2005 program

RV Southern Surveyor

MARINE NATIONAL FACILITY

CSIRO

voyagesummary SS07/2005

SS07/2005

Mapping benthic ecosystems on the deep continental shalf and slope in Australia's "South West Region" to understand evolution and biogeography and support implementation of the SW Regional Marine Plan and Commonwealth Marine Protected Areas.

Itinerary

Leg 1
Departed Dampier 1000 hrs, Thursday 21 July 2005
Arrived Fremantle 1700 hrs, Wednesday 3 August 2005

Leg 2
Departed Fremantle 1200 hrs, Thursday 4 August 2005
Arrived Fremantle 1000 hrs, Wednesday 17 August 2005

Principal Investigators

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Scientific Objectives

The aims of the project were: 1) to apply targeted field-based observation to develop, test, refine and validate multiple use management frameworks developed for the SW Region as part of Regional Marine Planning under Australia's Oceans Policy, and 2) explore and characterise marine ecosystems of the SW Region. This project comprises two voyages (each with two legs) in 2005. Only the first voyage is reported on here.

Ecosystem-based, integrated regional marine planning for the Australian marine environment depends on the identification of natural regions as planning units. Therefore, there are near-term requirements for regionalisation and mapping at a range of relatively fine scales throughout the Australian Marine Jurisdiction (AMJ). Given the vast size of the AMJ and the cost of marine surveys, Australia needs to develop the most efficient and cost-effective suite of methods for surveys, and to establish a national mapping program using an optimal methodology. It has been argued for some time that the most cost-efficient way to conduct such surveys will be by using a multibeam sonar (MBS) together with an optimally-designed, targeted program of geological and biological 'ground-truth' sampling. However, despite the already-demonstrated benefits of multibeam acoustics for mapping the physical seabed at fine resolution (10s m) over intermediate scales (10s to 100s of sq km), there are still technical and methodological issues to investigate before a multibeam-based, optimised method for predictive and reliable habitat assessment is fully developed. This voyage provided that opportunity.

Acoustic maps made in real time at sea using data from the Simrad EM300 multibeam sonar (MBS) were used to target samples with the towed, high-resolution video system and sediment grabs during this survey. A follow up survey in November/ December 2005 (SS10/2005), run on a reciprocal course and visiting all survey sites, will collect the biological and additional physical samples (consolidated substrata) using benthic sleds. A particular focus of methods refinement was to increase the types of data processed at sea (e.g. multibeam backscatter) and to increase the quantitative data acquired at sea (e.g. from video and digital still underwater images).

Our sampling was nested within spatial scales of habitat – by latitude, depth, and in features including canyons where sediment and rocky substrata will be sampled – to determine how biodiversity is distributed at particular scales. Overall, the allocation of samples considered the structure of the benthic bioregions off the west and southwest coasts of Western Australia: the Northwest Province, Central Western Transition Zone, Central Western Province, South-western Transition Zone and Southern Province. To the extent possible, sampling targeted sites that may become candidate sites for MPAs, or suited to the establishment of scientific reference sites, and that could demonstrate the different outcomes from alternative conservations strategies.

A primary focus of the second survey will be the program of sampling using benthic sleds to collect benthic invertebrate epifauna and infauna. There will be an emphasis of taxonomic effort on taxa that can be worked up to named species within 12 months (enabling comparison to pre-existing data); taxa that will be highly informative to biogeographic analysis (e.g. with limited dispersal mechanisms); taxa amenable to CO1 gene analysis "Bar-coding"; and commercial species. Surrogate-based metrics of biodiversity will be investigated based on morphotypes, and there will be a focus on those taxa amenable to monitoring (e.g. by non-destructive photographic sampling for MPA performance assessment). We plan that biological sampling for this objective will be undertaken during the second survey for this project, SS10/2005, in November/ December 2005.

The survey program (two voyages) addresses four primary objectives:

1) test hypotheses on the evolution and biogeography of Australia's biodiversity, in particular relating to species composition, distribution patterns and taxonomic surrogacy

2) validate and refine CSIRO's optimised methodology for mapping deep water benthic ecosystems on the western continental margin and in sub-tropical locations to enhance its application to natural resource management at a national scale

3) document the benthic biodiversity and identify areas of high conservation values in the context of Commonwealth MPA declaration

4) validate, and permit refinement of, a marine bioregionalisation during the development of the SW Regional Marine Plan by the National Oceans Office

Voyage 1 Objectives

At depths of 100 m, 200 m, 400 m and ~1000 m, and possibly a deeper site, in each survey area, sampling was designed to:

1. Generate maps (bathymetry, texture, slope and backscatter) with the Simrad EM300 multibeam sonar (MBS) of sample sites and an immediately adjacent area of seabed.

2. Collect physical and photographic ground-truth samples with a grab and the CMR deep towed camera platform to classify and test predictions of seabed habitat types based on acoustic data.

3. Collect phytoplankton and data on water mass structure at ~ 1 degree intervals to quantify the latitudinal gradients in phytoplankton species in relation to water masses, and enable a biogeographic description for Australia's west coast.

Secondary objectives:

4. Collect data to validate ocean colour measurements.

5. Collect water column acoustic backscatter at multiple frequencies

Voyage Track

Upper slope (400 m isobath) between transects and focus survey areas, Dampier to Fremantle, and Fremantle to Fremantle via Albany. The return from Albany to Fremantle was mostly along the 100 m isobath.

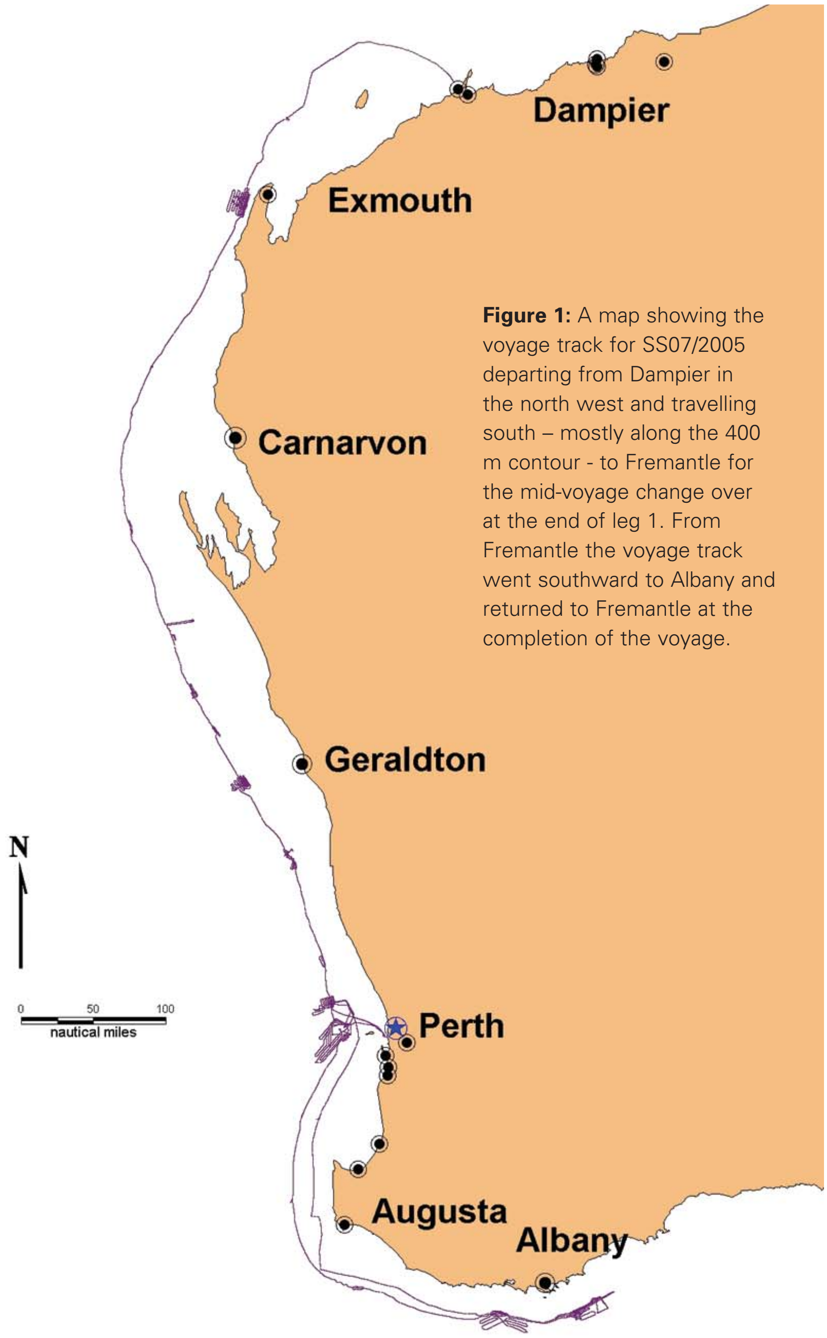

Figure 1: A map showing the voyage track for SS07/2005 departing from Dampier in the north west and travelling south – mostly along the 400 m contour - to Fremantle for the mid-voyage change over at the end of leg 1. From Fremantle the voyage track went southward to Albany and returned to Fremantle at the completion of the voyage.

Results

1. **Generate maps (bathymetry, texture, slope and backscatter) with the Simrad EM300 multibeam sonar (MBS) of sample sites and an immediately adjacent area of seabed.**

   Map data were collected successfully at all locations; map data were processed and products made on board; these were used to target photographic and sediment sampling. Initial map products are of extremely high quality and enable visualization of habitat features at a range of relevant spatial scales. These were used successfully to communicate initial results to stakeholders and the media.

2. **Collect physical and photographic ground-truth samples with a grab and the CMR deep towed camera platform to classify and test predictions of seabed habitat types based on acoustic data.**

   Sediment and photographic data were taken successfully at virtually all planned stations at depths of 100 m, 200 m, 400 m, 700 m and 1000 m (a few were lost to weather), and at several additional stations. Sub-samples from sediments were taken for geological analysis, faunal analysis, and stable isotope analysis. The quality of the video and still digital photographic data was very high; a wide variety of previously unseen seabed types and benthic animals were recorded.

3. **Collect phytoplankton and data on water mass structure at ~ 1 degree intervals to quantify the latitudinal gradients in phytoplankton species in relation to water masses, and enable a biogeographic description for Australia's west coast.**

   A full set of data were collected successfully. In addition, a set of samples were collected for analysis of picoplankton, and a number of lowered ADCP drops were targeted successfully on seabed features.

4. **Collect data to validate ocean colour measurements.**

   Samples and flurometer data were collected successfully from the entire voyage.

5. **Collect water column acoustic backscatter at multiple frequencies.**

   Samples were collected successfully from the entire voyage.

Voyage Narrative

Leg 1

Thursday 21st July
Following a very busy period of preparations alongside in Dampier, Southern Surveyor departed for the beginning of a month-long survey off the Western Australia coast at 10:30.

Friday 22nd July
We arrived at our first latitude sampling site (L1 Barrow) on the 400 m contour at 04:00. Following a completion of Job Hazard Analysis (JHA) for deploying the CTD and cameras, we began our first operation: a CTD to 400 meters (op 1) to characterize the water column and provide a sound velocity profile for the EM300 multibeam. Two Smith McIntyre grabs were taken for sediments (ops 2 & 3), followed by the first deployment of the newly configured Deep Video System (op 4). A successful tow of 30 minutes bottom time in 400 m showed a heavily bioturbated muddy seabed. We continued south from this site towards the Ningaloo focus area, collecting MBS data from the EM300 along the 400 m contour in transit. Sampling in the focus area (which also encompassed the two northern province transects) started on transect T1 in 200 m with a CTD and 2 successful sediment samples (ops 6, 7, & 8).

Saturday 23rd July
Sampling commenced at the 400 m station with a CTD (op 9) on transect T1 (T1 400). This was followed by two sediment samples in the same area using the Smith McIntyre grab (ops 10 and 11). Operation 12 was a camera tow in 400 meters. The tow proceeded well until we lost power for the winch just at the point when fast hauling was needed to avoid a steep mud bank. With several hundred meters of wire out and the camera on the bottom, the ship was stopped and we retrieved the system. There was no major damage although the tail fin and drogue were lost. The problem turned out to be an electrical trip on the main circuit breaker. We continued MBS mapping whilst checking the system and attaching the spare drogue to the camera frame. We redeployed the system in 200 meters to find that the platform was unstable and tilted about 30 degrees. MBS mapping continued on the shallow side of the focus area.

A new tail was fabricated for the camera platform and this proved to be successful on the next deployment: op 14, a tow in 100 m on transect 2 across muddy sand sediment with occasional low coral-rock subcrops. The remainder of the day was spent completing the CTD and sediment sampling at the 100 m stations on transects T1 and T2 (ops 15 to 21). We completed MBS mapping on the shallow-side line by 10:30 and moved westwards to pick up a new MBS line on extend coverage on the deep-side. CTD and sediment sample were taken at the 700 m station on transect T1 (ops 22 to 24) part way up the MBS line.

Sunday 24th July

Sampling operations for the new shift began with two Smith McIntyre sediment grabs in 700 meters of water on transect T1 (ops 23 and 24). A camera tow (op 25) in 700 m was completed and closely followed by another camera tow (op 26) in 200m. Operation 27 was targeted on hard bottom features evident from the MBS bathymetry. This was confirmed by the camera tow with 0.5 – 1.0 m (low relief) hard bottom patches interspersed with muddy sediments and site to sponges of varying shapes and sizes. This made for spectacular video footage and many digital still images being taken. The camera tow for operation 28 (T1 100) showed extensive muddy sediments with a moderate level of bioturbation. Another camera tow was completed at site T2 200 (op29) which was a repeat of operation 13 that was aborted as the system was unstable without a tail and only the drogue attached.

Two sediment samples and a CTD sample were taken, in that order, at three stations on transect T2 during the day shift: T2 200 (ops 30-32), T2 400 (ops 33-35) and T2 700 (ops36-38).

Monday 25th July

Night shift began with the completion of MBS lines in deep water to enable a site for a camera tow in 1000 m to be identified. The camera tow (op 39) was completed successfully although the altimeter had ceased to operate. A camera tow was then completed in 400 m on transect T2. The line of tow didn't achieve the desired depth (400 m) and was mostly in 310-360 meters. Part way through this operation the digital stills camera ceased to operate. Once back on deck the camera was checked and reset and began working again and by now several checks of the altimeter were completed and it was working again. Another camera tow was completed in 700 m (op 41). Again the sediments appeared muddy and there were several species of prawns, some squid and fish observed. At one point the camera descended a steep, hard drop off. On a couple of occasions we negotiated steep muddy banks. The final video tow for the shift was at 1000 m on transect T2 op 42. This showed a slightly sloping area of fine sediments with little invertebrate fauna.

The remainder of the day was used to complete, respectively, the CTD and two sediment sampling at the 1000 m stations on both transects. These started at transect T2 (ops 43-45). A spooling problem with the CTD wire on the first cast required the screw-drive to be reset; this was done in deep water (1300 m) on the final outer MBS line. The transect T1 sediment samples were taken en route (ops 46, 47).

Tuesday 26th July

Tuesday was effectively the final day to sample the Ningaloo area and the opportunity to investigate some interesting topographical and backscatter features using the camera system. We planned for 3-4 camera tows and 3 LADCP drops in the middle of a canyon. Whilst readying for the first of the camera tows, a couple of bolts sheared from the knuckle of the aft A-frame, starboard side. This indicated a serious problem and the operation ceased. Vessel engineers were called to investigate and Lee Panton called as well for advice (Lee had been involved in major works on the A-frame during previous employment). Following investigation and replacement of the sheared bolts, the A frame was repositioned to allow deployment and retrieval of the camera system in much the same manner as previous. Movement was restricted so not to be brought forward beyond vertical. This could be overridden by the master to improve ship stability in rough seas. During the down-time, we steamed to a site to commence LADCP drops. Problems were encountered in getting the LADCP to respond and checks etc failed to rectify the problem. The LADCP drops were abandoned and we steamed back to the camera tow position. The camera tow was targeted at a ridge in about 800 m (op 49). The camera tow confirmed that both steepness and hardness of the ridge were less than anticipated. Again, mostly muddy sediments with harder patches and boulders seen in only a couple of places. We moved into ~100 m where two camera tows were completed (ops 50 & 51) to verify backscatter differences identified by acoustics. The beginnings of both camera tows had hard, low relief bottom with large sponges and schools of fish. The soft bottom was generally highly bioturbated muddy sediments.

Sufficiently good repairs were made to the corroded LADCP battery case to enable a trial deployment. Data were collected without incident, and so we pressed on and completed a cut-down sampling program of casts along the axis of a prominent canyon immediately north of transect T2: the shallowest at the canyon head, and the deepest at 700 m depth, ops 52-55. Following this, a set of 10 sediment grabs were taken across the contrasting backscatter facies inshore of the canyon head (5 sets of duplicates, ops 56-65). A final MBS line on the shallow side of the mapped area was completed before leaving the Ningaloo focus area at 01:30 (5 1/2 hours behind schedule).

Wednesday 27th July

We steamed south running a MBS transit on the 400 m contour and reached the L3 (Point Cloates) site at about 08:00 hrs. Sampling commenced with a camera tow (op 66) in ~400m for 30 minutes bottom time. The bottom appeared to have a higher sand composition and less mud than the corresponding sites at Ningaloo. It had a slightly rippled irregular texture and sea-pens and crabs were seen throughout the tow. A CTD was completed adjacent to the video tow (op 67) and 2 sediment samples (ops 68 & 69) were collected using the Smith-McIntyre grab. The sediment samples confirmed the observations from the cameras showing a high fraction of sand. We continued south along the 400 m contour collecting MBS data to site L4.

Arrived at the L4 (Red Bluff) site at 19:45 and completed a successful camera tow in 1 hour (op 70). The CTD drop (op 71) took 1.5 hours to complete due to slow manoeuvring (in wind and current). Two failed grab drops before landing two good samples (ops 72, 73) delayed our departure until 23:00 when we proceeded south on the 400 m contour towards site L5.

Thursday 28th July

On arrival at the L5 (Carnarvon) site a 30 minute camera tow (op 74) was completed in ~380 m. Again the substratum appeared to contain a significant fraction of sand. There was little obvious attached epifauna, but numerous bugs and fish were seen. Two sediment grabs were completed (ops 75 & 76) yielding moderate quantities of sandy sediment. A CTD was completed at this site (op 77) before continuing the steam south along the 400 m MBS transit line to L6. Latitude station L6 Shark Bay site was on more complex seabed than the previous latitude stations: a small tributary canyon, numerous small channels, a shelf-edge scarp and small patches of hard bottom were seen on the run up to the station position. Accordingly a mini-MBS survey of two lines was completed to fix the camera transect. This included the canyon and a section of channelled-bottom (op 78). Only sediment substrata were seen – mostly a muddy bioturbated sand, with a slightly coarser looking and rippled sediment in the centre of the canyon. Again, there were few epifauna and modest numbers of bugs and fish – although an abundance of eels and/ or hagfish at the beginning of the transect was noteworthy. The CTD (op 79) and two sediment grab samples (ops 80, 81) were completed successfully in a strong current before heading south towards latitude station L7 at 21:00.

Friday 29th July

Arrived on latitude station L7 (Zuytdorp) site after completing a mini MBS survey inshore to 100 m. At the point of turning the vessel at ~100 m water depth, some hard features were noted on the TOPAS and MBS backscatter and bathymetry maps. We looped the vessel back to verify the extent of the hardness and set up a camera tow to the south to transect some of the more obvious features (ridges of 2- 5 m elevation running roughly east west). A short (20 min) camera tow (op 82) was completed. Areas of sandy wave rippled sediments were interspersed with low relief reef with a dense cover of invertebrate life including large cup sponges, a variety of other shaped large sponges and smaller octo-corals and bryozoans. A couple of off-reef areas consisted of what appeared to be a loose gravely substratum with small encrusting sponges. On completion of the tow we steamed back to the 400 m contour where a 30 minute camera tow was completed (op 83). The bottom appeared to be soft and muddy with mounds and holes from burrowing fauna. Eels and some other small fish were seen along the transect. Several deployments of the sediment grab resulted in the collection of two sediment samples (ops 84 & 85). A CTD was completed (op 86) before continuing on the MBS transit line at 400 m to the south.

The first of the potential seep sites was surveyed en route to latitude site L8 (Kalbarri) with a double MBS line. An unusual steep sided 40 m depression feature was found very close to the proposed position indicating that there was a seep present. Unfortunately there was no time to sample it. We arrived at L8 at 23:30 after mapping a second seep site where another unusual elongate depression feature was found. A CTD (op 87) was followed by two sediment grabs (ops 88, 89) in 400 m. Because we had accumulated a few unbudgeted hours, samples at the seep sites were taken. These were based on the MBS maps and very precise: two grabs in the first seep depression feature (op 90, 91) and one grab (op 92) and a CTD (op 93) at the second.

Saturday 30th July

Following the grabs and CTD, a camera-tow (op 94) transited the two depression features (seeps 1 and 2) along a channel extending to a canyon. The area between the two seeps showed mostly soft sediments but also with a section of steeply sloping hard bottom where we encountered the steep side of the channel. An additional targeted camera tow (op 95) was completed at the rim of a nearby canyon. The area appeared much harder and rougher on the MBS map than the muddy canyons of Ningaloo. This interpretation was confirmed by the video footage showing a confused jumble of very large boulders, flat ledges and walls. A less adventurous video tow (op 96) completed the sampling at L8 on the sediment terrace in 400 m. The vessel then steamed south to the next site: the third transect, T3, off the southern group of Abrolhos Islands.

Sampling at L9 (Abrolhos) began with a MBS line in 400 m and an adjacent line either side. Sediment grabs were completed at the 400 m station (ops 97, 98) before the CTD (op 99). Samples were then taken at 700 m and completed at the very end of the day shift around 0200: the CTD (op 100) and two grabs (ops 101, 102).

Sunday 31st July

The night program began with some MBS line fill in deep water and then the 700 m station (op 103). Following this, additional MBS lines were done before the video transect at 400 m (op 104). A second tow (op 105) was done at this depth over a bottom type that looked distinctly harder in backscatter – and video confirmed this. The pattern was repeated in shallower, with mapping preceding the video tow at 200 m (op 106), which was extended over the shelf edge as a targeted shot (op 107) on areas of high backscatter in the 200-550 m depth range. After the change of shift we completed the shallowest MBS line at ~100 m depth before dark – this had us less than 3 miles off the reef line of the Pelsaert Group. Three MBS lines were run before sampling commenced at 100 m: this was a CTD cast (op 108) and two grabs (ops 109, 110). We then moved straight to T3 200, leaving 2 to 3 shallow MBS lines to do, so that we could complete the physical sampling before 02:00. The grabs were difficult due to the coarse compact sandy bottom – with four needed (ops 111-114) and two collecting large sponges! After doing the T3 200 CTD (op 115) we headed straight out to the 1000 m depth to complete the deepest station.

Monday 1st August

We commenced the deep CTD, T3 1000, at 00:45 (op 116). Despite the spooling problem on the winch, the cast was done to 1000 m. This was followed by two grabs (ops117, 118) and then some short MBS lines in the area to map for the video tow at T3 1000. The camera tow (op 119) at 1000m showed muddy sediment with octocorals, sea slugs and several deepwater fishes including sharks. Following this operation, the vessel moved into the shallow end of the study area to complete the missing shallow water MBS lines and do the last video tow at 100 m. The 100 m tow was preceded by a target transect over the reef crest at 80 m for ground-truthing purposes (op 120). This showed very heavy limestone reef with a high abundance of epifauna including sponges and octocorals. Outside the reef edge on the 100 m survey area, the tow (op 121) revealed a mosaic of current rippled coarse sediment patches with relatively low relief reef patches. The final sample at T3 was a trial deployment of the Sherman sled to test its effectiveness on soft sediment (op 122). Following this we steamed south to latitude L10 (Jurien Bay) site.

Tuesday 2nd August

We arrived at site L10 (Jurien Bay) and commenced sampling with a CTD (op 123) in ~400 m. We completed a couple of short MBS lines to map this site and a 70 m deep depression was noted as we made a turn at the inshore extent of this mapping. We then deployed the Sherman sled (op 124). Due to strong winds and a moderate swell from the south west, we were unable to tow along depth and towed down-slope instead. A small sample of animals was collected including small crabs, holothurians, polychaetes, brittle stars and several species of fish.

An area of high backscatter was noted on the MBS map in an area north of this site and we decided it was worth steaming the ~ 10 nm back to the north to sample it. Further MBS mapping added to the picture. The high backscatter appeared to extend from ~280 m to ~500 m. We towed the camera down slope over the area of high backscatter from ~280 – 550 m (op 125). Hard bottom was encountered for most of the tow. Some of it was over rocky and steep ground whilst hard flat pavement was extensive. The hard areas in deeper water were covered with a thin veneer of sediment and had relatively few large attached epifauna. After several attempts, sediment samples were collected in ~400 m (ops 126, 127). We then MBS mapped a line into ~85 meters and deployed the camera for a short tow (op 128) to establish the geomorphology between ~85 and 105 m. Hard 1-2 m high reefs were covered with a diverse range large attached fauna. Some hard and gravely areas were site to large soft corals.

We spent the remainder of the evening steaming south on the 400 m contour towards latitude site L11 in heavy sea conditions.

Wednesday 3rd August
We continued MBS mapping in the heavy sea conditions. It wasn't possible to sample at L11 due to the rough conditions and so continued south along the 400 m contour towards the L12 (T4) (Two Rocks) site. Along the way cliff features with apparently shear 150 m walls were mapped. A video tow (op129) was completed on an area showing increased backscatter on the MBS map. The bottom showed signs of hardness with occasional sub-cropping and attached fauna. Once the camera system was returned to deck we steamed towards Fremantle for the mid-voyage science crew change and bunkering. Southern Surveyor berthed at Fremantle at ~1600 hrs.

The new science crew were soon at the ship and readying for their part of the voyage scheduled for departure at 1200 hrs the following day.

Leg 2

Thursday 4th August
The morning provided opportunity to purchase some lab consumables etc. The vessel received stores and bunkering took place throughout the morning. Our departure was delayed due to bunkering and contractor problems. Southern Surveyor departed for Leg 2 at 1400 hrs and headed back to the L12/ T4 (Two Rocks) site. Inductions, Safety at Sea, Muster and Job Hazard Analysis formalities were completed along with inductions for those joining the vessel. A general science meeting was held at ~1615 hrs to explain the leg 2 voyage plan and discuss shift working arrangements. We arrived at the 100 m L12 site at ~1930 hrs to do a CTD but once immersed in the water a problem became apparent. Eventually, the wire was cut (10 m removed) and re potted. Grab samples were taken at the 100, 200 and 400 m depths (ops 130 to 137). Typical of this region samples were coarse carbonate sands at the 100 and 200 m stations. A camera tow was planned for the next shift following some MBS mapping to scope out a tow site. The MBS map revealed a slump like canyon which appears to feed into the Perth Canyon. Some very good contrasting hard and soft ground was apparent in the MBS images which will be the focus of the video tows.

Friday 5th August
The camera system winch failed to start up and engineers were called to investigate. In the meantime we continued MBS mapping the site. Eventually the source of the problem was identified. The contact closures on a switching circuit were fused and irreparable. We proceeded to establish whether replacement components could be sourced in Perth, made arrangements for delivery to the ship by launch (c/o Stirling Marine) just outside the port of Fremantle and steamed towards Fremantle to rendezvous with the launch at 1330 hrs. The new component was immediately installed and the problem rectified. Once beyond port limits we also did a test deployment of the CTD (op 138) to see if re-terminating the cable had fixed its

problem. It was discovered that the oxygen sensor or its cable was the problem and once removed the CTD operated successfully. Steamed back to T4 100 (Two Rocks) following earlier MBS lines and commenced a CTD cast transect at 100 to 1000 m (op139 to142 and op147). Currents had changed to a 0.5 knot NW set compared to the previous 1.7 knot S set the previous evening. Weather conditions were favourable with light winds of less than 10 knots and a moderate swell. The 1000 m station was set at the edge of a large ledge (100 m) that dropped into a feeder canyon of the Perth canyon. Finished the 700 m and 1000 m sediment stations with good mud samples obtained. A school of garfish made home in the lights around the CTD hero-platform and were predated on by some very large squid.

Saturday 6th August

Video tows were targeted at both high and low acoustic backscatter (hard and soft terrain) at the 1000, 700 and 400 m depth stratums. This site – due to the feeder canyon bathymetry – provided many regions with contrasting soft and hard seabed types. The 1000 m video tow (op 148) on the north western edge of the canyon started with soft seabed with occasional gold and bamboo corals before moving onto the hard rubble of the canyon wall and floor. The next camera tow was at the 700 m site (op 149) on the NW canyon edge. During the video tow the drogue became entangled with a large boulder and snagged causing some anxious moments. The system was retrieved to find that the tail fin had been broken off but recovered as it was attached by a safety line. Although not related to the hook-up an optical fibre feed was repaired. This solved the problem of the sometimes flickering video signal that had become progressively worse. The final video tow (op 150) in ~400 m was targeted at the edge of the canyon after some delay due to the large swell. High numbers of unidentified fish were observed on the rough ground at the edge of the canyon wall before moving off to soft seabed characterized by many large flathead. This 400 m camera tow was completed at 14:10 hrs and we steamed for the L13 400 m study site without carrying out any extra transects at the Perth Canyon. This was required due to the long steam (10 hrs) and the need to complete the 2 sediment grabs and CTD cast (~ 2 hrs) prior to the next shift at 02:00 hrs. Of note en-route was the variable strength and direction of the current which at times flowed to the south at 1.2 knots and then to the north at 1.1 knots. The seabed backscatter near the Perth Canyon was characterized by undulating high and low backscatter with many steep walls as we steam further south away from the canyon the backscatter decreased to reveal a slightly sloping low backscatter (soft) seabed.

Sunday 7th August

The L13 (Australind) site was reached and sampling commenced with a CTD followed by 2 grabs (ops 152, 153). A camera tow was completed in ~400 m (op 154) and showed muddy soft sediments with moderate bioturbation and occasional seapens. We continued on our way south towards our next latitude site. We arrived at the L14 (Mentelle) site at ~1000 hours and proceeded with a camera tow (op 155). The tow direction was dictated by the moderate-to-large swell and the slope of the bottom. Consequently the camera touched down at ~440 m and reached 500 m in a short time. Once at this depth we decided to haul it up after 12 minutes bottom time as it wasn't representative of 400 m and the bottom was steeply sloping to deeper depths. Three casts with the sediment grab (ops 156, 157, 158) yielded two small samples (combined for elutriation). The third cast obtained a reasonable sample size. The CTD (op 159) was completed in 400 m and we recommenced the steam along the 400 m contour to the south. The CTD showed again the strong influence of Leeuwin Current water in the top 250 m.

Steamed along the 400 m contour with low backscatter (soft) gently sloping terrain grading to higher slope higher backscatter (hard) terrain with numerous canyons close to the L15 (Pt DÉntrecasteaux) study site. The sea surface temperature gradually decreased on our southern journey with 22o C off Perth to 19o C at the L15 study site. Also of note were a large number of pelagic schools observed on the 38 kHz echosounder in the 200 - 300 m depth range. Study site L15 was moved 17 n.miles east due to the steep canyon terrain at the existing L15 site as well as its long distance from the L16 study site. At the L15 site a CTD cast to 400 m (op160) showed high temperature high salinity Leeuwin current water constant to 225 m. Two sediment grab (ops 161, 162) showed that the ground was well-consolidated fine sand and had correspondingly low bucket penetration with the grab.

Monday 8th August

A camera tow (op 163) was completed at 400 m depth and showed a soft muddy seabed. After the camera tow there was a long steam of approximately 10 hrs to the L16 study site following the 400 m contour. At the L16 (Point Hillier) site the terrain was very steep and consisted of numerous small gullies. Two short sections of low backscatter (soft) terrain at 400 m were found and targeted with the camera (ops 164, 165). As the camera was deployed through the water column it revealed a high level of biological material with a high number of salps at depths to 425 m. At times the biological material (assumed to be small plankton – perhaps numerous copepods) density caused high backscatter and the video penetration was limited to less than a metre. Several mid-water camera shots were taken and video recorded of this significant concentration of salps and other planktonic biota. On the seabed the soft terrain contained numerous fish close to the seafloor and at times large patches of bioturbation. A highlight was at the end of the second segment of soft terrain a large steep rugged drop-off with several larger sharks noted swimming ahead of the camera system. In this very steep terrain the characterization of the seafloor and detailed bathymetry of the MBS were fully utilized. Two sediment grabs (op 166, 167) contained small samples of well consolidated sandy mud with a CTD cast characterizing the Leeuwin Current water as constant temperature in the upper 250 m.

The steam to the L17 (transect 6) was assisted with a tail wind and a strong Leeuwin Current flowing to the east.

Tuesday 9th August

Sampling at L17 (transect 6) in the Albany "focus area" site commenced with a CTD in 400 m (op 169) and was followed by two sediment grabs (ops 170, 171) in 400m. Two more sediment grabs were completed in 100 m (ops 172, 173). A CTD cast to 100 m (op 174) occured before some MBS mapping, at around that depth to scope-out the topography and backscatter. A camera tow was completed at 100 m (op 175) and revealed coarse current swept sediments and a moderate cover of sponges, bryozoans and ascidians. This was followed by another camera tow in 200 m (op 176). The 200 m depth contour was on a moderately steep slope and again revealed a diverse range of attached fauna including sponges and bryozoans. The camera tow in 400 m (op 177) -also on a sloping seafloor - had little attached fauna and appeared to be mostly softer muddy sediments with moderate levels of bioturbation. The final camera tow for the shift (op 178) was in 700 m and was on relatively flat bottom consisting of muddy sediments, little attached fauna and moderate levels of bioturbation.

A CTD (op 179) and two sediment grabs (ops 180, 181) were carried out at the 700 m depth contour with muddy sand of uniform size fraction obtained. Steamed to the 200 m site and carried out the CTD (op 182) and three sediment grabs, the first in 150 m (op 183) consisting of coarse carbonate sediment and two at 200m. The sediment grab (op 184) at 200 m contained a large sponge with associated bryozoans and was preserved for later analysis. The final sediment grab (op 185) at this site contained coarse carbonate sediments which confirmed the high backscatter observed on the MBS. A backscatter map of the region was completed with the multibeam sonar (MBS) to assist in targeting the video on soft and hard terrain. The region initially identified as Albany seamount was actually a small feature of only approximately 100 to 150 m height although it represented a distinctive acoustically hard feature in the region. A CTD at 100 m (op 186) was targeted at the side of the Albany mound with the 2 knot surface current moving us gradually to the East. The upper water column 150 m was typical of Leeuwin Current water. The vessel was manoeuvred to target acoustically soft terrain for the sediment grabs. At the 1000 m site the sediment grab failed to collect sediments after 4 attempts (ops 187, 188, 189, 190) and further attempts were ceased.

Wednesday 10th August

A camera tow was targeted at a knoll in about 1000 m (op 191) at T6. The camera system was flown to land on the top of the knoll (~830 m) and descend the western slope. Based on the MBS maps the knoll appeared to have heavy ridging on the top surrounded by high backscatter on the sides and at the base. As the camera tow transected the top we observed heavy undulating coarse sediments and coral debris. Whilst descending the slope high-relief rocky structure was encountered. The rock appeared hard and possibly of volcanic origin. An expansive area of hard ground at the base was crossed in ~1000 m and eventually onto softer bioturbated sediments. Of some surprise was a vessels ladder observed on the seafloor at this depth. A second camera tow was targeted at a high backscatter patch in 700 m (op 192). Initially the tow was over soft ground followed by heavy ridging and low and undercut current scoured hard bottom. These features were successfully negotiated ahead of a serious pinup. The camera system became lodged against a large and possibly undercut rock face. The vessel was immediately stopped and cable tension maintained. Retrieval was begun and we found that the winching in assisted the vessel in moving backwards – although not directly – towards the pinup site. At the time of the pinup, ~2400 m of cable was deployed and the system was in 770 m (strong currents – up to 2 knots - had required this wire to depth ratio to maintain bottom depth during the tow). The system remained lodged against the rock, we had lost lighting at the time of impact, but maintained telemetry and the ability to communicate with the stills camera. During the haul-up the system partially dislodged with debris and sediment clouds sweeping past the camera lens. We noted the odd angle the cameras were looking and that one of the strobes briefly came into view and dangled ahead of the camera. Retrieval of cable continued slowly and steadily until the camera came away from the bottom (~1400 m wire out). The system was retrieved to inspect the damage. We had lost one strobe, the flood lights weren't working, the towing bridle and frame were bent, and the look-ahead camera mounts strained and loosened. Subsequent troubleshooting reveal that the lights stopped working due to blown globes, the remaining strobe had also a blown globe. Some straightening and reinforcement of frame components plus reconfiguring with a replacement strobe had the system ready for a test deployment several hours later. The test deployment (op 193) in 100 m showed that all was working well. Lighting was adequate using one strobe and the system performed well.

Two Peoples Canyon was mapped whilst camera repairs were carried out which when combined with the GA Bremer Canyon survey data set provided an amazing view of the region. A shallow tow with the camera was targeted at a 100 m acoustically soft region to test the repairs. Due to the loss and damage to the strobes only one strobe was operable limiting the illumination to the central part of the still camera. Despite the damage suffered to the camera during the previous tow good video and still pictures were obtained and we concluded that the system could be used for further survey work. Completed the mapping of Two Peoples Canyon and commenced a sediment sampling transect T7 (Bald Island) on a section of soft terrain to the East of the canyon (ops 194, 195, 196, 197). This site was chosen for its gently sloping bathymetry and acoustically low backscatter being suitable for soft benthic physical samples. Good sediment samples were retained from 100 m (coarse sand) and 200-230 m (medium sand). A CTD at 400 m depth (op 198) showed that the Leeuwin Current high-salinity, high-temperature water was dominant to 270 m. Two sediment grabs at 400 m (ops 199 and 200) retained small samples of fine sand whilst the two grabs at 700 m (ops 201, 202) retained fine sandy mud.

Thursday 11th August

Sediment grabs were completed in 1000 m (ops 203, 204) at T7. A down-slope camera tow was decided upon instead of the usual along-slope tows at standard depths. With limited time remaining at this site, this would be the most efficient method of getting the depth coverage with the camera system. The tow (op 205) began in ~100 m. The slope was generally gentle but there was a steeper section around 200 m. Subtle bottom type changes and community changes were evident as we towed to 750 m. At this depth the camera system was hauled well-clear of the bottom and towed (~4 knots) to where the depth was ~900 m. At this depth the down-slope camera tow (op 206) was continued to 1050 m. Most of this was across soft bioturbated sediments although there was a short section with high-relief outcropping rocks.

Another camera tow (op 207) was completed adjacent to the canyon to the west. Initially at 400 m, then descended the edge of the canyon following some heavy ridging and hard bottom until ~500 m. We returned to the T6 (Albany) site to complete camera tows in 400 m and 200 m (ops 208, 209). The 400 m tow targeted a small area of apparent high backscatter. Soft bottom was observed for most of the tow along a steep bank. A small patch of hard bottom was seen but otherwise the area was characterized by current-swept sediments with occasional anemones. The tow was notable for the large number of salps drifting along just above and on the seafloor. The camera system was towed mid-water to the 200 m soft site. There was little of note at this site apart from the salps and occasional sponge either from nearby hard ground or attached to subsurface hard patches.

MBS maping continued for the remainder of the day back-
to and around the T5 (Point Hillier) site.

Friday 12th August

Once mapped with the MBS system, 2 camera tows were completed either side of the head of the canyon. The first (op 210) was to view a small low backscatter area on the eastern side of the canyon in 100 m. With strengthening northerly winds a short tow was completed in 100 m with the depth rising to 85 m. On the other side of the canyon head a small area of higher backscatter in 100 m was identified for a hard bottom site. Only a small patch of hardness was seen before we were again on soft sediments. At this stage, the wind was increasing and with a forecast frontal system we proceeded to map the deeper water around the seamount adjacent to this site with the MBS. The wind continued to increase during the afternoon from the north-west degrading the MBS output and only making 3 knots into the wind. Due to the deteriorating conditions we suspended MBS mapping activities at T5 (Point Hillier) at 22:00 hrs and proceeded at 3 to 4 knots towards the 100 m sampling sites. Due to the conditions the data quality from the MBS was marginal.

Saturday 13th August

Wind abated slightly during the morning before another front passed producing gusts of 50 to 60 knots. These conditions continued during the day and we gently punched into an increasing sea at an over the ground speed of 4 to 5 knots. Steamed pass the 100 m L15 site at 20:00 hrs without stopping as conditions remained at 30 to 50 knots westerly wind with a building sea. Vessel was steered to the west to reduce roll and prepare for the wind moving to the south-west during the early morning. Hopefully as the wind changes we can position the vessel to steer up the coast with the wind astern and make better time. Unlikely that we will be able to sample the inshore L14 site tomorrow.

Sunday 14th August

Strong winds continued throughout the morning and we did not sample the L14 100 m site but had dropped sufficiently to sample the L13 100 m Bunbury position. During the previous 24 hrs the wind peaked at 65.3 knots and averaged 58 knots. After discussions on the bridge and with gear crew we deployed the camera (op 212) and obtained some good footage all be it with a lot of movement. The sediment grabs (coarse calcareous sand) and CTD sample were also obtained as the seas decreased. We steamed to the Perth Canyon focus site on the 100 m depth contour as the wind and sea state eased. Arrived at the Perth Canyon at 0030 hrs and steamed to the first video station.

Monday 15th August

A camera tow (op 216) was targeted on an area of higher backscatter in 400 m on the north western side of Perth Canyon. The area was mostly low-relief with only slight signs of hardness with occasional small slabs and otherwise rubble fragments. Some MBS infilling was down as the ship moved to the next camera site (op 217) on the south eastern side of the canyon. This tow transited down-slope into the canyon and apart from some steep banks was mostly muddy and moderately sloping. Another camera tow (op 218) was completed on an area showing steep banks on the north eastern side.

Tuesday 16th August (check where Tuesday slots into sampling)

The fourth video tow (op 219) for the sunrise shift was completed at the 100 m T4 site over undulating sand wave terrain. The MBS backscatter showed a mosaic of high and low backscatter whilst the sub-bottom profiler revealed a 1 to 2 m sand wave sea bed with two layers underneath at approximately 3 and 5 m. This site represents a good example of varying patch structures observed with all the different instruments. The video showed frequent patches of attached fauna as well as continuing variations of sand wave structures. Seas were moderate with a confused swell making the video operation difficult. Mapped to the northern edge of the canyon to sample the 400 m sediments (ops 220,221) and completed a CTD (op 222). Due to the likelihood of poor weather continued to map the edges of the canyon and position the vessel for a CTD (op 223) in the deeper part of the canyon.

Wednesday 17th August

We continued to map the Perth Canyon using the multi-beam sonar (MBS). Strong winds prevailed and seas continued to build. No further deployments were possible in the rough sea conditions. By ~0430 hours it was time to depart the canyon and steam towards Fremantle. The Southern Surveyor was alongside and secure at Victoria Quay, Fremantle by 1000 hours.

Summary

The voyage was a technical and scientific success. All objectives were met, the sampling tools, especially the CMAR DVS towed camera system and NOO sponsored multibeam sonar, provided high quality data, and the science and vessel crews worked well together for the duration of the voyage. Multibeam sonar and seabed video data are in an advanced stage of processing and quality assurance and will be used to direct the biological sampling when all sampling sites are re-visited during the second voyage in November/ December 2005. Collectively, the data provide the first view of the structure and important components of the biodiversity inventory and distribution on the deep ocean seascape. Together with a high quality data set on fishes collected in 1991, they will contribute to developing, testing, refining and validating multiple use management frameworks developed for the SW Region as part of Regional Marine Planning that will inform the sighting of a representative system of marine protected areas.

It is clear from our study that technical and methodological issues remain to be investigated before a multibeam-based, optimised method for predictive and reliable habitat assessment is fully developed. While the multi-beam sonar in conjunction with seabed video has greatly advanced our understanding about the form and nature of the seafloor and we can reliably classify regional sites in terms of geomorphology (canyons, banks and sand waves etc) and substratum (e.g. soft and hard), less is known about the distribution of invertebrate fauna on these soft and hard seafloor types or their dynamics and partitioning due to other environmental and biological variables. The second voyage in this series will provide valuable data on species distributions in relation to geomorphology and substratum to assist us in addressing those questions. In particular are there reliable surrogates for invertebrate biodiversity beyond Province and depth?

Personnel

Leg 1 Scientific Contingent

Alan Williams	CMAR	Chief Scientist
Franziska Althaus	CMAR	Video processing
Nic Bax	CMAR	Spatial data management
Bruce Barker	CMAR	Camera systems
Pamela Brodie	CMAR	Data manager/ ADCP
Karen Gowlett-Holmes	CMAR	Invertebrate taxonomy
Rick Smith	CMAR	MBS mapping
Mark Lewis	CMAR	Gear operations
Matt Sherlock	CMAR	Camera systems
Alix Post	GA	Geoscience
Cameron Buchanan	GA	MBS mapping
Bob Beattie	CMAR	Voyage Manager/computing support/SST
Lindsay MacDonald	CMAR	NF electronics support
Neale Johnston	CMAR	NF Hydrochemistry/SST
Lee Panton	CMAR	System Support Technician

Leg 2 Scientific Contingent

Rudy Kloser	CMAR	Chief Scientist
Bruce Barker	CMAR	Camera systems
Pamela Brodie	CMAR	Data manager/ ADCP
Jeff Cordell	CMAR	Camera systems
Piers Dunstan	CMAR	Spatial data management
Karen Gowlett-Holmes	CMAR	Invertebrate taxonomy
Mark Lewis	CMAR	Gear operations
Gordon Keith	CMAR	MBS mapping
Alix Post	GA	Geoscience
Cameron Buchanan	GA	MBS mapping
Bob Beattie	CMAR	Voyage Manager/computing support/SST
Neale Johnston	CMAR	NF Hydrochemistry/SST
Peter Dunn	CMAR	NF electronics support
Lucy Potts	CSIRO	Communications

Marine Crew

Les Morrow	Master
Samantha Durnian	1st Officer
Brent Middleton	2nd Officer
Jim Hickie	Chief Engineer
Peter Dailey	1st Engineer
Seamus Elder	Electrical Engineer
Tony Hearn	Bosun

Helen Curran	Chief Steward
Andy Goss	Chief Cook
Angela Zutt	2nd Cook
Russel Williams	Integrated rating
Graham McDougall	Integrated rating
Paddy Chamberlain	Integrated rating
Tony Van Rooy	Greaser

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Alan Williams and Rudy Kloser
Chief Scientists SS07/2005

Table 1. Summary of deployments at each site.

Location	Latitude sample sites	Focus sites	Cross-slope transects	Box corer	CTD	Sherman benthic sled	Smith-McIntyre grab	camera	totals
Barrow	L1				1		2	1	4
Ningaloo North		F	T2	1	10		20	9	40
Ningaloo	L2	F					5	3	8
Ningaloo South		F	T1	1	4		5	3	13
Point Cloates	L3				1		2	1	4
Red Bluff	L4				1		2	1	4
Carnarvon	L5				1		2	1	4
Shark Bay	L6				1		2	1	4
Zuytdorp	L7				1		2	2	5
Kalbarri	L8				2		5	4	11
Abrolhos	L9		T3		5	1	12	8	26
Jurien	L10				1	1	2	2	6
Two Rocks	L12		T4		7		10	5	22
Perth Canyon		F			2		2	3	7
Mentelle	L14				1		3	1	5
Rottnest					1				1
Pt'DÉntercasteaux	L15				1		2	1	4
Bunbury					2		4	2	8
Point Hiller	L16		T5		1		2	4	7
Albany	L17	F	T6		5		13	9	27
Bald Island			T7		1		10	3	14
Grand Total				**2**	**49**	**2**	**107**	**64**	**224**

Table 2. List of sampling operations

Op#	Gear	Site	Area	Long	Lat	Depth (m)	Depth (m) end
1	CTD	L1	Barrow	114.381	-21.0079	398	-
2	Grab	L1	Barrow	114.381	-21.0084	397	-
3	Grab	L1	Barrow	114.381	-21.009	397	-
4	Camera	L1	Barrow	114.377	-21.0024	406	392
5	Box corer	T1 200 S	Ningaloo South	113.796	-22.0802	206	-
6	CTD	T1 200 S	Ningaloo South	113.795	-22.082	205	-
7	Grab	T1 200 S	Ningaloo	113.796	-22.079	206	-
8	Grab	T1 200 S	Ningaloo	113.797	-22.0796	205	-
9	CTD	T1 400 S	Ningaloo South	113.753	-22.0745	421	-
10	Grab	T1 400	Ningaloo	113.756	-22.074	394	-
11	Grab	T1 400	Ningaloo	113.754	-22.0745	409	-
12	Camera	T1 400	Ningaloo	113.756	-22.0729	398	445
13	Camera	T2 200	Ningaloo North	113.821	-21.9783	172	169
14	Camera	T2 100	Ningaloo North	113.834	-21.9856	108	108
15	CTD	T2 100	Ningaloo North	113.844	-21.9789	98	-
16	Box corer	T2 100	Ningaloo North	113.843	-21.9791	100	-
17	Grab	T2 100	Ningaloo North	113.843	-21.9792	100	-
18	Grab	T2 100	Ningaloo North	113.843	-21.9792	99	-
19	CTD	T1 100	NIngaloo South	113.809	-22.0822	109	-
20	Grab	T1 100	Ningaloo South	113.81	-22.0852	107	-
21	Grab	T1 100	Ningallo South	113.813	-22.086	103	-
22	CTD	T1 700	Ningaloo South	113.725	-22.0607	714	-
23	Grab	T1 700	Ningaloo South	113.723	-22.0629	715	-
24	Grab	T1 700	Ningaloo South	113.724	-22.0631	713	-
25	Camera	T1 700	Ningaloo South	113.724	-22.0535	648	649
26	Camera	T1 200	Ningaloo South	113.796	-22.0782	207	269
27	Camera	T1 100	Ningaloo	113.822	-22.0356	105	107
28	Camera	T1 100	Ningaloo South	113.814	-22.0743	101	104
29	Camera	T2 200	Ningaloo North	113.822	-21.977	172	225
30	Grab	T2 200	Ningaloo North	113.814	-21.9728	214	-
31	Grab	T2 200	Ningaloo North	113.813	-21.9719	216	-
32	CTD	T2 200	Ningaloo North	113.815	-21.9713	211	-
33	Grab	T2 400	Ningaloo North	113.789	-21.9669	429	-
34	Grab	T2 400	Ningaloo North	113.79	-21.9664	407	-
35	CTD	T2 400	Ningaloo North	113.789	-21.9659	412	-
36	Grab	T2 700	Ningaloo North	113.763	-21.966	724	-
37	Grab	T2 700	Ningaloo North	113.763	-21.966	727	-
38	CTD	T2 700	Ningaloo North	113.764	-21.9659	698	-
39	Camera	T1 1000	Ningaloo	113.649	-22.0131	1069	962
40	Camera	T2 400	Ningaloo north	113.793	-21.9707	349	389
41	Camera	T2 700	Ningaloo north	113.764	-21.9635	648	761
42	Camera	T2 1000	Ningaloo north	113.697	-21.9477	1078	979
43	CTD	T2 1000	Ningaloo North	113.712	-21.9559	1024	-
44	Grab	T2 1000	Ningaloo North	113.713	-21.9567	1019	-
45	Grab	T2 1000	Ningaloo North	113.713	-21.9568	1018	-
46	Grab	T1 1000	Ningaloo	113.657	-22.0239	1073	-
47	Grab	T1 1000	Ningaloo South	113.656	-22.0242	1071	-
48	CTD	T2 1300	Ningaloo North	113.629	-21.8998	1293	-
49	Camera	Ridge	Ningaloo North	113.707	-21.9729	898	816
50	Camera	T1 150	Ningaloo North	113.812	-22.0736	102	129
51	Camera	T1 150	Ningaloo North	113.821	-22.042	107	193
52	CTD	Canyon 300	Ningaloo North	113.798	-22.0647	306	-
53	CTD	Canyon 500	Ningaloo North	113.776	-22.0622	497	-
54	CTD	Canyon 700	Ningaloo North	113.749	-22.05	704	-
55	CTD	Canyon 100	Ningaloo North	113.816	-22.0603	106	-
56	Grab	Reflectivity	Ningaloo North	113.818	-22.0379	110	-
57	Grab	Reflectivity	Ningaloo North	113.819	-22.038	108	-

Op#	Gear	Site	Area	Long	Lat	Depth (m)	Depth (m) end
58	Grab	Reflectivity	Ningaloo North	113.816	-22.0323	123	-
59	Grab	Reflectivity	Ningaloo North	113.816	-22.0323	125	-
60	Grab	Reflectivity	Ningaloo North	113.814	-22.0275	135	-
61	Grab	Reflectivity	Ningaloo North	113.814	-22.0274	136	-
62	Grab	Reflectivity	Ningaloo North	113.813	-22.0224	151	-
63	Grab	Reflectivity	Ningaloo North	113.813	-22.0226	149	-
64	Grab	Reflectivity	Ningaloo North	113.81	-22.0165	178	-
65	Grab	Reflectivity	Ningaloo North	113.81	-22.0169	177	-
66	Camera	L3	Point Cloates	113.336	-22.8482	424	443
67	CTD	L3	Point Cloates	113.327	-22.8588	452	-
68	Grab	L3	Point Cloates	113.328	-22.859	449	-
69	Grab	L3	Point Cloates	113.327	-22.8588	452	-
70	Camera	L4	Red Bluff	112.544	-23.9843	400	403
71	CTD	L4	Red Bluff	112.54	-23.9923	399	-
72	Grab	L4	Red Bluff	112.549	-23.9961	385	-
73	Grab	L4	Red Bluff	112.551	-23.9967	383	-
74	Camera	L5	Carnarvon	112.257	-24.5596	390	370
75	Grab	L5	Carnarvon	112.253	-24.5875	406	-
77	CTD	L5	Carnarvon	112.254	-24.5867	406	-
76	Grab	L5	Carnarvon	112.254	-24.5863	406	-
78	Camera	L6	Shark Bay	112.243	-25.9288	407	418
79	CTD	L6	Shark Bay	112.254	-25.9572	404	-
80	Grab	L6	Shark Bay	112.254	-25.9593	405	-
81	Grab	L6	Shark Bay	112.257	-25.9598	394	-
82	Camera	L7 100	Zuytdorp	113.097	-27.0419	96	97
83	Camera	L7 400	Zuytdorp	112.75	-27.1321	417	408
84	Grab	L7 400	Zuytdorp	112.771	-27.1609	392	-
85	Grab	L7 400	Zyutdorp	112.778	-27.1676	376	-
86	CTD	L7 400	Zuytdorp	112.784	-27.1671	349	-
87	CTD	L8 400	Kalbarri	113.075	-27.9264	416	-
88	Grab	L8 400	Kalbarri	113.078	-27.9306	417	-
89	Grab	L8 400	Kalbarri	113.081	-27.9351	417	-
90	Grab	Seep 1	Kalbarri	113.099	-27.9003	305	-
91	Grab	Seep 1	Kalbarri	113.1	-27.9012	313	-
92	Grab	Seep 2	Kalbarri	113.114	-27.9173	320	-
93	CTD	Seep 2	Kalbarri	113.114	-27.9174	324	-
94	Camera	Seep 1	Kalbarri	113.096	-27.895	282	298
95	Camera	Cirque	Kalibarri	113.139	-27.9298	252	287
96	Camera	L8 400	Kalibarri	113.081	-27.9345	417	434
97	Grab	T3 400	Abrolhos	113.766	-28.9925	404	-
98	Grab	T3 400	Abrolhos	113.766	-28.9906	388	-
99	CTD	T3 400	Abrolhos	113.763	-28.9882	392	-
100	CTD	T3 700	Abrolhos	113.717	-29.0188	715	-
101	Grab	T3 700	Abrolhos	113.718	-29.019	711	-
102	Grab	T3 700	Abrolhos	113.719	-29.0198	712	-
103	Camera	T3 700	Abrolhos	113.713	-29.0115	706	699
104	Camera	T3 400	Abrolhos	113.763	-28.9886	401	406
105	Camera	T3 400	Abrolhos	113.778	-29.0077	411	434
106	Camera	T3 200	Abrolhos	113.78	-28.9835	173	212
107	Camera	T3 200-550	Abrolhos	113.791	-29.0035	212	564
108	CTD	T3 100	Abrolhos	113.841	-28.9872	103	-
109	Grab	T3 100	Abrolhos	113.837	-28.9882	117	-
110	Grab	T3 100	Abrolhos	113.84	-28.9903	114	-
111	Grab	T3 200	Abrolhos	113.787	-28.998	192	-
112	Grab	T3 200	Abrolhos	113.787	-29.0001	207	-
113	Grab	T3 200	Abrolhos	113.79	-29.0021	211	-
114	Grab	T3 200	Abrolhos	113.79	-29.0019	208	-
115	CTD	T3 200	Abrolhos	113.79	-29.0023	209	-

Op#	Gear	Site	Area	Long	Lat	Depth (m)	Depth (m) end
116	CTD	T3 1000	Abrolhos	113.643	-29.0698	987	-
117	Grab	T3 1000	Abrolhos	113.641	-29.069	997	-
118	Grab	T3 1000	Abrolhos	113.641	-29.0686	997	-
119	Camera	T3 1000	Abrolhos	113.627	-29.0775	1050	986
120	Camera	T3 100 Reef	Abrolhos	113.829	-28.964	81	110
121	Camera	T3 100	Abrolhos	113.84	-28.9862	109	112
122	Sherman	T3 400	Abrolhos	113.774	-29.0029	409	409
123	CTD	L10 400	Jurien Bay	114.466	-30.002	389	-
124	Sherman	L10 400	Jurien Bay	114.477	-29.9801	258	330
125	Camera	L10 400	Jurien Bay	114.377	-29.8326	259	543
126	Grab	L10 400	Jurien Bay	114.372	-29.8604	500	-
127	Grab	L10 400	Jurien Bay	114.374	-29.8515	362	-
128	Camera	L10 100	Jurien Bay	114.442	-29.802	88	115
129	Camera	L12 200	Two Rocks	115.004	-31.6235	206	212
130	Grab	T4 100	Two Rocks	115.179	-31.6122	105	-
131	Grab	T4 100	Two Rocks	115.178	-31.6119	105	-
132	CTD	T4 100	Two Rocks	115.178	-31.6119	105	-
133	CTD	T4 200	Two Rocks	115.019	-31.6484	196	-
134	Grab	T4 200	Two Rocks	115.021	-31.6484	196	-
135	Grab	T4 200	Two Rocks	115.024	-31.654	194	-
136	Grab	T4 400	Two Rocks	114.981	-31.6616	403	-
137	Grab	T4 400	Two Rocks	114.978	-31.6551	408	-
138	CTD	TEST	Rottnest				-
139	CTD	T4 100	Two Rocks	115.169	-31.6089	109	-
140	CTD	T4 200	Two Rocks	115.018	-31.6337	201	-
141	CTD	T4 400	Two Rocks	114.975	-31.6541	418	-
142	CTD	T4 700	Two Rocks	114.876	-31.6834	731	-
143	Grab	T4 700	Two Rocks	114.877	-31.6895	739	-
144	Grab	T4 700	Two Rocks	114.878	-31.6971	734	-
145	Grab	T4 1000	Two Rocks	114.754	-31.7262	993	-
146	Grab	T4 1000	Two Rocks	114.757	-31.7272	990	-
147	CTD	T4 1000	Two Rocks	114.76	-31.729	991	-
148	Camera	L12 1000	Two Rocks	114.75	-31.7245	1001	1064
149	Camera	L12 700	Two Rocks	114.834	-31.6777	713	678
150	Camera	L12 400	Two Rocks	114.98	-31.61	337	390
151	CTD	L13 400	Bunbury	114.579	-32.9999	400	-
152	Grab	L13 400	Bunbury	114.576	-32.9987	418	-
153	Grab	L13 400	Bunbury	114.579	-33.0003	399	-
154	Camera	L13 400	Bunbury	114.57	-33.009	422	397
155	Camera	L14 400	Mentelle	114.442	-34.0135	479	530
156	Grab	L14 400	Mentelle	114.452	-34.0118	367	-
157	Grab	L14 400	Mentelle	114.45	-34.0226	398	-
158	Grab	L14 400	Mentelle	114.452	-34.0365	395	-
159	CTD	L14 400	Mentelle	114.453	-34.0417	382	-
160	CTD	L15 400	Pt D'Entrecasteaux	115.363	-35.0749	470	-
161	Grab	L15 400	Pt D'Entrecasteaux	115.352	-35.0712	386	-
162	Grab	L15 400	Pt D'Entrecasteaux	115.354	-35.0714	398	-
163	Camera	L15 400	Pt D'Entrecasteaux	115.357	-35.0716	425	380
164	Camera	L16 400	Point Hillier	117.222	-35.3798	444	493
165	Camera	L16 400	Point Hillier	117.204	-35.3819	424	547
166	Grab	L16 400	Point Hiller	117.221	-35.3808	437	-
167	Grab	L16 400	Point Hiller	117.22	-35.3811	428	-
168	CTD	L16 400	Point Hiller	117.22	-35.381	431	-
169	CTD	T6 400	Albany	118.311	-35.3669	498	-
170	Grab	T6 400	Albany	118.305	-35.3651	390	-

Op#	Gear	Site	Area	Long	Lat	Depth (m)	Depth (m) end
171	Grab	T6 400	Albany	118.307	-35.3653	413	-
172	Grab	T6 100	Albany	118.281	-35.3395	101	-
173	Grab	T6 100	Albany	118.282	-35.3393	101	-
174	CTD	T6 100	Albany	118.28	-35.3391	101	-
175	Camera	T6 100	Albany	118.293	-35.3357	99	102
176	Camera	T6 200	Albany	118.309	-35.3516	192	194
177	Camera	T6 400	Albany	118.305	-35.3657	404	402
178	Camera	T6 700	Albany	118.334	-35.3701	679	697
179	CTD	T6 700	Albany	118.318	-35.3812	713	-
180	Grab	T6 700	Albany	118.316	-35.384	722	-
181	Grab	T6 700	Albany	118.319	-35.3802	713	-
182	Grab	T6 150	Albany	118.29	-35.3552	153	-
183	Grab	T6 200	Albany	118.29	-35.3584	194	-
184	Grab	T6 200	Albany	118.29	-35.3568	169	-
185	CTD	T6 200	Albany	118.291	-35.358	190	-
186	CTD	T6 1000	Albany	118.36	-35.4346	1029	-
187	Grab	T6 1000	Albany	118.363	-35.4317	1019	-
188	Grab	T6 1000	Albany	118.368	-35.4319	1035	-
189	Grab	T6 1000	Albany	118.364	-35.4287	1018	-
190	Grab	T6 1000	Albany	118.367	-35.4295	1030	-
191	Camera	T6 1000	Albany	118.349	-35.4353	897	1006
192	Camera	T6 700	Albany	118.314	-35.3956	773	757
193	Camera	T6 100	Albany	118.38	-35.3056	96	98
194	Grab	T7 100	Bald Island	118.631	-35.1773	102	-
195	Grab	T7 100	Bald Island	118.632	-35.1774	103	-
196	Grab	T7 200	Bald Island	118.649	-35.1937	245	-
197	Grab	T7 200	Bald Island	118.65	-35.1941	253	-
198	CTD	T7 400	Bald Island	118.659	-35.2095	422	-
199	Grab	T7 400	Bald Island	118.659	-35.2092	415	-
200	Grab	T7 400	Bald Island	118.658	-35.2094	412	-
201	Grab	T7 700	Bald Island	118.671	-35.2298	712	-
202	Grab	T7 700	Bald Island	118.672	-35.2298	716	-
203	Grab	T7 1000	Bald Island	118.718	-35.2805	979	-
204	Grab	T7 1000	Bald Island	118.718	-35.2792	981	-
205	Camera	T7 100	Bald Island	118.633	-35.1779	104	748
206	Camera	T7 1000	Bald Island	118.702	-35.2621	890	981
207	Camera	T7 400	Bald Island	118.615	-35.2256	408	534
208	Camera	T6 400	Albany	118.408	-35.3174	331	343
209	Camera	T6 200	Albany	118.341	-35.3404	223	221
210	Camera	T5 100	Point Hillier	117.256	-35.3537	103	78
211	Camera	T5 100	Point Hillier	117.217	-35.3568	96	87
212	Camera	L13 100	Bunbury	114.819	-33.037	95	115
213	Grab	L13 100	Bunbury	114.808	-33.0383	103	-
214	Grab	L13 100	Bunbury	114.808	-33.0375	103	-
215	CTD	L13 100	Bunbury	114.807	-33.0376	104	-
216	Camera	Focus Area	Perth Canyon	115.026	-31.9198	480	479
217	Camera	Focus Area	Perth Canyon	115.199	-32.0065	276	554
218	Camera	Focus Area	Perth Canyon	115.203	-31.9211	193	371
219	Camera	T4 100	Two Rocks	115.247	-31.7286	102	102
220	Grab	Focus Area	Perth Canyon	115.021	-31.8535	414	-
221	Grab	Focus Area	Perth Canyon	115.022	-31.8533	413	-
222	CTD	Focus Area	Perth Canyon	115.023	-31.8528	411	-
223	CTD	Focus Area	Perth Canyon	115.091	-31.9606	1208	-