RV *Southern Surveyor*

2007 program

MARINE NATIONAL FACILITY

voyageplan
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

AUV team arrives in Cairns Monday 24th Sep, 2007
Science team arrives in Cairns Tuesday 25th Sep, 2007
Mobilise and depart Cairns 1700hrs, Wednesday 26th Sep, 2007
Arrive Mackay 0800hrs, Tuesday 16th Oct, 2007 and demobilise

Principal investigators

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Phone: +61 07 4042 1693 **Email:** Robin.Beaman@jcu.edu.au

Professor Peter Davies (Alternate Chief Scientist & watch leader) – School of Geosciences, University of Sydney, NSW Australia

Dr. Stefan Williams – Australian Centre for Field Robotics University of Sydney, NSW Australia

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

CSIRO

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., 2004c) 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 between at depths -35 and -100m, while off Ribbon 5 east of Cooktown, two drowned structures have been identified at -50 and -70m (Davies and Montaggioni, 1985; Harris and Davies, 1989; Hopley et al., 1997; Hopley, 2006) (Figure 1). More recent information has recognised similar structures east of the outer reefs off Flora Passage and east of the outer reefs (Bowl to Viper) off Townsville. Most significant are Davies' unpublished observations and video imagery from ten submersible dives, confirming that the structures east of Ribbon 5 and east of Bowl Reef are indeed drowned reefs, and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 (Harris and Davies, 1989; Hopley et al., 1997, Davies, unpubl). No systematic high-resolution mapping, imaging or sampling has ever been attempted; such tasks will form the principal field objectives of our proposed program. The scientific objectives are:

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

Voyage Objectives

Our first voyage objective is to map four study sites along the Queensland margin (Fig. 1) where the approximate location (Ribbon Reefs, Noggin Pass, Viper Reef, and Hydrographers Passage) of submerged reefs is known (Fig. 1). Each study area is approximately 20 square nautical miles (Fig. 2). Depths for surveying range from shoal areas marked on charts to approx. 200 metres on the upper slope. For each

20 nm2 box, we wish to multibeam swath map 100% of the area, with a proposed track length of 160 nm and a line spacing of 250 m parallel to the depth contours. We then require several cross and parallel-shelf lines of sub-bottom profiles (Topas PS-18 and Sparker) through each box, with a track length of approx. 20 nm (does this include several parallel-shelf lines each site). Detailed multibeam bathymetric and backscatter (sea floor reflectivity) surveys using the *Southern Surveyor*'s Simrad EM300 will determine spatial distribution, depth and morphology of the reefs. These data will establish if the submerged reefs are regionally significant geomorphic features with consistent depths, as well as their relationship with shelf width and slope angle and finer-scale geomorphologic details. The *Southern Surveyor*'s Topas PS-18 sub-bottom profiler, as well as a towed Geoscience Australia (GA) Sparker seismic reflection system will provide information about the acoustic reflection and geometric characteristics of the drowned reefs and associated sediments. This will contribute to understanding of the internal structure and morphology of these features. Sparker seismic profiles may define the thickness and subsurface geometry of reef packages (Grossman et al., 2006), while the higher frequency Topas PS-18 system will constrain the thickness and character of sediments seaward of the drowned reefs as well as in paleo-lagoons between successive reefs.

A second voyage objective is to conduct seabed optical groundtruthing using high-resolution underwater stereoscopic video as well as a high-resolution multibeam system mounted on a state-of-the-art AUV. Designed and built by the Woods Hole Oceanographic Institution and delivered to the University of Sydney in 2005, the AUV uses the simultaneous localisation and mapping (SLAM) in addition to Ultra Short Baseline Accoustic (USBL) trackings methods for navigation in underwater environments. The AUV is completely untethered to the support ship, will undertake surveys at preset altitudes above the seabed at approximately 1 knot (depending upon bottom currents). The vehicle maintains an estimate of its location within the survey area by combining information from an onboard Doppler Velocity Log, compass and other sensors to allow it to complete survey missions ensuring dense coverage to be used for high-resolution terrain reconstruction. The AUV will survey transects across drowned reef and inter-reef areas to assess the substrate morphology and character of the modern epibenthic assemblages associated with shelf edge reefs. The AUV's onboard Seabird CTD will also take continuous measurements and water samples and representatives depths, establishing the present day oceanographic conditions on the shelf edge.

A third voyage objective is to collect dredged rock samples from the tops of the shelf edge reefs. The detailed bathymetric and video surveys will provide targeted groundtruthing sites 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. At least 24 rock dredges will be 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-cruise geochemical analyses, CTD and water sampling will be employed at each site. Note the swath mapping, seismics and rock dredging activities at the four proposed survey sites will be carried out under the research permit (#G07/20973.1) from the GBRPMA.

Voyage Track

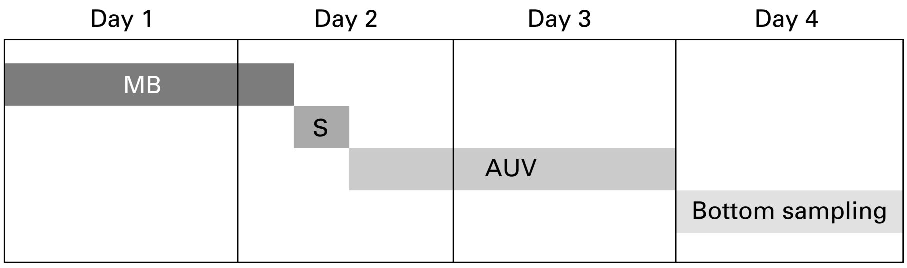
See attached figures (Figures 1-2) and appendix (Table 1-2) for details of the intended voyage track and primary survey boxes.

Time Estimates

	No of days	Justification
Transit (from preferred departure port to first station + last station to preferred arrival port)	3	3 days total time are requested to transit from Cairns to the first site at Ribbon Reef 5, then to Noggin Pass, Viper Reef and Hydrographers Pass, then to Mackay on conclusion. Transit distance is approx. 650 nm, so 650 nm @ 11kn = ~60 hours = ~ 2.5 days = 3 days. The water depth during transits expected to be around 300m.
Research program at each site (see Figure. 1, 2) (total time taken between first and last station)	15	We request 15 days in total for the four study sites along the Qld margin. Each study site is a box of approx. 20 nm2 and we wish to multibeam swath 100% of each box. The proposed track length for each box is 160 nm, which would require ~24 hrs at a speed of 7 kn and a line spacing of 250 m. Therefore 4 boxes x 24 hrs = 96 hrs = 4 days. We require several cross-shelf and shelf parallel lines for sub-bottom profiling (Topas PS-18) and sparker seismic systems within each box of approx. 20 nm, so 20 nm at 5 kn = 4 hrs. Therefore 4 boxes x 4 hrs = 16hrs or ~ 1 day. An AUV will then be deployed at several sites in each box for a total of 36 hours. Therefore 4 boxes x 36 hrs = 144 hrs = 6 days. Finally, we then wish to deploy at least 6 rock dredges and 10 sediment grabs at selected sites within each box. Sampling will take approx. 24 hours. Therefore 4 boxes x 24 hrs = 96 hrs = 4 days. Total time is 4 + 1 + 6 + 4 = 15 days.
Contingencies (allowance for unscheduled delays eg. bad weather and scientific equipment downtime)	1	We request 1 extra day at sea as we are deploying into the ocean a large AUV, which could present technical difficulties, and so the extra time is an insurance to allow technical staff to solve any problems.
Mobilisation/demobilisation (time required to load and install equipment at the preferred departure port + remove your equipment at the preferred arrival port)	2	We would load/unload the sparker seismic system, extra rock dredges and AUV at the start/end of the cruise. One extra day is also requested to mount the AUV transceiver on the ship's trolley. In total, 2 days are requested to load/install and demobilise the equipment.

Possible model of operations at each site and contingencies

Approximate time on station at each site ~ 4 days or 96 hrs.



MB = multibeam of survey area (includes CTD dip)
S = seismic profiling (Topas PS-18 and sparker) across shelf
AUV = ~three deployments @ 4 hours each
Bottom sampling = rock dredge and sediment grab deployments

Note, in case of extended equipment delays or unsafe navigation due to poor weather conditions, the vessel will conduct deep-water MB surveys in vicinity of the sites (see Figure 3 and Table 3).

Southern Surveyor Equipment

We request the following services, data products and facilities on the RV *Southern Surveyor*.

Scientific Equipment

Smith-McIntyre sediment grab

Seapath Seatex 200 – for accurate heading, pitch and roll and heave

Simrad EA500 sounder for bottom detection (12kHz)

ADCP - measures current vectors beneath the vessel

Expendable bathythermograph (XBT) launching system (XBTs provided at user's cost). Note the XBT is to be conducted at each site for each day, i.e. 4 x 4 XBTs = 16 XBTs

Laboratory and other Facilities

General purpose laboratory (includes fume hoods, fridge, freezer)

Wet laboratory/CTD room

Fish laboratory/geoscience laboratory

Photographic/preservation laboratory

Blast freezer – for quick freezing of samples

Walk in freezer

Moonpool transducer trolley

Winches, A-frames and Crane

Trawl winches, port and starboard, with 4,500m of 24mm wire (trawling and dredging)
CTD/Hydro winches each with 7,000m of 8mm single core conducting cable
Hydrographic A-frame
Stern A-frame (SWL 15 tonnes)
7.0 tonne knuckleboom crane
Chain pendant for stern A-frame in reserve for AUV if needed

Data Products

ADCP data to be specified
Underway data in netCDF format (sampling period to be specified)
Ship attitude – heave, pitch, roll and heading
Data from winch sensors (tension, winch speed and wire out)
Bridge log (photocopy)
CTD data
CTD log (photocopy)
XBT data

Conductivity, Temperature and Depth Profiling (CTD)

CTD (Seabird SBE 911 plus)
Rosette (12*10L Niskin bottles)

Other Equipment and Facilities

Moonpool transducer pole (for mounting user supplied packages)

Swath Mapper

Swath bathymetry
Swath seabed reflectance

Sampling Systems and Trawl Nets

Rock dredges (2)

Special requests

We request the underway data in CSV format produced at 1 minute intervals.

Additional consideration and discussion is needed between the science party, MNF and ship's crew to ensure the following efficient and safe operations:

Deployment, standby and retrieval of CTD
Deployment, standby and retrieval of Sparker streamer
Deployment, standby and retrieval of AUV
Deployment, standby and retrieval of rock dredge
Deployment, standby and retrieval of sediment grab

User Equipment

Swath post-processing workstation desktop (JCU)
Several laptop computers (JCU, USYD)
Sparker seismic system and supporting equipment (GA)
AUV and supporting equipment (USYD)
~ 40 plastic "nally" bins for storage of geological and biologic samples (JCU)
Biological preservation chemicals (JCU)
Binocular microscope (JCU)
Plastic and glassware for water sample storage (JCU)

Personnel List

Name	Affiliation	Voyage role
Dr. Jody Webster	JCU	Geologist – Chief scientist
Prof. Peter Davies	USYD	Geologist – Alternate chief scientist
Dr. Robin Beaman	JCU	Marine geophysicist
Thomas Bridge	JCU	PhD student – biology
Prof. Donald Potts	UCSC	Biologist
Kate Thornborough	USYD	Phd student – geology
Dr. Stefan Williams	USYD	AUV specialist
Dr. Oscar Pizarro	USYD	AUV specialist
Franz Villigran	GA	Sparker tech
Prof. Sandy Tudhope	Uni. Edin	Geologist/geochemist
Dr. Alex Thomas	Oxford U	Geochemist
Don McKenzie	MNF	Voyage Manager & operation support
Lindsay MacDonald	MNF	Electronics support
Bernadette Heaney	MNF	Computing support
Anne Kennedy	Fugro	EM300 swath tech

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

Dr. Jody Webster
Chief Scientist

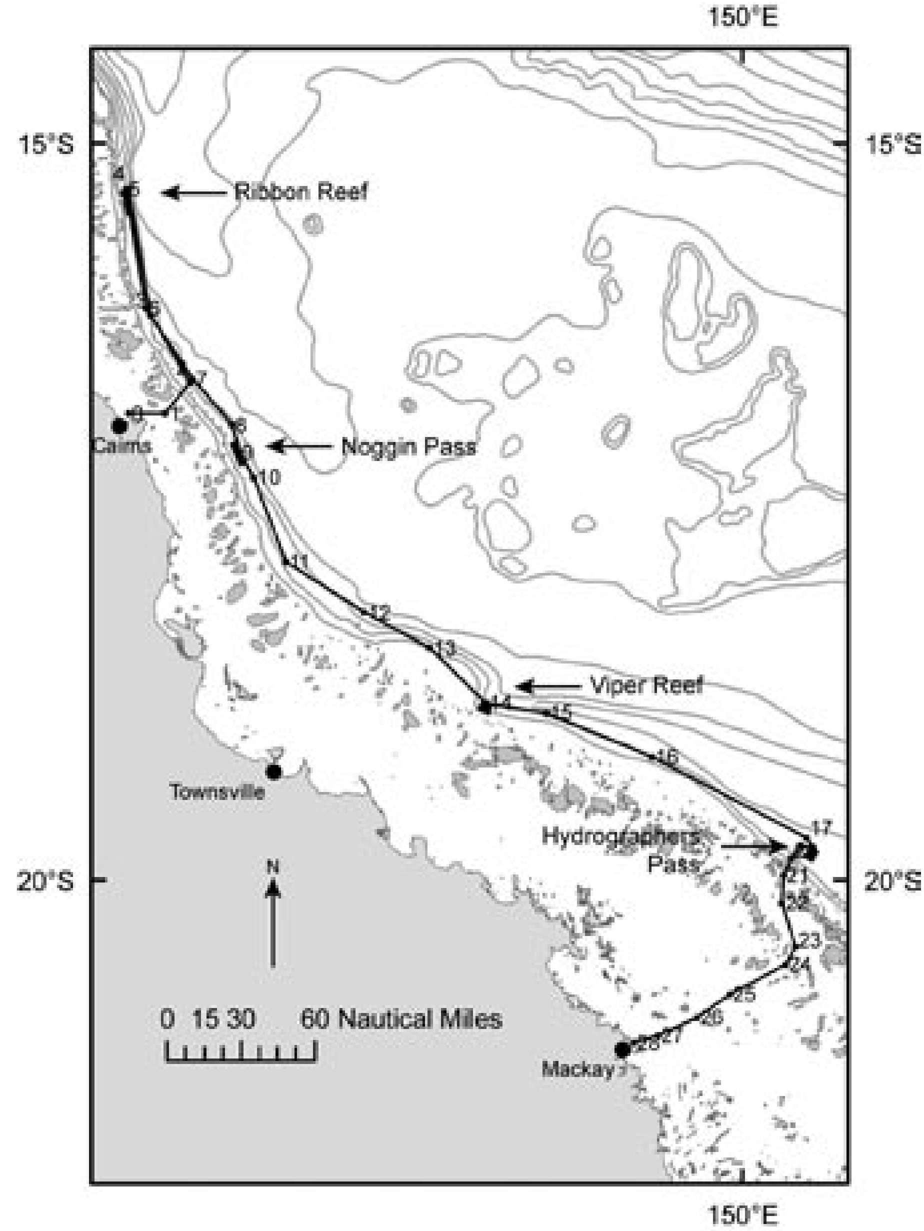


Figure 1: The proposed primary study sites (Ribbon Reef, Noggin Pass, Viper Reef and Hydrographers Pass) along the Queensland margin. Within the area of interest, the shelf edge slope is shallowest at approx. latitude 20° S, becoming steeper to the north. Hydrographers Passage is at the southern limit of the known submerged shelf edge reefs, while Noggin Pass is near the northern limit of submerged reefs. The Viper Reef survey site tests for features between these limits. The Ribbon Reef survey site is included to test for the existence of shelf edge features on a very steep upper slope as an important validation of results from the southern survey areas. The suggested Southern Survey voyage track is also shown.

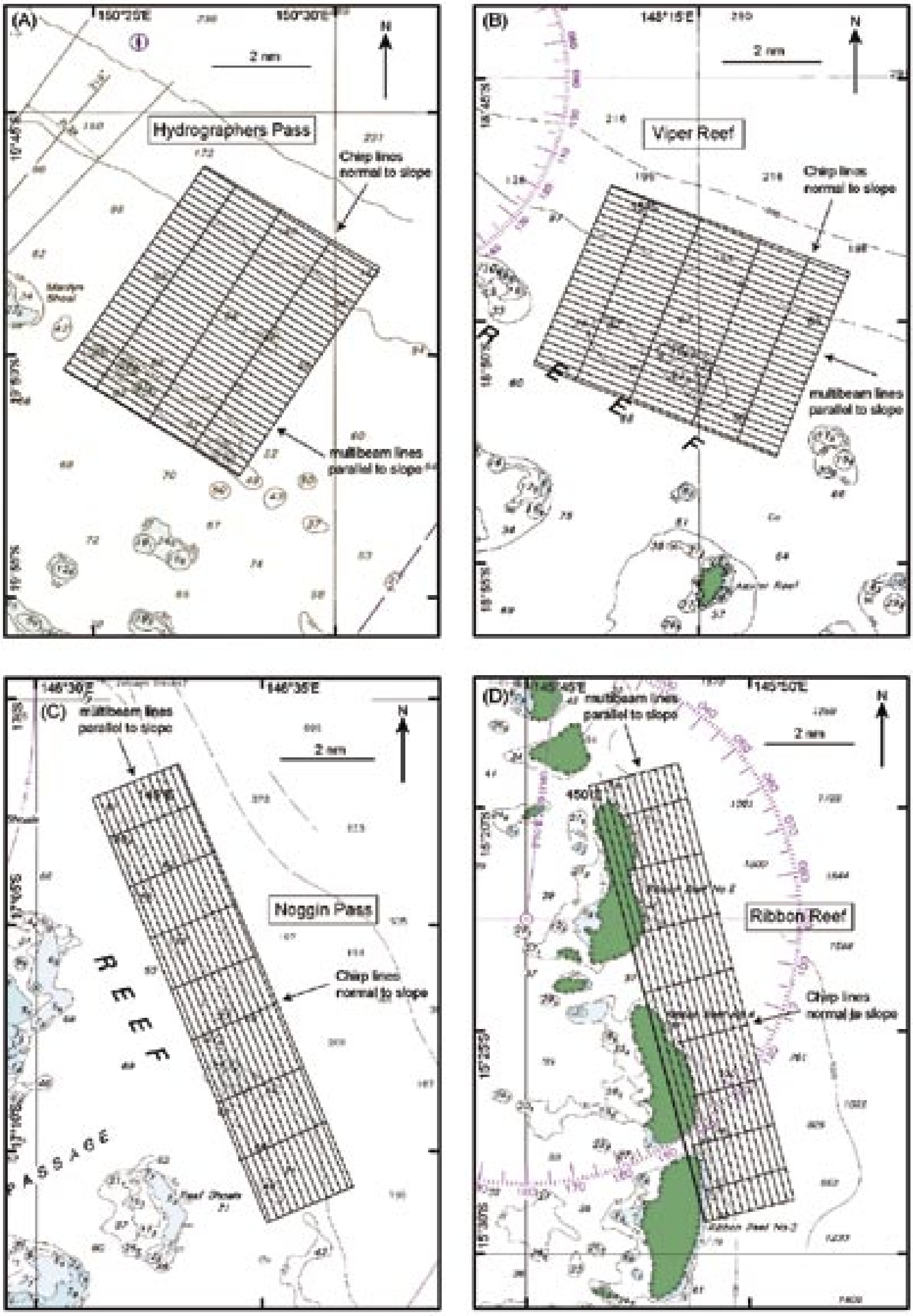


Figure 2: Proposed survey areas and tracks at: (A) Hydrographers Passage; (B) Viper Reef; (C) Noggin Pass; and (D) Ribbon Reef. Each primary study area is approximately 20 square nautical miles in order to survey the inner submerged reefs (charted shoal areas) and any shelf edge features to approximately 150 metres depth (see Table 1 for precise lat/lon of survey corners).

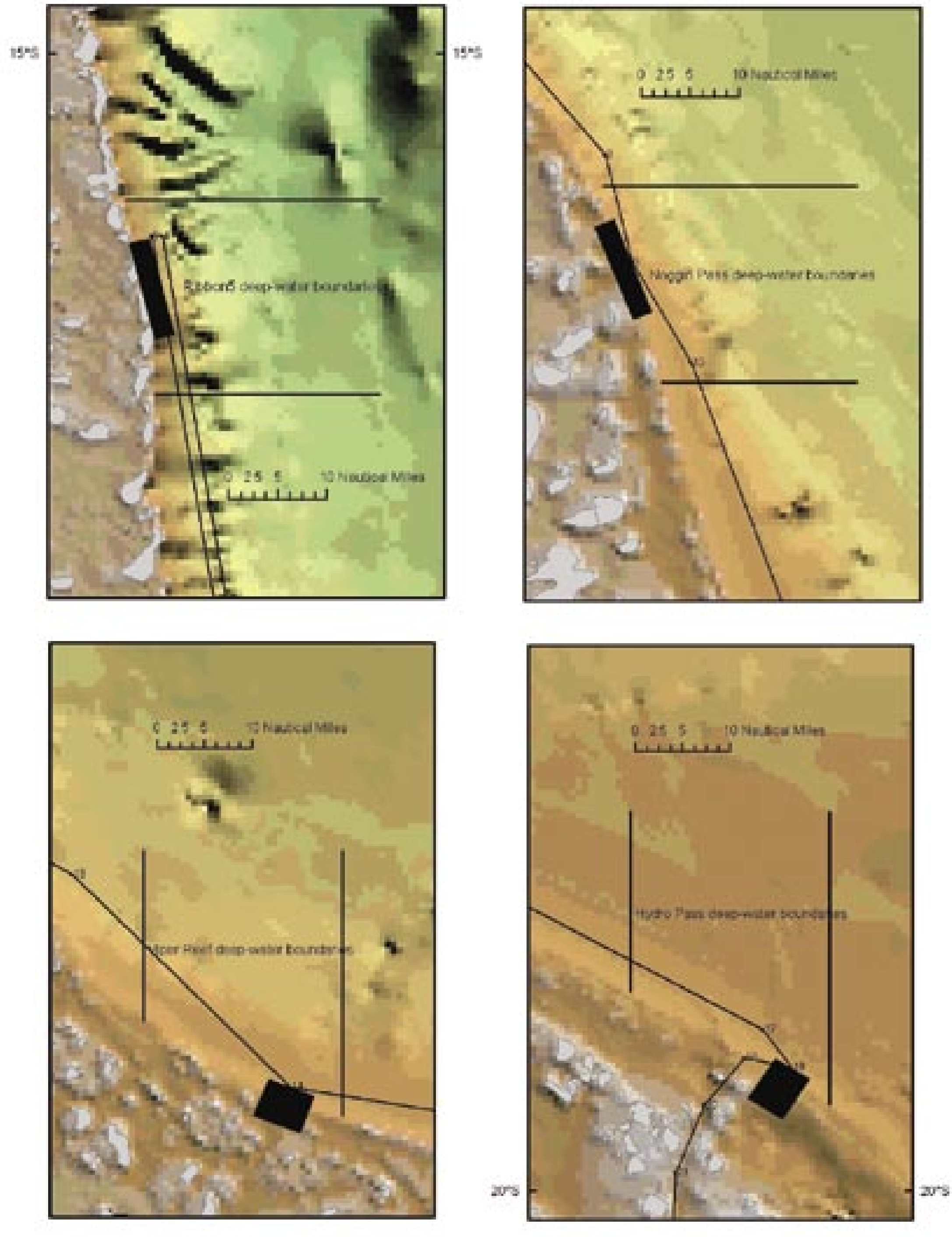


Figure 3: Proposed deep-water survey areas at: Ribbon Reef, Noggin Pass, Viper Reef and Hydrographers Pass (see Table 3 for north/south or east/west limits of survey area). Note, these areas will be mapped in case of extended equipment delays or unsafe navigation in the primary survey boxes (black squares).

Appendix

Table 1. Transit Waypoints along voyage track (see also Fig. 1).

WayPoint	Lat deg	Lat min	Lon deg	Lon min	Location	Distance nm
0	-16	50	145	49.8	Cairns leads	
1	-16	50	146	5	start Grafton Passage	14.6
2	-16	37.5	146	15	end Grafton Passage	15.8
3	-16	10.2	145	58.8	St. Crispin Reef	31.4
4	-15	18.7	145	49.8	arrive Ribbon5	52
5	-15	18.7	145	48.7	depart Ribbon5	1
6	-16	7.1	145	56.9	St. Crispin Reef	48.8
7	-16	36.1	146	16	Grafton Pass	34.3
8	-16	54.8	146	32.3	Flora Pass	24.3
9	-17	5.8	146	35	Noggin Pass	11.4
10	-17	16	146	41	Mustard Patches	11.7
11	-17	50.5	146	54	Moss Reef	36.6
12	-18	11	147	26	Myrmidon Reef	36.7
13	-18	25.5	147	52.5	Chicken Reef	29
14	-18	48	148	15.5	Viper Reef	31.4
15	-18	52	148	40	Lynx Reef	23.5
16	-19	10	149	23	Ellen Reef	44.6
17	-19	43	150	26	arrive Hydro Pass	68
18	-19	47	150	29	HydroPass	4.9
19	-19	46	150	24	Hydro Pass entrance	4.8
20	-19	51	150	19.8	Ferris Shoal	6.4
21	-19	58.1	150	16.8	Little Bugatti Reef	7.7
22	-20	9.5	150	16.2	Bugatti Reef	11.3
23	-20	27.1	150	21.3	Boulton Reef	18.2
24	-20	34.5	150	17.6	Warland Reef	8
25	-20	46.5	149	54.8	Shipping Route	24.5
26	-20	56	149	41.4	Three Rocks	15.8
27	-21	3.5	149	25.5	Gould Shoal	16.6
28	-21	6.3	149	15.6	arrive Mackay	9.6
						642.9

Appendix

Table 2. Primary survey site corners (see also Fig. 2)

WayPoint	Lat deg	Lat min	Lon deg	Lon min	Location
0	-15	28.8	145	51	Ribbon5 SE
1	-15	29.3	145	49	Ribbon5 SW
2	-15	19.5	145	46.4	Ribbon5 NW
3	-15	19	145	48.4	Ribbon5 NE
0	-17	10.8	146	37	NogginPass SE
1	-17	11.6	146	35.1	NogginPass SW
2	-17	2.2	146	31.2	NogginPass NW
3	-17	1.4	146	33.1	NogginPass NE
0	-18	52.8	148	16.5	ViperReef S
1	-18	51	148	11.6	ViperReef W
2	-18	47.2	148	13.2	ViperReef N
3	-18	49	148	18	Viper Reef E
0	-19	48.2	150	30.9	HydroPass E
1	-19	52.5	150	28	HydroPass S
2	-19	50.3	150	24.4	HydroPass W
3	-19	46.1	150	27.3	HydroPass N

Table 3. Deep-water survey limits for contingencies (see also Fig. 3)

Lon deg	Lon min	Lat deg	Lat min	Boundaries
		-15	15	Ribbon5 North limit
		-15	35	Ribbon5 South limit
		-16	58	NogginPass North limit
		-17	18	NogginPass South limit
148	0			ViperReef West limit
148	21			ViperReef East limit
150	33			HydroPass Nth limit
150	12			HydroPass Sth limit