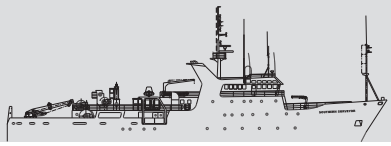

MARINE
NATIONAL FACILITY

2008 program

RV *Southern Surveyor*

CSIRO

voyage summary SS03/2008

SS03/2008

Estimating the effectiveness of spatial closures for deepwater gulper sharks and associated fishery species

Voyage period
Depart: 28/02/2008
PORT OF DEPARTURE: Adelaide, Australia

Return to port: 17/03/2008
PORT OF RETURN: Hobart, Australia

RESPONSIBLE LABORATORY
CSIRO Marine and Atmospheric Research
Castray Esplanade, Hobart, Tasmania
Australia

CHIEF SCIENTIST(S)
Dr Alan Williams

OBJECTIVES AND BRIEF NARRATIVE OF VOYAGE

Scientific Objectives

Areas of seabed in Commonwealth waters off temperate Australia are being closed to fishing – for marine reserves being developed by the DEHA, and as spatial closures are increasingly used by AFMA to manage fishery stocks. One current focus for both conservation and fishery closures is the protection of gulper sharks which are under consideration for endangered species listing. Other species and habitats assessed as being at high risk from fishing impacts co-occur with gulper sharks on the continental slope, as do important commercial species including the pink ling, blue eye trevalla and ribaldo. Large gaps in the ecological knowledge of these species will limit the effective design of area closures (e.g. optimising sizes and numbers) and assessment of their performance. Knowledge gaps include species movements, the key ecosystem properties of natural refuges, and the benefits of natural and closed area refuges for species harvested by multiple fishing gear types.

As part of a larger project, our aim during this survey is to fill some of these gaps by characterising the habitats and ecosystem processes in 200-700 m depths that sustain key species, and commencing a process to determine the relevant aspects of species ecology. Primarily this will be (1) to measure the movement of fish within and to/ from a large closed area in the GAB with a tagging program, and (2) estimate the abundance of selected species in relation to habitat features (substructure within submarine canyons, escarpments and rocky banks, and adjacent water column features) with two independent, non-extractive photographic methods. Data will be gathered using a combination of proven sampling tools and techniques (multibeam acoustics, towed camera system, baited underwater video) and new technology and applications (surveillance cages, deep deployment of an acoustic tracking system).

Voyage Objectives

1. Map and characterize the benthic ecosystem of the "60-mile closure" in the GAB using the EM300 multibeam and quantitative towed camera surveys

2. Quantify the abundance of gulper sharks and associated species, inside and outside the closure by non-extractive quantitative towed camera surveys.

3. Estimate species relative abundances inside and outside the "60-mile closure" using non-extractive underwater baited video cameras (BRUVs).

4. Assess the survivorship by gulper sharks and other species following tagging. This will use a specially designed trap with (1) a surveillance camera to monitor behaviour during descent, on the bottom, and during ascent, and (2) an acoustic receiver to track fish movements away from the trap after release.

5. Evaluate movement in and out of the "60-mile closure" using two curtains of acoustic VR2 listening stations to detect fish tagged with acoustic V16 tags.

6. Acquire additional deepwater camera calibration data with scalebar and rotating 16-laser array.

These will contribute to the project's overarching science objectives that aim to:

1. Identify, classify and quantify habitats at the multiple spatial scales relevant to the ecology of the study species.

2. Collect the data necessary to test hypotheses on the ecological roles of upper slope habitats, especially the links between biodiversity and target fishery species.

3. Estimate species' abundances with photographic techniques, and validate these by cross-comparison and modelling.

4. Implement an acoustic tag and release program to determine the movement of species between habitats and closed areas.

5. Evaluate the potential of gulper sharks to provide an indicator of ecosystem health.

Southern Surveyor's operations will commence with multibeam mapping of the central section of the "60-mile closure" to determine locations for the acoustic receiver arrays and the sites for camera and sled sampling. Mapping will also determine the locations for the fishing and tagging program to be undertaken by a companion vessel. Camera transects may be used to fine-tune the positions of the mooring sites, after which the receiver arrays will be deployed. The program of BRUVs and additional camera transects inside and outside the closured area will follow, and determine the daily sampling schedule for the remainder of the time at the "60-mile closure" site. Physical sampling with the sediment grab and sled, and current measurement drops with the LADCP, will be conducted opportunistically. Some of the acoustic receivers may be recovered and redeployed if the tagging program is successful, and if time and weather permit.

The survey will be undertaken with the assistance of a second chartered vessel (SARDI Aquatic Science's Ngerin) which will begin the one-week program of fishing, tagging and survivorship experiments as soon as it arrives at the site – probably five days after the Southern Surveyor. There will be the need to transfer scientific staff between the vessels at the start and end of the second vessel's sampling program.

Voyage Narrative

Thursday 28 February

Departed Port Adelaide at 12:00. Commenced first operation, a CASIUS calibration of the Sonardyne tracking system, in ~90 m depth at 23:20.

Friday 29 February

Calibration was completed successfully just after 02:00 and we continued the steam out to the survey area. Arrived around midday and commenced the program of swath mapping in the eastern half of the survey area.

Saturday 1 March

Several swath lines were run depth parallel to cover the upper slope and shelf edge of the eastern half of the closed area (~30 n.m.) and an area outside the closure (~10 n.m.). Mapping reveals the seabed has very complex topography with numerous gutters, small canyons and steep drop offs. Two trial camera transects were completed on the outer shelf in ~150 m depth to wet-test the system and adjust the orientation of cameras and lights. A relatively flat area on the down-slope face of a spur was selected for the first sampling site and a successful camera operation was completed. A mooring with 2 V16 tags and 2 VR2W receivers was deployed and retrieved to range test the tags.

Sunday 2 March

Four camera tows were completed along the eastern half of the closure in the morning. A set of 4 BRUVS was completed in the afternoon before more swath mapping in the evening.

Monday 3 March

Two camera tows were completed at site 1 and another started at site 2. The HID lights on the camera system failed to start up and the tow was aborted partway through. Whilst troubleshooting the camera system lighting problem the LADCP was deployed in 450 m and a mooring configured ready for deployment to re-test the range of the V16 tags. This mooring was deployed adjacent to the tow line of the camera tow to be repeated. Two V16 range test tags were mounted on the camera frame and the camera tow repeated.

The 6 BRUVS units were deployed at the site; the surface mooring for BRUVS unit E was cut after it fouled the propeller and remains on the seafloor.

Tuesday 4 March

A set of 5 LADCPs were completed in the morning, and 5 BRUVS drops in the afternoon. The sediment grab program was started with two samples taken.

Wednesday 5 March

Preparations for deploying the network of VR2 moorings commenced. Ropes were transferred from bobbins to the net drum in readiness for 4 deployments but this was very time consuming. Subsequently, the remaining moorings were successfully deployed directly from the bobbins using the pneumatic winder. A total of 7 moorings were deployed throughout the afternoon and into the evening. Four successful sediment grabs were also completed.

Thursday 6 March

Sampling continued with three LADCP drops at 3 of the predetermined locations including 2 deployments at the deep 1150 m site. VR2 moorings were prepared ready for deployments later in the morning. Listening station lines were made to the west of the fish release site and a further 3 individual moorings deployed further to the west (9 in total). A set of 5 BRUVS was deployed and recovered successfully, and two benthic sleds completed.

Friday 7 March

Two video transects were completed successfully in the western sector of the closure. These were followed by three more VR2 moorings, two LADCP drops, a set of 5 BRUVS units, and two benthic sled collections.

Saturday 8 March

Three camera tows in the western sector targeted an area of higher backscatter coinciding with a feature where the 500 m contour extended to the south from the general slope to form a promontory. The camera showed some areas with steep scarps, hard but smooth surfaces and some slabs and undercuts with large erect inverts including deepwater corals. Some time was then spent grappling for the lost BRUVS unit but these failed. Following this, one of the smart traps was rigged for fishing and deployed and then retrieved, catching only two ling. The trap was hauled slowly to determine if ling could be brought to the surface without damaging their swimbladders. Despite decompression stops for 5 minutes each at approximately 20 m and 10 m, the fish were in poor condition at the surface. Four sediment grabs completed the day's sampling.

Sunday 9 March

Following completion of a swath survey line, 3 LADCP deployments were completed before breakfast. Tony Smith was transferred to the Ngerin before Southern Surveyor steamed to the west for a camera transect on the north western flank of a prominent knoll showing higher backscatter on the swath map. The top of the knoll was hard with undercuts and a moderate number of large corals. The flank continued to be hard with a few invertebrates and some blue eye trevalla. Moderate bioturbation of a muddy substrate generally characterized the base of the knoll. The fish trap was set on the top of the knoll, the 5 BRUVS were deployed and retrieved for a day sample on the hard plateau to the west, and a sled tow completed on the plateau to the east.

Monday 10 March

The 5 BRUVS were redeployed for a night sample at the same sites on the plateau. Swath data were collected at the western deeper region of the closure and a camera calibration tow was completed in 1000 m of water. The fish trap was retrieved but yielded no fish. The BRUVS moorings were retrieved and four more VR2 moorings deployed.

Tuesday 11 March

The fish trap was retrieved and contained one large ling. A lack of depth marks on the new surface rope didn't allow for stops during the upper 40 m of retrieval and again the ling was near dead and bloated at the surface. We continued with five more mooring deployments and a camera tow. Another attempt was made to grapple the lost trap but was unsuccessful. The final sediment grab samples and benthic sled sample were collected

Wednesday 12 March

The vessel steamed eastwards, leaving the 60-mile closure for the DuCouedic Canyon. Four camera tows were completed: the first on the western side of canyon, from ~150 m to 467 m, showed a moderately rich sponge community on the shallower hard ground. The slope was steep and craggy in parts with relatively few fish seen. The next camera tow was on the eastern side of the canyon from ~140 m to 574 m water depth and again revealed the steep and rocky nature of the slope and bioturbated, sometimes heavily ridged, sediments deeper down. A camera tow in the central part of the canyon from 760 m to 950 m water depth showed heavily rippled and ridged sediments with a 20-30 m sheer face encountered near the final part of the tow. The final transect was on the eastern side from 1320 to 1680 m which was characterized by steep and craggy terrain. Three of the four camera tows were located to ground-truth sites sampled by SARDI on the previous voyage. We left the canyon and continued to steam eastwards.

Thursday 13 March

Continued steaming eastwards towards the Coral Coast hills and the Metis Hills area northwest of King Island.

Friday 14 March

Swath mapped the Metis Hills and Coral Coast Hills area and did two targeted camera tows on small features in 950 m. The camera tows revealed mostly bioturbated sediments with trawl gear marks common. A small hard feature had a considerable number of orange roughy, oreo, eels and black sharks, with some evidence of stony corals. From here, the vessel steamed through Bass Strait on the way to the Tasmanian east coast.

Saturday 15 March

We reached the first sampling site during late afternoon – the Flinders gulper shark closure adjacent to Banks Strait. Two swath lines were completed by midnight.

Sunday 16 March

The vessel steamed south to the penultimate sampling site: the St Helens seamount that has a long history of orange roughy fishing. Four camera tows were completed successfully on the main hill, a hard ridge to the east, and a second smaller hill to the east, and from the shelf edge to 950 m on the adjacent slope. A benthic sled tow to collect deep water corals on the small eastern hill was the final operation for the survey. Southern Surveyor left the final sampling site at 2000 hr and headed for Hobart.

Monday 17 March

Swath lines were run down the east coast, and the vessel berthed at 1500 hr at the CSIRO wharf.

Summary of initial results against objectives

1. Map and characterize the benthic ecosystem of the "60-mile closure" in the GAB using the EM300 multibeam and quantitative towed camera surveys.

The entire closure was mapped with the EM300, data were processed, and a variety of high quality maps were produced at sea to support the remainder of the sampling program – including the fishing program undertaken by the second vessel. Camera tows in the 60-mile closure provided 13.5 hours of high quality, calibrated stereo video along 19 transects (Tables 1 and 2) and 5600 high resolution digital still images that will permit quantified mapping and description of habitats and fauna; these concentrated on the key depth zone of interest (300-600 m), but some extended from the shelf edge (<200 m), or deeper than 600 m. The steepest and roughest seabed in the closure was surveyed successfully.

2. Quantify the abundance of gulper sharks and associated species, inside and outside the closure by non-extractive quantitative towed camera surveys.

3. Estimate species relative abundances inside and outside the "60-mile closure" using non-extractive underwater baited video cameras (BRUVs).

Data to quantify fish abundance was collected successfully from the towed camera transects (see objective 1) and from 35 deployments of baited underwater video cameras (BRUVs). Data previews show the primary fishes of interest, gulper shark, greeneye dogfish, swellshark, pink ling, blue-eye trevalla, blue warehou, deep ocean perch and ribaldo were seen regularly by both gears as were many other minor species. Blue-eye and spotted warehou were seen is schools, whereas the other species sighted appeared as lone individuals or in small groups; some minor species such as the banded whiptail were present in relatively high abundance. Both gears proved suitable for abundance estimates, but technical improvements can be made to improve performance. Identifying these improvements was an important outcome of this work.

Due to the relatively low abundances of target species, and because additional time was allocated to mapping entire closure and for mooring deployments, abundance estimates outside the closure were limited to towed transects at the DuCoeudic Canyon.

4. Assess the survivorship by gulper sharks and other species following tagging. This will use a specially designed trap with (1) a surveillance camera to monitor behaviour during descent, on the bottom, and during ascent, and (2) an acoustic receiver to track fish movements away from the trap after release.

Seven sets of the bottom longline fishing gear from the Ngerin provided 323 individual fish including sharks and scalefish for survivorship assessment and tagging. Most species were in vigorous condition after the capture process and retention in an aquarium for up to 2 hours prior to assessing survivorship in the 'smart trap'. A total of 135 individuals of 6 species were monitored with the surveillance cameras. Greeneye and swellsharks were most robust and survived the tag and monitoring process very well. Gulper sharks were less robust. Although almost all individuals survived during the capture process, their condition deteriorated in the aquarium and in the cage. An alternative approach was used for gulper sharks towards the end of the survey. Gulper sharks were tagged quickly and released immediately at the surface. Gulper sharks

showed no adverse affects using this approach. Among the scalefish, ocean perch were robust, while all pink ling and ribaldo cods died from ruptured swimbladders due to barotrauma. Acoustic receivers were used both to track fish released at depth away from the traps, and those released at the surface away from the vessel.

5. Evaluate movement in and out of the "60-mile closure" using two curtains of acoustic VR2 listening stations to detect fish tagged with acoustic V16 tags.

A total of 23 VR2 listening stations were deployed successfully. A more sophisticated array design was possible than anticipated. Because the slope was narrower than predicted from coarse scale bathymetry data, fewer receivers were required at each location to span the depth range of interest. A cluster of 'survivorship' moorings were placed in close proximity to the fish release site, curtains were placed at 4 and 8 km intervals either side, and five additional 'habitat' mooring were situated on rocky 'bottlenecks' along the 400-500 m depth corridor.

Importantly, on the last day at the 60-mile closure the four 'survivorship' moorings were retrieved after five days (and redeployed). Data were downloaded and analysed during the survey. All 42 fish at liberty at that time were detected, some on multiple receivers. This confirmed the short term survival of many individuals and indicated a reasonable expectation that all three species of deep water sharks will survive a surface tag and release process – although gulper sharks were the least robust. Survival of this species seems to require tag and release immediately following capture.

6. Acquire additional camera deepwater calibration data with scalebar and rotating 16-laser array.

Deepwater calibration data were acquired during two deployments using the scalebar and rotating 16-laser array – one in midwater 5 m to 1000 m, and one bottom-tracking from ~200 m to 950 m. This data will be analyzed and incorporated into a technical paper (in progress) to establish the effect of depth on camera calibration data and measurements at depth.

Additional results

7. Swath map Flinders gulper shark closure

The relevant upper slope depth range of the second gulper shark closure off Flinders Island was entirely mapped. This mapping, possible only from Southern Surveyor, will permit fishing and photographic survey from a smaller vessel in the near future to complement our main survey in the GAB.

8. Collect camera transect data to complement recent survey of the DuCouedic Canyon by SARDI (SS2008/02)

Four camera tows in the DuCouedic submarine canyon south of Kangaroo Island were completed to complement the benthic community and physical oceanographic sampling completed by SARDI during SS2008/02. These revealed the detail of the extreme, current swept topography and its associated fauna over a depth range of 150 to 1750 m. These data will contribute to the study of canyon-associated productivity.

9. Swath map and complete camera tows on Coral Coast hills

A group of small hill-like seabed features to the north east of King Island were surveyed for the first time. These hills had been heavily fished in the early days of the orange roughy fishery in the 1980's until fish catches declined. Small patches of coral rubble and occasional erect corals were seen, although the great majority of these features were devoid of epifauna; in many places only a veneer of sediment appeared to cover the underlying bedrock. Orange roughy and other species were seen in relatively high numbers (10s-100s) on the elevated rocky topography compared to the surrounding flat sediment areas.

10. Swath map and complete camera tows in the St. Helens seamount area

'St Helens Hill', the seamount off Tasmania's NE coast famous for its winter-time aggregations of orange roughy was systematically surveyed with the towed camera system for the first time to discover what remained of the seamount's benthic fauna and habitat after nearly two decades of fishing. The main seamount was bare rock and devoid of larger erect animals such as corals and sponges. Surprisingly, a staggering large number of large orange anemones covered much of the seamount flank. Whether these survived the sustained fishing impact or are early colonizers remains to be determined. A second but deeper and smaller conical seamount to the east was believed to have remained unfished. Video confirmed a luxuriant community of stony and erects coral exists there in what appears to be pristine condition. A small collection was made with a benthic sled for biodiversity and genetic connectivity analysis.

Project name

Estimating the effectiveness of spatial closures for deepwater gulper sharks and associated fishery species

Coordinating body: CSIRO Marine and Atmospheric Research

Principal investigator

Dr Alan Williams

Moorings, bottom mounted gear and drifting systems

Item No.	PI	Approximate position						Data type	Description
		Latitude			Longitude				
		deg	min	N/S	deg	min	E/W		
1	Alan Williams	35	12	S	134	24	E	B37	24 separate fixed moorings with VR2 listening stations to record acoustic tags on sharks. Moorings to be recovered in June 2008, interrogated for data and redeployed for a further six months+. Each mooring has a programmable burn-wire release for surface floats deployed 50-70 m below surface. Each VR2 receiver is mounted up the mooring line 100 m above the seafloor. All moorings are within a 60-mile fishery closure. Individual mooring positions provided in Operation list ('Mooring – VR2' in Appendix 2).

Summary of measurements and samples taken

Item No.	PI	NO	UNITS	DATA TYPE	DESCRIPTION
1	Alan Williams	2160	Square km	G74	Swath data – 60-mile closure area swath mapped. Additional swath mapping at the Metis Hills and the Flinders closure area as well as transit swath between the study areas and Hobart
2		19 + 11	Tows	G08	Towed camera – camera transects collecting 13.5 hours stereo video and 5600 high resolution digital still images from the closure area (19 transects). Remainder of image data from DuCouedic Canyon, Metis Hills and St Helens Hill area
3		5	Tows	B18	Benthic sleds – sled tows were to collect megabenthos from study areas. Animals sorted, photographed and preserved on board.
4		35	Deployments	B19	Baited Underwater Video System (BRUVS) – recording of 30+ hours video to assess fish species diversity and abundance
5		13	Grabs	G02	Sediment grabs for (1) grain size analysis to characterize typical substrate in study area; (2) infaunal assemblages from elutriated samples
6		14	Profiles	D71	CTD LADCP – The lowered acoustic doppler current profiler (LADCP) was deployed at several locations within the closure area to characterize water column and near bottom currents
7		3	Deployments	B19	Trap deployments – the 'smart trap' minus cameras but with a cone entrance was deployed with bait to trap fish to test survivability of fish brought to the surface in a controlled and gradual manner

Curation report

Item No.	DESCRIPTION
1	Stereo video on digital DVCam format tapes, digital video from GigE cameras on hard drive. Still images on CSIRO Data Centre server.
2	Invertebrate biodiversity samples from sleds preserved and sent to relevant taxonomic specialists at various national, and where appropriate, international museums. Identification information returned to CSIRO and collated. Taxonomic specimens curated at museums in perpetuity.
3	BRUVS video – original video retained by UWA collaborators (Dr Euan Harvey) for analysis. Copies held at CSIRO.
4	Fish and shark samples – held at the CSIRO Marine Labs, Hobart for near-term biological analysis.
5	Sediment sub-samples to be sent to Geoscience Australia for grain size analysis and Museum Victoria for biological analysis (elutriated samples)
6	Coral samples for chemical analysis to Dr Ron Thresher (CSIRO) and Dr Karen Miller (UTAS)
7	Acoustic multibeam (EM300), single beam (EA50) and sub-profile (TOPAS) data archived at CSIRO Marine Labs, Hobart
8	Standard National Facility data sets, and LADCP data, post-processed and maintained at the CSIRO data centre
9	All Ngerin data sets acquitted and held by CSIRO Marine Labs, Hobart and the Australian Maritime College, Beauty Point, Tasmania.

TRACK CHART

Sampling was primarily within the "60-mile closure" in the eastern Great Australian Bight (~134°E), and at selected sites on the continental slope on the transit back to Hobart via the east coast of Tasmania (Figure 1).

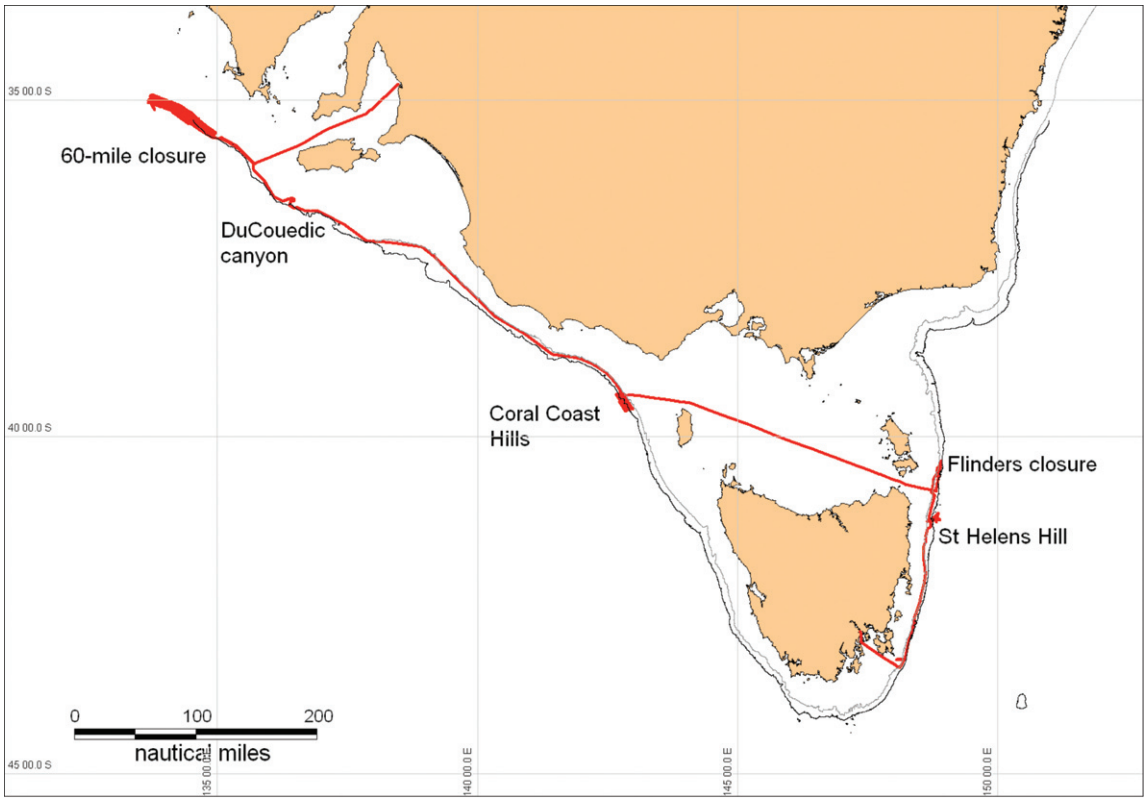

Figure 1. Map showing locations and names of survey sites, and ports of embarkation (Adelaide) and disembarkation (Hobart).

General ocean area(s)

Southern Ocean (Great Australian Bight)

Specific areas

Mostly the Great Australian Bight "60-mile" southern dogfish closure managed by the Australian Fisheries Management Authority

Personnel list

Scientific Participants

Name	Affiliation	Role
Alan Williams	CSIRO CMAR	Chief Scientist
Bruce Barker	CSIRO CMAR	Watch Leader/ Camera systems
Jeff Cordell	CSIRO CMAR	Camera systems
Matt Sherlock*	CSIRO CMAR	Camera electronics
Mark Lewis	CSIRO CMAR	Gear operations
Pamela Brodie	CSIRO MNF	NF Computing
Rick Smith	CSIRO CMAR	NF Swath mapping
Karen Gowlett-Holmes	CSIRO CMAR	Invertebrate biology
Tony Smith**	CSIRO CMAR	Data synthesis
Karl Forcey	CSIRO MNF	NF Electronics Support
Ben Ford	University WA	BRUVS

* to join Ngerin at sea for tagging
** to join Ngerin at sea for transport to Adelaide

RV Ngerin
(7 d from March 3rd) ***SARDI Research Vessel***

Name	Affiliation	Role
Ross Daley	CSIRO CMAR	Chief Scientist
Mark Green	CSIRO CMAR	Deck operations
Matt Sherlock	CSIRO CMAR	Camera systems
Cynthia Awruch	UTAS	Fish physiology
Dave Maynard	AMC/UTAS	Fishing operations
Nick Rawlinson	AMC/UTAS	Fishing operations

Marine Crew

Name	Role
Ian Taylor	Captain
John Boyes	Chief Officer
Darren Lack	Second Mate
John Morton	Chief Engineer
Dave Jonker	First Engineer
Grant Page	Second Engineer
Ashleigh Pollock	Chief Steward
Andy Goss	Chief Cook
John Leonard	Second Cook
Graham McDougall	Boatswain
Matthew Barrett	Integrated Rating
Andrew Roebuck	Integrated Rating
John Allwood	Integrated Rating
John Hall	Integrated Rating
Nick Jones	Cadet

Acknowledgements

The success of this survey is attributable to the wide variety of skills and sustained hard work contributed by each of the large scientific team and the bridge officers and crews of the National Marine Facility Southern Surveyor and the SARDI research vessel Ngerin. Collaborative contributions to the field program by seagoing staff and researchers from other institutions, particularly Dr Euan Harvey of UWA (BRUVS), Professor Chad Hewitt of the AMC (fishing gears) and Dr Stewart Fruscher of the TAFI (shark physiology), are gratefully acknowledged. Lee Warneke from SARDI coordinated the Ngerin charter. Inputs by many staff from CSIRO Marine and Atmospheric Research were vital to the successful mobilization of this survey, particularly those of Matthew Horsham, Dave Kube, Bob Driscoll, Christian Blood, Lindsay Pender, Greg Lyden, Debbie Vince, Alistair Hobday, Barry Bruce, Russ Bradford, Diana Reale, Don McKenzie and Lisa Woodward.

This survey was funded by the CSIRO Wealth from Oceans Flagship.

Alan Williams
Chief Scientist

APPENDICES

Appendix 1 - Summary tables of operations SS2008/03

Appendix 1 (Summary tables of SS2008/03 operations)

Table 1 Summary of deployments of different sampling gear types

Deployment gears	Number
Towed camera	30
BRUVS	35
Sediment grab	13
CTD LADCP	14
*Listening station mooring	37
Trap deployments	3
Sled tows	5

* includes mooring retrievals and redeployments

Table 2: Table of operations completed during survey SS2008/03. Start and end positions are given for all 'towed' operations and the positions are best estimates (taking layback into account) for the gear on the bottom. Non-towed operations have start positions only. Dates and time are in Coordinated Universal Time zone (UTC).

Op #	Gear	Location	Site	Start date (utc)	Start time hh:mm (utc)	Start position Long (dec deg)	Start depth Lat (dec deg)	End position (m)	End depth Long (dec deg)	Lat (dec deg)	(m)
1	Sonardyne calibration	Kangaroo Is.	100 m	28-Feb-08	12:50	136.6013	-35.6652	100	-	-	-
2	Towed camera	60-mile closure	Central	29-Feb-08	22:50	134.351	-35.1389	150	134.3789	-35.1541	156
3	Towed camera	60-mile closure	Central	1-Mar-08	0:08	134.3991	-35.1656	151	134.4208	-35.1748	150
4	Towed camera	60-mile closure	Centr al	1-Mar-08	3:06	134.4305	-35.2156	450	134.4535	-35.2284	675
5	Mooring - range	60-mile closure	Central	1-Mar-08	7:26	134.44	-35.2217	500	-	-	-
6	Mooring - range	60-mile closure	Central	1-Mar-08	9:56	134.4409	-35.2242	500	-	-	-
7	Towed camera	60-mile closure	East	1-Mar-08	17:26	134.7281	-35.3899	280	134.7185	-35.4106	620
8	Towed camera	60-mile closure	East	1-Mar-08	19:53	134.6224	-35.3147	243	134.6063	-35.3276	605
9	Towed camera	60-mile closure	Central	1-Mar-08	21:58	134.6025	-35.2944	190	134.5694	-35.2952	620
10	Towed camera	60-mile closure	Central	1-Mar-08	23:55	134.5451	-35.2593	325	134.5312	-35.2707	657
11	BRUVS	60-mile closure	Central	2-Mar-08	7:19	134.2982	-35.1461	464	-	-	-
12	BRUVS	60-mile closure	Central	2-Mar-08	7:36	134.298	-35.1414	434	-	-	-
13	BRUVS	60-mile closure	Central	2-Mar-08	8:07	134.2981	-35.1383	427	-	-	-
14	BRUVS	60-mile closure	Central	2-Mar-08	8:40	134.3074	-35.153	452	-	-	-
15	Towed camera	60-mile closure	Central	2-Mar-08	16:47	134.3309	-35.1386	187	134.308	-35.1697	602
16	Towed camera	60-mile closure	Central	2-Mar-08	19:13	134.268	-35.1414	350	134.2714	-35.1526	520
17	Towed camera	60-mile closure	Central	2-Mar-08	21:19	134.4325	-35.2005	190	134.423	-35.2031	300
18	CTD LADCP	60-mile closure	Central	2-Mar-08	23:17	134.4316	-35.2187	420	-	-	-
19	Mooring - range	60-mile closure	Central	3-Mar-08	0:50	134.417	-35.2083	505	-	-	-
20	Towed camera	60-mile closure	Central	3-Mar-08	1:11	134.435	-35.1995	189	134.4045	-35.2093	626
21	Mooring - range	60-mile closure	Central	3-Mar-08	5:53	134.4221	-35.2109	470	-	-	-
22	BRUVS	60-mile closure	Central	3-Mar-08	6:15	134.4318	-35.22	476	-	-	-
23	BRUVS	60-mile closure	Central	3-Mar-08	6:38	134.4302	-35.218	468	-	-	-
24	BRUVS	60-mile closure	Central	3-Mar-08	6:56	134.4272	-35.2134	456	-	-	-
25	BRUVS	60-mile closure	Central	3-Mar-08	7:17	134.4387	-35.223	505	-	-	-
26	BRUVS	60-mile closure	Central	3-Mar-08	8:00	134.4371	-35.2187	444	-	-	-
27	BRUVS	60-mile closure	Central	3-Mar-08	8:33	134.4352	-35.2163	433	-	-	-
28	CTD LADCP	60-mile closure	Central	3-Mar-08	20:41	134.4449	-35.1887	110	-	-	-
29	CTD LADCP	60-mile closure	Central	3-Mar-08	21:16	134.4312	-35.1868	150	-	-	-
30	CTD LADCP	60-mile closure	Central	3-Mar-08	22:39	134.4501	-35.2102	440	-	-	-
31	CTD LADCP	60-mile closure	Central	3-Mar-08	23:32	134.4423	-35.2212	440	-	-	-
32	CTD LADCP	60-mile closure	Central	4-Mar-08	2:34	134.4425	-35.2212	440	-	-	-
33	BRUVS	60-mile closure	Central	4-Mar-08	4:15	134.5627	-35.2857	420	-	-	-
34	BRUVS	60-mile closure	Central	4-Mar-08	4:42	134.5611	-35.2817	343	-	-	-
35	BRUVS	60-mile closure	Central	4-Mar-08	5:38	134.5779	-35.2898	455	-	-	-

Op #	Gear	Location	Site	Start date (utc)	Start time hh:mm (utc)	Start position Long (dec deg)	Start depth Lat (dec deg)	End position (m)	End depth Long (dec deg)	Lat (dec deg)	(m)
36	BRUVS	60-mile closure	Central	4-Mar-08	5:54	134.5754	-35.2839	388	-	-	-
37	BRUVS	60-mile closure	Central	4-Mar-08	6:28	134.5717	-35.2796	407	-	-	-
38	Grab	60-mile closure	Central	4-Mar-08	10:40	134.5786	-35.2947	472	-	-	-
39	Grab	60-mile closure	Central	4-Mar-08	10:55	134.5794	-35.2949	486	-	-	-
40	Mooring - VR2	60-mile closure	Central	5-Mar-08	6:28	134.4007	-35.1966	340	-	-	-
41	Mooring - VR2	60-mile closure	Central	5-Mar-08	7:44	134.3973	-35.2026	475	-	-	-
42	Mooring - VR2	60-mile closure	Central	5-Mar-08	8:21	134.4293	-35.2042	230	-	-	-
43	Mooring - VR2	60-mile closure	Central	5-Mar-08	2:57	134.4248	-35.2127	485	-	-	-
44	Mooring - VR2	60-mile closure	Central	5-Mar-08	10:01	134.4724	-35.2398	530	-	-	-
45	Mooring - VR2	60-mile closure	Central	5-Mar-08	10:53	134.4748	-35.2308	400	-	-	-
46	Mooring - VR2	60-mile closure	Central	5-Mar-08	-	134.4761	-35.2214	225	-	-	-
47	Grab	60-mile closure	Central	5-Mar-08	12:02	134.4502	-35.2094	456	-	-	-
48	Grab	60-mile closure	Central	5-Mar-08	12:30	134.4509	-35.2089	457	-	-	-
49	Grab	60-mile closure	Central	5-Mar-08	12:43	134.451	-35.2094	461	-	-	-
50	Grab	60-mile closure	Central	5-Mar-08	13:22	134.4411	-35.2214	463	-	-	-
51	Grab	60-mile closure	Central	5-Mar-08	13:46	134.442	-35.2216	460	-	-	-
52	CTD LADCP	60-mile closure	Central	5-Mar-08	17:33	134.4389	-35.2724	1150	-	-	-
53	CTD LADCP	60-mile closure	Central	5-Mar-08	19:02	134.4262	-35.2671	1150	-	-	-
54	CTD LADCP	60-mile closure	Central	5-Mar-08	20:20	134.4386	-35.2494	880	-	-	-
55	Mooring - VR2	60-mile closure	Central	5-Mar-08	22:41	134.3426	-35.174	455	-	-	-
56	Mooring - VR2	60-mile closure	Central	5-Mar-08	23:12	134.3505	-35.1686	355	-	-	-
57	Mooring - VR2	60-mile closure	Central	5-Mar-08	23:31	134.3518	-35.1593	305	-	-	-
58	Mooring - VR2	60-mile closure	Central	6-Mar-08	0:20	134.3731	-35.1926	555	-	-	-
59	Mooring - VR2	60-mile closure	Central	6-Mar-08	0:46	134.3787	-35.1853	460	-	-	-
60	Mooring - VR2	60-mile closure	Central	6-Mar-08	1:10	134.3857	-35.1778	245	-	-	-
61	Mooring - VR2	60-mile closure	Central	6-Mar-08	2:28	134.269	-35.145	385	-	-	-
62	Mooring - VR2	60-mile closure	Central	6-Mar-08	3:06	134.2991	-35.1424	455	-	-	-
63	Mooring - VR2	60-mile closure	Central	6-Mar-08	4:03	134.3283	-35.1646	415	-	-	-
64	BRUVS	60-mile closure	Central	6-Mar-08	4:53	134.3754	-35.1787	439	-	-	-
65	BRUVS	60-mile closure	Central	6-Mar-08	5:00	134.3726	-35.1743	425	-	-	-
66	BRUVS	60-mile closure	Central	6-Mar-08	5:40	134.3694	-35.1699	395	-	-	-
67	BRUVS	60-mile closure	Central	6-Mar-08	5:56	134.3666	-35.1667	370	-	-	-
68	BRUVS	60-mile closure	Central	6-Mar-08	6:13	134.3641	-35.163	360	-	-	-
69	Sherman sled	60-mile closure	Central	6-Mar-08	10:57	134.2747	-35.1406	450	-	-	-
70	Towed camera	60-mile closure	West	6-Mar-08	16:45	133.9332	-35.0441	430	133.9134	-35.0435	655

Op #	Gear	Location	Site	Start date (utc)	Start time hh:mm (utc)	Start position Long (dec deg)	Start depth Lat (dec deg)	End position (m)	End depth Long (dec deg)	Lat (dec deg)	(m)
71	Towed camera	60-mile closure	West	6-Mar-08	18:10	133.9556	-35.0531	470	133.9635	-35.0579	712
72	Mooring - VR2	60-mile closure	Central	6-Mar-08	23:19	134.451	-35.2215	605	-	-	-
73	Mooring - VR2	60-mile closure	Central	6-Mar-08	23:36	134.4515	-35.212	490	-	-	-
74	Mooring - VR2	60-mile closure	Central	7-Mar-08	0:23	134.4476	-35.203	385	-	-	-
75	CTD LADCP	60-mile closure	Central	7-Mar-08	0:39	134.4492	-35.2101	430	-	-	-
76	CTD LADCP	60-mile closure	Central	7-Mar-08	1:50	134.4414	-35.2209	430	-	-	-
77	BRUVS	60-mile closure	Central	7-Mar-08	4:48	134.5078	-35.2398	445	-	-	-
78	BRUVS	60-mile closure	Central	7-Mar-08	5:19	134.5046	-35.2359	444	-	-	-
79	BRUVS	60-mile closure	Central	7-Mar-08	5:22	134.5005	-35.2326	440	-	-	-
80	BRUVS	60-mile closure	Central	7-Mar-08	5:57	134.4966	-35.2291	399	-	-	-
81	BRUVS	60-mile closure	Central	7-Mar-08	6:18	134.4916	-35.2256	344	-	-	-
82	Sherman sled	60-mile closure	Central	7-Mar-08	10:46	134.6021	-35.2946	200	134.591	-35.2946	300
83	Towed camera	60-mile closure	West	7-Mar-08	16:10	133.9081	-35.0455	427	133.9075	-35.0326	525
84	Towed camera	60-mile closure	West	7-Mar-08	18:05	133.9175	-35.0446	430	133.9206	-35.0331	450
85	Towed camera	60-mile closure	West	7-Mar-08	20:31	134.1183	-35.0883	442	134.1045	-35.1048	673
86	Trap deploy	60-mile closure	Central	8-Mar-08	10:23	134.3889	-35.1916	430	-	-	-
87	Grab	60-mile closure	Central	8-Mar-08	11:25	134.4328	-35.2034	210	-	-	-
88	Grab	60-mile closure	Central	8-Mar-08	11:45	134.4326	-35.2028	204	-	-	-
89	Grab	60-mile closure	Central	8-Mar-08	12:08	134.4388	-35.2118	318	-	-	-
90	Grab	60-mile closure	Central	8-Mar-08	12:25	134.4383	-35.2116	322	-	-	-
91	Trap deploy	60-mile closure	Central	8-Mar-08	-	134.3919	-35.1929	444	-	-	-
92	CTD LADCP	60-mile closure	Central	8-Mar-08	17:29	134.4472	-35.2489	940	-	-	-
93	CTD LADCP	60-mile closure	Central	8-Mar-08	18:53	134.4417	-35.2213	450	-	-	-
94	CTD LADCP	60-mile closure	Central	8-Mar-08	19:42	134.4495	-35.2104	450	-	-	-
95	Towed camera	60-mile closure	West	9-Mar-08	2:23	134.1605	-35.1158	436	134.1572	-35.1107	602
96	BRUVS	60-mile closure	West	9-Mar-08	4:30	133.916	-35.0446	423	-	-	-
97	BRUVS	60-mile closure	West	9-Mar-08	5:06	133.9153	-35.0372	445	-	-	-
98	BRUVS	60-mile closure	West	9-Mar-08	5:30	133.9145	-35.0334	435	-	-	-
99	BRUVS	60-mile closure	West	9-Mar-08	5:55	133.9134	-35.0276	466	-	-	-
100	BRUVS	60-mile closure	West	9-Mar-08	6:32	133.9126	-35.023	467	-	-	-
101	Trap	60-mile closure	West	9-Mar-08	11:31	133.9564	-35.054	480	-	-	-
102	Sherman sled	60-mile closure	West	9-Mar-08	11:34	133.9172	-35.0434	430	133.9202	-35.0437	496
103	BRUVS	60-mile closure	West	9-Mar-08	12:58	133.9158	-35.0447	430	-	-	-
104	BRUVS	60-mile closure	West	9-Mar-08	13:45	133.9152	-35.0388	447	-	-	-
105	BRUVS	60-mile closure	West	9-Mar-08	14:27	133.9137	-35.0329	452	-	-	-

Op #	Gear	Location	Site	Start date (utc)	Start time hh:mm (utc)	Start position Long (dec deg)	Start depth Lat (dec deg)	End position (m)	End depth Long (dec deg)	Lat (dec deg)	(m)
106	BRUVS	60-mile closure	West	9-Mar-08	14:47	133.9128	-35.0268	440	-	-	-
107	BRUVS	60-mile closure	West	9-Mar-08	15:11	133.9119	-35.0214	470	-	-	-
108	Towed camera	60-mile closure	West	9-Mar-08	18:32	133.8	-35.1493	5	133.797	-35.1404	1000
109	Mooring - VR2	60-mile closure	Central	10-Mar-08	4:37	134.39536	-35.20289	340	-	-	-
110	Mooring - VR2	60-mile closure	Central	10-Mar-08	6:05	134.42247	-35.21276	475	-	-	-
111	Mooring - VR2	60-mile closure	Central	10-Mar-08	-	134.42425	-35.20219	485	-	-	-
112	Mooring - VR2	60-mile closure	Central	10-Mar-08	10:37	134.42678	-35.21603	230	-	-	-
113	Mooring - VR2	60-mile closure	Central	10-Mar-08	11:47	134.4294	-35.2047	230	-	-	-
114	Mooring - VR2	60-mile closure	Central	10-Mar-08	12:19	134.4248	-35.2136	485	-	-	-
115	Mooring - VR2	60-mile closure	Central	10-Mar-08	12:52	134.3972	-35.2028	475	-	-	-
116	Mooring - VR2	60-mile closure	Central	10-Mar-08	-	134.4011	-35.1967	340	-	-	-
117	Mooring - VR2	60-mile closure	Central	10-Mar-08	17:20	134.4165	-35.1975	395	-	-	-
118	Mooring - VR2	60-mile closure	Central	10-Mar-08	18:03	134.4134	-35.2078	485	-	-	-
119	Mooring - VR2	60-mile closure	Central	10-Mar-08	22:27	134.5378	-35.2636	480	-	-	-
120	Towed camera	60-mile closure	Central	10-Mar-08	23:14	134.5322	-35.2675	595	134.5193	-35.2852	1048
121	Mooring - VR2	60-mile closure	Central	11-Mar-08	2:23	134.5822	-35.2955	450	-	-	-
122	Grapple lost gear	60-mile closure	Central	11-Mar-08	8:46	134.42425	-35.20219	450	-	-	-
123	Mooring - VR2	60-mile closure	Central	11-Mar-08	8:27	134.4295	-35.2141	415	-	-	-
124	Grab	60-mile closure	Central	11-Mar-08	8:47	134.4453	-35.229	550	-	-	-
125	Grab	60-mile closure	Central	11-Mar-08	9:29	134.4444	-35.2291	550	-	-	-
126	Sherman sled	60-mile closure	Central	11-Mar-08	10:44	134.5133	-35.2295	300	134.513	-35.2378	400
127	Towed camera	DuCouedic	Video 1	12-Mar-08	0:35	136.3907	-36.4649	150	136.403	-36.4796	467
128	Towed camera	DuCouedic	Video 2	12-Mar-08	2:45	136.4696	-36.4757	141	136.4432	-36.4646	574
129	Towed camera	DuCouedic	Video 3	12-Mar-08	4:46	136.4116	-36.5053	760	136.4056	-36.5248	950
130	Towed camera	DuCouedic	Video 4	12-Mar-08	7:45	136.4149	-36.5776	1320	136.4218	-36.5807	1680
131	Towed camera	Coral Coast	Video 1	14-Mar-08	1:44	142.7556	-39.4322	930	142.7504	-39.4277	1010
132	Towed camera	Coral Coast	Video 2	14-Mar-08	3:26	142.7202	-39.4014	1000	142.7017	-39.3902	1078
133	Towed camera	St Helens	Main Hill	15-Mar-08	16:04	148.7605	-41.2301	585	148.7836	-41.2306	1105
134	Towed camera	St Helens	East Ridge	15-Mar-08	-	148.8085	-41.2282	1230	148.8242	-41.2272	1438
135	Towed camera	St Helens	East Hill	15-Mar-08	19:31	148.8257	-41.2439	1190	148.8337	-41.2401	1437
136	Mooring	St Helens	Shelf	15-Mar-08	-	148.6536	-41.2495	170	-	-	-
137	Towed camera	St Helens	Shelf	15-Mar-08	23:55	148.6498	-41.2524	201	148.6643	-41.2465	226
138	Towed camera	St Helens	Slope	16-Mar-08	2:27	148.6686	-41.247	176	148.7359	-41.2281	970
139	Sherman sled	St Helens	East Hill	16-Mar-08	8:05	148.8258	-41.2431	1170	148.8273	-41.2395	1380

CSR/ROSCOP PARAMETER CODES	METEOROLOGY
M01	Upper air observations
M02	Incident radiation
M05	Occasional standard measurements
M06	Routine standard measurements
M71	Atmospheric chemistry
M90	Other meteorological measurements
	PHYSICAL OCEANOGRAPHY
H71	Surface measurements underway (T,S)
H13	Bathythermograph
H09	Water bottle stations
H10	CTD stations
H11	Subsurface measurements underway (T,S)
H72	Thermistor chain
H16	Transparency (eg transmissometer)
H17	Optics (eg underwater light levels)
H73	Geochemical tracers (eg freons)
D01	Current meters
D71	Current profiler (eg ADCP)
D03	Currents measured from ship drift
D04	GEK
D05	Surface drifters/drifting buoys
D06	Neutrally buoyant floats
D09	Sea level (incl. Bottom pressure & inverted echosounder)
D72	Instrumented wave measurements
D90	Other physical oceanographic measurements
	CHEMICAL OCEANOGRAPHY
H21	Oxygen
H74	Carbon dioxide
H33	Other dissolved gases
H22	Phosphate
H23	Total - P
H24	Nitrate
H25	Nitrite
H75	Total - N
H76	Ammonia
H26	Silicate
H27	Alkalinity
H28	PH
H30	Trace elements
H31	Radioactivity
H32	Isotopes
H90	Other chemical oceanographic measurements
	MARINE CONTAMINANTS/POLLUTION
P01	Suspended matter
P02	Trace metals
P03	Petroleum residues
P04	Chlorinated hydrocarbons
P05	Other dissolved substances
P12	Bottom deposits
P13	Contaminants in organisms
P90	Other contaminant measurements

	MARINE BIOLOGY/FISHERIES
B01	Primary productivity
B02	Phytoplankton pigments (eg chlorophyll, fluorescence)
B71	Particulate organic matter (inc POC, PON)
B06	Dissolved organic matter (inc DOC)
B72	Biochemical measurements (eg lipids, amino acids)
B73	Sediment traps
B08	Phytoplankton
B09	Zooplankton
B03	Seston
B10	Neuston
B11	Nekton
B13	Eggs & larvae
B07	Pelagic bacteria/micro-organisms
B16	Benthic bacteria/micro-organisms
B17	Phytobenthos
B18	Zoobenthos
B25	Birds
B26	Mammals & reptiles
B14	Pelagic fish
B19	Demersal fish
B20	Molluscs
B21	Crustaceans
B28	Acoustic reflection on marine organisms
B37	Taggings
B64	Gear research
B65	Exploratory fishing
B90	Other biological/fisheries measurements
	MARINE GEOLOGY/GEOPHYSICS
G01	Dredge
G02	Grab
G03	Core - rock
G04	Core - soft bottom
G08	Bottom photography
G71	In-situ seafloor measurement/sampling
G72	Geophysical measurements made at depth
G73	Single-beam echosounding
G74	Multi-beam echosounding
G24	Long/short range side scan sonar
G75	Single channel seismic reflection
G76	Multichannel seismic reflection
G26	Seismic refraction
G27	Gravity measurements
G28	Magnetic measurements
G90	Other geological/geophysical measurements