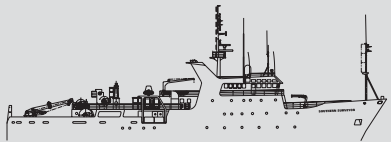

MARINE
NATIONAL FACILITY

2005 program

RV *Southern Surveyor*

CSIRO

voyage summary SS04/2005

SS04/2005

(Geoscience Australia Survey 276)

Submerged coral reefs and benthic habitats of the southern Gulf of Carpentaria

Itinerary

Departed Weipa 1000, Wednesday 23 March 2005
Arrived Darwin 0900, Wednesday 13 April 2005

Principal Investigators

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Scientific Objectives

The hypothesis we are testing is that "the growth of coral reefs has been widespread in the Gulf of Carpentaria throughout the late Quaternary, particularly when sea level was around 30 m below its present position, resulting in numerous submerged catch-up reefs in the southern Gulf". The two main objectives of the survey are to:

(A) to identify and characterise rocky reef-type substrates, and their associated biological communities in the southern Gulf; and

(B) to sample and date relict reefal sediments to attempt to provide more accurate indicators of past sea levels and their time of occurrence.

Four secondary objectives will be:

(C) to determine the reefal extent according depth strata and their inter and intra biotic variations

(D) to collect information on the physical oceanographic environment, such as currents, water temperature, salinity, and suspended sediment concentrations

(E) collect seismic and sediment core data from deposits adjacent to the rocky substrate areas to document late Quaternary sedimentation and environmental changes

(F) to determine the origins of carbon and nitrogen supplying the coastal benthic and pelagic food web using natural abundance stable isotopes.

The hypothesis we are testing is that "the growth of coral reefs has been widespread in the Gulf of Carpentaria throughout the late Quaternary, particularly when sea level was around 30 m below its present position, resulting in numerous submerged catch-up reefs in the southern Gulf".

Voyage Objectives

1. To acquire drill core samples from suspected submerged coral reef to confirm their coral composition and provide material suitable for radiometric dating

2. To collect multibeam sonar and sub-bottom profile information from other bathymetric mounds in the southern Gulf to ascertain their geomorphic nature

3. To collect biological samples and underwater video records of the seafloor in order to document the benthic communities and fauna associated with the submerged reef features; and

4. Collect data on water properties, currents and suspended sediments to document the modern reef habitats and their environments.

Voyage Track

GA Survey 276 started in Weipa on 23-03-05 and after testing of multibeam sonar equipment, the ship transited to the first drill sites on a submerged coral reef (R1 in Fig. 1). Drilling continued on reefs R1, R2 and R3 before the ship sailed to a site located off the eastern side of Mornington Island (Fig. 1). Drilling was completed on this site at 0700 hrs on Easter Sunday, 27th March (see Voyage Narrative, below, for a discussion of the daily activities).

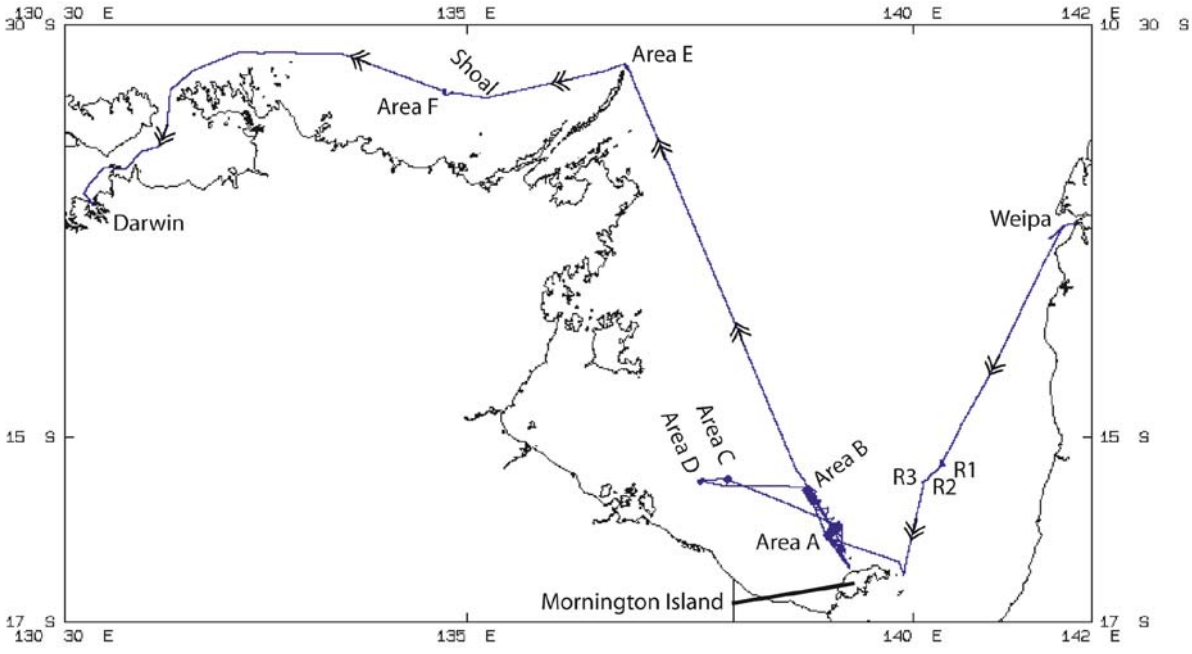


Figure 1 Voyage track of the RV Southern Surveyor during GA survey 276 of the southern Gulf of Carpentaria. The total voyage track covered 6,925 km from Weipa to Darwin.

A further 6 areas were explored and investigated in the southern Gulf of Carpentaria and in the Arafura Sea. Activities included recovery and deployment of current meters, multibeam swath mapping and seafloor sampling. Different activities were carried out in specific study areas as described below. The ship arrived in Darwin on 13th April after 22 days at sea.

Results

Sampling results

The sampling program completed operations at 72 stations. A full listing of all operations completed, with coordinates and water depths, is provided in Appendix 1. Operations are summarised as follows:

67	Underwater cameras
43	Rotary Drill Cores
39.03	metres of core
60	CTD's
120	Filter papers of surface and bottom water samples
43	Rock Dredges
63	Smith Mcintyre Grabs

In addition to the above, the BRUCE and ADCP instrument frames were successfully recovered at the start of the voyage, redeployed and then recovered again at the end of the voyage. Some highlights of the sampling results are described in the survey narrative (below).

Multibeam swath sonar results

Two multibeam sonar systems were used on the survey; the ships EM-300 30 Khz system, plus a Reson 8101 240 KHz system were used.

Although there were some initial problems with the Reson system, we eventually had both systems running in parallel. This has enabled some comparative studies of the two systems to be carried out which will be reported in detail in later post-survey reports.

In general, the two systems provided good quality data in the 20-50 m depth range in which we were working. There is little difference apparent in bathymetry grids where a grid spacing of 5 to 10 m was used. At finer grid spacings (< 5m), however, the higher frequency of the Reson system provided better resolution data in comparison with the EM-300, which tended to look a bit more "grainy" than the Reson data. For most mapping purposes, therefore, we conclude that the ship's EM-300 system will provide useful, good-quality products (especially at >10 m grid spacing) in shallow water conditions as encountered on this survey (i.e. in 20 to 50 m water depth).

Multibeam surveys were carried out at 6 locations (Areas A, B, C, D E and F). In general, the Topas sub-bottom profiler was run at the same time as the two swath mappers, so the line km of data collected applies to both the multibeam and sub-bottom profiler data sets. A list of the separate survey areas with the line km of data collected in each area is as follows:

Survey Area	Line km run
Area A	1540
Area B	1520
Area C	240
Area D	260
Area E	73
Area F	170

Area A is the south-eastern end of the elongate platform that extends north-westwards from Mornington Island. Area A includes the locations of the two re-deployed current meters (ADCP and Bruce; Fig. 2). The area is characterised by elongate ridges, spur and groove platform margins and Karst doline features. The adjacent channel exhibits localised depressions that appear to have been formed by local tidal currents. The overall appearance is of widespread erosion and the features all appear rounded and muted, in comparison with the previously-mapped platform reefs (Fig. 2).

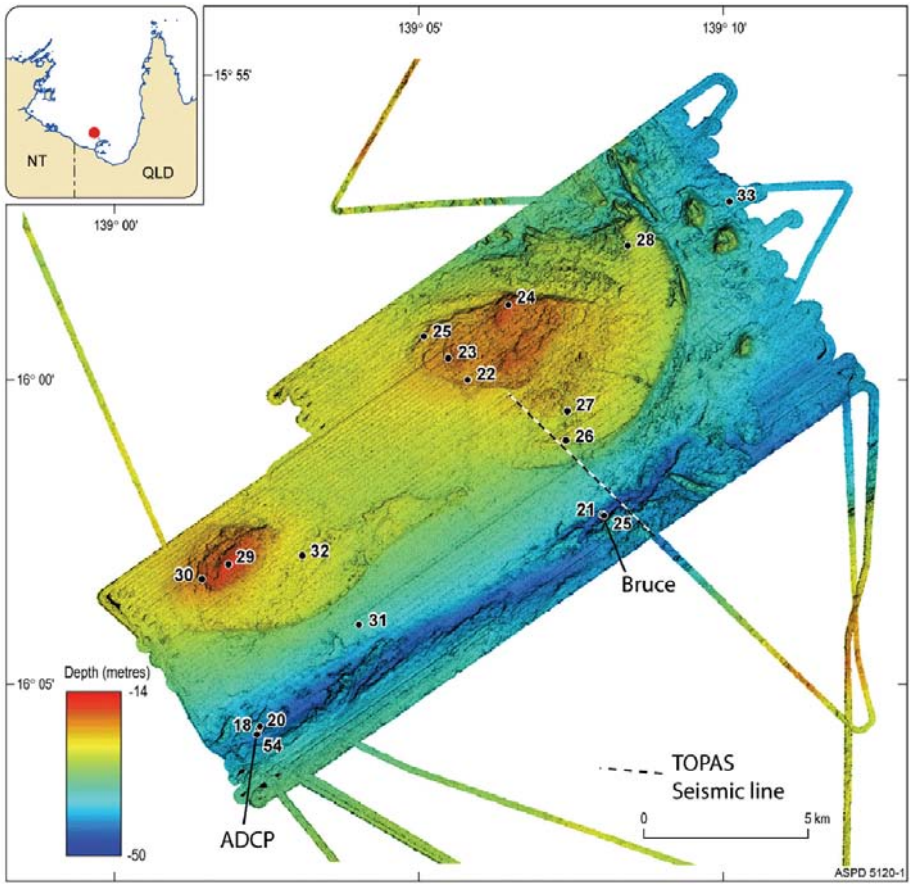


Figure 2 Bathymetric image of Area A, showing the locations of sample sites, the two current meters (ADCP and Bruce) and the location of a Topas seismic line shown in Figure 7.

Area B includes the north-western end of the same elongate platform that extends north-westwards from Mornington Island. It is also characterised by elongate ridges forming an oval-shaped rim along the platform margin, spur and groove incision into the platform margins and Karst doline and fluvial-erosion features. Four areas of active reef growth have formed dome-shaped reefs that rise up to within <20 m of the sea surface (red spots on Fig. 3). The largest of these is nearly 1 km in diameter and is located on the southern edge of the mapped area (Fig. 3). The Bruce current meter frame was moored on the southern edge of this site.

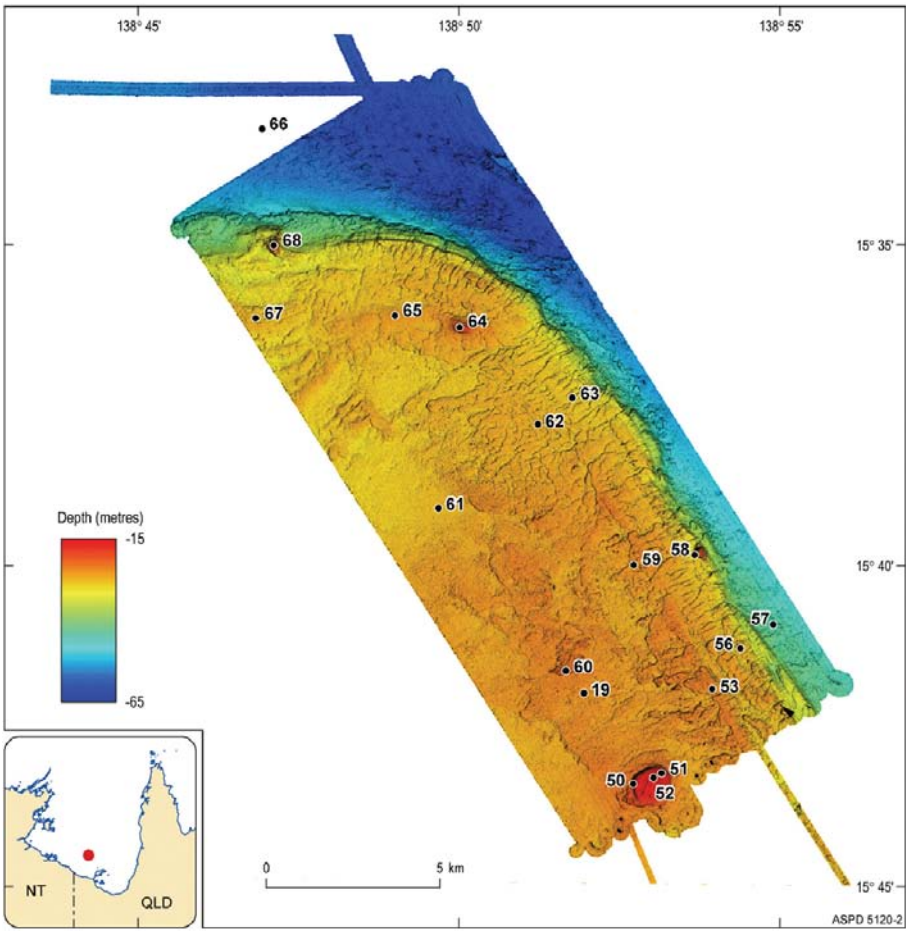
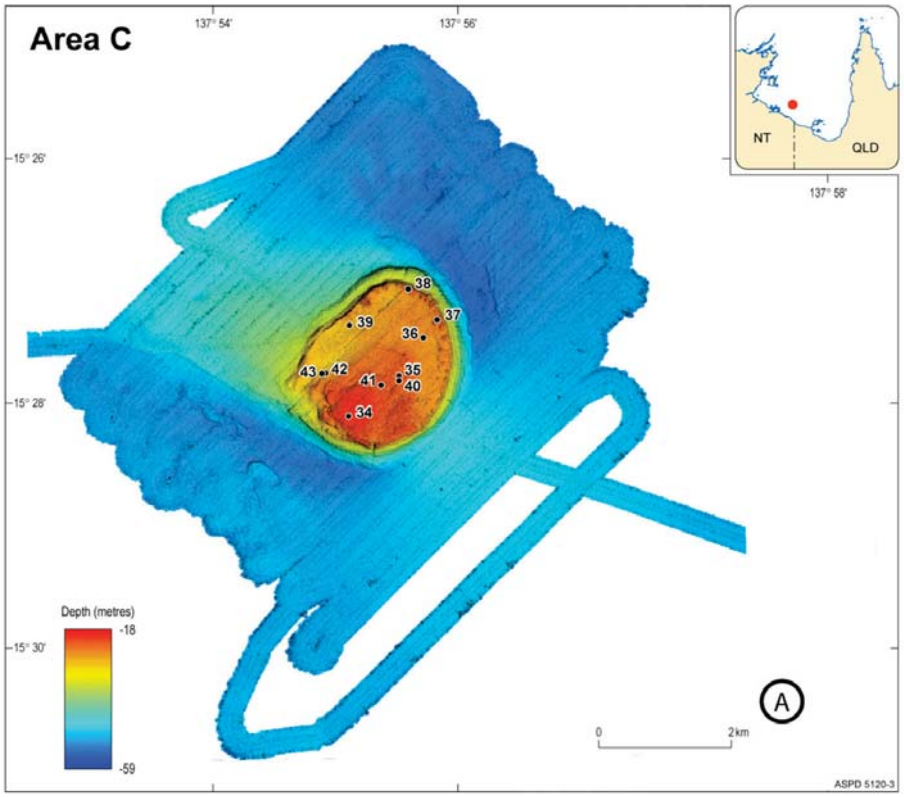
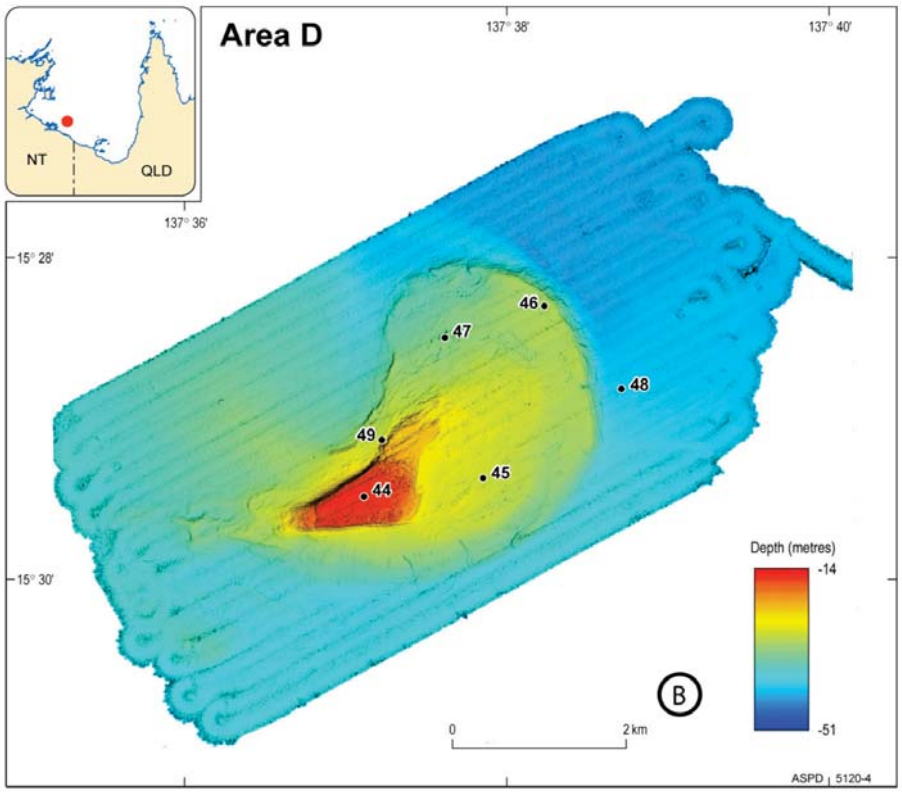


Figure 3 Bathymetric image of Area B, showing the locations of sample sites. The Bruce current meter was recovered at Station 19.

Areas C and D are both small platform reefs located 200 km to the west of Mornington Island. They are two of approximately 50 such bathymetric banks that occur in this region of the Gulf. Their reef-geomorphology and character is exhibited by the occurrence of spur and groove margins, raised rim, central platform with localised reef build-up and karst erosion features (Fig. 4a and b).

Figure 4 (A) Bathymetric image of Area C; and (B) Bathymetric image of Area D. The images show locations of sample sites. These two platform reefs both have sediment talus slopes extending to the WNW, streaming away from their leeward sides. Transport of sediment off the reef flats and onto these talus slopes is most likely to be the result of tropical cyclones.





Area E is a tidally-scoured depression on the seafloor located directly north of Cape Wessel, at the northern end of the Wessel Islands (Fig. 5). Tidal scour is suggested by the closed bathymetric contours and the curved shape of the depression which is aligned with the main orientation of tidal flow across the area. The depression is up to 114 m in water depth, and it is therefore the deepest point within the Gulf of Carpentaria. Biologically, its significance may be as the home to a population of hammerhead sharks, although none were seen in our underwater video records from the area.

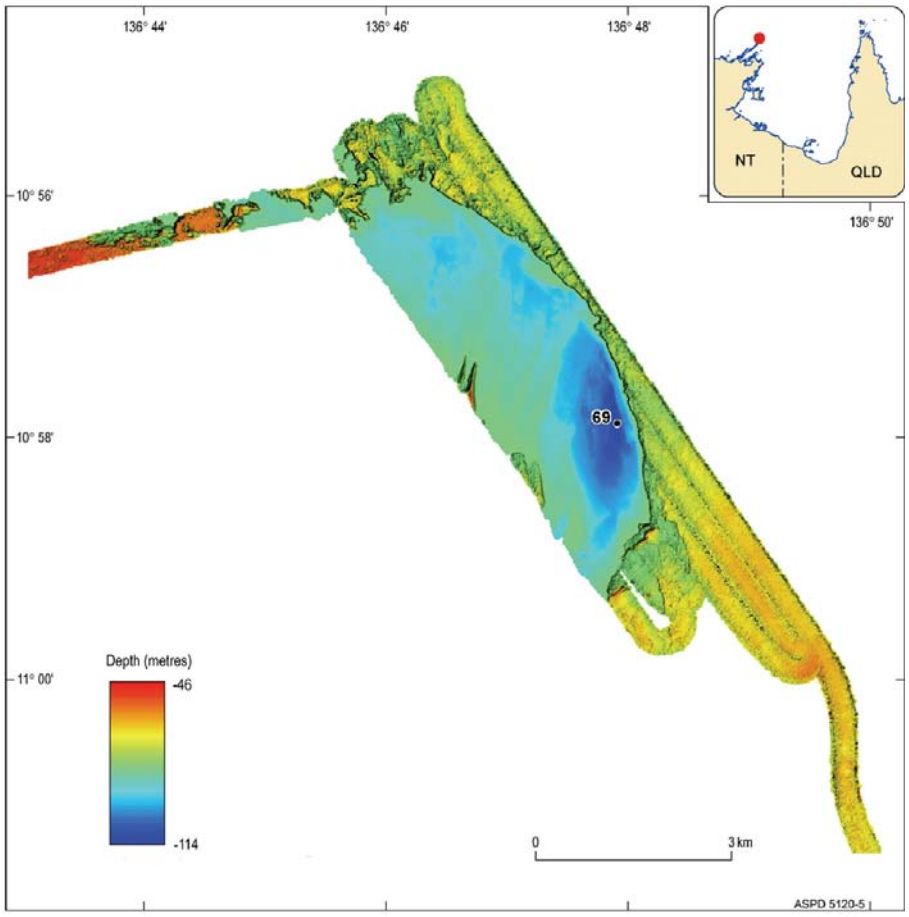


Figure 5 Bathymetric image of Area E, showing the locations of sample site 69.

Area F is another small platform reef; it was one of two bathymetric shoals that can be seen in the nautical charts for this area. One of the shoals turned out not to exist at the indicated location. The reef-character of this second shoal is significant because it points to the prospect of others like it existing in the Arafura Sea region. A recent analysis of geomorphic features on the Australian continental margin (Harris et al., 2005) identified several banks and rocky pinnacles in the area – our identification of a submerged reef in this area points to the possibility that some or all of these other features may be submerged coral reefs.

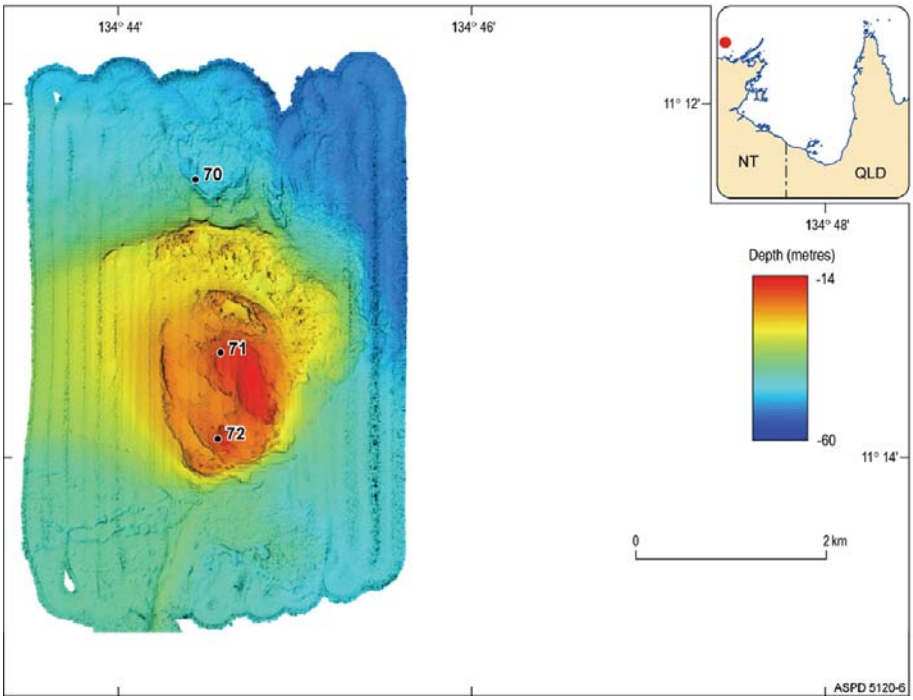


Figure 6 Bathymetric image of Area F, showing the locations of sample sites. Note the sediment talus slope extending to the west, streaming away from the leeward side of the reef.

TOPAS sub-bottom profiler results

As noted above, the Topas sub-bottom profiler was run throughout the voyage at the same time as the multibeam sonar; hence these two data sets are complementary. The Topas system gave good results in the shallow waters of the survey areas and was operated in Ricker mode at all times. There was no occurrence of interference between the Topas and either of the two multibeam systems being operated.

Sub-bottom profiler results were mixed: excellent results were obtained in areas of soft sediment deposits on the seafloor surrounding the reef platforms. In particular, images from talus slope deposits located on the flanks of all platform reefs that we examined were imaged by the Topas system (talus slope deposits are also apparent in the multibeam images; Figs 4 and 6). Good penetration was also obtained from some of the relict fluvial, cut and fill deposits that were mapped in Area A (Fig. 7).

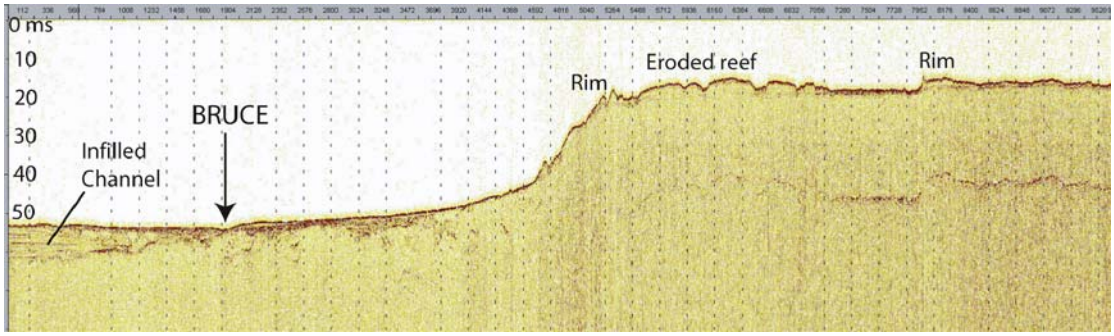


Figure 7 Example of Topas sub-bottom profile data collected across a reef and submarine valley in Area A (see Fig. 2 for location of the line). The location of the Bruce current meter site is indicated.

In contrast, the limestone reef surfaces were acoustically opaque to the frequency and power of the Topas system and minimal sub-surface information was obtained (eg. Fig. 7). The main reef platform in Area A was also subjected to seismic profiling using a towed sparker system, but again the results did not yield sub-surface information.

Summary

In 2003, Geoscience Australia discovered three large patch reefs in the southern Gulf of Carpentaria (GA Survey 238; SS-03/2004; Harris et al., 2004). The submerged platform reefs (R1, R2 and R3) are located east of Mornington island and appear to have been formed when sea level was ~30 m below its present position, however as the ship did not come prepared with a drill-core sampler, the sub-surface composition of the reefs was not determined. The submerged platforms support live hard corals in many locations and their discovery raised the question of the possibility of widespread reef occurrence in that region. Survey 276 was designed to deliver some answers to these questions.

The current survey used rotary drilling of reefs R1, R2 and R3 which recovered coral material from 8 sites and confirmed the coral reef composition of these features. Multibeam sonar bathymetry and rotary drill cores were collected over two sections of a large (>100 km long) submerged platform that extends westwards from Mornington Island. The platform exhibits a Karst erosion surface, exhibiting drainage and depressions with raised rims, overprinting relict reef-growth geomorphic features. Reef growth features include raised rims, spur and groove reef front and elevated back-reef mounds. Two additional platform reefs were mapped in the south-western Gulf. Rotary drilling at all sites confirmed the coral reef composition of these features.

This voyage has proved that the southern Gulf of Carpentaria contains a previously unknown major coral reef province in Australia. The reefs support locally diverse and luxuriant coral growth. Preliminary assessments of the recovered drill cores indicate that reef growth has persisted in the region for several glacial cycles, extending over at least the past 120,000 years. Rotary drill core samples obtained on this voyage will provide material for radiometric dating and sedimentologic analysis that will allow the Quaternary history and nature of reef growth to be determined.

References Cited

Harris, P.T., Heap, A.D., Wassenberg, T. and Passlow, V., 2004. Submerged coral reefs in the Gulf of Carpentaria, Australia. *Marine Geology*, 207: 185-191.

Harris, P.T., Heap, A.D., Passlow, V., Sbaffi, L., Fellows, M., Porter-Smith, R., Buchanan, C. and Daniell, J., 2005. Geomorphic Features of the Continental Margin of Australia: Report to the National Oceans Office on the production of a consistent, high-quality bathymetric data grid and definition and description of geomorphic units for part of Australia's marine jurisdiction. 2003/30, Geoscience Australia, Canberra.

Voyage Narrative

22-3-05 Tuesday. Loading and stowage of scientific equipment was completed @1700. The new drill rig was assembled and a trial-test run carried out along side the jetty. The drill penetrated about 1.5 m into hard-packed clay. The drill-core sample was retained. The Reson swath mapping equipment was installed and made ready for testing at sea.

23-3-05 Wednesday. Southern Surveyor sailed from Weipa @ 1000 hrs to conduct a patch test using the Reson 8101. Had to leave one member of the science party (Andrew Hislop) ashore because the ship is only allowed to carry 29 persons at sea. The patch test was completed @1530 hrs and the boat called from shore to take off the Reson technician and return Mr. Hislop. However, @1545 hrs the Reson system unexpectedly shut-down and could not be restarted. The ship anchored @ 2000 hrs and repair work was attempted all night by the Reson Technician but to no avail – he had not brought any spares from Singapore. An outline of the survey plan was presented @1800 hrs by the Chief Scientist to the ships crew and science party.

24-3-05 Thursday. The Reson technician was put ashore @ 0630 and the ship was underway by 0700. The Scientific party were taken on a tour of the ship by the first mate Samantha Durnian and a fire/lifeboat drill was conducted @1030 hrs. Transit to first sample stations arriving @2230 hrs. It has been agreed that Reson will send another technician, this time with spares, to attempt to repair the 8101 system on board. We will pick him up from Mornington Island. There is no replacement Reson unit available to the company in Singapore. If the repairs are not successful, the science plan will have to be altered to focus more on deep-water areas where the ship's EM-300 system will be effective.

25-3-05 Good Friday. The first drill core was recovered @0015 on reef R1, 2.3 m long, comprised of reefal limestone. This core confirms our hypothesis that the reef structure is indeed comprised of coral and associated reef material. Two further drill-cores were collected, but at Station 3 the ship was blown off station by a gust of wind. The drill was recovered but with some damage sustained. Electric wires had to be replaced and some mechanical parts rebuilt. Station work continued through the day collecting CTD, grab, camera and dredge samples while the drill was being repaired. Station 9 was completed @2230 hrs by which time the drill repairs were nearly completed.

26-3-05 Saturday. Stations 10 to 16 were completed, with 8 successful rotary drill cores collected. Drill core lengths ranged from 17 cm to 206 cm and confirm that the reef rims are comprised of coral framework material. The drill has performed very well and it has proved to be moderately easy to deploy and operate. There was a minor incident when Craig Wintle cut his hand on the sharp metal edge of a control panel.

27-3-05 Easter Sunday. Station 17 was completed @ 0700 hrs, on the surface of a Karst limestone bank located in the tidal channel east of Mornington Island. The drill core penetrated 3 m, but only a 50 cm core was obtained, comprised of compact clay with Caliche nodules. The drill core catcher seems to be unable to retain non-lithified material, even hard clay. Another problem occurred when the main winch was being used to raise the drill tower – it surged in causing a wire to part and a heavy metal sheave fell to the deck from the A-frame. As a result the drill tower will henceforth be raised using the main ships wire and movement using the A-frame to raise-lower the tower. Transit to recover the ADCP mooring, completed @1100 hrs; BRUCE was recovered @ 1330 hrs. A regional survey was commenced along zig-zag lines that crossed the shallow bank top, to seek the best place to commence swath mapping, and to test the overall performance of the EM-300 system. The EM-300 has been found to give acceptable results in shallow water depths of around 20 to 30 m, albeit with a narrower swath width and coarser resolution than would be expected from the Reson 8101. The sub-bottom profiler is giving excellent results, and has been providing detailed sub-seafloor images to 30 ms depth, of fluvial cut/fill processes as well as some images of faulted and folded units that crop-out at the seabed. One issue is that there is no hard-copy printer that generates a paper trace with time-stamps (the printer we have does not add time stamps). A hard copy record with time stamps is needed for station selection and interpretation and I recommend we purchase an EPS recorder that does this job.

28-3-05 Easter Monday. Swath mapping of a channel and platform/barrier margin proceeded using the EM-300. Water depths are from 45 to 17 m and 20 lines, each 20 km in length, were completed by 2400 hrs. The ADCP and BRUCE instrument frames were re-deployed, the ADCP in its original location and the BRUCE frame located in the deepest section of the valley, in about 44 m water depth. On interrogation, the ADCP was found to have recorded data but the lead weight was not installed on its gimbaled mounting, which seems to have caused a few minor artifacts in the data. In the BRUCE package the Nortek CM seems to have recorded data, along with the OBS sensors, but the LISST and Seacat CTD sensors failed to record any data. The LISST laser particle size analyzer is suspect and it was not included on the frame when BRUCE was redeployed.

29-3-05 Tuesday. Guido the Reson Technician was received aboard @0730 and Jon Stratton went ashore; one of the science party had to go ashore because the ship is only allowed to carry 29 persons at sea. Guido will spend 24 hrs on board and attempt to repair the 8101 system. Swath mapping during the night has revealed more of the submerged platform feature which exhibits spur and groove, parallel ridges and abundant erosion features. The platform is looking more like a heavily eroded submerged barrier reef, but further swath mapping and sampling will be required to reveal its true identity.

30-3-05 Wednesday. Swath mapping of Area A continues. Both the EM-300 and Reson systems are now fully functional and we are starting to make comparisons in the quality of data generated by the two machines. The nature and origin of the platform is still ambiguous. There are elongate ridges, spur and groove platform margins and Karst doline features, but the overall appearance is one of widespread erosion and the features all appear rounded and muted, in comparison with the 3 platform reefs. This may be due to the closer proximity of land and therefore the greater influence of fluvial processes.

31-3-05 Thursday. Swath mapping of Area A completed @ 1030 hrs. Heap and Harris selected 12 stations in Area A based on geomorphology and seismic characteristics, targeting rocky-reef type features, Karst features, rim features and the highest peaks of mound-shaped features. Drilling completed at the five locations by 2400 hrs.

1-4-05 Friday. Drilling at 12 locations has proven the elevated portions of the platforms are calcareous and of coral reef origin. Cores have penetrated 3m but maximum recovery has been only up to about 1.5 m; this is attributed to gravel and unconsolidated material falling out of the drill core during pull-out. The new system of raising and lowering the drill tower using the A-frame is working safely. The cores recovered so far have included an upper lithified limestone unit about 30 to 50 cm thick, which overlies an unconsolidated gravel comprised of reefal carbonate material. In some cores two lithified units and two rubble units or compact clayey limestone units have been encountered. Work was stopped @1430 hrs to take the 2nd cook to Mornington Island (5 hrs 30 mins return trip); she is going home due to a death in the family.

2-4-05 Saturday. Station work was completed @ 0200 hrs and transit to Area C, a small bathymetric mound 60 miles west of Mornington Island. Arrived at the bathymetric mound and commenced swath mapping @0900 hrs. The mound (R4) exhibits the same patch reef geomorphology as the other three patch reefs we have mapped. Swath mapping completed by 2230 hrs and commenced sampling @ 2300.

3-4-05 Sunday. At the first sampling station on Reef R4 the drill was damaged during recovery. Nevertheless a 1.2 m core was obtained at this site comprised of coral. Six stations were occupied without the drill until it was repaired @1000 hrs. The underwater video revealed the reef is host to the most dense and diverse coral cover we have seen in the Gulf to date. Staghorn, brain and plate corals are present. Another drill was obtained @1200 hrs, penetrated around 1 m into limestone comprised of coral and associated reef fauna. Three attempts to dredge the reef top resulted in a small sample being obtained and the ship departed for Area D, arriving @1400 hrs. Swath mapping of this small bathymetric mound located 60 miles northeast of the Edward Pellew group of islands, again revealed it to exhibit the same patch reef geomorphology as the other reefs previously mapped. Harris and Heap selected six stations based on the swath image for sampling.

4-4-05 Monday. Swath mapping of Area D was completed @0300 hrs and sampling began at six stations using CTD, grab and camera. Drill cores from three locations encountered limestone comprised of coral and other reef fauna. Transit to Area B, arriving @ 2330 hrs and began swath mapping. Sewage smell incidents continue to occur.

5-4-05 Tuesday. Swath mapping of Area B continues. Wind speed up to 18 knots today and some choppy seas but mostly calm weather.

6-4-05 Wednesday. Swath mapping of Area B continues. Some problems with sewage smells inside vessel.

7-4-05 Thursday. Swath mapping of Area B was completed @1700 hrs. The sparker system was deployed to run 3 lines over the reef front, normal to isobaths, but the results were not very informative. The ship speed was kept at 5 knots and the seas were calm, and we attribute the lack of penetration to the properties of the rocks and sediments. No significant sub-surface reflectors were seen in the data. Station work commenced @2230 hrs.

8-4-05 Friday. Three stations were completed by 0645 hrs, including 3 drill cores. The longest drill core of the 3 was 1.95 m at station 51. The seabed is rocky-reef with some corals, but not overly abundant. No "coral gardens". The ship transited to Man O'War Island where we picked up a gas detector unit @0945 hrs to measure the gas content in the sewage smell. To minimize the disruption of this diversion to our program, I have decided to collect the current meters today (1 day early) as

we are passing nearby them. Arrived at the first (ADCP) mooring @ 1130 hrs and completed recovery of BRUCE @1430 hrs. Transit back to Area B arriving @ 1700 hrs and start sampling. A 1.5 m core taken from station 57 in 44 m water depth contained >1 m of lithified carbonate gravelly sand overlying compact clay.

9-4-05 Saturday. Alas the opposite shift has taken the record for the longest core – 2.5 m penetrated into limestone overlying siltstone. This information will be crucial to determining the basement composition of the platform. Station work progressed through the day, with station 67 (drill #42) completed @2400 hrs.

10-4-05 Sunday. Station 68 was completed @0330 hrs on a submerged reef-top in 20 m water depth and a short drill core obtained. This concluded the sampling work in Area B. Started transit to Darwin. At 0930 hrs I was advised by the Captain that an extra 16 hrs was available for work due to an error in his transit time estimate. Andrew Heap and I devised a program to map a >100 m deep incised valley north of the Wessel Islands and also to map a submerged reef in the Arafura Sea. Watches will continue until 12-4-05.

11-4-05 Monday. Mapping of the "Wessel Deep" was completed @0700 hrs, with a CTD, grab and camera station completed at the centre of the deep in 107 m water depth. The water was turbid and the seabed composed of mobile coarse sand and gravel. Arrived at the position of a shallow sounding (Little Reef?) @1700 but 3 passes over the region of this chart sounding showed it to be a false depth. Arrived at the "Big Reef" location @1900 hrs and commenced swath mapping. The feature is indeed a submerged reef, but its western half is draped by a thick sediment blanket, that streams away to the WNW. Mapping continued through the night.

12-4-05 Tuesday. Completed 3 grabs, 1 CTD and 2 camera operations at the "Big Reef" site. The reef supports some live corals (Turbinaria) and abundant fish, but turbid water restricted visibility. Work was completed by 0650 and we resumed our transit to Darwin.

13-4-05 Wednesday. Arrive Darwin. Gear unloading commenced @ 0900. Scientific party departed for airport @1100 hrs.

Personnel

Scientific Participants

Peter Harris	GA	Chief Scientist
Andrew Heap	GA	Co-Voyage Leader
Mark Hemer	GA	Oceanography
David Brewer	CSIRO	Biological sampling
Don Heales	CSIRO	Biological sampling
James Daniell	GA	Computer support; swath bathymetry
Allison Hancock	GA	Technician (sediment sampling, database)
Cameron Buchanan	GA	Computer support; swath bathymetry
John Stratton	GA	Technician (sediment sampling, drill operation)
Andrew Hislop	GA	Technician (sediment sampling, drill operation)
Craig Wintle	GA	Technician (sediment sampling, drill operation)
Jack Pittar	GA	Electronics Technician
David Holdway	GA	Electronics Technician
Hiski Kippo	CSIRO MNF	Computing Support
Stephen Thomas	CSIRO MNF	Electronics Support

Marine Crew

Ian Taylor	Master
Samantha Durnian	1st Officer
Rob Ferries	2nd Officer
John Morton	Chief Engineer
Stefan Mason	1st Engineer
Chris Heap	2nd Engineer
Mal McDougall	Bosun
Pat Chamberlaine	IR
Graham McDougall	IR
Phil French	IR
Mark McRae	IR
Pat Wainwright	Chief Cook
Angela Zutt	2nd Cood
Charmaine Aylett	Steward

Dr Peter Harris
Chief Scientist

Appendix 1. List of stations and activities completed on Survey 276.

Station number	SampleName	SampleType	Start latdeg	Start latMin	Start longdeg	Start longMin	Start Water Depth
01	276/01CAM01	CAMERA	-15	17.72	140	19.47	26.80
01	276/01CAM02	CAMERA	-15	17.772	140	19.504	26.40
01	276/01CTD01	CTD	-15	17.72	140	19.47	26.80
01	276/01DR01	DREDGE CHAINBAG	-15	17.73	140	19.503	26.40
01	276/01GR01	GRAB SMITH MCINTYRE	-15	17.74	140	19.475	26.80
01	276/01RD01	CORE ROTARY DRILL	-15	17.74	140	19.475	26.80
02	276/02CAM03	CAMERA	-15	16.501	140	20.152	26.40
02	276/02CAM04	CAMERA	-15	16.516	140	20.122	26.40
02	276/02CTD02	CTD	-15	16.491	140	20.129	26.80
02	276/02DR02	DREDGE CHAINBAG	-15	16.47	140	20.102	26.40
02	276/02GR02	GRAB SMITH MCINTYRE	-15	16.506	140	20.136	26.80
02	276/02RD02	CORE ROTARY DRILL	-15	16.522	140	20.143	26.40
03	276/03CAM05	CAMERA	-15	15.143	140	18.495	30.80
03	276/03CAM06	CAMERA	-15	15.157	140	18.527	31.20
03	276/03CTD03	CTD	-15	15.149	140	18.5	30.40
03	276/03DR03	DREDGE CHAINBAG	-15	15.187	140	18.493	31.20
03	276/03GR03	GRAB SMITH MCINTYRE	-15	15.144	140	18.501	30.40
03	276/03RD03	CORE ROTARY DRILL	-15	15.146	140	18.484	30.80
04	276/04CAM07	CAMERA	-15	19.507	140	18.687	26.00
04	276/04CTD04	CTD	-15	19.481	140	18.676	26.00
04	276/04DR04	DREDGE CHAINBAG	-15	19.59	140	18.643	26.00
04	276/04GR04	GRAB SMITH MCINTYRE	-15	19.487	140	18.475	26.00
05	276/05CAM08	CAMERA	-15	19.28	140	17.471	26.40
05	276/05CTD05	CTD	-15	19.291	140	17.446	26.40
05	276/05GR05	GRAB SMITH MCINTYRE	-15	19.289	140	17.45	26.40
05	276/05GR06	GRAB SMITH MCINTYRE	-15	19.253	140	17.428	26.40
06	276/06CAM09	CAMERA	-15	19.836	140	18.282	26.40
06	276/06CTD06	CTD	-15	19.86	140	18.27	26.40
06	276/06DR05	DREDGE CHAINBAG	-15	19.74	140	18.192	26.40
06	276/06GR07	GRAB SMITH MCINTYRE	-15	19.849	140	18.279	26.40
07	276/07CAM10	CAMERA	-15	18.012	140	21.522	27.20
07	276/07CTD07	CTD	-15	18.01	140	21.532	27.60
07	276/07DR06	DREDGE CHAINBAG	-15	18.013	140	21.509	27.20
07	276/07GR08	GRAB SMITH MCINTYRE	-15	18.007	140	21.523	27.60
07	276/07GR09	GRAB SMITH MCINTYRE	-15	18.005	140	21.516	27.20
08	276/08CAM11	CAMERA	-15	18.992	140	21.108	27.60
08	276/08CTD08	CTD	-15	19157	140	21.144	28.40
08	276/08DR07	DREDGE CHAINBAG	-15	19.029	140	21.105	28.40
08	276/08GR10	GRAB SMITH MCINTYRE	-15	19.007	140	21.011	27.60
09	276/09CAM12	CAMERA	-15	19.001	140	19.496	27.20
09	276/09CTD09	CTD	-15	18.987	140	19.466	27.20

09	276/09DR08	DREDGE CHAINBAG	-15	18.989	140	19.475	27.20
09	276/09GR11	GRAB SMITH MCINTYRE	-15	18.988	140	19.479	27.20
09	276/09GR12	GRAB SMITH MCINTYRE	-15	18.994	140	19.494	27.20
10	276/10RD04	CORE ROTARY DRILL	-15	19.247	140	17.45	26.40
11	276/11RD05	CORE ROTARY DRILL	-15	19.365	140	18.572	23.20
11	276/11RD06	CORE ROTARY DRILL	-15	19.332	140	18.604	23.20
12	276/12RD07	CORE ROTARY DRILL	-15	19.758	140	18.231	26.40
13	276/13CAM13	CAMERA	-15	26.347	140	9.976	29.20
13	276/13CAM14	CAMERA	-15	26.341	140	9.974	29.20
13	276/13CTD10	CTD	-15	26.358	140	9.967	29.20
13	276/13DR09	DREDGE CHAINBAG	-15	26.433	140	9.757	29.20
13	276/13GR13	GRAB SMITH MCINTYRE	-15	26.358	140	9.967	29.20
13	276/13RD08	CORE ROTARY DRILL	-15	26.358	140	9.967	29.20
14	276/14CAM15	CAMERA	-15	26.86	140	10.185	26.40
14	276/14CAM16	CAMERA	-15	26.87	140	10.191	26.40
14	276/14CTD11	CTD	-15	26.863	140	10.168	26.40
14	276/14DR10	DREDGE CHAINBAG	-15	27.127	140	10.229	26.40
14	276/14GR14	GRAB SMITH MCINTYRE	-15	26.863	140	10.189	26.40
14	276/14RD09	CORE ROTARY DRILL	-15	26.874	140	10.185	26.40
15	276/15CAM17	CAMERA	-15	30.864	140	6.627	30.40
15	276/15CAM18	CAMERA	-15	30.859	140	6.658	30.40
15	276/15CTD12	CTD	-15	30.879	140	6.63	30.40
15	276/15DR11	DREDGE CHAINBAG	-15	30.854	140	6.61	32.80
15	276/15GR15	GRAB SMITH MCINTYRE	-15	30.879	140	6.629	30.80
15	276/15RD10	CORE ROTARY DRILL	-15	30.879	140	6.629	30.80
15	276/15RD11	CORE ROTARY DRILL	-15	30.879	140	6.629	30.40
16	276/16CAM19	CAMERA	-15	31.387	140	6.842	20.60
16	276/16CTD13	CTD	-15	31.401	140	6.846	20.80
16	276/16GR16	GRAB SMITH MCINTYRE	-15	31.401	140	6.846	20.20
16	276/16RD12	CORE ROTARY DRILL	-15	31.401	140	6.846	20.20
17	276/17CAM20	CAMERA	-16	30.132	139	53.659	27.60
17	276/17CTD14	CTD	-16	30.164	139	53.662	27.60
17	276/17DR12	DREDGE CHAINBAG	-16	30.021	139	53.614	28.80
17	276/17GR17	GRAB SMITH MCINTYRE	-16	30.163	139	53.663	27.60
17	276/17RD13	CORE ROTARY DRILL	-16	30.163	139	53.663	27.60
18	276/18CM01	CURRENT METER	-16	5.748	139	2.374	41.20
19	276/19CM02	CURRENT METER	-15	41.992	138	51.947	26.00
20	276/20CM03	CURRENT METER	-16	5.7	139	2.4	41.20
20	276/20CTD15	CTD	-16	5.7	139	2.4	41.20
21	276/21CAM21	CAMERA	-16	2.188	139	8.064	44.80
21	276/21CM04	CURRENT METER	-16	2.213	139	8.031	44.80
21	276/21CTD16	CTD	-16	2.222	139	8.022	44.80
21	276/21GR18	GRAB SMITH MCINTYRE	-16	2.221	139	8.021	44.80
22	276/22CAM22	CAMERA	-16	0.008	139	5.812	23.60
22	276/22CTD17	CTD	-16	0.055	139	5.799	23.60

22	276/22DR13	DREDGE CHAINBAG	-15	59.73	139	5.543	22.00
22	276/22GR19	GRAB SMITH MCINTYRE	-16	0.053	139	5.798	23.60
22	276/22RD14	CORE ROTARY DRILL	-16	0.053	139	5.799	23.60
23	276/23CAM25	CAMERA	-15	59.631	139	5.579	22.00
23	276/23CTD18	CTD	-15	59.653	139	5.495	22.00
23	276/23DR14	DREDGE CHAINBAG	-15	59.56	139	5.63	21.20
23	276/23GR20	GRAB SMITH MCINTYRE	-15	59.654	139	5.495	22.00
23	276/23RD15	CORE ROTARY DRILL	-15	59.653	139	5.495	22.00
24	276/24CAM24	CAMERA	-15	58.777	139	6.481	19.60
24	276/24CTD19	CTD	-15	58.777	139	6.496	20.40
24	276/24GR21	GRAB SMITH MCINTYRE	-15	58.777	139	6.496	20.40
24	276/24RD16	CORE ROTARY DRILL	-15	58.777	139	6.496	19.60
25	276/25CAM25	CAMERA	-15	59.289	139	5.102	23.60
25	276/25CTD20	CTD	-15	59.241	139	5.067	23.60
25	276/25DR15	DREDGE CHAINBAG	-15	59.299	139	5.161	23.60
25	276/25GR22	GRAB SMITH MCINTYRE	-15	59.292	139	5.114	23.60
25	276/25RD17	CORE ROTARY DRILL	-15	59.299	139	5.093	23.60
26	276/26CAM26	CAMERA	-16	1.008	139	7.425	25.60
26	276/26CTD21	CTD	-16	1.004	139	7.413	26.00
26	276/26DR16	DREDGE CHAINBAG	-16	0.885	139	7.367	26.80
26	276/26GR23	GRAB SMITH MCINTYRE	-16	1.009	139	7.423	26.00
26	276/26RD18	CORE ROTARY DRILL	-16	1.002	139	7.44	25.60
27	276/27CAM27	CAMERA	-16	0.515	139	7.447	25.20
27	276/27CTD22	CTD	-16	0.518	139	7.446	25.20
27	276/27DR17	DREDGE CHAINBAG	-16	0.375	139	7.505	26.00
27	276/27GR24	GRAB SMITH MCINTYRE	-16	0.058	139	7.447	25.20
27	276/27RD19	CORE ROTARY DRILL	-16	0.518	139	7.447	25.20
28	276/28CAM28	CAMERA	-15	57.81	139	8.44	29.60
28	276/28CTD23	CTD	-15	57.799	139	8.102	29.60
28	276/28DR18	DREDGE CHAINBAG	-15	57.936	139	8.332	29.60
28	276/28GR25	GRAB SMITH MCINTYRE	-15	57.801	139	8.101	29.60
28	276/28RD20	CORE ROTARY DRILL	-15	57.8	139	8.101	29.60
29	276/29CAM29	CAMERA	-16	3.04	139	1.867	18.40
29	276/29CTD24	CTD	-16	3.034	139	1.884	16.80
29	276/29DR19	DREDGE CHAINBAG	-16	3.081	139	1.86	17.20
29	276/29GR26	GRAB SMITH MCINTYRE	-16	3.061	139	1.949	16.80
29	276/29RD21	CORE ROTARY DRILL	-16	3.037	139	1.883	18.40
30	276/30CAM30	CAMERA	-16	3.28	139	1.444	20.00
30	276/30CTD25	CTD	-16	3.273	139	1.433	20.00
30	276/30DR20	DREDGE CHAINBAG	-16	3.577	139	1.424	24.00
30	276/30GR27	GRAB SMITH MCINTYRE	-16	3.282	139	1.431	20.00
30	276/30RD22	CORE ROTARY DRILL	-16	3.28	139	1.458	20.00
31	276/31CTD26	CTD	-16	4.022	139	1.88	27.20
31	276/31GR28	GRAB SMITH MCINTYRE	-16	4.027	139	4.027	27.30
31	276/31RD23	CORE ROTARY DRILL	-16	4.027	139	4.027	27.20

32	276/32CAM31	CAMERA	-16	2.89	139	3.092	26.40
32	276/32CTD27	CTD	-16	2.855	139	3.044	26.40
32	276/32DR21	DREDGE CHAINBAG	-16	2.896	139	3.199	26.40
32	276/32GR29	GRAB SMITH MCINTYRE	-16	2.885	139	3.094	26.40
32	276/32RD24	CORE ROTARY DRILL	-16	2.897	139	3.102	26.40
33	276/33CAM32	CAMERA	-15	57.106	139	10.141	38.00
33	276/33CTD28	CTD	-15	57.052	139	10.094	37.60
33	276/33DR22	DREDGE CHAINBAG	-15	56.126	139	10.154	38.00
33	276/33GR30	GRAB SMITH MCINTYRE	-15	57.052	139	10.082	37.60
33	276/33RD25	CORE ROTARY DRILL	-15	57.085	139	10.112	38.00
34	276/34CAM33	CAMERA	-15	28.107	137	55.109	18.20
34	276/34CTD29	CTD	-15	28.067	137	55.106	19.60
34	276/34GR31	GRAB SMITH MCINTYRE	-15	28.105	137	55.123	19.20
34	276/34RD26	CORE ROTARY DRILL	-15	28.105	137	55.123	19.20
35	276/35CAM34	CAMERA	-15	27.786	137	55.509	24.00
35	276/35CTD30	CTD	-15	27.798	137	55.495	23.20
35	276/35GR32	GRAB SMITH MCINTYRE	-15	27.777	137	55.521	23.20
36	276/36CAM35	CAMERA	-15	27.467	137	55.72	25.20
36	276/36CTD31	CTD	-15	27.461	137	55.698	25.60
37	276/37CAM36	CAMERA	-15	27.32	137	55.833	22.40
37	276/37CTD32	CTD	-15	27.315	137	55.84	22.40
37	276/37GR33	GRAB SMITH MCINTYRE	-15	27.315	137	55.84	22.40
38	276/38CAM37	CAMERA	-15	27.074	137	55.601	23.20
38	276/38CTD33	CTD	-15	27.066	137	55.603	26.40
38	276/38GR34	GRAB SMITH MCINTYRE	-15	27.067	137	55.597	26.40
39	276/39CAM38	CAMERA	-15	27.365	137	55.117	28.80
39	276/39CTD34	CTD	-15	27.37	137	27.37	28.80
39	276/39GR35	GRAB SMITH MCINTYRE	-15	27.37	137	55.132	28.80
40	276/40CAM39	CAMERA	-15	27.817	137	55.523	23.60
41	276/41CAM40	CAMERA	-15	27.852	137	55.373	23.60
42	276/42CAM41	CAMERA	-15	27.757	137	54.92	29.60
43	276/43DR23	DREDGE CHAINBAG	-15	27.76	137	54.891	28.00
43	276/43DR24	DREDGE CHAINBAG	-15	27.303	137	55.13	28.00
43	276/43RD27	CORE ROTARY DRILL	-15	27.77	137	54.885	29.60
44	276/44CAM42	CAMERA	-15	29.507	137	37.093	16.00
44	276/44CTD35	CTD	-15	29.489	137	37.115	15.60
44	276/44DR25	DREDGE CHAINBAG	-15	26.667	137	37.947	16.00
44	276/44GR36	GRAB SMITH MCINTYRE	-15	29.489	137	37.115	15.60
45	276/45CAM43	CAMERA	-15	29.372	137	37.854	29.20
45	276/45CTD36	CTD	-15	29.358	137	37.863	28.80
45	276/45DR26	DREDGE CHAINBAG	-15	29.365	137	37.743	29.20
45	276/45GR37	GRAB SMITH MCINTYRE	-15	29.358	137	37.863	28.80
45	276/45RD28	CORE ROTARY DRILL	-15	29.36	137	37.885	29.20
46	276/46CAM44	CAMERA	-15	28.303	137	38.21	31.60
46	276/46CTD37	CTD	-15	28.321	137	38.214	31.60

46	276/46DR27	DREDGE CHAINBAG	-15	28.297	137	38.208	31.60
46	276/46GR38	GRAB SMITH MCINTYRE	-15	28.312	137	38.19	31.60
46	276/46RD29	CORE ROTARY DRILL	-15	28.303	137	38.234	31.60
47	276/47CAM45	CAMERA	-15	28.501	137	37.616	33.60
47	276/47CTD38	CTD	-15	28.518	137	37.646	33.60
47	276/47GR39	GRAB SMITH MCINTYRE	-15	28.52	137	37.647	33.60
48	276/48CAM46	CAMERA	-15	28.781	137	38.7	41.60
48	276/48CTD39	CTD	-15	28.821	137	38.709	41.60
48	276/48DR28	DREDGE CHAINBAG	-15	28.639	137	38.415	31.00
48	276/48GR40	GRAB SMITH MCINTYRE	-15	28.818	137	38.712	41.60
49	276/49CAM47	CAMERA	-15	29.134	137	37.224	24.00
49	276/49CTD40	CTD	-15	29.157	137	37.378	24.40
49	276/49DR29	DREDGE CHAINBAG	-15	29.159	137	37.387	25.60
49	276/49GR41	GRAB SMITH MCINTYRE	-15	29.169	137	37.361	24.00
49	276/49RD30	CORE ROTARY DRILL	-15	29.139	137	37.416	25.60
50	276/50CAM48	CAMERA	-15	43.429	138	82.767	18.00
50	276/50CTD41	CTD	-15	43.405	138	52.755	18.00
50	276/50DR30	DREDGE CHAINBAG	-15	43.56	138	52.903	18.00
50	276/50GR42	GRAB SMITH MCINTYRE	-15	43.425	138	52.762	18.00
50	276/50RD31	CORE ROTARY DRILL	-15	43.408	138	52.722	19.20
51	276/51CAM49	CAMERA	-15	43.242	138	53.16	17.60
51	276/51CTD42	CTD	-15	43.273	138	53.091	17.20
51	276/51DR31	DREDGE CHAINBAG	-15	43.249	138	53.224	17.60
51	276/51GR43	GRAB SMITH MCINTYRE	-15	43.264	138	53.089	17.20
52	276/52CAM50	CAMERA	-15	43.3	138	53.071	16.40
52	276/52RD32	CORE ROTARY DRILL	-15	43.312	138	53.037	16.40
53	276/53CAM51	CAMERA	-15	41.937	138	53.952	24.80
53	276/53CTD43	CTD	-15	41.925	138	53.958	25.20
53	276/53DR32	DREDGE CHAINBAG	-15	41.869	138	54.064	24.80
53	276/53GR44	GRAB SMITH MCINTYRE	-15	41.925	138	53.958	25.20
53	276/53RD33	CORE ROTARY DRILL	-15	41.929	138	53.953	25.20
54	276/54CAM52	CAMERA	-16	5.842	139	2.318	41.60
54	276/54CM05	CURRENT METER	-16	5.731	139	2.429	42.00
54	276/54CTD44	CTD	-16	5.81	139	2.361	41.60
54	276/54GR45	GRAB SMITH MCINTYRE	-16	5.828	139	2.349	41.60
55	276/55CM06	CURRENT METER	-16	2.235	139	8.052	45.20
55	276/55CTD45	CTD	-16	2.332	139	8.222	39.00
56	276/56CAM53	CAMERA	-15	41.318	138	54.391	27.60
56	276/56CTD46	CTD	-15	41.302	138	54.391	27.60
56	276/56DR33	DREDGE CHAINBAG	-15	41.226	138	54.235	30.00
56	276/56GR46	GRAB SMITH MCINTYRE	-15	41.302	138	54.392	27.60
56	276/56GR47	GRAB SMITH MCINTYRE	-15	41.302	138	54.391	27.60
57	276/57CAM54	CAMERA	-15	40.924	138	54.903	44.00
57	276/57CTD47	CTD	-15	40.962	138	54.901	44.00
57	276/57DR34	DREDGE CHAINBAG	-15	40.767	138	54.972	44.00

57	276/57GR48	GRAB SMITH MCINTYRE	-15	40.954	138	54.907	44.00
57	276/57RD34	CORE ROTARY DRILL	-15	40.952	138	54.923	44.00
58	276/58CAM55	CAMERA	-15	39.806	138	53.707	22.00
58	276/58CTD48	CTD	-15	39.801	138	53.73	22.00
58	276/58DR35	DREDGE CHAINBAG	-15	39.854	138	53.674	22.00
58	276/58GR49	GRAB SMITH MCINTYRE	-15	39.836	138	53.691	22.00
58	276/58RD35	CORE ROTARY DRILL	-15	39.836	138	53.679	30.40
59	276/59CAM56	CAMERA	-15	39.993	138	52.725	24.40
59	276/59CTD49	CTD	-15	39.994	138	52.918	26.80
59	276/59DR36	DREDGE CHAINBAG	-15	40.087	138	52.705	24.40
59	276/59GR50	GRAB SMITH MCINTYRE	-15	39.996	138	52.906	26.80
59	276/59RD36	CORE ROTARY DRILL	-15	40.017	138	52.829	26.40
60	276/60CAM57	CAMERA	-15	41.632	138	51.693	24.00
60	276/60CTD50	CTD	-15	41.631	138	51.674	24.00
60	276/60DR37	DREDGE CHAINBAG	-15	41.64	138	51.69	24.00
60	276/60GR51	GRAB SMITH MCINTYRE	-15	41.643	138	51.676	24.00
60	276/60RD37	CORE ROTARY DRILL	-15	41.645	138	51.665	24.80
61	276/61CAM58	CAMERA	-15	39.111	138	49.684	29.20
61	276/61CTD51	CTD	-15	39.082	138	49.693	29.20
61	276/61DR38	DREDGE CHAINBAG	-15	39.323	138	49.679	29.20
61	276/61GR52	GRAB SMITH MCINTYRE	-15	39.067	138	49.717	29.20
61	276/61RD38	CORE ROTARY DRILL	-15	39.088	138	49.729	29.20
62	276/62CAM59	CAMERA	-15	37.868	138	51.22	27.60
62	276/62CTD52	CTD	-15	37.897	138	51.216	28.00
62	276/62DR39	DREDGE CHAINBAG	-15	37.831	138	51.265	27.60
62	276/62GR53	GRAB SMITH MCINTYRE	-15	37.892	138	51.199	28.00
62	276/62RD39	CORE ROTARY DRILL	-15	37.803	138	51.237	27.60
63	276/63CAM60	CAMERA	-15	37.392	138	51.771	30.80
63	276/63CTD53	CTD	-15	37.185	138	51.805	30.80
63	276/63DR40	DREDGE CHAINBAG	-15	37.315	138	51.771	30.80
63	276/63GR54	GRAB SMITH MCINTYRE	-15	37.186	138	51.856	30.80
63	276/63RD40	CORE ROTARY DRILL	-15	37.14	138	51.815	30.80
64	276/64CAM61	CAMERA	-15	36.293	138	49.998	20.00
64	276/64CTD54	CTD	-15	36.284	138	50.041	20.80
64	276/64GR55	GRAB SMITH MCINTYRE	-15	36.297	138	50.012	20.80
65	276/65CAM62	CAMERA	-15	36.108	138	49.008	26.40
65	276/65CTD55	CTD	-15	36.133	138	49.019	26.40
65	276/65DR41	DREDGE CHAINBAG	-15	36.13	138	48.937	26.40
65	276/65GR56	GRAB SMITH MCINTYRE	-15	36.111	138	49.008	26.40
65	276/65RD41	CORE ROTARY DRILL	-15	36.119	138	49.031	26.00
66	276/66CTD56	CTD	-15	33.15	138	46.93	59.20
66	276/66GR57	GRAB SMITH MCINTYRE	-15	33.199	138	46.936	59.20
67	276/67CAM63	CAMERA	-15	36.153	138	46.834	29.60
67	276/67CTD57	CTD	-15	36.126	138	46.885	29.60
67	276/67DR42	DREDGE CHAINBAG	-15	36.188	138	46.676	29.60

67	276/67GR58	GRAB SMITH MCINTYRE	-15	36.132	138	46.828	29.60
67	276/67RD42	CORE ROTARY DRILL	-15	36.117	138	46.949	29.60
68	276/68CAM64	CAMERA	-15	35.128	138	47.045	22.80
68	276/68CTD58	CTD	-15	35.021	138	47.112	22.80
68	276/68DR43	DREDGE CHAINBAG	-15	35.128	138	47.039	22.80
68	276/68GR59	GRAB SMITH MCINTYRE	-15	35.033	138	47.118	22.80
68	276/68RD43	CORE ROTARY DRILL	-15	35.009	138	47.119	24.00
69	276/69CAM65	CAMERA	-10	57.888	136	47.912	112.00
69	276/69CTD59	CTD	-10	57.914	136	47.923	112.00
69	276/69GR60	GRAB SMITH MCINTYRE	-10	57.915	136	47.923	112.00
70	276/70CTD60	CTD	-11	12.435	134	44.423	42.00
70	276/70GR61	GRAB SMITH MCINTYRE	-11	12.43	134	44.438	42.00
71	276/71CAM66	CAMERA	-11	13.41	134	44.582	18.80
71	276/71GR62	GRAB SMITH MCINTYRE	-11	13.436	134	44.553	18.80
72	276/72CAM67	CAMERA	-11	13.952	134	44.522	22.00
72	276/72GR63	GRAB SMITH MCINTYRE	-11	13.896	134	44.564	22.00