Topas and Sparker systems provided quality information about the geometry and thickness of sediment packages behind the 50 m reef as well as the fore-reef slope talus deposits seaward of the main shelf edge.

High-resolution seabed imagery was obtained from one AUV mission across the 50 m reef feature. Dredge operations were also successful with four rock dredges recovering limestone from between 46 m and 110 m off Ribbon Reefs No. 3 and 5.

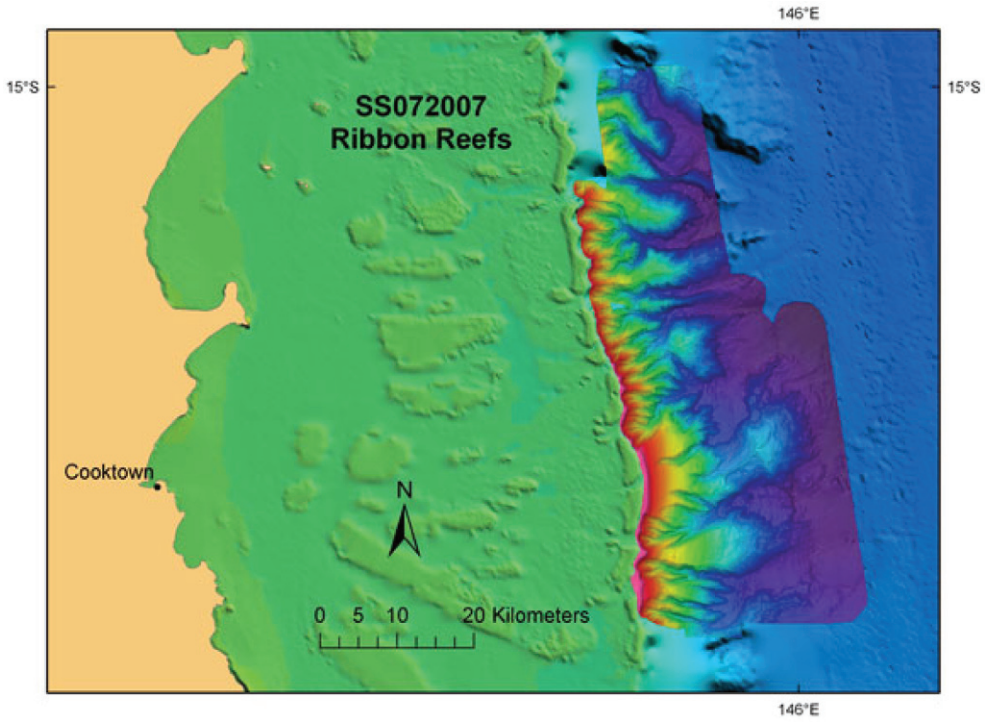

Figure 3: Sun-shaded relief map of the Ribbon Reefs survey area.

Noggin Pass survey area

EM300 swath mapping of the Noggin Pass survey area covered 1243.27 km2. These data confirm that the area is characterised by distinct fossil reef and terrace features at 40 m, 50 m, 60 m, 100 m and 110 m (Fig. 4). Closer examination of the data also reveal numerous pinnacles, lagoons and multi-generational channel structures that cross-cut the fossil reefs. Below about the 250 m, the upper slope is deeply incised by a well-developed canyon system that extends down to 1400 m in the Queensland Trough. The swath bathymetry data also show that the canyon margins are commonly scalloped, and combined with obvious debris deposits, suggests extensive mass wasting is prevalent along the margin.

The Topas recorded sub-bottom information within the sediments of the palaeo-lagoon behind the 60 m reef, as well as the sediment packages on the fore-reef slope in 130 m. Sparker surveys across these fore-reef slope sediments achieved greater penetration and imaged at least 100 milliseconds of sediment characterised by several distinct seismic units.

High-resolution seabed imagery was generated by two AUV missions across the 50 m and 100 m reef and terrace features at Noggin Pass. Dredge operations were also successful with eleven rock dredges recovering limestone rock between 54 m and 124 m.

Shipboard examination of existing GLORIA sidescan imagery revealed several highly reflective seafloor features in the Queensland Trough to the southeast of the Noggin Pass area. We investigated these features with the EM300 and Topas systems to discover a cluster of large knolls up to 2 km long and over 100 m high in depths of about 1100 m. Dredge sampling on the top of one of these knolls recovered several types of deep-water corals (some living), bivalves, gastropods, and black manganese-covered concretions in a matrix of muddy sediment. We named these features the GLORIA Knolls.

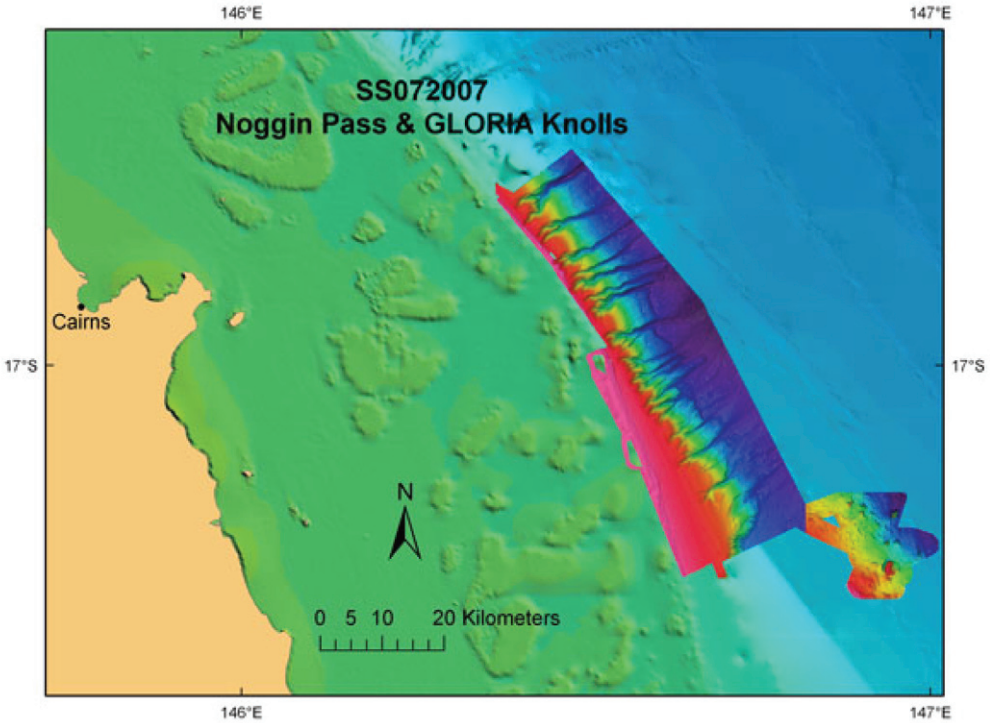

Figure 4: Sun-shaded relief map of the Noggin Pass and GLORIA Knolls survey area.

Viper Reef survey area

EM300 swath mapping of the Viper Reef survey area covered 524.53 km2. These data show distinct fossil reef and terrace features at 40 m, 60 m, 100 m and 110 m (Fig. 5). In the southeast of the survey area, the bathymetry data revealed pinnacles, lagoons and multi-generation channel structures that also cross-cut the fossil reef features. In the northwest of the survey area, the shelf edge is characterised by a 5 km long by 6 km wide slope failure and deposit on the upper slope to a depth of 225 m. Numerous fossil reef features appear to have developed on the slump scar between 100 and 80 m. At Viper Reef the upper slope is relatively smooth and gently sloping, but one possible canyon head was observed at 285 m.

Topas and Sparker systems revealed significant sub-bottom information in the Viper Reef area. Both systems clearly showed sub-surface sediment packages in the lagoons between the reefs as well as channel-like features in the fore-reef and upper slope.

High-resolution seabed imagery was obtained from three AUV missions across the 60 m, 100 m and 110 m reef and terrace features at Viper Reef. Dredge operations were also successful with ten rock dredges recovering limestone between 60 and 163 m.

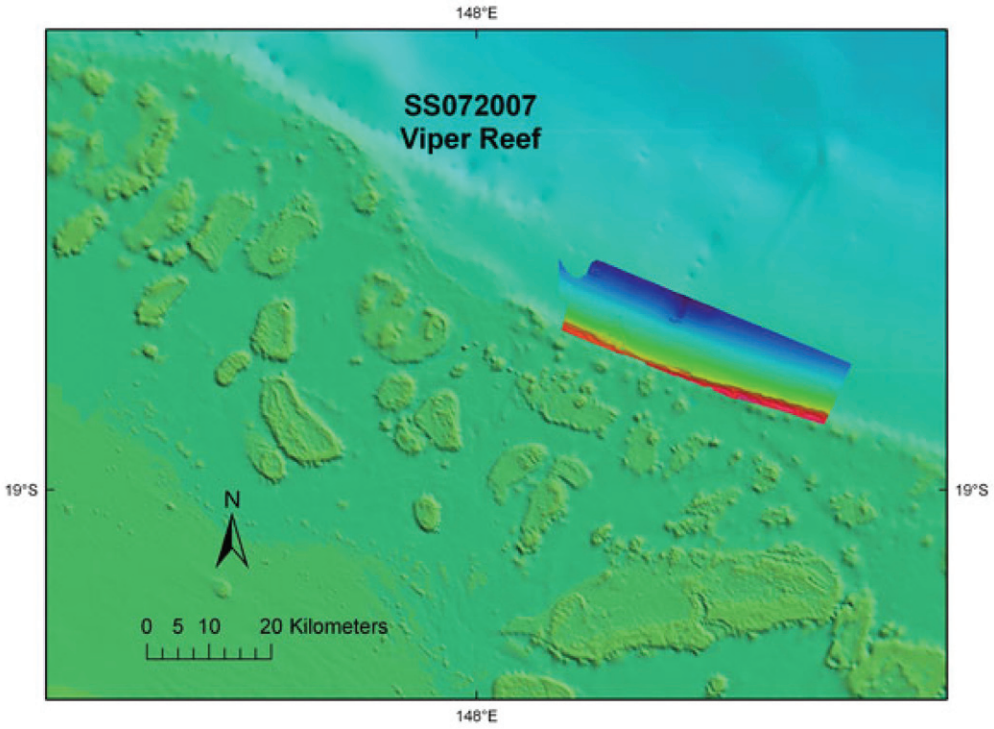

Figure 5: Sun-shaded relief map of the Viper Reef survey area.

Hydrographers Passage survey area

EM300 swath mapping of the Hydrographers Pass survey area covered 810.68 km2. These data show distinct fossil reef and terrace features at 40 m, 50 m, 60 m, 90 m, 100 m and 128 m (Fig. 6). No submarine canyons were observed at this site. Hydrographers Passage recorded the most diverse and spatially continuous suite of fossil reef and terraces features. The bathymetry data revealed pinnacles, palaeo-lagoons up to 3 km wide, multi-generation fossil reefs, and channel features cross-cutting the reefs. Prominent active sand waves were also observed to landward of the shallowest shoals in 60 to 70 m.

The Topas and Sparker systems recorded prominent sub-surface reflectors in the sediment packages within the palaeo-lagoons. In some cases prominent reflectors with similar seismic characteristics could be traced on both the landward and seaward sides of individual reef features. Sparker surveys imaged over 160 milliseconds of fore-reef slope sediments seaward of the shelf edge.

High-resolution seabed imagery was obtained from three AUV missions on the 20 m shoals and sand waves, the 50 m and 90 m reefs, and across the shelf edge to 149 m. Dredge operations were also successful with eight rock dredges recovering limestone from 54 m to 131 m. A Smith-Macintyre grab was also used to recover 22 sediment samples from the sand waves, palaeo-lagoons and fore-reef slope between 53 m to 166 m.

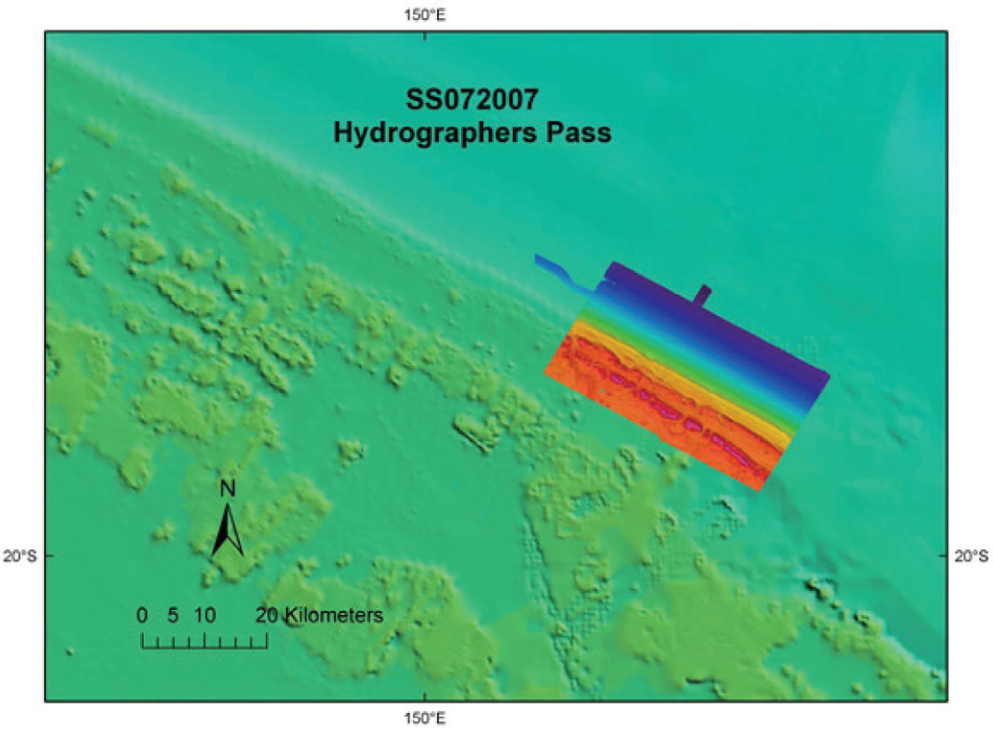

Figure 6: Sun-shaded relief map of the Hydrographers Pass survey area.

Voyage Narrative

Wed 26th September. Science Party met the RV *Southern Surveyor* at dock in Cairns, Trinity #4. Mobilisation began at 0800 hrs, completed by 1700 hrs. Depart dock 1715 hrs for the Ribbon Reefs. Started EM300 swath mapping and Topas operations. Initiated Sparker seismic test at 2010 hrs. Tested the Sparker 'squid' and it failed to receive or display data from the 'eel'. Retrieved Sparker and eel at 2145 hrs. Continued transit to Ribbon Reef 5. Extensive palaeo-channels and steep terrace (down to 120 m) features imaged on the EM300 and Topas.

Thursday 27th September. Arrived to start swath mapping survey of the Ribbon Reefs at 0640. Completed surveying at 1300 hrs. Toolbox meeting on Bridge at 1230 (Skipper, ships crew, AUV PIs, Webster, Beaman, Davies, Thornborough, Scott, Manning, Thomas) to discuss AUV deployment. Deployed AUV at 1425 hrs but had problems with AUV communications and the mission was aborted. Asked bridge for a tender in water at 1445 to recover the AUV then continued the swath mapping survey.

Friday 28th September. Swath mapping and Topas survey continued in the deep water (<1500 m) 0025 hrs. Toolbox meeting at 0600 hrs to discuss safe CTD operations (ships crew, Webster, Thomas, Tudhope, Bridge). Successfully deployed CTD. Deployed AUV at 0915 but it had problems reaching origin point and the mission was aborted. AUV was then towed by backup boat to the point of origin. Commenced new AUV survey grid and AUV was pushed toward the southeast. Phil Manning phoned Franz Villigranz at 1145 hrs of Geoscience Australia regarding the problem with the Sparker seismic system. Test of Sparker equipment to be conducted after AUV operations are completed. Not successful. At 1350 hrs communications with the AUV was lost. The ship moved to re-establish contact with the AUV at 1350 hrs. Established that the AUV was in 50-60 m and that most likely it was "lodged" against the wall of the 50 m reef. Unexpectedly the AUV popped to the surface at 1615 hrs. Ship mobilised to pick up AUV and moved alongside in shallow water near southern end of Ribbon 5. The AUV was finally recovered at 1815 hrs using a tender. Commenced Sparker testing at 1900 hrs which again was unsuccessful, although the seabed bottom multiple was visible on the record.

Sat 29th September. Completed deep swath mapping at 1015 hrs. Moving to southern part of survey box near Ribbon Reef 1. Tool box meeting to conduct rock dredging operations was convened at 1245 hrs. Sparker now working and commenced Sparker line-crossing of dredge targets around 1540 hr. Deep water swath mapping initiated at 2045 hrs after about 1hour of transit.

Sunday 30th September. Finished deep swath mapping at 0600 hrs. Began Sparker profiles across the 50 m and 70 m reef features off the front of Ribbon Reef 5 at 0800 hrs. Dredge operations conducted successfully on the 50 m and 70 m features. Left Ribbon 3 at 1400 hrs and continued swath mapping operations before heading south to Noggin Pass.

Monday 1st October. Completed transit south to Noggin Pass survey area and arrived on station at 0241 hrs. Started swath mapping the shelf edge reef features to 110 m. At 1030 hrs, swapped over to Sparker 'toothbrush' and set out the same distance from the ship as the 'eel', which recorded greater penetration

in the sedimentary section. The 2D sections showed reefs and channels, unconformities, mounds, reef, seismic 'wipeouts' and Holocene transgressive wedges. Continued swath mapping after the Sparker was recovered.

Tuesday 2nd October. Swath mapping continued until 0800 hrs. Dredge sampling conducted successfully on Noggin Pass submerged features from 50 m to 110 m between 0825 and 1258 hrs. Commenced Sparker seismic surveys and successfully completed survey grid at 1745 hrs.

Wednesday 3rd October. Deep swath mapping continued overnight to the north of Noggin Pass adjacent to Flora Pass. Arrive in the Noggin survey box at 0845 hrs and began shallow survey line to the west of the reefs. Successfully conducted dredging operations of the 90 to 110 m reef features. We decided to practice launching and recovering AUV as we are still having problems with this operation. It was decided to postpone the mission to Thursday. Continued swath mapping then headed east to investigate a cluster of deep-water reef structures forming distinct mounds in approximately 1100 m of water, up to 2.2 km in length and over 100 m high rising above a sea floor. Scouring was observed at the base of the features on the northern and western sides. The largest feature was successfully dredged, recovering pelagic ooze and several types of deep water corals (e.g. Bamboo coral), bivalves, gastropods, and manganese-covered concretions in a matrix of mud to fine sand sized sediments.

Thursday 4th October. Swath mapping continued to map the extent and morphology of the mound features. Completed deep water mound survey at around 0300 hrs then moved to the Noggin Pass survey area to deploy the AUV to investigate the 50-90 m reef features. Both AUV missions were successful. Swath mapping continued to fill gaps in the grid. At 1850 hrs commenced the transit to the south towards the Viper Reef survey area.

Friday 5th October. Arrived on site at Viper reef at 0608 hrs. Commenced swath mapping of deep eastern side of the survey box. Mapping in shallower southwest region of the box revealed reef targets at 95 m and 110 m. Successfully deployed the AUV at a depth of 75 m to 100 m at this site. Swath mapping, Topas and Sparker surveys commenced again around 1700. Dredging operations commenced around 2200 hrs and a dredge was lost. The dredge was replaced and operations continued.

Sat 6th October. Ridge features at 160 m and terrace features at 100 m dredged successfully. Continued swath mapping then successfully deployed the AUV at 1030 hrs on the 50 m feature and transected northeast along the terraces to the 100 m feature. Swath mapping and Sparker surveys continued until 2330 hrs, after which we went back onto deep water swath mapping.

Sunday 7th October. Deep water swath mapping continued until 0700 hrs followed by Sparker surveys. AUV operations started at 1230 hrs with successful retrieval at 1600 hrs. Commenced a four hour transit to the north to investigate the canyon system near Bowl Reef.

Monday 8th October. Reached the canyon feature at 2136 hrs and swath mapped across the mouth to the northern shoulder of the feature by 2222 hrs. Deployed the Sparker for the survey to the west and then back across to the southeast to

identify the head of the canyon. Finished the survey at the Bowl Canyon to arrive back at the Viper Reef survey area at 0519 hrs. Successfully completed dredging operations on the 50 m to 110 m reef features. Commenced a Sparker survey of the same features at 1116 hrs. Began transit to Hydrographers Passage at 1230 hrs.

Tuesday 9th October. Arrived at Hydrographer Passage survey area at 2035 hrs. Commenced swath mapping and Topas surveying in around 150 m at 2130 hrs and then moved to the west to investigate 100 m shelf break. Moved to deep water swath mapping during the evening.

Wed 10th October. Continued swath mapping until 1900 hrs then started Sparker survey grid.

Thursday 11th October. Pulled the Sparker in for repairs at 0020hrs. Back in the water at 0128hrs and continued survey until 0315 when the equipment was pulled because the Topas was not operating. Completed successful dredging operations on the 125 to 100 m reef feature at 0600 hrs. However, the dredge got hung up at one site and the pin sheared. The metal bar securing the chain bag to the lower part of the dredge was also bent. The crew replaced the bar with the one from a previously damaged dredge. Began swath mapping, then commenced successful AUV operations on the northern region of the study site at 0930 hrs from 50 m down to 145 m. Successfully completed the Sparker survey by 2300 hrs.

Friday 12th October. Conducted successful dredging operations on the 50 m, 90 m and 130 m reef features. Continued shallow swath mapping to the east of the survey box and then successfully deployed the AUV on the shallow 20 m reef shoal and large sand wave features at 60 m. Swath mapping continued until 1845 hrs followed by a Sparker survey until after midnight.

Sat 13th October. Retrieved the Sparker and effected repairs to the toothbrush. Sparker re-deployed and a dense survey grid in the north and south completed by 1035 hrs. Swath mapping of the shallow areas commenced.

Sun 14th October. About 0600 hrs moved east again to complete swath mapping of the shallow shoal areas. Finished Hydrographer Pass Sparker survey grid at 2135 hrs. Commenced Smith-Macintyre grab sediment sampling program at 2145 hrs in the southeast region of the survey area and continued until midnight.

Mon 15th October. Smith-Macintyre grab sampling finished at 0442 hrs. Commenced deep-water swath mapping transect to the east to identify the start of any canyon heads. Unable to locate any canyon heads and moved to west to finish Smith-Macintyre grab sampling across the northwest part of the survey box. Successfully completed grab sampling at 1103 hrs. Commenced swath mapping, filling in holes in previous coverage and extending further to the west. Preparations for port advanced. Head for Mackay at 2000 hrs.

Tues 16th October. Finished swath mapping and Topas operations at 0557 hrs. Arrived at Mackay 0700 hrs and completed demobilization at 1300 hrs. Science party left the ship for the airport.

Summary

From both an operational and scientific standpoint the SS07/2007 voyage to the GBR was a great success. The voyage was completed on time and achieved all the voyage objectives. We are confident that following our post-voyage analyses of the marine geophysical, geological and biological sample data, we will also achieve the overall scientific objectives.

We now have a complete 3-dimensional view of the fossil reefs and terraces at the shelf edge of the GBR in four different regions along the North Queensland margin. This picture of the surface and subsurface includes a diverse suite of distinct fossil fringing reefs, barrier reefs, patch reefs, lagoons, old river channels, dunes and sand bars. Geochemical and sedimentological analyses of the recovered limestone samples will establish the age of the reefs and their paleoenvironmental conditions. Combined with a wealth of geophysical data (EM300, Topas and Sparker), analyses of these data may allow us to reconstruct the growth and demise of the GBR during successive periods of sea level and climate variability.

High-resolution stereographic images of the fossil reefs and the adjacent seabed using the AUV also show a diversity of modern benthic communities which currently inhabit these different environments and substrates. Combined with analyses of rock and sediment samples, we will gain a more quantitative understanding of the modern GBR biota that live on fossil reef systems deeper than 40 m.

We were also able to map for the first time, large and continuous sections of the margin of the GBR from the shallow shelf in 40 m to over 2 km into the deep Queensland Trough. Although not a primary objective of the voyage, these new datasets reveal a spectacular picture of the upper slope and deep margin of the GBR. This includes a network of submarine canyons, channels, mass debris deposits, and a new deep-water coral habitat observed at 1100 m in the Queensland Trough, called the GLORIA Knolls. Analysis of these data will generate significant discoveries as well as stimulate new expeditions to understand the biologic and geologic evolution of the deep Great Barrier Reef.

Personnel

Scientific Participants

Name	Affiliation	Voyage role
Dr. Jody Webster	JCU	Geologist – Chief scientist
Prof. Peter Davies	USYD	Geologist – Alt chief scientist
Dr. Robin Beaman	JCU	Marine geophysicist
Thomas Bridge	JCU	PhD student - biology
Erika Woolsey	USYD	Masters student - biologist
Kate Thornborough	USYD	PhD student - geology
Dr. Stefan Williams	USYD	AUV specialist
Dr. Oscar Pizarro	USYD	AUV specialist
Phil Manning	USYD	Sparker technician
Prof. Sandy Tudhope	Uni. Edin	Geologist/geochemist
Dr. Alex Thomas	Oxford U	Geochemist
Don McKenzie	MNF	Voyage Manager
Lindsay MacDonald	MNF	Electronics support
Bernadette Heaney	MNF	Computing support
Anne Kennedy	Fugro	EM300 swath technician

Marine Crew

Ian Taylor	Master
Bryan Payne	Chief Officer
Rob Ferries	2nd Officer
John Morton	Chief Engineer
Dace Jonker	1st Engineer
Jarrad Taft	2nd Engineer
Tony Hearne	Bosun
John Howard	IR
John Hall	IR
Joel Wilkinson	IR
Paul Hansen	IR
Charmayne Aylett	Chief Steward
Andy Goss	Chief Cook
Rebecca Lee	2nd Cook

Acknowledgments

We would like to sincerely thank the captain and crew of the RV *Southern Surveyor*, as well as the Marine National Facility staff, for their outstanding work throughout the voyage. They did everything asked of them and more, under sometimes very challenging conditions. We appreciate their great effort in making this voyage a success.

Dr Jody Webster (James Cook University)
Chief Scientist

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Appendix

Table 1. Swath mapping survey statistics for SS07/2007. Note that the Topas sub-bottom profiler was run simultaneously with the EM300 swath mapping system.

Area	Coverage (m^2)	Coverage (km^2)
Ribbon Reefs	1609867200	1609.87
Noggin Pass	1243270800	1243.27
GLORIA Knolls	214705800	214.71
Viper Reef	524531250	524.53
Hydro Pass	810684375	810.68
Cairns transit	20541283	20.54
Cooktown transit	691408125	691.41
Innisfail transit	724043750	724.04
Townsville transit	306296250	306.30
Mackay transit	70536100	70.54
Total	**6215884933**	**6215.88**

Table 2. List of CTD locations for SS07/2007.

CTD #	Start Time	Bottom Time	Finish Time	Lat Start	Lon Start	Lat Bottom	Long Bottom	Lat Finish	Long Finish	Depth (m)
1	21:32	21:46	22:10	-15.37	145.79	-15.38	145.79	-15.38	145.79	176
2	8:20	8:24	8:38	-17.13	146.60	-17.13	146.60	-17.13	146.60	167
3	1:40	1:45	2:01	-18.87	148.48	-18.87	148.48	-18.87	148.48	154
4	10:59	11:04	11:18	-19.64	150.28	-19.64	150.28	-19.64	150.28	216

Table 3. List of AUV mission locations for SS07/2007.

AUV mission #	Start latitude	Start longitude	Area	Image depth range (m)
AUV_gbr02_ribbon	-15.38	145.50	Ribbon Reefs	40-62
AUV_gbr04_noggin	-17.09	146.57	Noggin Pass	57-99
AUV_gbr05_noggin	-17.09	146.57	Noggin Pass	58-67
AUV_gbr06_viper	-18.88	148.45	Viper Reef	67-100
AUV_gbr07_viper	-18.88	148.44	Viper Reef	53-149
AUV_gbr08_viper	-18.88	148.44	Viper Reef	53-90
AUV_gbr09_hydro	-19.69	150.23	Hydrographer Pass	56-149
AUV_gbr10_hydro	-19.70	150.25	Hydrographer Pass	53-94
AUV_gbr11_hydro	-19.87	150.46	Hydrographer Pass	18-72

Table 4. List of rock dredge locations for SS07/2007.

Rock dredge #	Latitude	Longitude	Area	Depth (m)
D1	-15.47	145.82	Ribbon Reefs	110
D2	-15.38	145.80	Ribbon Reefs	59
D3	-15.38	145.80	Ribbon Reefs	70
D4	-15.49	145.82	Ribbon Reefs	48
D5	-17.13	146.59	Noggin Pass	102
D6A	-17.13	146.59	Noggin Pass	91
D6B	-17.13	146.59	Noggin Pass	91
D8	-17.10	146.57	Noggin Pass	60
D7A	-17.10	146.58	Noggin Pass	109
D7B	-17.10	146.58	Noggin Pass	109
D9	-17.09	146.57	Noggin Pass	62
D10A	-17.02	146.54	Noggin Pass	110
D10B	-17.02	146.54	Noggin Pass	124
D11A	-17.09	146.57	Noggin Pass	109
D11B	-17.09	146.57	Noggin Pass	118
D12	-17.30	146.94	Queensland Trough	1294
D13	-18.78	148.20	Viper Reef	159
D14	-18.78	148.20	Viper Reef	163
D15	-18.88	148.45	Viper Reef	100
D16	-18.88	148.45	Viper Reef	100
D18	-18.88	148.44	Viper Reef	61
D17	-18.88	148.45	Viper Reef	74
D19A	-18.88	148.49	Viper Reef	117
D19B	-18.88	148.49	Viper Reef	114
D20A	-18.89	148.49	Viper Reef	103
D20B	-18.89	148.49	Viper Reef	103
D25A	-19.78	150.46	Hydrographer Pass	128
D25B	-19.78	150.46	Hydrographer Pass	129
D26A	-19.79	150.46	Hydrographer Pass	106
D26B	-19.79	150.46	Hydrographer Pass	107
D21	-19.69	150.23	Hydrographer Pass	55
D22	-19.68	150.24	Hydrographer Pass	92
D24A	-19.73	150.36	Hydrographer Pass	132
D24B	-19.73	150.36	Hydrographer Pass	131

Table 5. List of sediment grab locations for SS07/2007.

Grab #	Latitude	Longitude	Area	Depth (m)
G0	-15.47	145.82	Ribbon Reefs	127
G2	-19.87	150.45	Hydrographer Pass	63
G1	-19.87	150.43	Hydrographer Pass	71
G3	-19.85	150.45	Hydrographer Pass	53
G4	-19.84	150.45	Hydrographer Pass	74
G5	-19.82	150.46	Hydrographer Pass	72
G6	-19.81	150.47	Hydrographer Pass	92
G7	-19.80	150.47	Hydrographer Pass	100
G8	-19.80	150.48	Hydrographer Pass	101
G9	-19.80	150.48	Hydrographer Pass	129
G10	-19.79	150.48	Hydrographer Pass	141
G11	-19.79	150.49	Hydrographer Pass	166
G19	-19.66	150.25	Hydrographer Pass	161
G18A	-19.67	150.25	Hydrographer Pass	138
G18B	-19.67	150.25	Hydrographer Pass	135
G17A	-19.67	150.24	Hydrographer Pass	100
G17B	-19.67	150.24	Hydrographer Pass	94
G16	-19.68	150.24	Hydrographer Pass	99
G15A	-19.69	150.24	Hydrographer Pass	90
G15B	-19.69	150.23	Hydrographer Pass	89
G14	-19.70	150.23	Hydrographer Pass	68
G13	-19.73	150.22	Hydrographer Pass	74
G12	-19.74	1.50.20	Hydrographer Pass	78