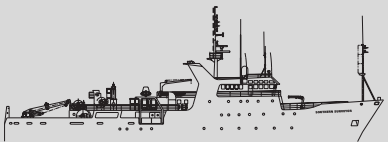

MARINE
NATIONAL FACILITY

2004 program

RV *Southern Surveyor*

CSIRO
MARINE RESEARCH

voyage summary SS04/2004

SS04/2004

Testing, refinement and application of methodology for optimised seabed mapping on the continental shelf and slope (200-2000 m depth) to support sustainable management of biodiversity and fisheries.

Itinerary

Depart Hobart 1700 hrs, Saturday 10th April, 2004

Arrive Sydney 1400 hrs, Thursday 29th April, 2004

Note: This voyage includes 5 days Research Charter by CSIRO Marine Research.

Principal Investigators

• Dr Alan Williams (Chief Scientist) • Mr Rudy Kloser

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Scientific Objectives

Ecosystem-based, integrated regional marine planning for the Australian marine environment depends initially 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 multibeam acoustics (swath mapping) 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 (10's m) over intermediate scales (10's to 100's of sq km), there are still many technical and methodological issues to investigate before a multibeam-based, optimised method for predictive and reliable habitat assessment is developed and tested.

This voyage provides an opportunity to test and refine optimal techniques to map and assess seabed habitat developed in a previous CMR project (NOO OP2000-SE02). Importantly, this voyage will use the National Facility's high-resolution EM300 swath mapper for its first program of biological and physical habitat mapping.

The sampling locations are a number of submarine canyons and their immediately adjacent flanks on the west coast of Tasmania and east of Bass Strait. These are prime targets for our methods development because each canyon area is characterised by a great variety of seabed topography and benthic communities concentrated in a relatively small area (< 300 sq km).

This voyage is also an opportunity to apply the data collected to marine resource management planning in the South East Region. Submarine canyons represent a type of habitat unit ('Level 3 biogeomorphic units') having a strong influence on the location of offshore Marine Protected Areas on the continental slope and rise, and many are likely to be biodiversity 'hotspots'. Several canyons are also the locations of the largest known aggregations of feeding and spawning fishes in the South-East Fishery region, and these support a range of intense, increasing and, in places, conflicting fishing activities. Given the immediate and increasing relevance of submarine canyons to conservation and fishery managers, it is then surprising to realize that virtually all those in the SE region remain unsampled by scientists, and are named only by commercial fishers. For these reasons, sampling on this voyage will focus on the "Big Horseshoe Canyon" mapped previously with the EM1002 and EM12 swath instruments (to enable comparison of data types, and to investigate temporal persistence of features), and several 'new' areas.

Selection of new target areas for this voyage is to be based on three factors:
1) their immediate relevance to the roll-out of offshore MPA's as part of the National Representative System of MPA's and the SE Regional Marine Planning process;
2) their relevance to understanding the efficacy of spatial planning initiatives for fishery management purposes; and 3) their prospective contribution to two existing CMR projects investigating, firstly, fishing impacts on shelf-edge habitat, and secondly, to estimate the spawning biomass of blue grenadier. In the event of insufficient time to sample all target areas, prioritisation will take into account the requirements of each of the above three factors.

Targeted sampling with the biological and physical sampling 'toolkit' will be based on swath acoustic maps made in real-time at sea using data from the Simrad EM300 multibeam, and existing, but un-ground-truthed, swath maps made using the EM1002 and EM12, and guided by the predictive methods developed in CMR project OP2000-SE02. The physical and biological attributes of target areas will be assessed by sampling sediments, consolidated sediments, invertebrates and fishes with a rock dredge and benthic sleds, and by obtaining image data with a towed, high-resolution video system. Acoustic position-tracking beacons mounted on these instruments will allow them to be positioned accurately, and for data to be precisely georeferenced.

Voyage Objectives

At each of several target areas on the west coast of Tasmania and east of Bass Strait:

1. Generate swath acoustic maps of submarine canyons and their immediately adjacent continental shelf and slope (~200-2000 m) with the Simrad EM300 multibeam.

2. Collect biological, physical and photographic ground-truth samples with a sediment grab, rock sled, epibenthic sleds and the CMR SVS camera platform from regions of upper continental slope seabed (~200-700 m) to classify and test predictions of seabed habitat types based on acoustic swath data (primarily backscatter, bathymetry and bathymetry-derived variables such as slope and aspect).

In addition, to enable identification of biodiversity values and the refinement of biophysical regionalisation at continental slope depths by

3. Collecting and curating benthic invertebrates to provide a biological inventory at various scales of taxonomic resolution

4. Collecting and curating demersal fishes to provide a biological inventory at species-level

Additional objectives related to providing material for two CSIRO Marine Research piggy-back projects:

5. Collecting hard corals for age estimation, and collection of the molluscs Gazameda gunnii and the invasive Maoricolpus for genetic probe development. (Gazameda gunnii has been recommended for listing on the Threatened Species Protection Act under Schedule 3 (Endangered). As a precursor to a larger environmental impact study currently genetic tools to identify larval M. roseus in the plankton and benthic samples are being developed at CMR through a NHT funded project "Development of genetic probes for rapid assessment of impacts of marine invasive species on native biodiversity - Maoricolpus roseus" (J. Patil, PI).

Voyage Track

Shelf edge/ upper slope (west of Tasmania, north to King Island, east through Bass Strait to shelf edge/ upper slope in Banks Strait, north to the eastern arm of Bass Canyon and north to Sydney (see Figure 1). Voyage track through Bass Strait via the newly defined candidate MPA 2 area south of Black Pyramid, and three of the historical Museum of Victoria "sponge beds" sampling stations.

Results

1. Generate swath acoustic maps of submarine canyons and their immediately adjacent continental shelf and slope (~200-2000 m) with the Simrad EM300 multibeam.

High resolution map products (bathymetry, texture, backscatter and slope) of all key target features were made at sea; this aspect of the voyage was highly successful. Performance of the newly installed EM300 system exceeded expectations for data acquisition in the depth range surveyed (~100-1000 m) with respect to transecting speed, performance in poor sea state and width of swath cover. We successfully generated maps of unprocessed data in real time, thereby enabling the locations of physical ground-truth sampling to be planned and implemented with very short lead times. A range of target terrains, including the most challenging escarpments, were successfully sampled as a result. A strategy for post-processing the bathymetry data was developed and implemented at sea, resulting in all data (except transit data collected on the last day) being dealt with by the end of the voyage.

Importantly, pre-existing scientific reference sites established in 2000 during the evaluation of the EM1002 were also resurveyed to enable comparison and calibration of the two multibeams. These data also provide some scope to evaluate temporal changes in terrains such as sediment transport, burial of outcrops or turbidity flows.

2. Collect targeted biological, physical and photographic ground-truth samples to classify and test predictions of seabed habitat types based on acoustic swath data.

High quality ground-truth data were successfully collected from a variety of contrasting seabed acoustic facies in all key target areas. Superb imagery of target terrains was captured with a state-of-the-art towed camera platform carrying paired (stereo) high resolution video cameras and a high resolution digital stills camera. The system was successfully piloted down the most challenging of these terrains – the rocky escarpments forming the walls of the submarine canyons. This was a particularly pleasing result because the system had not previously been used from Southern Surveyor. In all, some 18 hours of video (each camera) and 2,900 stills were collected from the key target sites. All image data were geolocated on the seabed with a small and quantifiable absolute accuracy using the Sondardyne USBL beacon carried by the camera platform. This enables precise referencing and overlay of images on swath maps to examine boundaries. Collections of benthic animals and substratum types with the sleds and sediment grab were mostly successful, although some repeat sampling was necessary to get samples of adequate size. Initial evaluation of the data suggest strong correlations of facies types to substratum and community types in previously unsurveyed terrains, and the ability to predict substratum types and community dominants at different locations in the previously surveyed Big Horseshoe Canyon.

Rock samples have been transported to the Geoscience Australia laboratories in Canberra for expert identification and curation.

3 & 4 Enable identification of biodiversity values and the refinement of biophysical regionalisation at continental slope depths by collecting and curating benthic invertebrates and fishes to provide a biological inventory at various scales of taxonomic resolution

This objective was very successfully completed with collections of all macroinvertebrates sorted to the lowest possible resolution, all recognizable taxa photographed in high-resolution digital images and systematically incorporated in a field guide to enable consistency in data recording, and all taxa being properly preserved on board. Sub-collections have already been distributed to the relevant experts and collections at the Australian Museum, Museum of Victoria, Queensland Museum and the Northern Territory Museum for definitive identification of taxa necessary to provide a more complete account of biodiversity, and biodiversity values. In addition, unsorted and coarse-sorted samples of sediment substrata from sleds and the sediment grab were retained to evaluate the community composition of the small invertebrates and infauna (those requiring examination with a microscope). The few fishes caught by the epibenthic sleds were frozen and deposited in the Australian Fish Collection at the CSIRO Marine Laboratories in Hobart.

5. Collection of hard corals for age estimation, and collection of the molluscs Gazameda and the invasive Maoricolpus for genetic probe development

A small collection of solitary corals was made and provided to Dr Ron Thresher; frozen and alchohol-fixed specimens of Gazameda were provided to Drs Jawahar Patil and Nic Bax.

Additional objectives

(relevance of data collections to other projects)

In addition to addressing the primary methodology-development objectives for this voyage, it was possible to add-value to the sampling by careful selection of the target areas. This took account of prospective relevance to the roll-out of offshore MPAs, understanding the efficacy of spatial planning initiatives for fishery management purposes, and contribution to existing CMR projects investigating fishing impacts on shelf-edge habitat, and to estimate the spawning biomass of blue grenadier.

Value-adding was very successful because it was possible to target several sites important for methods development that were also relevant to other projects. For example, canyon sites in the western province of the Southeast Region important to methods development because of their broadly different shelf edge geomorphology and location in a previously unsampled faunal province, were able to be chosen in the recently declared MPA sites in the "Zeehan" broad area off King Island. As well, bathymetry and ground-truth data from several sites and the transits on the west coast of Tasmania, and from the Banks Strait and Babel Canyons have direct application to the "fishing impacts on shelf-edge habitat" project; the bathymetry data from the Pieman, Ling Hole and Strahan Canyons will be used in the sampling design for the "spawning biomass of blue grenadier" project; and all data will be valuable to developing fishery spatial management plans through the CSIRO "Ecological Risk Assessment" and "Alternative Management Strategies" projects.

Our success in value-adding highlights not only the power of the 'optimised mapping methodology' built around multibeam acoustics, but also the general lack of high quality, multi-scale spatial data available to projects built around some sort of spatial framework. These most obviously involve the spatial management of human activity through MPAs and fishery closures.

Voyage Narrative

General
EM300 multibeam, EK500, ADCP and underway data were collected continuously throughout the voyage except for short periods when computers crashed, or when specific acoustic trials were being made.

Saturday 10 April
Delayed departure from Hobart for seven hours due to a dirty residue found in a batch of fuel. Steamed to the 50 m depth contour in Storm Bay to calibrate the Sonardyne tracking system. Sondardyne deck unit not recognizing transceiver unit consistently resulted in the calibration being abandoned until the problem was resolved. Transferred the staff member who was assisting the calibration (Simon Allen, CMR) to a pilot vessel at Iron Pot and then steamed towards Southwest Cape to commence survey. Problem with Sonardyne diagnosed afterwards as being due to the deck unit overheating in a new enclosed racking system.

Sunday 11 April
Headed northwards up the west coast of Tasmania along the 500 m depth contour towards survey sites at three major submarine canyons. The transect depth was chosen based on its relevance to understanding fishery catch and effort distribution, and because it is an optimal depth for the EM300 in terms of swath width and data quality; depth range covered by swath was approximately 400-600 m. Completed a short cross-shelf-edge transect for swath map data off Southwest Cape (a prospective future sampling site) and then moved north to the Strahan Canyon where a full swath survey of the upper slope portion (~200-1000 m depths) of the canyon was completed.

Monday 12 April
Moved north along the 500 m contour to the Pieman Canyon. A mini-swath survey of a sampling site for the "Shelf-edge fishery interaction project" just north of the Strahan Canyon was completed en route. Conducted a full swath survey of the upper slope portion of the Pieman Canyon.

Tuesday 13 April
Moved north from the Pieman Canyon along the 500 contour to the Ling Hole Canyon. A full swath survey of upper slope portion of this feature was completed before heading north towards the final west coast survey area adjacent to King Island, again following the 500 m contour.

Wednesday 14 April

Commenced swath survey of a relatively large outer shelf/ upper slope area west of King Island containing a number of canyons, and the site of the "Zeehan broad area, draft candidate MPA 1". Departed during mid-afternoon for Phoques Bay at the north of King Island to do the Sonardyne tracking system calibration in ideal calm conditions. Had difficulty in maneuvering the ship close to the beacon because full DP wasn't used. We then had the misfortune to run over the buoy line, pulling it into the starboard stern thruster and severing the surface buoys from the beacon. Decided to return to complete the calibration and grapple for the beacon during daylight the following day. Returned to the King Island Canyon survey area and continued swath mapping.

Thursday 15 April

Returned to Phoques Bay at 08:00, completed the calibration and then attempted to grapple for the beacon and mooring. Our failure to hook the gear up indicated the line between the beacon and mooring had probably been severed, so we gave up in frustration around 14:00, abandoning the beacon in the knowledge that we had a spare, and returned to the survey area to complete the swath survey of the core survey area.

Friday 16 April

Swath mapped during the night then steamed to Grassy Harbour on King Island to do the staff transfer, arriving at 09:30. Transfer prolonged due to trouble with outboard motor on rubber ducky and need to change A-frame blocks in sheltered waters, but eventually completed by early afternoon. Steamed out into fresh winds and large seas. Completed first station with benthic sled in deteriorating conditions, then reduced to running E-W swaths in shallow component of MPA 1 box as winds gusted above 40 knots. Data collection was still possible in these conditions, although a much greater degree of overlap of adjacent swath tracks was necessary.

Saturday 17 April

Returned to benthic sled sampling as winds and sea moderated; problems with poor targeting and the sled overturning meant both sides of the northern MPA canyon had to be repeated. Some additional swath mapping completed between sleds – mainly filling gaps between our coverage and pre-existing data from the AUSCAN voyage.

Sunday 18 April

Completed the first SVS video transect – an extended tow across the northern MPA canyon and adjacent Y-shaped canyon. This was followed by benthic sled sampling at same sites resulting in no sample from the first, but a good sample from the second.

Monday 19 April

Completed sampling at King Island canyons with rock sampling in the early hours of morning, followed by three video tows, three sediment samples on the outer shelf, a sled sample from the outer shelf, and LADCP casts over northern canyon site 2. Weather good with lights winds and no swell. Commenced steam south to Ling Hole Canyon survey area.

Tuesday 20 April

Arrived at the Ling Hole Canyon at 10:00 and commenced ground-truth sampling with a video transect in NW section covering a range of acoustic facies from outer shelf to deep upper slope. Became entangled close to the seabed on what turned out to be a set of discarded fishing gear. Camera platform was eventually winched to the surface and the old fishing gear cut free at the stern ramp. Unfortunately the optic fibre was broken in the process and several hours of investigation was unable to trace the break. Sampling continued with benthic sled on the NW and NE sections, a CTD/ LADCP cast over the canyon axis in 500 m and a few swath lines to fill gaps in existing coverage.

Wednesday 21 April

Completed a rock dredge sample at the NW escarpment then steamed south to the Pieman Canyon. Arrived at 06:15 and completed a set of six Smith MacIntyre grabs samples for Dave Mills' "shelf-edge trophic links project" on the shelf edge. The broken optic fibre was realigned by streaming the video cable to release tension built up while hauling the tangled fishing gear. A video transect across both sides of the Pieman Canyon (down-slope on the southern edge and up-slope on the northern edege) was completed successfully by 16:00. The new acoustic target strength instrument ('fat boy') was tested at ~150 m depth over the canyon axis in about 400 m of water. Thirty minutes of data logging was completed, with sequential shut down of other acoustic instruments (EM300, ADCP, and EK500) during test; all bridge sounders were off.
A benthic sled on the northern wall followed; it became bogged fairly quickly and a weak-link was broken during retrieval – but returned an adequate sample including ~10 k of mudstone. Following this we steamed south to collect a further 6 sediment samples at two sites on the outer shelf ("south of Pieman Canyon") and then returned north to complete the benthic sled sampling in the Pieman Canyon. Winds freshening ahead of front.

Thursday 22 April

Arrived back at Pieman Canyon at 02:00 and successfully completed two benthic sled stations along the camera transect at the NW and SE canyon walls. The first took a very large sample. We then headed north, back to the Ling Hole Canyon where the final video transect was completed. The direction was not ideal due to the prevailing weather of strong northerly winds of 25 knots gusting to 30. However the lower shelf break and dunes facies were covered. Departed the Ling Hole at 15:00 steaming north along the inside of our existing swath lines as far as the Sandy Cape region where we turned NE towards the next survey area – the second of the draft candidate MPA areas for the 'Zeehan' region: MPA 2. Arrived at 18:00 and commenced 'ladder' swath survey design (two parallel N-S runs of 18 km with two 4 x 3 km fill-in boxes; one targeted at structured bottom features at the southern end and the second on a region of trawl effort towards the top).

Friday 23 April

Completed a sled tow at 03:00 and video tow shortly afterwards in the northern most of the two survey boxes in MPA 2, but rapidly deteriorating weather conditions (wind exceeding 30 knots) prevented any further sampling in MPA 2. Winds increased to 40 knots, with gusts exceeding 50 knots as we steamed to the MPA 3 area, giving us no chance for any data collection there. Steamed north and then eastwards into Bass Strait in windy and rough conditions towards the sponge bed sites, with the intention of taking swath data along a line between the historical MOV sites four and six. Bad weather continued, and swath data quality along sponge bed sample sites was poor.

Saturday 24 April

We continued to swath sponge bed sample sites towards Flinders Island. The swath didn't show any bottom features of note and continuing bad weather prevented any sampling. Steamed east through Banks Strait and into storm force winds of 40-60 knots. Endured a very uncomfortable night during which we moved into deeper waters and remained hove-to for ~14 hours.

Sunday 25 April

At 07:00 we turned the ship and headed back to pick up our first swath transect. Abating conditions allowed us to recommence sampling by mid-morning and we completed acoustic survey and benthic sled sample at the Banks Strait canyon site, and a mini-swath survey of sites at the Babel canyon before heading north directly to the Big Horseshoe canyon off eastern Victoria.

Monday 26 April

Sampling at Big Horseshoe commenced with a video transect across a range of acoustic facies in a long tow across the western arm. This was followed by a swath survey at pre-existing reference sites at Broken Reef and followed by a benthic sled sample over rocky bottom at the same location. Subsequently we returned to Big Horseshoe and took benthic sled samples along the video transect in the western arm.

Tuesday 27 April

The day started with completion of swath transects over pre-existing reference sites as the last sled catch from the day before was processed. This was followed by three down-slope video transects along the northeastern escarpment of Big Horseshoe. Each required skilled piloting to traverse the numerous rocky edges and ledges between the shelf edge and canyon floor. Aggregations of pink ling were recorded on two transects. Two sled samples were taken from the deep upper slope region close to a pre-existing camera transect and reference site. A line of four LADCP drops was completed at the mid-point of the canyon on the shelf/ shelf-break/ mid-escarpment and canyon floor.

Wednesday 28 April

The final day of sampling began with swath sampling of the remaining reference sites in the canyon on the southeastern terrace. At 04:30 we headed off to the northeast to re-swath the pre-existing scientific reference sites at Gabo Reef and Disaster Bay. One final sled sample was taken with the large sled, primarily to obtain samples of molluscs for the CMR genetics group. The final scientific operation of the survey was the collection of swath data for the transit to Sydney.

Thursday 29 April

Completed cleaning of scientific work areas and packing en route to Sydney and came alongside at 13:30. All scientific equipment was removed and loaded ready for transportation to Hobart by 18:00.

Summary

Southern Surveyor proved itself to be an excellent base for this successful program of complex offshore research. It provided a steady and comfortable platform in locations (western Tasmania and Bass Strait) notorious for challenging sea conditions, and proved to be a safe and reliable platform in terms of all the equipment and infrastructure necessary for using our sophisticated sampling toolkit. In particular, the EM300 performed well in the depths surveyed, and in all but the worst sea conditions, although centre-beam noise was evident in some situations and some in-field experience was needed to run the Neptune software reliably. Electronics and computing support provided by the National Facility was first class.

Acknowledgements

The principal investigators would like to thank the science crew for a great team effort – the bringing together of a diverse range of skills, perseverance during long hours, and all done cheerfully and cooperatively – to achieve a great result during our 20 days at sea. Our science achievement was made possible by the efforts of the Master, Mates and ships crew, and we thank them for their professionalism during the voyage. In addition, we would like to acknowledge the essential support provided by many people from CSIRO Marine Research in the Ship's Management group, Workshop, MTE group, and administration for getting us mobilised, and to the multibeam acoustics group at Geoscience Australia who supported the acquisition and processing of multibeam data. Special thanks are due to Bruce Barker for his expertise in effectively managing the voyage.

Personnel

Scientific Staff (CSIRO Marine Research unless otherwise specified)

Alan Williams (Chief Scientist)	Full voyage
Bruce Barker (Voyage Manager; Camera system operations)	Full voyage
Pamela Brodie (Data manager; ADCP/LADCP support)	Full voyage
Gordon Keith (Acoustics software programmer)	Full voyage
Lindsay MacDonald (National Facility electronics support)	Full voyage
Miroslaw Ryba (National Facility computing support)	Full voyage
Andrea Cortese (GA) (Acoustics data manager)	Full voyage
Cameron Buchanan (GA) (Acoustics data manager)	Leg 1 only
Michele Spinoccia (GA) (Acoustics data support)	Leg 1 only
Mark Lewis (Gear technologist; camera systems support)	Leg 2 only
Matt Sherlock (Electronics engineer; camera system operations)	Leg 2 only
Karen Gowlett-Holmes (Invertebrate taxonomist)	Leg 2 only
Robin Wilson (Museum Victoria) (Invertebrate taxonomist)	Leg 2 only
Dave Mills (TAFI Post-doc) (Invertebrate biologist)	Leg 2 only

Marine Crew

Les Morrow (Master)	Full voyage
Arthur Staron (First Mate)	Full voyage
Drew Meincke (Second Mate)	Full voyage
Roger Thomas (Chief Engineer)	Full voyage
Rob Cave (First Engineer)	Full voyage
Andrew Forrest (Second Engineer)	Full voyage
Tony Hearne (Boatswain)	Full voyage
Allan Brownlie (Integrated Rating)	Full voyage
Manfred Germann (Integrated Rating)	Full voyage
Bruce Noble (Integrated Rating)	Full voyage
Peter Morcombe (Integrated Rating)	Full voyage
Craig Dawkins (Trainee Rating)	Full voyage
Wendy Page (Steward)	Full voyage
Andy Goss (Chief cook)	Full voyage
Alan Sessions (2nd cook)	Full voyage

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

Dr Alan Williams
Chief Scientist

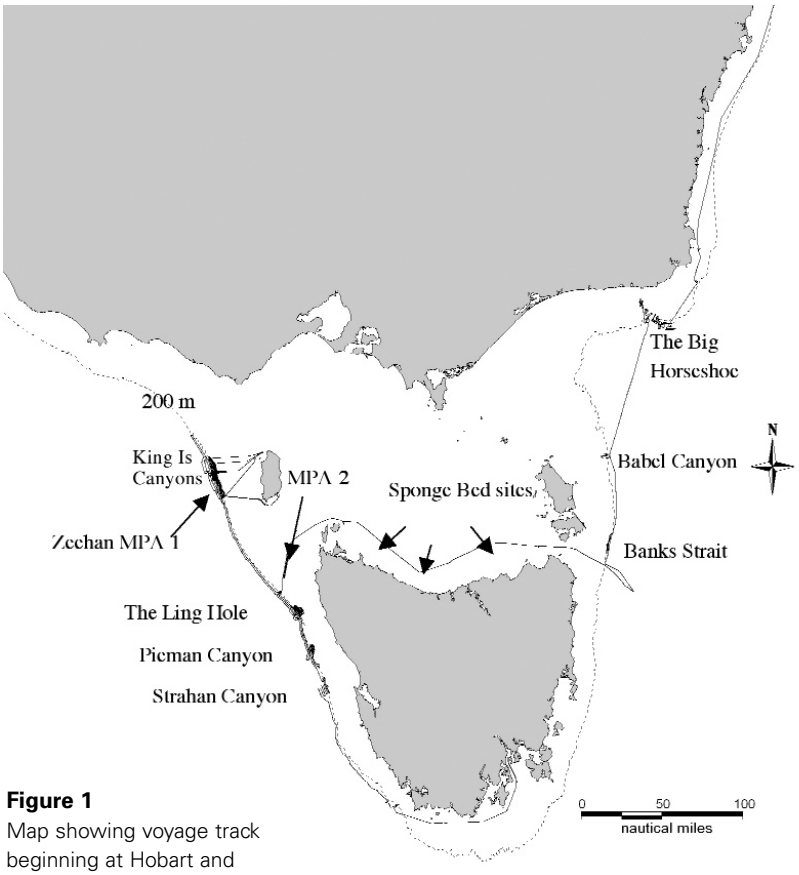

Figure 1
Map showing voyage track beginning at Hobart and ending at Sydney. 200 m depth contour also shown.

Table 1

SS0404 operations list

Operation	Operation_Type	Area_Name	Date (UTC)	Time (UTC)	Start Latitude	Start Longitude	Depth (m)
1	swath transit	SW Cape	11-Apr-04	02:18:00	-43.477	145.624	814
2	ctd	West of SW cape	11-Apr-04	02:12:00	-43.478	145.624	813
3	swath survey	West of SW cape	11-Apr-04	02:12:00			500
4	swath survey	Strahan Canyon	11-Apr-04	14:47:00	-42.306	144.705	500
5	swath survey	Nth Strahan Canyon	11-Apr-04	21:00:00	-42.154	144.763	172
6	swath transit	Strahan Canyon to Pieman Canyon	11-Apr-04	22:45:00	-42.116	144.700	459
7	swath survey	Pieman Canyon	12-Apr-04	00:50:00	-41.850	144.540	509
8	ctd	Pieman Canyon	12-Apr-04	06:57:00	-41.795	144.557	447
9	ctd	Pieman Canyon	12-Apr-04	07:45:30	-41.795	144.538	459
10	swath transit	Pieman to Ling Hole	12-Apr-04	09:00:00	-41.801	144.526	383
11	swath survey	Ling Hole	12-Apr-04	15:07:00	-41.395	144.419	176
12	swath transit	Ling Hole to crab survey site	12-Apr-04	15:07:00			500
13	swath survey	Sandy Cape crab marks	12-Apr-04	20:40:00	-41.434	144.365	430
14	swath transit	Sandy Cape crab Nth to King Is.	12-Apr-04	20:40:00			500
15	ctd	King Island Canyons	13-Apr-04	10:12:00	-40.058	143.233	459
16	swath survey	King Island Canyons	16-Apr-04	10:36:00	-39.899	143.225	133
17	swath survey	King Island Canyons	16-Apr-04	08:51:00	-40.086	143.312	124
18	cross-shelf survey	King Island Shelf	16-Apr-04	18:41:00	-39.820	143.196	156
19	Sonardyne	Phoques Bay, King Island	16-Apr-04	07:30:00	-40.107	143.578	46
20	cross-shelf survey	King Island Shelf	16-Apr-04	07:30:00			120
21	swath survey	King Island Canyons	16-Apr-04	07:30:00	-39.892	143.181	401
22	cross-shelf survey	King Island Shelf	16-Apr-04	07:30:00			180
23	swath survey	King Island Shelf	16-Apr-04	07:30:00			80
24	swath survey	King Island Canyons	16-Apr-04	09:12:10	-40.058	143.322	123
25	sled-Sherman	King Island Canyons	16-Apr-04	13:47:50	-39.823	143.186	196
26	swath	King Island Canyons	16-Apr-04	18:43:10	-39.820	143.202	151
27	sled-Sherman	King Island Canyons	17-Apr-04	03:48:00	-39.826	143.175	241
28	sled-Sherman	King Island Canyons	17-Apr-04	05:33:00	-39.857	143.173	237
29	sled-Sherman	King Island Canyons	17-Apr-04	07:49:40	-39.868	143.173	237
30	sled-Sherman	King Island Canyons	17-Apr-04	14:00:30	-39.855	143.172	249
31	swath survey	North King Island Canyons	17-Apr-04	20:36:40	-39.634	143.009	298
32	video	King Island Canyons	18-Apr-04	05:17:30	-39.819	143.176	206
33	video	King Island Canyons	18-Apr-04	06:57:30	-39.868	143.167	238
34	sled-Sherman	King Island Canyons	18-Apr-04	10:16:50	-39.857	143.185	165
35	sled-Sherman	King Island Canyons	18-Apr-04	12:53:40	-39.811	143.147	348
36	rock-sled	King Island Canyons	18-Apr-04	15:44:00	-39.842	143.170	470
37	rock-sled	King Island Canyons	18-Apr-04	17:13:10	-39.809	143.145	323
38	rock-sled	King Island Canyons	18-Apr-04	18:08:10	-39.812	143.150	350
39	video	King Island Canyons	18-Apr-04	20:13:10	-39.800	143.184	170
40	video	King Island Canyons	18-Apr-04	22:53:00	-39.822	143.165	221
41	video	King Island Canyons	19-Apr-04	02:35:20	-39.830	143.238	233

Operation	Operation_Type	Area_Name	Date (UTC)	Start Time (UTC)	Start Latitude	Start Longitude	Depth (m)
42	sediment grab	King Island Canyons	19-Apr-04	05:17:20	-39.826	143.196	168
43	sediment grab	King Island Canyons	19-Apr-04	05:44:00	-39.825	143.196	165
44	sediment grab	King Island Canyons	19-Apr-04	06:03:40	-39.825	143.194	171
45	ctd	King Island Canyons	19-Apr-04	06:53:20	-39.828	143.213	136
46	ctd	King Island Canyons	19-Apr-04	08:18:30	-39.843	143.138	495
47	ctd	King Island Canyons	19-Apr-04	09:33:00	-39.852	143.148	621
48	ctd	King Island Canyons	19-Apr-04	10:36:30	-39.857	143.161	496
49	video	Ling Hole	20-Apr-04	00:32:10	-41.312	144.351	116
50	sled-Sherman	Ling Hole	20-Apr-04	05:18:00	-41.365	144.424	174
51	sled-Sherman	Ling Hole	20-Apr-04	06:55:00	-41.378	144.392	330
52	sled-Sherman	Ling Hole	20-Apr-04	10:27:30	-41.330	144.333	163
53	swath transit	Ling Hole	20-Apr-04	08:15:00	-41.406	144.317	566
54	ctd	Ling Hole	20-Apr-04	15:01:00	-41.370	144.336	554
55	rock-sled	Ling Hole	20-Apr-04	15:45:50	-41.374	144.342	525
56	swath transit	Ling Hole to Pieman	20-Apr-04	19:33:40	-41.738	144.506	201
57	sediment grab	Pieman Canyon	20-Apr-04	20:18:50	-41.729	144.576	184
58	sediment grab	Pieman Canyon	20-Apr-04	20:42:10	-41.724	144.581	173
59	sediment grab	Pieman Canyon	20-Apr-04	20:59:00	-41.724	144.578	172
60	sediment grab	Pieman Canyon	20-Apr-04	22:18:30	-41.783	144.604	153
61	sediment grab	Pieman Canyon	20-Apr-04	22:49:30	-41.779	144.601	153
62	sediment grab	Pieman Canyon	20-Apr-04	23:08:00	-41.776	144.601	152
63	video	Pieman Canyon	21-Apr-04	02:51:00	-41.792	144.585	175
64	Acoustic logger	Pieman Canyon	21-Apr-04	06:49:50	-41.760	144.567	391
65	sled - Sherman	Pieman Canyon	21-Apr-04	08:02:50	-41.778	144.575	226
66	sediment grab	South of Pieman Canyon	21-Apr-04	11:34:10	-41.978	144.674	170
67	sediment grab	South of Pieman Canyon	21-Apr-04	12:05:40	-41.978	144.671	174
68	sediment grab	South of Pieman Canyon	21-Apr-04	12:29:50	-41.975	144.670	172
69	sediment grab	South of Pieman Canyon	21-Apr-04	13:46:30	-41.946	144.667	160
70	sediment grab	South of Pieman Canyon	21-Apr-04	14:11:40	-41.945	144.665	160
71	sediment grab	South of Pieman Canyon	21-Apr-04	14:27:20	-41.945	144.667	160
72	sled - Sherman	Pieman Canyon	21-Apr-04	16:35:30	-41.795	144.586	174
73	sled - Sherman	Pieman Canyon	21-Apr-04	19:33:10	-41.740	144.560	176
74	swath transit	Pieman to Ling Hole	21-Apr-04	21:40:10	-41.785	144.519	230
75	video	Ling Hole	22-Apr-04	02:31:30	-41.409	144.381	345
76	swath transit	MPA2 Area	22-Apr-04	07:20:00	-41.012	144.150	110
77	ctd	MPA2 Area	22-Apr-04	10:44:00	-40.700	144.242	180
78	sled - Sherman	MPA2 Area	22-Apr-04	16:11:20	-40.793	144.219	95
79	swath survey	MPA2 Area	22-Apr-04	16:59:40	-40.757	144.229	95
80	video	MPA2 Area	22-Apr-04	18:17:40	-40.775	144.227	94
81	swath survey	Banks Strait	25-Apr-04	03:05:00	-40.634	148.797	2174
82	seld - Sherman	Banks Strait	25-Apr-04	05:10:40	-40.640	148.788	168

Operation	Operation_Type	Area_Name	Date (UTC)	Start Time (UTC)	Start Latitude	Start Longitude	Depth (m)
83	ctd	Babel Canyon	25-Apr-04	13:43:40	-39.645	148.820	840
84	video	Big Horseshoe (West)	26-Apr-04	01:31:50	-38.114	149.359	160
85	swath survey	Broken Reef	26-Apr-04	04:47:20	-38.177	149.316	282
86	sled - combination	Broken Reef	26-Apr-04	06:21:00	-37.942	149.241	115
87	swath survey	Broken Reef	26-Apr-04	05:36:10	-38.027	149.297	121
88	sled - Sherman	Big Horseshoe (West)	26-Apr-04	13:18:20	-38.115	149.357	160
89	ctd	Big Horseshoe	26-Apr-04	16:06:10	-38.182	149.485	657
90	video	Big Horseshoe (NE escarpment)	26-Apr-04	17:48:40	-38.175	149.562	264
91	swath survey	Big Horseshoe	26-Apr-04	19:59:40	-38.168	149.644	230
92	video	Big Horseshoe (NE escarpment)	26-Apr-04	22:06:50	-38.120	149.505	161
93	video	Big Horseshoe (NE escarpment)	27-Apr-04	01:06:20	-38.089	149.469	157
94	sled - Sherman	Big Horseshoe (NE escarpment)	27-Apr-04	06:11:20	-38.194	149.535	593
95	swath survey	Big Horseshoe (SE)	27-Apr-04	07:30:00	-38.234	149.531	863
96	ctd	Big Horseshoe Cast 1	27-Apr-04	09:10:20	-38.166	149.465	583
97	ctd	Big Horseshoe Cast 2	27-Apr-04	10:09:00	-38.141	149.475	348
98	ctd	Big Horseshoe Cast 3	27-Apr-04	11:01:20	-38.117	149.491	165
99	ctd	Big Horseshoe Cast 4	27-Apr-04	11:36:20	-38.101	149.501	155
100	sled - Sherman	Big Horseshoe (SE)	27-Apr-04	13:00:00	-38.192	149.516	679
101	swath survey	Big Horseshoe to Disaster Bay	27-Apr-04	15:58:20	-38.246	149.554	629
102	sled - combination	Disaster Bay	28-Apr-04	03:14:40	-37.289	150.071	79

Additional voyage documents held by Chief Scientist

– Data acquittal form

– National Facility Electronics Support report

– EM300 multibeam performance technical report

– Voyage Managers report