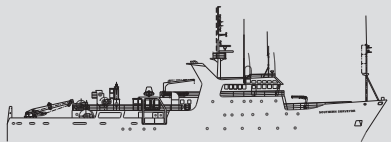

MARINE
NATIONAL FACILITY

2008 program

RV *Southern Surveyor*

CSIRO

voyage summary SS12/2008

SS12/2008

Submarine landslides and mass sedimentation model for the SSE Australian margin.

Voyage period
05/11/2008 to 21/11/2008
Port of departure: Newcastle Australia
Port of return: Sydney Australia

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Scientific Objectives

On this voyage we planned to 1): investigate the potential for underwater landslides to generate tsunamis that would impact the coastline of NSW and Queensland; 2) develop and test a model for gravity driven sedimentation on the deep water margin of SE Australia. Our recent work indicates that underwater landslides have occurred on this margin before and will occur again in the future. We aim to estimate the size of the slides, their likely location and frequency of occurrence. This will enable an assessment of the threat posed by tsunamis in eastern Australia, a potential natural disaster capable of affecting national infrastructure and productivity.

Voyage Objectives

The scientific objectives were met on the SS12/2008 voyage by:

1) Conducting a regional survey using EM300 multibeam (MBES) and Topas high resolution seismic (HRS) equipment to map the seabed of the eastern Australian margin seaward of the second most populated coastal region of Australia between northern NSW and the Sunshine Coast, including the

Brisbane and Gold Coast regions (see voyage track). We concentrated on the continental slope, the steepest and most landslide-prone region of the margin lying approximately between 100 m and 4500 m water depth.

2) Identifying the locations of major landslides found on the multibeam and seismic data. We investigated the sediment distribution in these regions by means of Smith McIntyre grab samples, dredges, and by coring the slide scars to identify their sediment character and age.

3) Finally we ground truthed the MBES and HRS data with a number of regional sediment grab samples to determine sediment composition and dispersal mechanisms on the margin, followed by dredging in any major canyons discovered to determine the makeup of the margin stratigraphy in this area.

Results

1) Approximately 3,000 line km over an area of 13,000 square km was successfully surveyed for MBES echo sounder data, and approximately half this amount for Topas seismic data. As a result we have completely surveyed the continental slope, the area of most concern for geohazard occurrence, between 26.5-29.5 degrees S, and 154.4 degrees E and the 80 isobath (i.e., from the Clarence River Mouth NSW, to off Noosa Heads, Queensland)

2) We discovered two extensive regions of landslide occurrence separated by a large submarine plateau of continental crust. The first region was in the north off the Sunshine Coast while the second region was in the south and extended from the Clarence River to the Gold Coast. Both regions had large and frequent landslide scars up to 10 cubic km volume on the upper continental slope and resembled the frequent landslides encountered on previous voyages north and south of the current study location. As a result of these voyages the margin is considered a degradational one dominated by landslides, gravity mass transport and erosional canyons but lacking the constructional morphology seen on other margins such as submarine channel, levee and fan features.

3) A number of successful cores were taken in the landslide scars and encountered basal submarine slide surfaces at distances of 50-200 cm from the seabed. Based on sediment accumulation rate, these sediment thicknesses indicate that the landslides are relatively recent and of Late Pleistocene to early-mid Holocene age. Regional sediment data collected indicated that the material sliding down the continental slope is primarily made up of pelagic carbonates and hemipelagic mud on the continental slope and cemented carbonate banks and river delta deposits in shallow water at the shelf edge.

4) The consolidated rocks dredged from the sides of submarine canyons show that Mesozoic-Tertiary sedimentary basins extend from the Maryborough and Clarence-Moreton basins onshore to the base of the current continental slope.

Voyage Narrative

(times in AEST = UTM/GMT – 10hrs)

Day 1: Wednesday, November 5, 2008

Ship departed Forgacs Shipyard Newcastle at 10:00 hours and proceeded to a point around 3 miles NE of the harbour entrance, passing over and mapping an exposed shoal. The ship then turned and ran down a line approximately due East to a point SE of Port Stephens in 1000 m water depth, collecting Multibeam Echosounding (MBES) data and Topas seismic data enroute. Along the way a safety induction was performed at 11:00 and at the end of the line around 14:00 a CTD/XBT calibration test was run and a sound profile for the MBES collected. The ship then turned N to a position inshore of the existing MBES swath coverage and collected additional swath coverage north just seaward of the shelf break.

A new line was taken off Forster to map the occurrence of a series of linear carbonate banks on the upper slope in around 160 m water depth. These features had a broad flat top and a scoured trough on the landward side up to 20 m deep. The seaward side also had a relatively steep slope. After crossing the majority of these features that appeared on the 1:250,000 National Mapping sheet, the ship track moved back out to the edge of the previously acquired swath data set and continued to the north.

Day 2: Thursday, November 6, 2008

The ship continued northward on the inside of the previously acquired swath data until a point off Port Macquarie where a new course was laid to cross a series of long ridges on the upper continental slope in around 180-250 m depth in the early morning hours of November 6 around 02:00 – 04:00 hours. After crossing these ridge features, the ship track returned to the margin of the existing swath coverage on the transit north. Initially this track was on the inside as far north as South West Rocks, then it switched to the outside and then back to the inside north of Coffs Harbour. On the outside tracks the bathymetry was rough and Topas data collection became difficult and was eventually switched off. Around 15:30 the northward swath track was ended and the ship transited due E to 1050 m water depth to collect a CTD/XBT comparison station. Topas was run down the slope as a continuation of Line 9.

After completion of CTD/XBT station the ship resumed a northerly course and joined the end of a swath line heading between previous swath lines to extend coverage on the voyage north. Topas data collection was resumed near the turn onto the northward swath line and was continued as line 10. When data became of poor quality in rough terrain Topas line 10 was completed and switched off, and later line 11, in smoother bottom conditions, was begun. Near the end of the long transit north on Topas lines 10 and 11, line the ship crossed to the outside of the swath coverage to line up the first line of the official Survey.

Day 3: Friday November 7, 2008

Day 3 began with running north into the official survey area on Line 12 (MBES Line 52). Weather was fine and the seas calm. In deep water off the Ballina Canyons, the Topas was ineffective, and was left switched off. XBT drop was successful at 02:00. Topas was restarted towards the end of the line when sea floor became smooth as it rose to 450 m. Penetration of 10 ms through parallel reflectors overlying a strong reflector continued till the end of the line. Turned to starboard just north of Tweed Heads and started Line 13 (MBES Line 58) south parallel to previous line. Turned Topas off because of poor returns once a slump scarp and slump material was crossed and water depths increased.

Ended line 13 just north of Cape Byron after crossing several tributaries of a major canyon system (Tweed Canyon). Started Line 14 (MBES line 61) at 07:53 hours to the east of previous line and heading north and turned on Topas near end of line when water depth 1140 m. Turned to NNE for new line (Topas line 15; MBES line 62 cont,.) to follow down-slope side of line collected during previous cruise. Rough topography (slumps?) gave no meaningful information and Topas interfered with MBES so ended that operation. At 10:40 turned north for a long line across the top of the marginal plateau on Topas line 16 with external trigger making good speed at 10.3 kts. The sea floor has hummocky topography with 10-20 relief and penetration of bedded sediments of 10 ms on eroded basement.

Completed southward Survey Line 13 at southern end of survey off Cape Byron and turned northward along Survey Line 14 (parallel to previous Line 13). Topas data in rougher deeper water was of poor quality. Survey Line 15 was conducted in NE direction parallel to existing swath coverage, then turned N off Burleigh Heads to conduct the long Survey Line 16. Topas Line 16a begun around 10:40 and data quality was good for around 50% of this line, showing conformably bedded sediments eroded by gully topography and overlying earlier cycles of erosion. The line then bent to the NW and descended into a series of deeper canyons near the last known position of HMAS Centaur and the Topas data quality deteriorated and it was turned off around 14:00. Survey line 16 then traversed the larger canyon features until it ended around 17:00 off Cape Moreton which was also the end of MBES71. A successful XBT was deployed at the end of this line at 16:55 as it was the most northern point of the survey to date. A joining line was run (MBES72) and then we commenced Survey Line 17 heading SE toward the bend on MBES73. No Topas was run as water depth was still too great and topography too rough. Approximately off central Moreton Island Line 74 was broken to allow a ship to pass through, a loop was steamed and then Survey Line 17 was recommenced running MBES 75 to the bend still with no Topas. MBES 77 was begun at the bend around 20:34 off N Stradbroke Island. Topas was turned on Line L17a around 20:50 and produced good data still heading S. The rest of day 3 was spent on completing Survey Line 17. The Topas data remained good quality until 23:45 when deeper water and several canyons were encountered and Line 17a was terminated. The remainder of Survey Line 17 continued on into Day 4 heading south.

Day 4: Saturday November 8, 2008

Continued multibeam survey south on line 17 and MBES80 till just north of Cape Byron in small canyons approximately 2500 m water depth. Commenced survey line 18 and MBES81 at 01:29 on a reciprocal course to the north and seaward of the previous line. The seas were calm and the ship speed was ~10 kts into the EAC. At 03:54 started Topas line 18a in water depth of 1290 m and rising relatively steeply over several small canyons offshore of Tweed Heads. The water depth stayed at around 1200 m for this Topas line. The record revealed irregular topography with relief of 10-50 m and a similarly irregular strong 'basement' reflector sometimes exposed at the sea floor and sometimes buried by up to 20 ms of sediment with parallel internal reflectors. These reflectors appear to drape the underlying basement topography. The sediment reflectors are truncated by scarps on the sea floor and some sediment may be debris flow deposits.

Topas line 18a ended at 08:51 when the water depth increased to 1560 m as we approached a canyon some 25 nm east of Point Lookout at the northern tip of North Stradbroke Island. Data quality for the Topas line was good and useful for interpreting the multibeam data. The weather was overcast and the wind increased to 20-25 kts during the morning. At the end of Topas line 18a the survey line 18 turned some 10 degrees to port to trace a more NNW course running MBES88.

At 08:55 had to adjust the survey line 18 to the west by 365 m because of narrower swath in extra deep mode as we crossed canyons. The northern flanks of the canyons were reached at 09:30 and relatively smooth sea floor continued at 1800-2500 m until more major canyons at 10:15. While crossing these canyons we lost the ping on the multibeam on MBES90 and it had to be rebooted. The ship slowed to 6 kts to minimise the gap in data along the line. Rebooting was successful and data collection commenced at 11:00 on MBES94 and we looped back to starboard to redo the survey line where data was missing. By 11:30 the ship was back on course on SL18 and filled the data hole.

By the end of watch at 12:00 we were due east of Cape Moreton on the northern tip of Moreton Island and some 25 nm seaward in ~3,000 m of water on the northern side of a canyon system. Subsequently, the ship continued NNW across a region of deeper water around 3000 m and imaged a number of isolated rises and depressions on the seaward side of the line. Near the middle of the transit across this deeper water basin off the Sunshine Coast, the ship had to slow to 5 kts to avoid a another ship in its path for around 20 minutes. Survey line 18 then continued northward to approximately E of Noosa Heads and turned tightly to begin Survey Line 19 heading SSE parallel to SL 18. Topas Line 19a was a short line that collected minimal data at the shallow water turn around point. As we moved into deeper water the Topas data became poor and it was switched off. Survey Line 19 was completed south to a point off Cape Moreton with no further Topas data. After a turn to starboard, the ship commenced SL 20, north again to off Noosa Heads and parallel to SL 19. In the middle of these lines the MBES data was near the boundary of very deep mode and extra deep mode and shifting between these saw the swath coverage narrow and widen, resulting in some gaps in the data. Subsequent lines were shifted slightly to try and reduce the problems due to mode switching. A single line (SL 20) was not sufficient to fill the existing gap so an extra line (SL 21) was added to accomplish this. The remainder of Day 4 was spent in traversing

NNW to SSE infilling the continental slope between Noosa Heads and Cape Moreton along SL 21 and turning again to the N to start SL 22 on the landward side. Topas data (L21a) was collected on the northern turn at the end of SL 20, and the southward beginning of SL 21 before it headed into deeper water. Sound velocity was of good quality throughout the day and no further CTD or XBT deployments were conducted.

Day 5: Sunday November 9, 2008

The next data collection period for MBES concentrated on filling in gaps in the coverage in the area between Noosa Heads and Cape Moreton and 20-40 nm seaward. A short segment of Topas data (L22a) was collected near the end of SL22 starting in 900 m of water. Irregular topography with 20-40 ms of relief was characteristic but subsurface reflectors were fuzzy. At 03:12 we turned to follow the upper slope (water depth. 267 m) heading SSW (1900) for SL23 (MBES116) with Topas collecting good data (L23a) showing a hard reflector rising to the sea floor to form pinnacles (see record at 18:01 to 18:03UTM) and onlapped by sediments (maximum thickness 25 ms) and cut by small canyons/gullies. At 03:20 and XBT (drop 8) was successful in 280 m of water. The data was not used as the MBES data was good. Survey line 23 was continued through a bend to head 1640 and ended in water depth of 280 m. Survey line 24 and Topas L24a were short to the east down the slope as we filled in 'holidays' (data gaps). At 05:43 we turned north to start SL 25 and Topas L25a in 1000 m of water. Topas data showed disorganised slump sediments along with a coherent bedded sediment block before ending L25a as water depth increased. Line 25b was started in 880 m of water but only lasted for eight minutes as water depth increased. At 07:28 we headed NE on SL26 (MBES122) and L26a. During this line we passed over undulating topography in 660 m of water (260 33.402'; 1530 49.154'). The depressions are ~10 m deep and have a wavelength of ~1500 m and parallel bedding (50 ms penetration) mimics the sea floor similar to aggrading dunes (Note: these depression may be the 'scour/flute like' holes seen on the MBES). At 08:20 we ended SL26 and turned to port for a short, 4 km, survey line 27 and Topas L27a going up slope to the NW where we turned again to port to head 2220 on survey line SL28 (MBES124) and Topas line L28a. This Topas line showed a hard (?) sea floor with subsurface reflectors that come and go down to 30 ms. At 09:04 we again turned to port to run down slope to the south on SL29 and Topas L29a. We recorded a good trace of parallel reflectors (50 ms) going down slope til they were truncated by a slip fault (400 m water depth. see 2222UTM) that reached the sea floor and displaced sediment down slope. At 09:30 hours the Topas line ended in 1080 m of water. SL29 ended in 1345 m water depth.

This completed our infilling of gaps in the data and we turned to starboarded heading SW towards Cape Moreton starting SL30 in a canyon 1673 m so Topas L30a was aborted with no data. At 10:50 we started L30b collecting data as we went up the axis of a canyon and profiled debris and a slump block and the crown scarp at its head. This survey line continued onto the shelf to water depth of 213 m. Line SL31 and L31a were short to the north before we turned east again (0780, water depth. 201 m) for SL32 and L32a. This line revealed spectacular buried sand bodies. When we reached the edge of the surveyed area at 11:15 we turned south to follow the hardground outcrop that forms a ledge at this depth (SL 33, L33a, water depth 244 m). This surface has very irregular 'karst-like' topography in places.

The midnight to midday shift had no equipment or software problems and the ship maintained a speed of 10-11 kts. The weather was overcast. The seas were calm at the start of watch but wind increased along with sea state later in the watch.

On the second shift of Day 5, the ship continued a long line (SL33) south, initially along the carbonate bank escarpment in around 200-300 m water, running Topas line L33a in Ricker mode. This line took a bend to the east to follow previous swath coverage and depth increased to 800-1200 m at the western margin of several large canyons. Topas data rapidly deteriorated despite Chirp mode being selected in Line 33b and the Topas was turned off at the end of Line 33b at 13:12. The line continued southward in around 800-900 m depth off the edge of the carbonate bank approaching the latitude of South Passage between Moreton and Stradbroke Islands. Topas was then turned back on as the bottom was relatively flat and produced reasonable data on Chirp L33c starting at 14.46. Line 33 was continued S and Topas data collected on L33c until 16:47. The heads of several large canyons were traversed and then SL33 continued across the central Nerang Plateau. Depths decreased and the topography was relatively subdued so the Topas was switched on again for line L33d at 17:49. At 18:30 a 15 m thick slide was imaged on Topas L33d. Weather continued to deteriorate along SL 33 and the Topas record was noisy and the MBES 300 missed numerous pings due to cavitation under the gondola. However, the Topas system continued to function during the long southern transit on SL33 and produced good data with up to 50 ms of penetration, imaging laminated strata with an undulating style and several internal unconformities and channel features south to 21:00. The MBES continued to experience poorer data with yaw problems crabbing across the line and missed pings. At 21:16 we switched to SL34 heading 2100 to fill a hole in the swath further inshore and then shift over to the inside of the existing swath coverage. As we transited through the data gaps, we encountered two canyons, the first a narrow rill style and the second a broader amphitheatre tributary style. Topography was rough and deep so the Topas was switched off in this area, ending line L34a at 22:11. Penetration in the region of the southern slab slides was minimal suggesting either gas or some lithification. However, lithification does not correlate with the onion skin style of slab sliding so gas might be a more likely reason for low penetration.

With Topas still off, the ship turned S on SL35 at 23:00, still in the upper part of the Byron Canyon. As we exited the canyon we shifted to the inside of the existing MBES coverage and climbed up the carbonate platform outer escarpment from 600 m depth onto the platform around 200-250 m. At the end of the shift we remained on SL35 running L35a Topas. Most of this line since rising above the edge of the carbonate platform has been an irregular hard ground surface.

Day 6: Monday November 10, 2008

At the start of watch the ship was heading south 20 nm off Cape Byron under overcast skies on SL35 (MBES145) in 230 m of water following the upper slope. Ship speed slightly reduced to 9 kts due to rough seas with winds 20-30 kts from the SE. At 00:20 we changed course to 2000 to map the heads of the canyon system offshore of Ballina and the Richmond River. Topas (Ricker pulse) was able to record a hard rough sea floor as we followed 200 m isobath (approx.). At 01:10 we turned south on the same line and

a thin veneer of sediment (10 ms) on-lapped the hard ground just before we crossed three small canyons with ~100 m of relief. Weak reflectors were detected below the hard ground reflector adjacent to the canyon walls. At 01:56 we crossed a 20m high ridge/pinnacle of hard ground rising to 195 m water depth with a moat on the north side with a sediment levee on-lapped by younger sediments. The south side of the ridge was exposed hard ground. Unfortunately the quality of the bathymetric data was poor along this line due to the rough seas. The lack of an expected sediment wedge of deltaic deposits on the slope above these canyons requires explanation. Line 35 ended at 02:20.

We then made a broad turn to port to run two lines to fill data gaps. Line 36 (MBES148) eventually began at 02:45 in water depth of 560 m heading north along slope after slowing to avoid a ship. MBES changed from medium to deep mode. Topas L36a was attempted but data very poor and no records of any use. SL36 ended at 04:37 (MBES150) just south of Cape Byron and we turned to starboard for start of next line south to fill the remaining gaps. Line 37 started at 04:48 in 1051 m water depth and heading 1850. This line ended at 06:00 in water depth 1062 m off Ballina.

The next series of lines to be surveyed were in new territory 4nm to the east and running N-S. While manoeuvring during the turn to minimise ship motion in the rough seas another ship was detected coming south along our next line! We decided to skip the first line and go to the second line and run north along it. SL38 started at 06:30 heading north in water depth of 2238 m. The MBES data improved with following seas. Before the end of the line we made XBT drop 10. The first XBT failed but the second was successful and the profile was entered during the turn at the end of the line (08:48) when the ping could be turned off without loss of data.

Line SL39 (MBES155) started at 09:00 in 1280 m water depth and 20nm ENE of Cape Byron. This line was the one missed and lies between lines 37 and 38. Winds still 20-25 kts and seas moderate. While running south along this line it was noticed that the beams had an unusual pattern on the display. This issue with beam steering has the experts puzzled (!) and remains unresolved. The line ended at 11:10 in 1892 m water depth and the ship turned to port to join the start of SL40.

For the next approximately 4 hours SL 40 was run to the north until 15:45 and then a long turn to the SE was made to bring the ship on to SL 41 running to the south. MBES data was collected with fair quality but no Topas. This line began around 16:30 off Burleigh Heads and continued S. As the ship was in shallow water, traversing along a gradually increasing slope into the Byron Canyon, the Topas was started while in the turn and Line L41a commenced at the start of SL 41 at 16.32. Weather remained poor with 30 kts winds from the S and 3 m seas. Speed along SL 41 was slowed to around 7.5 kts making this SL a slow one into the sea. The Topas provided good to fair data until the northern edge of Byron Canyon around 18.30 when it was switched off. The line then continued to its southern limit off Ballina at 22:58 local time. The southern end of this line had poor MBES data and an unswathed strip was left on one side. The final segment of the line was shifted west to avoid missed swath. At 22:03 SL 42 was commenced heading N. The first part of this line was run on manual ship control to fit to the last segment of SL 41. No further Topas was collected on Line 41 as water was too deep and weather too rough.

Day 7: Tuesday November 11, 2008

Day 7 was spent initially completing MBES data acquisition in the SE corner of the study area off Ballina and Byron Bay, taking up SL 42-46 (MBES171-180). These lines are in 2500-3500 m of water. The winds were 30-40 kts and seas rough. During SL45 at 06:35 the MBES stopped pinging. It was successfully re-booted as we did a loop to start the line again at 07:30. Several shorter lines were completed in a N-S orientation and then the ship traversed NW on SL 47 MBES180-181) filling in several small gaps in the data before climbing up on the shelf edge and traversing N along it on SL 50 with Topas L50a beginning at 12:06 while on MBES 182 and MBES 183 began soon after at 12:10 some 15 nm off Ballina Head. A scientific meeting was held from 13:00 to 14:30 providing an update of the voyage. During this time the ship traversed N and NNE acquiring MBES and Topas data along the landward side of the existing swath coverage in relatively shallow water of 100-250 m depth. This line passed several large canyon heads (Richmond and Tweed) while continuing a sinous path to stick close to the depth contours.

After completing the line up the landward side of the swath, the line continued to pick up a large gap in the swath coverage on the inner shelf heading N. However after a short time on this line at 18:31 we were forced to break the line due to a ship on the same course as ours heading S. We took this time to fill in several small swath gaps from earlier coverage before coming back on to the line and heading N again at 19:53 on Topas L51a, MBES 194.

Day 8: Wednesday November 12, 2008

The ship was 25 nm east of Moreton Island when the morning shift started. Winds were 22 kt from the SE and the seas were moderate. The survey continued on SL51 (MBES199) and Topas L51b heading 3460. At 01:30 we lost Topas data as water depth increased beyond 800 m. Survey line 52 was to 2990 and Topas was switched on with water depth. 600 m. At 02:28 at the start of SL53 XBT drop 11 was successful and the velocities implemented. At 03:10 in 235 m water we turned we turned to port to go WSW up slope for SL54 and a Topas transect. We ended SL54(MBES202) and L54a in 207 m water. The sea floor was rough hard ground which was buried by sediment up slope. The next line was on a reciprocal course and adjacent on the north side. This line (SL55, L55a) started in water depths of 183 m and we slowed to 6 kts with the aim of getting better quality data. The line ended after collecting good data down slope to 400 m. From there we continued along slope at reduced speed heading 3520 and crossed a steep drop which forms the southern margin of a slab slide. It has an unusual moat at its base with rough surface. A smoother seafloor continued till another drop into a narrow channel which on MBES looks like a recent slide and possible core site. The floor of this was not clearly resolved by Topas. We continued across the northern flank to the end of SL56 (E204, water depth 442 m) and L56a before turning west to go up slope for SL57 and L57a.

At 06:24 these lines ended in 204 m of water and 30 nm east of Caloundra. The wind picked up to 28 kts as we turned to starboard to run a reciprocal course to the east for the next line which ended in 800 m of water. This line showed the hard ground mostly buried by sediment and regularly bedded hemipelagic sediment down slope which had failed and formed a steep scarp. Below the scarp

the bottom was detected by no sub-bottom strata. We switched off logging the MBES at the end of this line (MBES205) and proceeded to the first dredge site.

At 08:20 we were manoeuvring to approach the dredge site from the east. The target scarp runs approximately N-S on the north side of a ridge. It has about 150 m of relief with an average slope of 260. The wind was 20 kts from 1630 and seas moderate. The ship stopped some 1000 m from base of cliff in water depth 1240 m. At 08:52 the dredge was in the water and lowered at ~70 m/min. The ship moved slowly towards the base of the scarp as wire was played out and reached the bottom at 1109 m of water. More wire was played out as the ship moved to the top of the scarp w.d. 1015 m. We started pulling in at 09:45 after some moderate 'bites'. The dredge was on deck at 10:15 with several kilograms of semi-consolidated mudstones and grey hemipelagic sediments. By 10:35 we were on our way to dredge station 2. This site was another head wall scarp above a debris slide with an average slope of 250 on the north side of the same ridge as dredge 1. The target was from the base of the scarp at 1640 m to the top at 1450 m. Due to drift conditions the dredge reached the bottom when the ship was in water depth of 1601 m part way up the scarp. Eighteen hundred meters of wire was played out. There were no significant bites and the dredge was off the bottom at 12:35 and on deck soon after with some more mudstones. It appears that the top of this ridge is capped by weakly lithified mudstones with a thicker (>200 m) of moderately lithified mudstone beneath. These mudstones are non-calcareous which is significant as it implies they are not marine.

After Dredge 2 was completed the ship moved to deeper water of 2773 m and collected grab sample GR1 at 04:21. The sample was successful and was composed of foraminiferal ooze (sandy silty clay sized) with an oxidised surface layer of around 1-2 cm. After the previous dredge attempts (DR 1 & 2) returned mainly semi-consolidated mudstone, it was felt that by dredging at a deeper stratigraphic level it may be possible to sample a lower stratigraphic unit. Consequently, Dredge 3 was attempted near GR 1 in 2612 m water at 05:56. This dredge was in the water for around 1.5 hours and was successful, returning brown mudstones that were more consolidated than the previous two dredges and also contained lithified crusts that appeared to be manganese and/or glauconitic in nature. Following this dredge, the rest of Day 8 was taken up by acquiring 4 further grab samples (GR 2-5). These were taken between 20.30 and 23:35 on a westerly transect up the slope beginning in 1327 m and ending 252 m. These samples were mainly foram ooze in deeper water with a small but increasing macrofaunal content into GR4 containing echinoderms, bivalves and gastropods. GR5 was quite different in shallow water, containing mainly bioclastic carbonate sand stained orange brown. This sample was a medium sand with a broad faunal diversity that appeared to be a mixture of modern and relict material, with many echinoderm spines, forams, gastropods, bivalves etc.

Day 9: Thursday November 13, 2008

Following the Smith- McIntyre grab station (GR5) the ship headed 0110 at 10 kts on survey line SL59 (MBES206) and Topas L59a at 23:43. The line started in water depth. 245 m and followed the upper slope on the western margin of the existing lines. The ship was 30 nm east of Caloundra Head and the weather was overcast, seas moderate and winds 20-30 kts from 1380. There was a small

change in course to the line to 0390 at 00:45. At 00:53 we had to slow to 6 kts to allow a cruise liner to cross our bow. The Topas profiled the hard ground during the first part of the line and it was onlapped by sediments as we went north with a strong reflector coming and going at about 20m subsurface. At 02:10 the hard ground reappeared as the sea floor rose to 200 m water depth and it is then truncated by a scarp shortly before the end of the line in 293 m of water.

The next line (SL60; MBES208) was to fill in gaps in the northern part of the survey area. It went south down slope across several small canyons that trend east into a lager canyon (Noosa Canyon?). The line ended in water depth 2174 m and it was followed by two more parallel lines (SL61, SL62) to the east that extended the coverage to the north to 45 nm east of Noosa Head. Turns were made in existing lines where possible to maximise data coverage in the time available. The northern ends of the lines were in canyon country and relatively shallow (~1000 m) whereas the southern ends were in 3300-3500 m of water and at the limit of the MBES. Nevertheless we did collect good data for this area. The final line (SL63; MBES216; water depth. 2479 m) was as short line to the west to map the northern side of the major cannon at the north of the area and whose southern sides were dredged successfully yesterday. The MBES logging was then turned off and we continued west to the first core site.

The core site was located down slope from a scarp where a slab of sediments appears to have slid off the slope. The target was one of several 5-10 m depressions in this surface. They are a 200-400 m wide and trend down slope. Topas was able to pick a strong reflector beneath a thin (2-5 m) layer of transparent sediment and along with the real-time location on a fledermaus seafloor were of great assistance in visualising and recording what was being sampled. There was a delay of about an hour when we got the gravity corer (GA's Thomas) in the water because of the electronics in the block failed to give a reading for the wire out/wire speed. It was soon decided to lower the core at fast speed and watch the tension graph which was working. With this, along with a jump in the block, we were easily able to tell when the corer hit the sea floor. Wind and currents combined to make it impossible to hold the ship on a small target but Topas and fledermaus were able to show we did core in a 400 m wide depression with 10 m of relief a short way down slope from the target in 841 m of water. The coring operation itself went smoothly for the first attempt for this cruise. Once in the water it was down and back in 20 minutes and another 30 minutes to retrieve the core in one meter lengths before the ship could get underway for the next operation. This site is 40 nm east of Point Cartwright. The core proved to have 4.14 m of sediment fill. All of this was an olive green silty clay mainly containing foram ooze with little stratigraphy. The core was firm throughout but not overconsolidated, it was burrowed and became darker and gray-brown towards the base but no clear surface was seen in the core. Hence this location either has no modern sediment on the surface and the seabed is bare and we are sampling the base of the slide surface, or there is a thick Pleistocene fill over the slide surface and it is old. A C14 date at the surface will be required to determine if the surface is old or not.

By 11:35 we were underway to the SSW for the next core station. At 11:55 were approaching the core station. The core was located in a small bowl shaped depression and was sited to sample the basal unit of 4 layers that had failed. The first attempt (GC2) was on bottom around 01:22 in 552 m but drifted over the target and sampled the next

layer exposed to the west (either a younger stratum or some slumped material). This core site was attempted again (GC3) and this time the ship drifted a little more to the north. The core hit bottom at 02:30 in 759 m depth in the bowl but around 250 NW of the target. This still looked like a good site on a slide surface so we considered the site accomplished and completed the two core sites at this location. The next dredge sites were located over 30 km to the S so the ship moved on course 3000 6 km and began a SL 65 on a bearing of approximately 165, running Topas L65a and MBES 220 filling in extra area on the inside of the existing MBES coverage near several inshore boxes where Topas profiles had previously been run. After 9 km the line moved further to the west but parallel to the earlier course and continued as L65a to the south and then further along a dog leg to the S until the line ended L65a at 17.30. The ship then made a turn back to the N (running L 65b first in the turn) and then while running back to the N ran SL 66 and L 66a. Both lines 65 b and 66a were of low quality and bottom tracking was difficult. These lines were run to extend swath coverage and fill holes while the crew were having dinner prior to the next dredge deployment.

Dredge 4 was designed to sample the outcropping seaward margin of the carbonate platform hard ground in around 320 m depth. The dredge was put in the water 08:32 hit bottom around 11 minutes later and experienced several very strong bites before breaking free. When the dredge was retrieved at 09:07, it was found to have broken the weak link, and emptied the contents of the bucket and broken the back plate. However, the pipe dredges retained a small amount of a ferrigenous crust over a carbonate hardground material and this was considered representative of the site. A new dredge was brought into service and the ship tracked E collecting MBES 300 data filling small holes in the existing swath coverage heading to Dredge site 5 in deeper water.

Dredge 5 was designed to sample the steep face seaward of a prominent bowl at the toe of a large ridge. The dredge was put in the water at 11:08 and back on deck at 12:46. The dredge did not hit bottom and had nothing in the bag when brought back on deck. The ship was moving W through the water at 2 kts even though it was headed north throughout the deployment. Thus the current/ wind drift was quite strong and it was decided to try this dredge again in daylight hours. The ship then moved E and commenced a series of MBES lines, the first beginning in the N as line MBES229 soon after midnight Thursday.

Day 10: Friday November 14, 2008

Following dredge 5 a survey was conducted to map the eastern extent of a bulge in the slope on the southern side of the canyon where dredge 5 was attempted. This area is 35 nm east of Moreton Island. Five north-south lines were run extending the coverage out to 3500 m water depth. Four of the lines (SL67-70; MBES229-237) were ~23 km long while the last line (SL71;MBES238) was ended at 07:24 to go to a dredge station. During the survey at 01:35 XBT drop 12 was successful and the new velocity profile entered at the next turn when data recording was off. The survey was valuable in revealing that this block has a relatively straight eastern edge parallel to the trend of the slope. This edge is retreating by mass wasting by several slides on the upper slope and landslides on the mid-slope with small linear E-W canyons on the lower slope.

During the second last line the data was quickly processed and entered into fledermaus and a dredge site selected on a prominent ridge with a step. The ridge runs E-W and

rises from 3080 m to 2920 m over a distance of 600 m with slopes on the lower step of 190 and slopes on the upper step of 350. Dredging of DR 06 started at 08:00. The dredge was in the water at 08:15 and we dredged to the north. There was a strong current from the NE. Several good bites were followed by one to 12,000 kilos and the dredge was hung up. The ship was manoeuvred back over the ridge and the dredge broke free. The dredge was on deck at 11:25 and fortunately only the bridle was bent. About 100 kg of rocks were sampled of various lithologies ranging from trachy-andesites, sandstones, siltstones, carbonaceous shale, calcareous mudstones and chalk. The more lithified rocks are possibly from the Maryborough Basin sequence.

The ship then moved to dredge site DR 07 which was located in a bowl shaped depression adjacent to the unsuccessful dredge site DR 08. This dredge site was chosen in order to approach the dredge site from down current and minimise drift across the site. This technique appeared to work well and the ship manoeuvred in position at 13:00 to let the dredge down and then proceeded up the slope. A few small dredge nibbles were observed around 14:01 on the wire tension but then little else and the dredge was pulled up at 14:35 without further contact. When on deck the dredge was empty except for a small amount of carbonate mud in the pipe dredge. Perhaps the cliff face of 500 m height at a 60-70 deg slope is too steep for effective dredging? Since there was good recovery at DR 06 nearby it was decided to abandon DR 07 and switch to the survey located in the Centaur Canyon.

The ship transited south to the beginning of the Centaur Canyon survey and commenced the survey running the first line CL 1 with MBES 239 to the S at around 16:16, followed by CL 2 to the N, CL 3 to the S and CL 4 to the N, ending on MBES 245 at 24:00. Although this survey produced many more pings on the ground, the ability to image the seabed did not significantly improve. Backscatter values appeared more comprehensive, but again the problem was locating a very small target of 100 m in a large area of 130 sq km. In such rough terrain this problem will require a better methodology than the MBES 300 can provide such as ROV/AUV surveying with camera and high resolution MBES.

Day 11: Saturday November 15, 2008

Following the Centaur survey a short transit to data gaps in the survey found us 20 nm east of Cape Moreton with the wind at 10 kts from 0490 and the seas calm. At 01:55 we started MBES and Topas logging on SL72 (MBES246) and L72a at 13 kts heading south (1650) in 552 m of water. This was an excellent line with a strong reflector with irregular topography coming to the surface to form highs with very angular topography. One of these highs (water depth 400 m) has a moat on its north side and onlapped by sediments on their southern side in (270 23.788'; 1530 53.902'). At 02:55 we ended SL72 and turned to the west to commence a line running north along the western edge of the survey data. Because of a ship we had to slow and maintain a NW course before joining the line. We did XBT drop 13 during this time and applied the velocities. At 03:50 we started SL73 (MBES248) and L73a to the NW at 9 kts in 301 m of water. It ended in 378 m.

At 05:32 we started SL74 (MBES248) and L74a to the SSE, water depth 433 m. This was another excellent line with good penetration, sometime even beneath the 'hard ground'. Old slumps are obvious in the sub-surface. We crossed one of the three circular, flat-topped knolls that had previously been identified by MBES. The knolls are where the hard ground reflector comes to the surface. It and underlying beds are truncated

by a moat on the north side and a deeper moat on the south side with accretionary mound of lee sediments. At 09:18 hours we had finished filling the gaps and we ceased logging MBES (MBES252). We continued south with Topas on L74a to the core site GC4. More excellent Topas data was collected with dipping blocks of sediment beneath an unconformity. At 10:00 we ended L74a in water depth 577 m as we approached the core site 20 nm offshore of the Tweed River. Winds were increasing to 14 kts from 3520.

We moved onto correct position GC4 in 488 m, a reference site on undisturbed sediment. There was no pullout tension and only a handful of slightly muddy sand was recovered which consisted mostly of benthic carbonate and brown/greenish grey lithic grains (swept from where they grow on the hard grounds by the EAC?) and planktonic foraminifers and pterpods. The next two cores (GC5 and GC6) were nearby and down slope on what we believe to be slide surfaces. GC6 was on deck at 12:00. Both had good pull-out but each only retrieved just over a metre of sediment.

The ship went on to collect a series of cores, starting with GC 7, a "reference core", on the flat ridge top adjacent to GC 6 and approximately at the same water depth (740 m). The first attempt at GC 7 failed but the second attempt took a relatively long core around 4-5 m. The ship moved across the narrow rill submarine canyon and 10 km NNE to GC 8 where another core was successfully obtained in a broad slide surface around 15:00, followed by two more cores, GC 9 and 10 which were obtained in a deep slide (later seen on seismic to contain slump fill) and an adjacent high isolated knoll where a second "reference core" was taken around 17:56. This concluded coring activities and Southern Surveyor began a series of cross seismic lines with Topas collecting profiles at right angles to each other and with the core sites at the centre. Site surveys of this type were run over GC 9 and 10 and then a longer line across GC 8 and on to a continuous line across GC 7 and 6 in a NE-SW direction followed by an E to W line through GC 6 upslope to shallow water at the top of the slide surfaces. In each case, seismic data was collected under relatively calm conditions at 5 kts and produced excellent results indicating that some sites were accumulating a "normal" sequence of mainly pelagic carbonates with continuous reflections up to 80 m thick, alternating with slide masses and relatively bare slide surfaces.

Day 12: Sunday November 16, 2008

The day started with a continuation of the Topas survey over the cores we took yesterday in a region on the upper slope on the north side of the Tweed canyon and 25 nm east of the Tweed River. Most core sites had two lines crossing them. This was very successful and excellent quality seismic profiles were obtained at 5 kts in these water depths of ~1000 m. They showed buried erosion surfaces, slump blocks, well-bedded strata in broad folds, slip scarps and slip planes with and without overlying rubble. The weather was kind with wind at 17 kts from the north.

At 02:50 the core traverses were finished and we started SL75 and 75a as we traced the strata up slope to the NW at 9 kts. At 03:15 we took XBT drop 14 in preparation for MBES mapping in shallow water west of our surveyed lines. The drop was successful and the velocities applied. We started logging MBES at 03:20 (MBES53) as the line continued shorewards to 164 m water depth (end SL75). We turned to go east on SL76 and L76a until we reached the edge of the surveyed area and we then went south (SL77 and L77a) following its margin and collecting bathymetry and seismic around the heads of the many tributaries to the Tweed canyon. At 04:45 we had to do a loop to port to avoid a ship. This took 25 minutes to get back on line. At

05:30 we ended the line in 166 m of water and headed north (SL78 and L78a) to fill data gaps and get to the core site by 08:00. The canyons along the first part of this line were too rough and deep to seismic but towards the end of the line useful data was collected on a smoother sea floor. At 06:55 we ended line SL78 and L78a and stopped logging the MBES (MBES256). We turned to run a Topas line SE over the next core site (L79a). Data for the site looked like a slip surface in a slide on the sea floor. The line was ended at 07:30 about one nm passed the site and we returned to the core site. Core GC11 was successful with over two meters of recovery. By 09:30 we were on dredge station DR8 on the north side of the Tweed canyon in water depth of 1700 m where the slope and backscatter indicated outcrop. The aim of this dredge was to obtain rocks from the southern side of the plateau. The dredge was successful and on deck before lunch with 100 kg of rocks, nearly all mudstones. It also included a small amount of volcanic rock (hyaloclastite and cemented tuff?).

At 12:10 the ship had moved to the new dredge site DR 09 on a small knoll associated with features that resembled dykes. A dredge was conducted on the NE side of this feature in water depths of around 1300-1600 m beginning around 12:10, on bottom at 12:45 and back on surface at 13:40. The dredge was successful and returned some semi-lithified sandstones and semi-consolidated mudstones, some with plant fossils. Following this dredge, the ship attempted a third dredge in this southern area at DR 10, a 500 m high wall on the N side of a canyon tributary. The dredge entered the water at 14.37 and was on the bottom from 15:40 until 16:34 taking some big bites and tension of around 9t. However, the cable parted and the dredge was lost, resulting in a kinked cable necessitating repairs. This brought dredging to a halt and the ship instead moved to core a large semi-circular slide further S off Byron Bay. This was core site GC 12 in around 1170 m on the SW face of the large slide. The ship got to within 200 m of the preferred site but strong S winds prevented a closer approach and the core was taken about 200-300 m SW. It entered the water around 19:13, hit bottom at 19:22 and was back on deck at 19:28. A good hit and pullout occurred even thought the seas were increasing and there was no depth readout on the block. The core recovered around 2.5 m with a sticky consolidated clay in the catcher. With increasing sea and swell the ship headed for the head of the Richmond Canyon to conduct seismic surveying in the canyon head and to try and locate the sediment transport routes from rivers to the slope. For the remainder of the day we surveyed Topas lines RC (Richmond Canyon) 1 and 2 and then moved on to RC 3. RC 1 and 3 were dip lines targeted to image any prograding clastic deposits in the head of the Richmond Canyon, while RC 2 was a strike line parallel to the margin and along a paleoshoreline around 85-90 m depth. The deposits on RC 1 were minimal in the canyon head and soon became hardground features, while RC 2 imaged a long shoreline of rough carbonate mounded features formed into resistant hardgrounds with rough topography of 3-5 m relief and occasional mounds to 10 m. Several different levels of carbonate growth appeared on the data suggesting that these were lowstand deposits that, like reefs, grew one layer per sea level cycle.

Day 13: Monday November 17, 2008

The watch started with a continuation of the shelf survey landward of the circular head of the Richmond Canyon looking for Richmond River deltaic deposits formed during sea level low stands. Heading NNE on Topas line RC2 10 nm offshore of Ballina we surveyed very rough hard ground in ~90 m w.d. (see 10 m pinnacle at 280 47.141'; 1530 47.200') before crossing a channel partly filled by sediment near the end of the line. The wind was 17 kts from 1400 and the seas moderate. Line RC3 was to the SSW landward of the previous line and profiled rough hard ground with sparse sediment cover. At the end of RC3 (MBES259) in 83 m water depth we turned to run eastward down slope on RC4. At the start of this line we crossed a channel, possibly the same one that RC2 crossed to the north east. The line down the slope was smooth sediment with very thin prograding delta lobes below 300 m. At 02:20 at the end of RC4 we did XBT drop 15 in a canyon (water depth ~800 m). MBES logging was stopped (MBES261) and the new velocity profile entered as we turned to starboard to go back up slope to start a survey line south on the upside of the surveyed area.

Survey line SL80 (MBES262) and Topas L80a took us south across uneven topography with water depths of between 100 and 300 m. There were two small bends in the line and there were problems with the MBES tracking the bottom as the ship headed into moderate but lumpy seas. We had to slow to 6 kts to improve data quality. The seismic showed a reef with an irregular surface lying on well bedded sediments at 130 m (low stand shore line?). We then tracked obliquely down slope across a series of delta lobes but only 10 m of penetration. Other features include a buried erosion surface that comes to the sea floor as a ridge/pinnacle several times (see 290 02.191'; 1530 50.348') and transparent lenses up to 15 m thick filling bedrock channels (e.g. 290 04.064'; 1530 50.072', Clarence River deltas?). Line 80 ended at 08:30 25 nm east of the Clarence River with winds of 20 kts from 1040. We turned down slope to move east for a line to the north covering a gap in the data. Topas was continued down slope a profiled two bedrock ledges at 315 m buried beneath 5 m of sediment forming a smooth sea floor. The start of SL81 (EM268) was too deep for Topas and the MBES was in deep mode (water depth 935 m). At 11:45 we were approaching the end of the line (MBES270; water depth 874 m) between Evans Head and Ballina and 20 nm offshore.

After SL 81 was completed the ship turned around off Woodburn and ran SL 82 down to a point off Evans Reef and then back up almost as far as Ballina on SL 83. These lines were run as MBES survey lines with no Topas. While the lines were being run the scientific staff had a science meeting from 13:00 to 14:30 and then moved to a position close to DR 11 where the crane was used to raise the spare dredging weight and prepare the spare dredge. The ship was in position for the dredge by 17:19 at 2750 m, on the bottom at 18:30, and back on deck at 20:00. The dredge was successful but only returned a small haul including one boulder of conglomerate, some smaller pebbles including a 4 cm coal clast, and a quantity of red, oxidised quartz silt that contained around 60% quartz, plus lithics, mica, feldspars and looked like a fine silt-sized river sediment stained bright red-brown.

After 20:00 the ship moved across to the southern wall of the canyon and completed DR 12. This dredge was slightly shallower at 2550 m. The dredge went into the water at 20:40, was on the bottom at 21:14 and back on deck at 22:15 but unfortunately there was no recovery. The ship then headed south to commence a set of MBES survey lines south to the Clarence River region and back again overnight.

Day 14: Tuesday November 18, 2008

At the start of watch the ship was 30 nm off Evans Head and heading south on SL82 at 12 kts. The wind was 10 kts from 1000 and the seas calm. The line ended (02:35; MBES279) 30 nm ESE of the Clarence River at 290 30'S at but we couldn't turn for the next line north because of a ship. At 03:00 we started SL83, to the east of the previous line, and heading north. Water depth was 1400 m at the start of the line and increased to the north as we crossed the Clarence canyon. The line SL83 ended at 07:30 and we stopped logging MBES (MBES28) and turned westward and headed up slope to dredge site DR13 on the shelf where the target was a hard reflector, surveyed on line RC2, that forms a mound 200 x 400 m oriented NW-SE with 6 m of relief (water depth 90 to 84 m). On the line up to the target Topas was recording thin sediment lenses that pinched out up-slope as a hard reflector came to the sea floor and this continued to the dredge site.

Dredge DR13 was on the top of the mound and was unsuccessful in retrieving rock despite a large 'bite'. Coarse bioclastic sand was sampled in the pipe dredge. The second attempt (DR14) let more wire out and the dredge was dragged down the north side (slope only 2 degrees). A couple of good bites broke off a 5kg piece of limestone along with some smaller pieces. Benthic organisms coated the surface of this hard substrate. The broken surface exposed grey limestone consisting of a mix of large fragments of bryozoa, bivalves, corals, oncoliths, rhodoliths and gastropods forming a boundstone (reef deposit).

The next station was in a channel running NE profiled on lines RC2 and RC4. The RC2 profile of the channel was the one targeted. The grab GR6 sampled slightly muddy, coarse bioclastic sand. Most of the sand was brownish yellow and well rounded. The only non-carbonate components in the sand were some rounded lithic granules/small pebbles, possible eroded from nearby exposed older ferruginous/phosphatic hard ground.

Dredge DR 15 was targeted to sample up the side of a large carbonate hard ground promontory from around 385-280 m and part of a linear platform edge in the region. Calculations suggested that the dredge haul came from the base of this slope and it consisted of 30 kg of hard limestone/dolomite that resembles Tertiary carbonate platform material dredged from east of Fraser Island and Breaksea Spit. In addition there was 1 kg of friable "beach rock", a carbonate hard ground but not as lithified as the underlying material and most likely Pleistocene in age.

After DR 15 the ship collected a succession of grab samples GR7-9 moving down the slope east from DR 12. The first of these, GR 7 collected only a small haul of carbonate hard ground cobbles and pebbles plus a small quantity of coarse carbonate sand in 500 m depth. GR 8 was in 1100 m depth and did not fire correctly but a small amount of carbonate mud adhered to the grab body and this was taken as the sample for GR 8. GR 9 was taken in 1620 m and proved to be a good sample of standard carbonate ooze. The ship then transited to a dredge site DR 16 on the north wall of the canyon that leads to the Byron Slide.

The DR 16 site was dredged from 2030 m to 1530 m (ship depths) up the Byron Slide from 18:22 to 20:50 and returned a large haul (40 kg) of coarse conglomerate, sandstone cased with iron oxide joint fill, oil shale and the ever present khaki mudstone sampled

in many dredges. The conglomerate was unusual in that its clasts were mostly angular basalt with altered margins and they are supported by a mud matrix with gastropods and other fossils. It appears to be a debris flow deposit or lahar. The ship then transited south to the Richmond Canyon where the northern wall of one of the southern tributary valleys was dredged. The dredge (DR17) entered the water at 22:39 and was on bottom at 23:30. The target was a slope from 1900 to 1600 m with an average slope of 27 degrees. This location is 18nm east of Ballina. The dredge was on deck at 00:40 and the ship headed for the planned overnight MBES mapping to the south east.

Day 15: Wednesday November 19, 2008

It was raining when the dredge came on deck and the wind was 24 kts from 050 and the seas moderate. By 01:15 the deck was cleared and the ship headed east for the start of the first MBES line. The start of the line was delayed because of other shipping. At 02:20 logging (MBES286) was started on the first line which ran south in water depth of 2400 m. The line ended at 290 20'S offshore of the Clarence River in 1900 m of water. Logging was stopped for the turn (04:50, MBES288). The next overlapping line, a mile and a half to the east and running north, was commenced at 05:05 (MBES289, water depth 2090 m). The run north was slower than planned due to head wind, current and seas and we reached the end of the line at 08:40 (MBES292, water depth 2828 m) adjacent to the next dredge site.

Dredge DR18 was in the water at 08:55 with the target the resistant ridge on the north side of a 'plunge pool' with the hope of obtaining sedimentary rocks lower in the sequence than those dredged so far. The wire out/tension meter went down just before the dredge was on the bottom. This software problem was quickly fixed and dredging to the NW continued. The dredge was back on deck at 11:45 but was empty except for a small sample of ooze in the pipe dredge. At 12:35 we were logging MBES293 heading south at 12 kts.

For the remainder of Day 15 we traversed south collecting MBES data in transit along previously unsurveyed regions of the continental slope, navigating landward and seaward as required to avoid previously surveyed tracklines.

Day 16: Thursday November 20, 2008.

The ship continued south in good weather, collecting MBES data, until offshore from Port Macquarie a short survey of a bedrock outcrop on the upper slope was conducted, beginning around 08:00. This survey collected MBES and Topas data over a series of ridges on the upper slope with the objective of determining their composition and origin. The results showed the ridges to be exposed sedimentary bedrock, layered and swept bare of most sediment by the East Australia Current. Subsequent sampling indicated that the rock type was coarse sandstone and conglomerate, possibly associated with the Lorne Basin and similar to that outcropping as Triassic Camden Haven Group of coarse conglomerates, brown and purple coloured volcaniclastic sandstones and shales at Perpendicular Point on the coast 40 km to the SW.

After completion of the survey and sampling, the ship continued south along the upper continental slope in around 200 m depth until arriving off the Manning River mouth on the outer shelf around 15.30 and commencing a zig-zag path

south to add extra swath coverage to a line collected at the start of the voyage heading north. This line also aimed to image a series of raised mounds on the outer shelf to upper slope seaward of Tuncurry. MBES and seismic data were collected along this line and showed a series of shore-parallel ridges with up to 25 m of relief, scoured by the EAC on both sides and containing a series of cemented features interpreted as lowstand cool-water carbonate mounds or reefs.

Day 17 Friday November 21, 2008.

The ship continued south off Newcastle along the shelf edge where around midnight it imaged the seaward extension of a Late Quaternary fault previously discovered on several Fearnot voyages conducted by the University of Newcastle. This fault occurs in unconsolidated sediments in around 170 m water depth, comes to within 10 m of the seabed and has 8m of offset. Further south the ship encountered buried migrating ridges at the shelf edge around 33deg 23' to 33 deg 27' S. After this the ship turned W toward Broken Bay, collecting a cross-shelf line for Michael Kinsela's PhD project, and then continued south in shallow water around 40-80 m till around 03.30 when the survey was ended . The ship took the pilot on board and docked at White Bay around 07:00.

Summary

Southern Surveyor 12/2008 collected the first regional seabed map of the Australian continental margin off northern NSW and southern Queensland between 100-3500 m water depth. It discovered a large marginal plateau of continental crust, the Nerang Plateau, flanked on either side by a continental margin experiencing extensive mass movement. Seven major submarine canyons were discovered surrounded by two extensive regions of numerous submarine landslides ranging up to 10 km3 in volume and larger regions of up to 100 km3 volume identified as potential future hazards. Sediment cores in these landslides indicated that the events that caused the landslides were relatively recent and likely less than 20,000 years old with some as young as 5,000 years. Geological sampling indicated that the continental margin in this region is made up largely of sedimentary basins, likely southeastward extensions of the Maryborough Basin and northeastward extensions of the Clarence-Moreton Basin. Sediment transport from the shelf to deep water on this margin is controlled by gravity mass transport, resulting in a degradational margin. Overall, these results indicate that the scientific objectives of the voyage were achieved, and that all major outcomes are likely to be successfully completed with the data set collected.

Principal investigators

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Item No	PI	NO	Units	Data Type	Number	Latitude	Longitude	Date_UTC	Depth
1	RB JK	12	Stations	G04	1	-26.694816	153.75205	12-Nov-08	841
				G04	2	-26.76066	153.728	13-Nov-08	585
				G04	3	-26.75366	153.73083	13-Nov-08	759
				G04	4	-28.21716	153.9562	14-Nov-08	485
				G04	5	-28.23516	153.96433	15-Nov-08	655
				G04	6	-28.2267	153.9792	15-Nov-08	735
				G04	7	-28.2119	153.9947	15-Nov-08	600
				G04	8	-28.1211	154.0459	15-Nov-08	930
				G04	9	-28.0299	154.0473	15-Nov-08	894
				G04	10	-28.2174	154.0376	15-Nov-08	1024
				G04	11	-28.225	153.9825	15-Nov-08	754
				G04	12	-28.632	153.97	16-Nov-08	1227
2	RB JK	20	Stations	G01 Start	1	-26.66683	153.78466	11-Nov-08	1010
				G01 Start	2	-26.7085	153.8375	12-Nov-08	1690
				G01 Start	3	-26.6945	153.8661	12-Nov-08	2800
				G01 Start	4	-26.98116	153.79	13-Nov-08	310
				G01 Start	5	-27.05456	153.95263	13-Nov-08	3016
				G01 Start	6	-27.19916	154.095	13-Nov-08	3150
				G01 Start	7	-27.07183	153.946	14-Nov-08	2487
				G01 Start	8	-28.3933	154.06133	15-Nov-08	1800
				G01 Start	9	-28.4066	153.99383	16-Nov-08	1500
				G01 Start	10	-28.51283	153.00601	16-Nov-08	1580
				G01 Start	11	-28.7866	154.0086	17-Nov-08	2730
				G01 Start	12	-28.82466	153.979	17-Nov-08	2090
				G01 Start	13	-28.5595	153.9238	17-Nov-08	83
				G01 Start	14	-28.5595	153.9238	17-Nov-08	83
				G01 Start	15	-28.56166	153.92616	18-Nov-08	360
				G01 Start	16	-28.6223	154.017	18-Nov-08	2020
				G01 Start	17	-28.857	153.9555	18-Nov-08	1882
				G01 Start	18	-28.884	154.105	18-Nov-08	3356
				G01 Start	19	-28.12383	153.91183	19-Nov-08	1563
				G01 Start	20	-31.44533	153.22366	20-Nov-08	270
3	RB JK	9	Stations	G02	1	-29.809683	153.80583	06-Nov-08	996
				G02	2	-26.70966	153.81186	12-Nov-08	1295
				G02	3	-26.69465	153.752	12-Nov-08	838
				G02	4	-26.7108	153.71731	12-Nov-08	423
				G02	5	-26.75641	153.69198	12-Nov-08	252
				G02	6	-28.67183	153.8007	17/11/2008	104
				G02	7	-28.5665	153.9379	18/11/2008	525
				G02	8	-28.55133	153.97885	18/11/2008	1104
				G02	9	-28.5981	154.00698	18/11/2008	1574
4	RB JK	1	Stations	H10	1	-29.809683	153.80583	06-Nov-08	996
5	RB JK	13	Stations	H13	1	-33.024174	152.673483	05-Nov-08	820
				H13	2	-30.568969	153.436232	05-Nov-08	846
				H13	3	-29.837058	153.797096	06-Nov-08	77
				H13	4	-29.827486	153.800452	06-Nov-08	850
				H13	5	-28.602383	153.962167	06-Nov-08	842
				H13	6	-27.034133	153.588983	07-Nov-08	852
				H13	7	-26.562702	153.729965	08-Nov-08	249
				H13	8	-28.608167	154.021667	09-Nov-08	877
				H13	9	-26.96865	153.756617	11-Nov-08	331
				H13	10	-27.230836	154.054956	13-Nov-08	867
				H13	11	-27.57572	153.861463	14-Nov-08	303
				H13	12	-28.211747	153.910154	15-Nov-08	281
				H13	13	-28.74695	153.887054	16-Nov-08	872

Item No	PI	NO	Units	Data Type	Number	Comments	Comments
6	RB						
	JK	1	Lines	G74	1	Regional Multibeam Survey Location: See Trackline Plot	Location: See Trackline Plot
7	RB						
	JK	1	Lines	G75	1	Seismic Survey	Plot

1 Digital multibeam echo sounder data archived with MNF data base at CSIRO Hobart, and also at the School of Environmental and Life Sciences at the University of Newcastle, curated by Ron Boyd

2 Digital Topas data archived at School of Environmental and Life Sciences at the University of Newcastle curated by Ron Boyd

3 Geological Samples (Cores, dredges and grab samples) archived at the School of Geosciences at the University of Sydney curated by Jock Keene and Tom Hubble

Personnel list

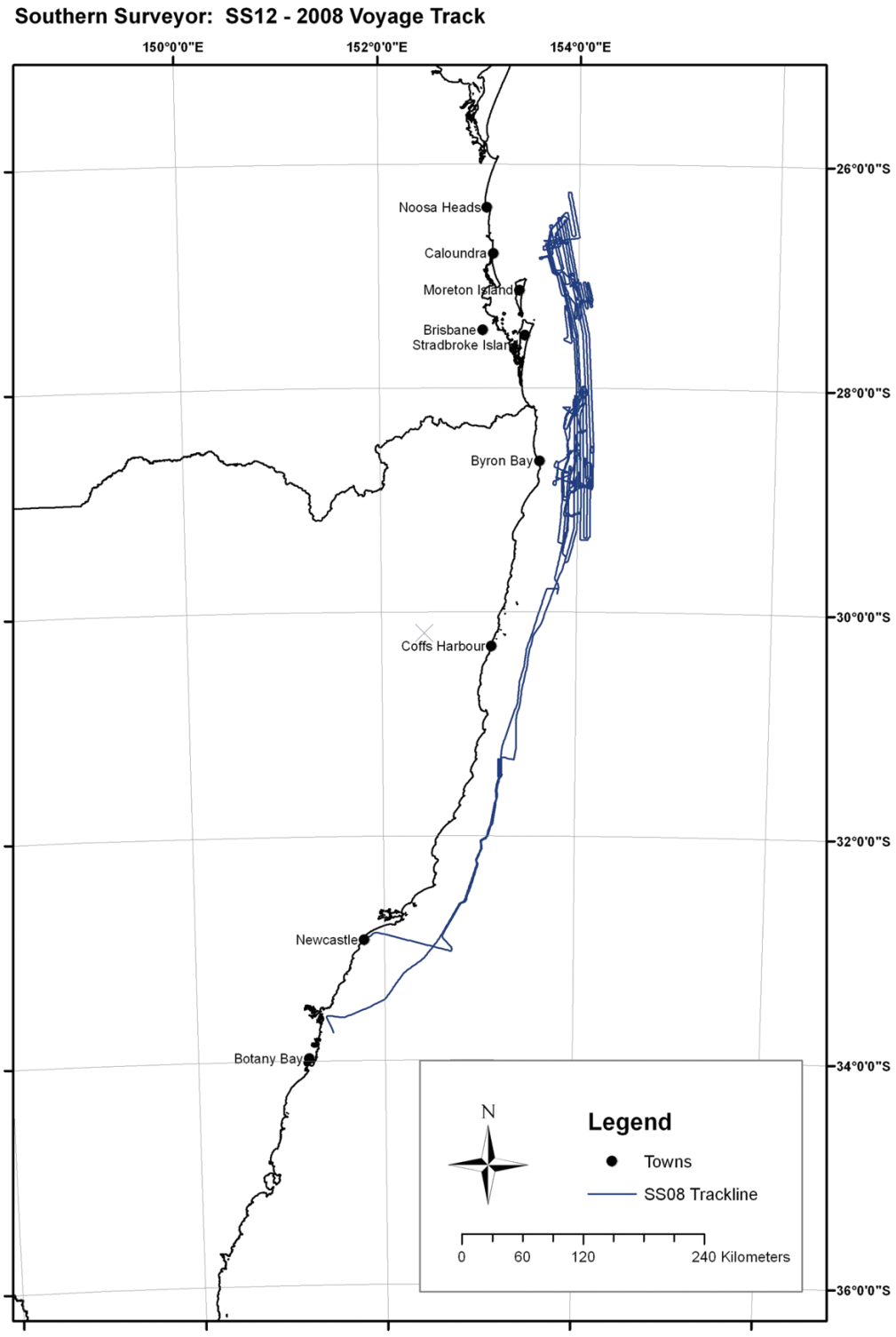
Scientific Participants

Name	Affiliation	Role
Ron Boyd	University of Newcastle	Chief Scientist
Kevin Ruming	NSW DPI	Research Scientist
Jock Keene	University of Sydney	Research Scientist
Michael Kinsela	University of Sydney	Research Student
Samantha Clarke	University of Sydney	Research Student
Tom Hubble	University of Sydney	Research Scientist
David Mitchell	University of Sydney	Technician
James Gardner	University of New Hampshire	Research Scientist
Janice Felzenberg	University of New Hampshire	Research Student
Neville Exon	Australian National University	Research Student
Asrar Talukder	CSIRO Perth	Research Scientist
Peter Dunn	CMAR	MNF Voyage Mgr/Electronics Support
Hispi Kippo	CMAR	MNF Computing Suppport
Rick Smith	CMAR	MNF Swath Mapping Support
Tony Veness	CMAR	MNF Swath Mapping Support

Marine Crew

Name	Role
Ian Taylor	(Master)
John Barr	(Chief Officer)
Naomi Petersen	(Second Officer)
Roger Thomas	(Chief Engineer)
Rob Cave	(First Engineer)
Aminul Haq	(Second Engineer)
David Willcox	(Chief Steward)

Name	Role
Wendy Morice	(IR)
John Fabics	(Chief Cook)
Dayal Patel	(Second Cook)
Graham McDougall	(Bosun)
John Howard	(IR)
Gareth Gunn	(IR)
John Allwood	(IR)



GENERAL OCEAN AREA: Western Tasman Sea, adjacent to Australian continent

SPECIFIC AREAS: Between 26.5-29.5 degrees S, and 154.4 degrees E and the 80 isobath near the shelf edge off northern NSW and southern Queensland, Australia