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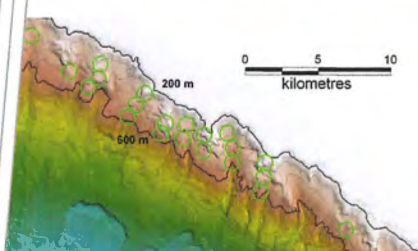

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Mapping the distribution and movement of gulper sharks, and developing a non-extractive monitoring technique, to mitigate the risk to the species within a multi-sector fishery region off southern and eastern Australia

Wealth from Oceans National Research Flagship

FRDC Final Report 2009/024
May 2012

• Alan Williams • Ross Daley
• Bruce Barker • Mark Green
• Ian Knuckey

Australian Government
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List of Acronyms

AATAMS	Australian Animal Tagging and Monitoring System (IMOS facility)
ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
AFMA	Australian Fisheries Management Authority
AMC	Australian Maritime College
ASDD	Australian Spatial Data Directory
BRUVS	Baited Remote Underwater Video Systems
CAPEX	Capital Expenditure (CSIRO)
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CTD	Conductivity, Temperature, Depth (recording equipment)
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities
EPBC	Environment Protection and Biodiversity Conservation (Act 1999)
FRDC	Fisheries Research and Development Council
FRV	Fishery Research Vessel
FV	Fishing Vessel
GAB	Great Australian Bight
GIS	Geographic Information System
GLM	General Linear Model
ISO	International Organisation for Standardization
ISMP	Integrated Scientific Monitoring Program
IMOS	Integrated Marine Observing System
MarLIN	Marine and Atmospheric Research Laboratories Information Network
MNF	Marine National Facility
NSW	New South Wales
OGC	Open Geospatial Consortium
OTLF	Ocean Trap and Line Fishery
PIRVic	Primary Industries Research Victoria
QLD	Queensland
RV	Research Vessel
SEMAC	South East Management Advisory Council
SESSF	South East Scalefish and Shark Fishery
SETFIA	South East Trawl Fishery Industry Association
SlopeRAG	Slope Resource Assessment Group
TAS	Tasmania
TSSC	Threatened Species Scientific Committee
URL	Uniform Resource Locator
USDMS	Upper Slope Dogfish Management Strategy
UWA	University of Western Australia
WFS	Web Feature Service
WMS	Web Map Service
WTO	Wildlife Trade Order

1. NON-TECHNICAL SUMMARY

FRDC Final Report 2009/024 Mapping the distribution and movement of gulper sharks, and developing a non-extractive monitoring technique, to mitigate the risk to the species within a multi-sector fishery region off southern and eastern Australia

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OBJECTIVES:

1. Map the current distribution of gulper sharks in eastern Australia

2. Measure the rates of movement of gulper sharks in and out of closed areas

3. Develop non-lethal methods for long term monitoring of gulper shark populations

4. Provide early results (that integrate field results with existing knowledge) for evaluation by the EPBC listing (TSSC) process, and for an overarching implementation strategy to underpin the development of management responses

OUTCOMES ACHIEVED:

1. Interpreted results from a large volume of data generated by eight successful field surveys (that documented the east and south coast distributions of gulper shark species and movement data on Southern Dogfish) that underpinned the design of fishery closures for the implementation of AFMA's Upper Slope Dogfish Management Strategy, and contributed substantially to CSIRO and industry submissions to influence the EPBC listing process for gulper sharks being undertaken by the TSSC.

2. An effective and proactive stakeholder engagement and communication program enabled a consensus view about fishery closures to be achieved across fishery stakeholder groups.

3. A tool to provide long term non-extractive monitoring data, and a detailed proposal for a long term monitoring strategy will help gain Wildlife Trade Order (WTO) approval for the SESSF, and address the TSSC advice that 'Conservation Dependent' listing of gulper sharks, depends in part, on the establishment of a monitoring program.

This two year project provided the science to support the development of a management strategy for three gulper sharks species (genus *Centrophorus*) being assessed for threatened species listing. Their listing represented one of the most urgent environmental challenges to the South East Scalefish and Shark Fishery (SESSF), and had potential to threaten the fishery's "licence to operate". The project successfully completed and communicated research results, and did so to the tight timelines dictated by the development of the management strategy, and the timetable of the listing process. Much of the science advice relied on an intensive and extensive field campaign, which was conducted very successfully, and which had strong support from the fishing industry.

Mapping gulper shark distributions

Updated geographical and depth distributional ranges were established for the two gulper shark species of greatest interest, Harrisson's Dogfish (*C. harrissoni*) and Southern Dogfish (*C. zeehaani*).

Measuring the rates and scales of movement of gulper sharks

This project developed techniques to use acoustic telemetry technology in the deep ocean for the first time; this enabled movement data to be collected at spatial scales relevant to the sizes of fishery closures (10s of kilometres). Acoustic tagging in the GAB 60 mile closure showed 38% of sharks were detected near the margins of the acoustic receiver array at least once, but sharks were 5–14 times more likely to be detected near the middle section of the array, indicating that the closure is buffered for edge effects (sharks leaving the area and being caught by fishing). In this closure, mature breeding females were also concentrated near the centre of the closure. A strong diurnal pattern was evident with sharks moving inshore into shallower waters at night, and offshore into deeper waters during the day. Results indicate the appropriate size for gulper shark closures is likely to vary between latitudes, seasons and species, and depend on the precise management objective.

Develop non-lethal methods for long term monitoring of gulper sharks

The project evaluated and cross-referenced two methods with potential to provide quantitative, non-lethal, and cost effective data on gulper shark population status: capture by hook and line, and *in situ* photography. Observation of gulper sharks in three surveys confirmed the potential of both methods. Development of the new DeepBRUVS survey tool provides the potential to collect monitoring data on the status of gulper shark populations, but further work is required to establish whether photographic summaries of species abundance, size structure and sex ratio can be calibrated to the same metrics measured by hook-and-line catch data.

Results to underpin the development of management responses

Timely delivery of results enabled 36 candidate areas for protecting gulper sharks across temperate Australia to be identified and short-listed. These areas were detailed as specific options for individual area closures, and as a closure network. All results were provided in discussion papers to stakeholders and the South East Management Advisory Committee (SEMAC), and underpinned the design of fishery closures for the Stage 2 implementation of AFMA's Upper Slope Dogfish Management Strategy.

2. ACKNOWLEDGEMENTS

The success of this project was assisted with input from many scientific colleagues, AFMA managers, and industry stakeholders. Important direction and review of key documents was provided by Drs Tony Smith, David Smith, John Stevens and Professor Nic Bax from CSIRO Marine and Atmospheric Research. Other staff from CSIRO also contributed to the success of the project in a number of ways: Pamela Brodie made a significant contributions to data management and analysis, and was assisted by Scott Cooper (data management and data entry), Matt Lansdell (collating tag returns and data entry); Franzis Althaus helped with documentation and document production, and Lea Crosswell designed the report cover.

The research work benefited from the involvement of many industry stakeholders. We thank Simon Boag (Executive Officer, SETFIA) who made a major contribution to communicating the needs and aims of the project's research, co-ordinating trawl sector input, and supporting the development of the management strategy for gulper sharks. Several skippers and industry operators contributed knowledge and assistance; we thank Chris Currie, Semi Skoljarev, Slavko Kolega, Les Scott, David Guillot, Craig Tooker and Andy Prindiville. We particularly thank Will Mure, Russel Potter and crew of the FV *Diana* that was used for the large east coast survey in 2009.

Special thanks also to Ken Graham, formerly of NSW Fisheries, for generously donating one full month of his time/skill/knowledge and enjoyable company to the *Diana* 2009 survey.

We thank observers Grant Johnson (ISMP/PIRVic), Lauchie Kranz (AFMA), Justin Bell (PIRVic), Craig Bambling and Nick Rudzinskas (AFMA) for assisting with the initial GAB survey on board FV *Diana* and FV *Riba* 2 in 2005. We thank David Maynard (AMC) for co-ordinating CSIRO's involvement in two voyages on board the Australian Maritime College vessel FRV *Bluefin*. David Maynard and Nick Rawlinson (AMC) also contributed to early trials of survey and tagging methods.

Collaboration in this project came from the University of Western Australia (UWA) and we thank Dr Euan Harvey for his support. Through this collaboration BRUVS equipment and field support was supplied for the BRUVS investigation. Thanks to Sam McMillan for his participation on the FV *Diana* 2009 and RV *Naturaliste* 2010 surveys. Thanks again to Sam and also various UWA students and support staff who viewed and extracted the data from the many hours of BRUVS video. Thanks to Dr Peter Last (CSIRO Fish Taxonomy) for his time and expertise in identifying fish and sharks from the BRUVS footage.

We also thank Sally Weekes (AFMA) for her liaison role, Debbie Vince (CSIRO) for administrative work, and Carolyn Stewardson and other FRDC staff for their ongoing support, input and advice.

Funding was provided by CSIRO Wealth from Oceans Flagship and the Fisheries Research and Development Corporation (FRDC) and CSIRO Corporate CAPEX (capital equipment) funding.

3. BACKGROUND

Gulper sharks (for the purpose of this report these are defined as deepwater dogfish species only of the genus *Centrophorus*) occupy the upper continental slope and some offshore seamounts around southern and eastern Australia. This group represents one of the most urgent environmental challenges to the Southern and Eastern Scalefish and Shark Fishery (SESSF), and may even threaten its "license to operate". There are three primary gulper shark species impacted by fishing off SE Australia: Harrisson's Dogfish (C*entrophorus harrissoni*), Southern Dogfish (C*entrophorus zeehaani*) and Endeavour Dogfish (C*entrophorus moluccensis*). Previous studies have shown that these species have been heavily depleted in areas where they have been fished (Graham *et al*., 2001; Daley *et al*., 2002), in some areas down to less than 1% of initial population levels. Gulper sharks have in the past been targeted using a range of fishing methods on different habitats including demersal trawl, dropline and (deep set) gillnets. Gulper sharks are no longer targeted in Commonwealth fisheries, (although the Leafscale Gulper Shark [C*entrophorus squamosus*] is still targeted off NSW). However, there are concerns regarding continued bycatch in the trawl and auto-longline sectors of the SESSF. These concerns stem from the extremely low reproductive rates of gulper sharks and other aspects of their biology (Daley *et al*., 2002; Graham and Daley, 2010). For populations of gulper sharks that have been depleted in Australia, recovery is likely to take tens of years and possibly even centuries (Daley *et al*., 2002; Kyne and Simpfendorfer, 2010).

Concerns about overfishing of these species led to them being nominated for endangered species listing under the EPBC Act. A decision by the TSSC made prior to this research proposal saw them given a high priority for evaluation; the decision on formal listing had been scheduled for September 2010.

Several management measures had been put in place to help protect remaining populations of these species in south-eastern Australia, including trip limits and specific closures in the GAB, waters off eastern Tasmania, and near Wollongong. However, with the exception of the GAB closure, it was not known whether those closures were actually protecting viable populations of gulper sharks, and even for the GAB it was not known whether the area closed was sufficiently large. There were clearly large gaps in understanding about the distribution and behaviour of these species, and the level of protection afforded by existing management measures. This increased the uncertainty risk and likelihood that they would be listed as Conservation Dependent or at an even higher category when the decision on listing is made.

The project research built on other work to improve identification of species catches by industry, and on a successful pilot project funded by CSIRO Wealth from Oceans that demonstrated gulper sharks can survive the tagging process and modern electronic tracking technologies will work in the deep ocean. The present project is therefore the second stage in developing an understanding of gulper shark distribution, home range, and to evaluate methods for non-lethal monitoring of populations following implementation of a management plan. Accordingly, the project was developed to address the most urgent gaps in understanding for gulper sharks (particularly related to the potential for listing), and to develop longer term monitoring tools that would form the basis for a recovery strategy should they receive formal listing as Conservation Dependent or higher under the EPBC Act.

4. NEED

The need for targeted research on gulper sharks, particularly in temperate Australian waters, had been widely canvassed for several years prior to this proposal being funded. The primary reasons included evidence of their dramatic decline in abundance off NSW (as measured by the repeat RV *Kapala* surveys, Graham *et al.*, 2001); a pattern of increasing and expanding demersal trawl and auto-longline fishing effort in their core depth range on the upper continental slope during the early to mid-2000s (particularly in the east coast trawl sector of the SESSF); impacts of targeted gillnet and line fisheries under NSW and Commonwealth jurisdiction and their extremely low intrinsic productivity (Daley *et al*., 2002; Graham and Daley, 2011). The need for research was given greater emphasis when three species were listed by DSEWPaC for priority assessment for threatened species listing. This development represented one of the most urgent environmental challenges to the SESSF, and had potential to threaten its "licence to operate".

The most pressing needs, and those addressed by this project, were:

a) Identifying areas where viable gulper sharks populations still existed, particularly on the east coast of Australia (Tasmania to northern NSW) and on adjacent seamounts in the Tasman and Coral Seas, to help determine suitable areas for protection from fishing, and, to some extent, determine whether existing closures off eastern Tasmania and Wollongong (NSW) were appropriately located.

b) Determining movement rates and movement ranges of gulper sharks, particularly into and out of closed areas. This information would assist in designing effective fishery closures, and provide evidence to help determine whether the current size and location of closures was appropriate.

c) Developing a monitoring technique(s) that uses non-lethal sampling to follow trends in abundance over time and between areas. A technique needs to be cost effective (ideally involving the fishing industry) and provide sufficient resolution to detect change in population status. It was anticipated that monitoring data would form a key plank in a recovery strategy for gulper sharks should they be listed. The need for non-lethal sampling methods follows directly from concerns about the already highly depleted state of these species in key parts of their range.

5. OBJECTIVES

1. Map the current distribution of gulper sharks in eastern Australia

2. Measure the rates of movement of gulper sharks in and out of closed areas

3. Develop non-lethal methods for long term monitoring of gulper shark populations

4. Provide early results (that integrate field results with existing knowledge) for evaluation by the EPBC listing (TSSC) process, and for an overarching implementation strategy to underpin the development of management responses

A Special Condition of the project was also to:
Collect and summarise data on distribution, size frequencies and sex ratios for Greeneye Spurdog (*Squalus chloroculus*) and other dogfishes (Squalidae) from the upper continental slope.

6. METHODS

6.1 Map the current distribution of gulper sharks in eastern Australia

6.1.1 Methods

Survey design

The first step in the survey design was to collate extensive habitat mapping data. Swath mapping bathymetry data from the MNF *Southern Surveyor* was used to define areas within the suitable depth range: ~300–600 m. These data were examined in detail to identify habitat features such as canyons and ledges, and backscatter images were used to identify hard bottom that was more likely to have attached epifauna that can serve as refuge. Trawl effort data were then overlaid to determine which areas were most likely to remain intact. These analyses have subsequently contributed to evaluation of spatial closure options [Appendix F]. The next step was to identify correlation between suitable habitat and recent catch records of the species of interest. A number of sources of data were used. For NSW, surveys by the *Kapala* provided the most data. Industry also provided additional records that were validated where possible by specimens sent to Hobart. Fishers from trawl, autoline and NSW Ocean Trap and Line Fishery (OTLF) contributed to this step. The final stage of the survey planning was to develop a shortlist of survey sites. This was completed at two workshops in Hobart with input from managers and industry. An additional site was added, the Taupo Seamount, as industry had confidence that Harrisson's Dogfish are present on remote seamounts in the Tasman/Coral Seas.

Fishing Surveys

Auto-longline fishing vessels (FV *Diana* - Mures Fishing, and FV *Sarda* - Bluebeards Fishing) were used for the main scientific surveys (Table 6.1), covering the New South Wales and eastern Tasmanian coastlines and areas of the eastern Great Australian Bight (Figure 6.1). For the east coast survey [Appendix E4] positions for survey sampling were pre-selected by the research team after carefully examining the bathymetry (swath map) and backscatter (bottom hardness) data; industry was given opportunity to comment on these locations before the charter commenced. For the Bass Strait survey [Appendix E9] a number of options (areas of interest) for scientific shots were provided to the skipper on the basis of pre-existing data. On all trips the precise start and end positions of each shot were determined following discussion between the voyage leader and the skipper taking into consideration science objectives, safety, weather and tide.

A number of steps were taken to maximize survivorship of all gulper sharks caught. Apart from the commercial fishing survey on board the FV *Sarda* (where soak times of up to 13.45 hours were part of the normal commercial fishing operations), soak times were restricted to 2–4 hours. In order to prevent jaw damage, all gulper sharks captured were removed from the hook by the crew and not allowed to pass through the 'rollers' normally used for removing hooks from fish.

Figure 6.1 General locations of research (red) and commercial (blue) surveys

Setting and hauling the longline was controlled using a Mustad Coastal auto-line system with automatic baiting of two hooks per second whilst steaming at five knots. The mainline used was 7 mm Mustad roto line (swivelled) with snoods at 1.4 m intervals, and 400 mm snoods (1.8 mm monofilament). The hooks used were 12/0 Mustad 'super baiters'. The line was anchored at each end with 60 kg steel weights, extra weights (and floats) were deployed along the line according to terrain and to fish either hard on the bottom or off the bottom. Lines and surface floats marked the start and end of the line and were used to retrieve the longline. The hooks were baited with Mackerel or squid sourced from Australia and overseas.

Two supplementary demersal longline surveys were conducted in 2008 and 2010 from the AMC *Bluefin* (Table 6.1). These surveys did not use auto-longline equipment, hooks were hand baited and the snoods clipped to the longline by hand.

Table 6.1 Voyages that contributed shark distribution data

Vessel	Year	Region	Voyage type	Reference
FV Diana	2005	Ceduna Terrace to Port Lincoln	Chartered research survey	Appendix E1
FV Diana	2009	Brisbane to NE Tasmania	Chartered research survey	Appendix E4
FV *Sarda*	2010	West of Portland – Great Aust. Bight	Chartered research survey	Appendix E8
FV *Sarda*	2010	Bass Strait	Commercial fishing – Observer survey	Appendix E9
AMC *Bluefin*	2008	Eastern Flinders	Collaborative research survey	Appendix E2
AMC *Bluefin*	2010	Eastern Flinders	Collaborative research survey	Appendix E11

Data quality

For each species, several specimens were retained and deposited in the CSIRO Australian Fish Collection and the Australian Museum in Sydney for the purposes of species verification. Samples of *C. harrissoni* were retained from Taupo Seamount and the eastern seaboard to confirm that they were the same species using genetic methods targeting the Cyt B and 16S gene (Daley *et al*., 2011).

Data analysis

For each site fished, the overall percentage catch rate (number caught/100 hooks) was calculated for each species of *Centrophorus* caught. Length frequency data for each species and site were plotted separately for males and females.

6.2 Home range and movement

6.2.1 Methods

Range testing of acoustic receivers and transmitter tags

Two methods were used to test the effective range of the tags: (1) Static range tests, and (2) towed tests. Both tests were undertaken on board the MNF *Southern Surveyor* as part of a pilot CSIRO project (Williams 2008). Details of the methods are provided [Appendix C].

Acoustic receiver array

An array of 21 Vemco VR2 receivers was used to detect tag transmissions across 40 miles of the GAB 60 mile closure (Figure 6.2). Two of the receivers were deployed separately and in isolation to examine behaviour around two particular habitat types: peninsula hill and canyon. The remaining 19 moorings were deployed in curtains (~20 km or ~10 minutes longitude apart) to examine home range and diurnal movements. Each curtain consisted of 4–5 receivers spanning the 300–600 m contours across the study site. Within curtains, receivers were positioned 650 m apart to ensure range overlap between them. The array was deployed twice. The first deployment was for four months in spring 2009 (Spring 09 data); sharks were captured and tagged at the start of these four months. The second deployment was for a full 12 months from summer 2009/2010 to spring 2010 (09/10 data). These two deployments allowed for comparisons between seasons and between years (for spring). However, most analyses focussed on the 09/10 data to eliminate between year effects and any abnormal behaviour associated with the stress of capture and release. Results described in Section 7 relate to the 09/10 data unless otherwise noted.

VR2 receivers were moored separately. The mooring design is described at the end of this document [Appendix D]. Moorings were deployed from the FV *Lucky S* [Appendix E3, Appendix E6] to recover the moorings, the acoustic releases were activated using a hydrophone and the receivers and associated floats and lines were recovered at the surface. Data were then downloaded from the recovered receivers using Vemco Vue software.

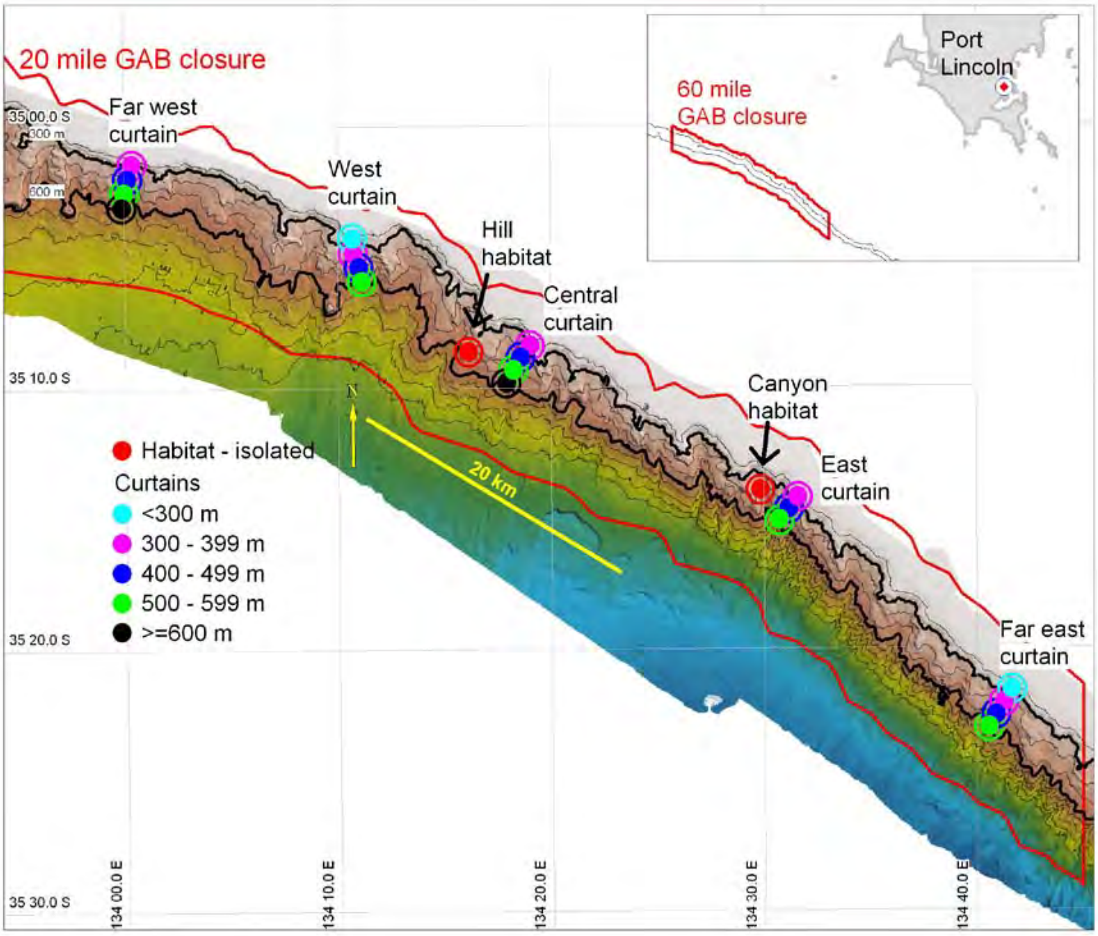

Figure 6.2 Map of the acoustic receiver array of five curtains and two habitat receivers within the 60 mile GAB closure off Port Lincoln (red lines and inset); the estimated detection range of each receiver is indicated by the circles.

Tagging

The fishing method is described in Section 6.1.1. Immediately after capture, acoustic tags (Vemco V16 69 kHz, 4H battery, 60 second transmission interval) with depth and temperature sensors were attached to the dorsal fin. A leather punch was used to make two holes in the dorsal fin. The holes were located using a plastic template to match the tag. Each tag was then fitted using two 4 mm stainless metal thread screws and 'Nyloc' nuts to secure a backing plate. Sharks were released in close proximity to VR2 receivers so depth data could be used to check that released sharks had successfully returned to the ocean floor.

Survivorship

A set of data flags were used to establish survivorship and data quality status: not detected (ND); constant depth = dead (DD); only detected in spring 09 (S09); detected after spring 09 (09/10). For sharks that died during the experiment, the date of death was determined and subsequent detections were excluded. Tags that were scored ND were not assumed to be dead but could not be included in the analysis, other than to give further consideration as to why they were not detected. S09 sharks were considered lower quality than 09/10 sharks because they were potentially affected by release effects and these data were only used to compare spring 2009 results to spring

2010. It is assumed that most of these sharks left the area, or alternatively were resident between curtains with very small home ranges.

For tags that were found to represent live sharks, the temperature data was examined to identify any individuals that might have been eaten by warm bodied predators, such as white sharks, mako sharks[1] or killer whales. In such cases it would be possible that the predatory shark was being tracked, rather than a Southern Dogfish. Any individuals that recorded temperatures lower than 7 degrees, or higher than 16 degrees, were scrutinised by comparing their daily depth and pressure profiles to those of other predators that occur in the area.

Depth range and bathymetric range

Detection data from different individuals were pooled and the distribution of detections against depth was plotted for each receiver (Figure 6.2). The bathymetric range of each receiver was visualised by overlaying the detection range, as determined from range testing over the detailed bathymetric map of the area. For each receiver the average detection depth was determined and tested for correlation with the bottom depth at the receiver location. It was expected that if gulper sharks were moving throughout the water column at all locations there would be little correlation.

Along slope scale of home range

The size of home range along the slope was examined by treating individuals separately and determining the number of detections each individual recorded at each of the five major curtains separated by ~10 minutes of longitude across the closure. The data for each curtain were standardised for the number of recovered receivers.

Diurnal and seasonal variation in temperature and depth

General linear models (GLM) were used to define diurnal depth and temperature patterns on a 24 hour time scale. Data were grouped into eight three hour bins to minimise auto-correlation. The timing of movements was expressed in relation to sunset at the spring equinox at Adelaide, South Australia. These data were then summarised for the one year average (09/10 data) and the seasonal averages for the five seasons observed during the study (S09 and 09/10 data). For 'between-year' comparisons only the spring 09 and spring 10 data were used.

The CMAR Tag Database

All fish tag data collected by CMAR reside in the Tag Database, an Oracle 10 repository. The tag data from the GAB 60 mile closure area were loaded after the schema was extended to include attributes for quality control and to enhance spatial analyses.

[1] These sharks are endothermic poikilotherms, which means they can regulate their internal temperature but not hold it constant like mammals do.

6.3 Develop non-lethal methods for long term monitoring of gulper shark populations

6.3.1 Methods

Developing monitoring methods and performance measures to evaluate the status and recovery of gulper sharks is challenging because their slow growth and low reproductive rates mean that signals of change will be slow and difficult to detect. Populations in some areas are likely to be small and quite isolated, meaning that non-lethal sampling is essential. Moreover, gulper sharks live at great depth (~300–600 m), and the populations now protected in closed areas exist in exposed offshore locations. Thus, compared to near-shore situations, collection of field data is relatively difficult and expensive.

An effective long term monitoring method will need to provide at least an index of abundance in selected closures (or areas), that can be measured consistently to document change. The monitoring should provide data on the distribution of gulpers so that expansion or contraction of the populations can be determined. Data on the sex ratio of gulpers is also important as the mixing and segregation of the sexes is critical to monitoring the success, or otherwise, of the population. Continued long term movement monitoring will add data to current movement models and enable better understanding of sex segregation and spatial requirements for populations to remain viable. Long term monitoring of recruitment (the presence of pups) is necessary to confirm that successful mating is occurring and to understand how new recruits contribute to recovery – by increasing abundance in occupied areas, or recolonising other areas.

Clearly, long term monitoring needs to be quantitative so that comparisons from one year to another, and between locations, can be made.

A long term non-lethal method needs to be cost effective – meaning that monitoring will need to be undertaken mainly from fishing industry vessels during commercial fishing trips. There are few options to non-lethally monitor deepwater fishes such as gulper sharks. In Section 7.3 we evaluate and cross-reference two methods that are essentially non-lethal, quantitative and potentially cost-effective: capture by hook and line, and *in situ* photography using a method established for shallow water surveys – Baited Remote Underwater Video Systems (BRUVS).

BRUVS have been used to document the community composition and structure of fish assemblages in shallow waters across Australia (e.g. Willis and Babcock 2000; Cappo *et al.*, 2004; Harvey *et al.*, 2007; Langlois *et al.*, 2010)[2]. In its simplest form, the BRUVS has been a 'handycam' video camera mounted on a frame, with a bag of fish bait attached in front of it to attract fish. An attached surface line and floats are used to relocate and retrieve it. When used in deeper water illumination is required so lights are added. Extra weights may be needed to keep the BRUVS anchored with increased drag on the buoy lines. Deployments are generally short as the bait source is depleted and fish activity decreases. Because of the simple and relatively inexpensive arrangement, a fleet of BRUVS can be deployed providing replicate data

[2] Further review is provided in Appendix H.

sets for a study area that provide robust statistics for fish population estimates. The recorded video imagery is downloaded to a computer hard drive for subsequent analysis. The data generally recorded are species and number of individuals in the camera's field of view. To value-add to the data obtained from BRUVS deployments, the use of calibrated stereo video cameras enabled accurate measurement, e.g. lengths of individuals to be derived (Shortis & Harvey,1998).

The operating depths (300–600 m) for this project were greater than those in which BRUVS had previously been deployed. We used BRUVS (with stereo cameras) supplied by Dr Euan Harvey from the University of Western Australia (UWA) that were adapted for deployment at gulper shark depths with additional weights and long buoy lines. Squid and pilchard bait (~700 grams) was held in a plastic mesh bag on the bait boom, in front of the cameras. Lighting was provided by LED flood lights. A flashing LED dial provided the means to synchronise camera images whilst taking measurements from the stereo imagery. The video cameras recorded direct to disk (hard drive recording) and were downloaded to computer and backed up on external hard drive units.

6.4 Provide research to underpin the development of management responses

6.4.1 Methods

Please see methods sections for Sections 6.1, 6.2 and 6.3.

6.5 Collect data for other upper slope squalid sharks

6.5.1 Methods

Please see methods sections for Sections 6.1, 6.2 and 6.3.

6.6 Data management

6.6.1 Methods

This project used data gathered during several surveys, conducted from various vessels between the years 2005 and 2009, as detailed in the Voyage Reports in Appendix E. Several data types were acquired, each with their own protocols and processes. Details are in the Results and Discussion, Section 7.6.

7. RESULTS AND DISCUSSION

7.1 Map the current distribution of gulper sharks in eastern Australia

7.1.1 Results and Discussion

This Section addresses Objective 1: *Map the current distribution of gulper sharks in eastern Australia*.

The need to manage overfishing and enable the recovery of overfished populations is a common impetus for the implementation of spatial management measures. However, many attempts at spatial management fail due to inadequate design considerations. The foremost consideration is the selection of suitable locations. The most immediate need for the SESSF was to prevent further declines of remnant populations. Therefore areas where recent catch records indicate the species are still present are of key importance, although potentially limited in geographic scale. Normally suitable locations could be identified based on species specific fishery catch and effort data or observer data. However, such data are not available for gulper sharks in the SESSF (Daley *et al*., 2002; Wilson *et al*., 2009), therefore purpose-designed surveys were needed.

Many species of marine fishes including many sharks are known to segregate by sex and size class. For most scalefish, pelagic sharks and migratory species these patterns of segregation are too variable in space and time to be used as predictors. In stark contrast, there are many species of deepwater dogfish that show patterns of demographic segregation that are known to be stable in space for up to ten years (Kyne and Simpfendorfer 2010, Graham and Daley 2011, Irvine *et al*., 2012). It is important for closures or managed areas to include males, females and juveniles to ensure that mating and pupping is protected. Although two years of telemetry data are available to measure movements of Southern Dogfish, any attempts to measure breeding range based on these data are likely to lead to under estimates because one breeding cycle is thought to take three years (McLaughlin and Morrisey, 2005).

Despite limited species specific knowledge of preferred habitat for gulper sharks, it is possible to base assumptions on three things that are known to apply to a range of species. Firstly increasing the area of occupancy limits fragmentation and aids connectivity, therefore larger areas are preferred. Secondly, although preferred bottom type is unclear it is likely that species use different habitat types for different purposes (mating, feeding and refuge) therefore including a range of habitats should increase suitability. Thirdly, trawling is likely to remove structural epi-benthos that provides refuge for benthic fish species and maintains ecosystem processes (Thrush and Dayton 2002; Williams *et al*., 2005). Therefore un-trawled areas are more likely to be suitable for closures.

Data quality

Species identification was confirmed in Hobart using traditional methods for all species. Additionally, genetic tests confirmed that *C. harrissoni* from Taupo Seamount and the eastern seaboard were con-specific.

Data analysis

The FV *Diana* 2009 voyage provided the key distributional information for the east coast [Appendix E4] and was the key survey voyage for the project. This extensive survey was completed on schedule, including the extra Taupo Seamount site, and a summary of results was presented to industry on the very day the survey vessel docked in Hobart. Gulper shark distribution on the south coast of Australia had already been initially mapped during 2005 [Appendix E1]. Charter operations from the FV *Sarda* during 2009 to catch and tag gulper sharks in the GAB closure also improved distribution/abundance data [Appendix E5, page 6 - Tables 1 & 2]. Additional observer voyages on board the FV *Sarda* in 2010 further improved information from eastern Victoria and Flinders Island [Appendix E8, page 6 - Tables 1 & 2, page 9 - Figure 1; Appendix E9, page 15–16 – Figures 3 & 4], filling in some geographic detail and establishing the stability of some gear dependent demographic patterns. These observations confirmed predictions that the Flinders region is an important breeding area for Harrisson's Dogfish. Two additional voyages by the AMC *Bluefin* deployed a small amount of demersal longline gear in 2008 [Appendix E2] and 2010 [Appendix E11]. The first of these captured a single mature female in the Flinders MPA. The second caught a single juvenile male on very hard bottom with coral cover off the Babel area where juveniles had been recorded twice previously by this project. Details of distribution catch rates and demographic analyses were mapped and summarised for the east and south coasts [Appendix F, page 35; Appendix G, page 16–17]. These were presented at a stakeholder workshop in August 2010 and subsequently to Southeast Management Advisory Committee (SEMAC), Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) and for international review.

Key findings

These new sources of data, together with re-analysis of pre-existing data, provided more accurate maps of range and depth distribution for both Harrisson's and Southern Dogfish. These established both the geographical bounds within which to identify candidate areas for spatial closures, and the depth ranges to be encompassed by closures. Core distributional ranges for both species, including 'extra-limital' extensions where there are few verified records of species being present, and presence at low abundance, are shown below in Figure 7.1. Re-analysis of depth distributions, in the pre-fishery *Kapala* data from 1976 and 1977 and New South Wales Fishery survey data, shows the core and full depth distributions of both species in Figure 7.2. Both species show a strong diel shift in population distribution by depth, clearly indicating that closure depths need to account for the shallower range at night. Depth distributions are defined for Harrisson's Dogfish as a core depth of 300–900 m, with full range of ~180–1050 m, and for Southern Dogfish, a core depth of 300–700 m, and a full range of ~200–850 m. The third species of interest, Endeavour Dogfish, has a core depth of 200–550 m, and a full range of ~150–650 m.

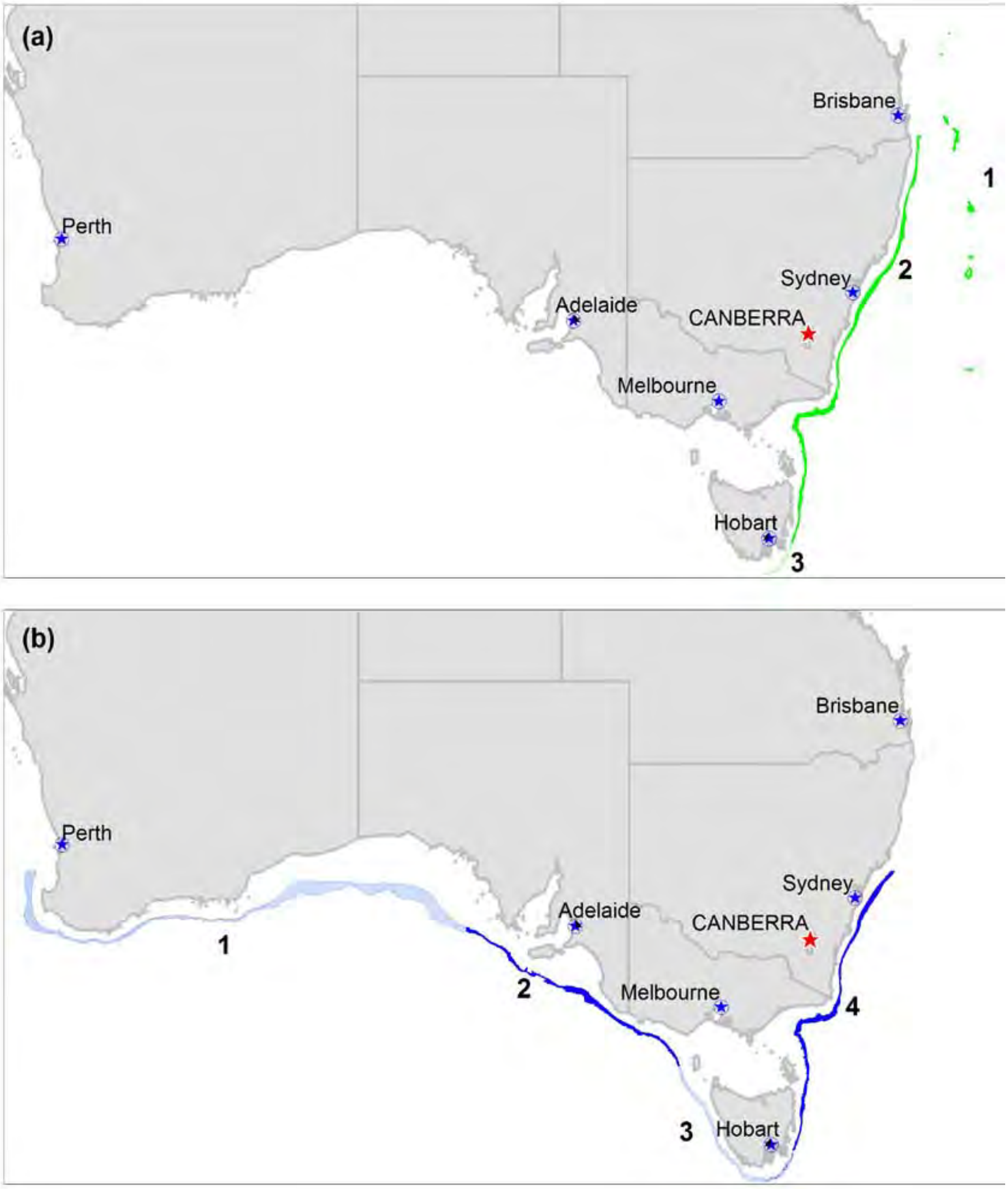

Figure 7.1 Maps showing the known range of two species of gulper shark in Australian waters on the upper continental slope (here shown as ~200–1000m depths). (a) Harrisson's Dogfish: (1) core range on seamounts, (2) core range on the continental margin, (3) extra-limital distribution (defined by few records of presence and low abundance); (b) Southern Dogfish: (1) Apparent extra-limital distribution (defined by few records of presence and low abundance), (2) core western range, (3) apparent gap in distribution around western and southern Tasmania (defined by few records of presence and low abundance), (4) core eastern range.

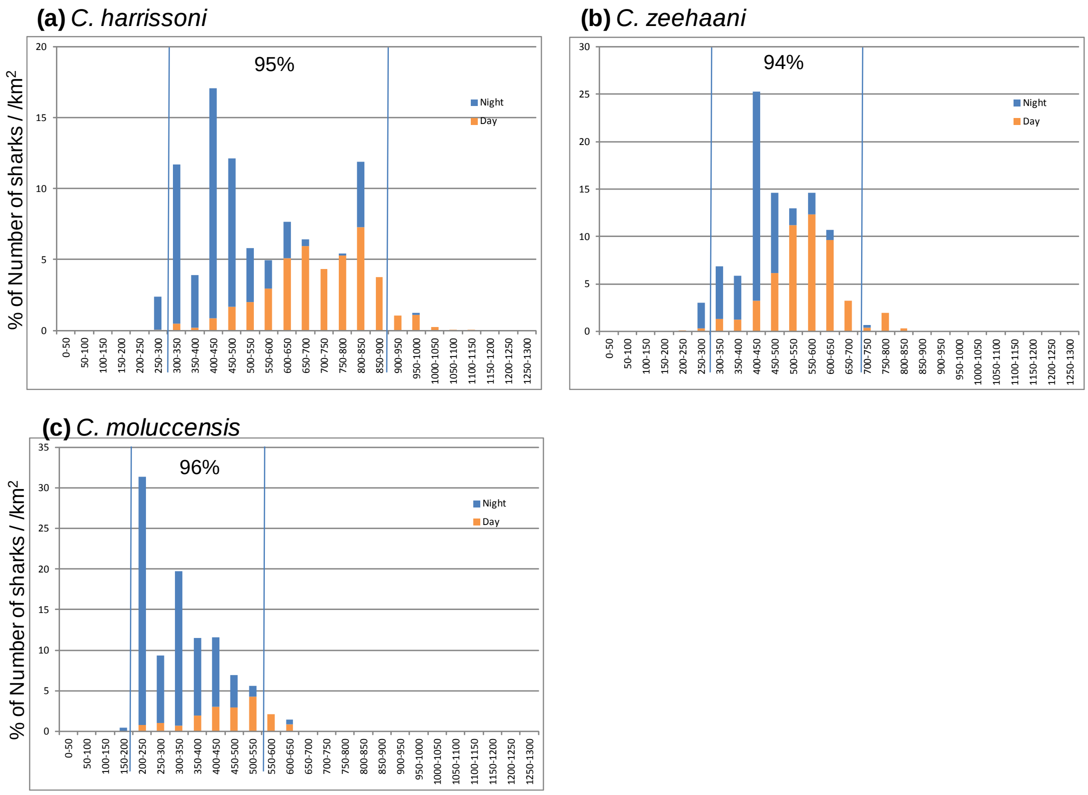

Figure 7.2 Plots showing the known depth range of (a) Harrisson's Dogfish, (b) Southern Dogfish and (c) Endeavour Dogfish. Data are from swept-area standardised survey data, predominantly off NSW from *Kapala* and NSW fishery surveys (1976-2006), plotted in 50 m depth intervals by day and night. Core depths are defined arbitrarily as those containing about 95% of sharks (% of total individuals over a 24-hour period).

7.2 Home range and movement

7.2.1 Results

This Section addresses Objective 2: *Measure the rates of movement of gulper sharks in and out of closed areas.*

In 2005, two auto-longline vessels (FV *Diana* and FV *Riba 2*) conducted a collaborative fishing survey designed by industry, AFMA and CSIRO. The aim of the survey was to identify areas where gulper shark populations could be protected, before geographic expansion of the auto-longline sector would be permitted. Based on data collected on these surveys the ‘60 mile closure’ was established approximately 100 nautical miles (NM) southwest of Port Lincoln (South Australia) with the eastern and western closure boundaries located at 133º45’E and 134º45’E respectively (Figure 7.3; AFMA 2008). This closure is centred on a 30 NM area where Southern Dogfish were concentrated and where mature females were observed. Buffers of 15 NM were added to the east and west to allow for edge effects (mortality due to sharks leaving the closure and being captured by fishers). The closure was designed to cover the main bathymetric range of Southern Dogfish in the area as indicated by catch data from the FV *Diana* 2005 survey results.

Although the 2005 survey indicated the closure is suitably located, the evidence for adequate size was weaker. In particular, size of home range and movements of Southern Dogfish were unknown, apart from data from two tagged individuals that were recaptured 7–8 miles from their release points eight years after being tagged.

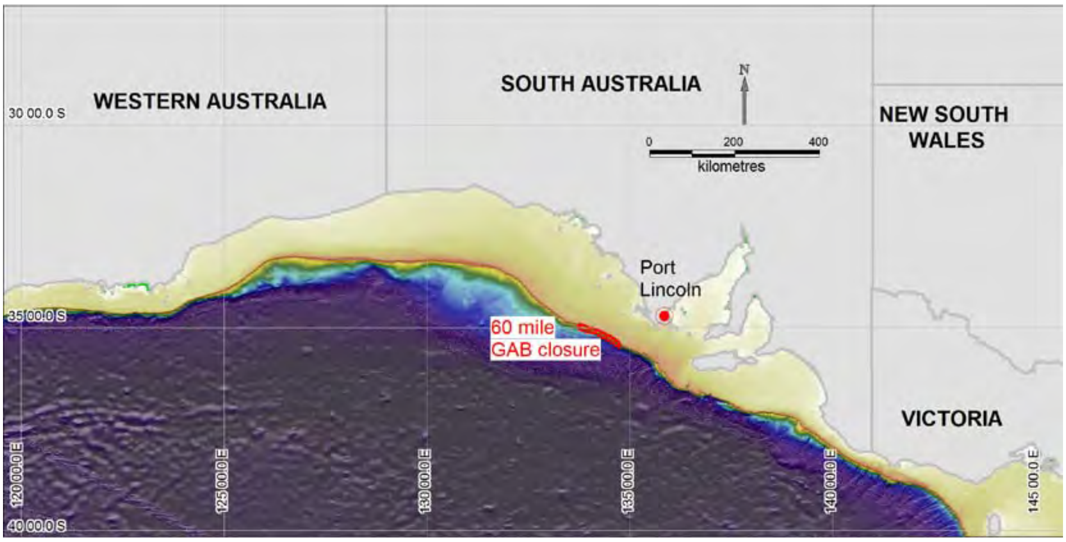

Figure 7.3 The 60 mile GAB closure (red boxed area southwest of Port Lincoln) implemented by AFMA to mitigate fishery impacts on Southern Dogfish (AFMA 2008); the study for the acoustic tagging experiment is located within the closure.

Acoustic telemetry is an emerging method for monitoring movements. Animals are fitted with electronic transmitter tags that can now include sensors for depth and temperature. This information, together with date and time and the tag number, is transmitted when a tagged fish swims into proximity of an acoustic receiver. A group of receivers are positioned on moorings to form an array. Arrays are configured to match the hypothesis to be tested, in this case whether a proportion of Southern Dogfish remain inside the closure designed to protect them. This method has three key advantages: (1) observations are repeated with a frequency that is orders of magnitude higher than can be achieved with other methods (e.g. survey and convention tag data); (2) data is compiled remotely such that the instruments only need to be accessed every 6–12 months (particularly advantageous for data collection in the deep ocean); (3) subjects do not need to be recaptured (which can be logistically difficult and expensive to achieve) and also minimises additional mortality (important for protected species).

To date acoustic telemetry in the deep ocean has been limited to a few trials (Yano and Tanaka, 1998) and there are no published tagging studies for deepwater sharks. Many assumptions about deepwater shark behaviour are based on the shallower White-spotted Dogfish (*Squalus acanthias*) which is commercially valuable in the North Pacific and North Atlantic and therefore studied in detail. This species is known to migrate hundreds of miles across latitudes to maintain a temperature range of 9–14º C and will also move in the water column to maintain this temperature (McFarlane and King 2003).

Acoustic telemetry is commonly used to measure home range. Typically an array of receivers is deployed in a two dimensional matrix and data from tagged animals are analysed using Gaussian or normal distribution kernel methods (Worton 1989; Seaman and Powell 1996). It is not practical to implement this type of experiment in this instance as it would require the deployment of many moorings outside the closure which would illegally interfere with commercial fishing.

Southern Dogfish are restricted to the upper slope, reportedly 210–700 m (Last and Stevens 2010). This restricted habitat forms a narrow strip of habitat only a few miles wide off South Australia and in this respect is similar to rivers. Previous telemetry studies of river sharks have successfully used an array of receivers configured as a series of ‘curtains’ arranged in lines with overlapping detection ranges (Huepel *et al.*, 2004). Given the linear similarity of rivers and the upper slope, a similar array design with curtains was used in this study.

In this Section we determine the home range of Southern Dogfish in the 60 mile GAB Closure off South Australia using acoustic telemetry data from 54 tagged individuals. Home range is defined in terms of extent along the slope, bathymetric range across the slope and height in the water column. Diurnal behaviour and seasonal variation are described. Factors affecting survivorship are discussed together with other considerations for management.

Range testing of acoustic receivers and transmitter tags

The towed range test detected 50–67% of transmissions at a range of 984 m when the tow speed was minimised [Appendix C]. The static range tests detected 27% of transmissions at 450 m but the detection rate fell to 15% at 850 m (Figure 7.4). The lower detection rate achieved during the static test is attributed to tag collisions due to the use of multiple tags. Tag collisions occur when multiple tags transmit at the same time. This results in interference because the receivers can only detect one transmission at any point in time. The maximum range predicted by tags near the float was 1,140 m and for tags near the bottom, 1,525 m. For subsequent analyses a maximum predicted detection range of 1,000 m was used.

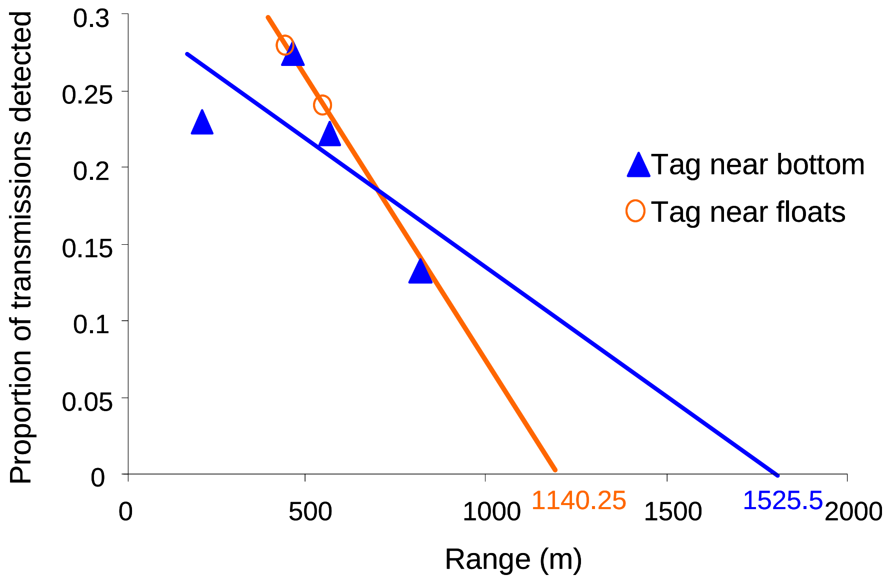

Figure 7.4 Proportion of electronic tag transmissions detected at various ranges during static range testing

Acoustic receiver array

A total of 16 out of 22 receivers were recovered (Figure 7.5). All receivers were recovered from the central curtain. The shallowest receiver was lost from three of five curtains: west, east and far-east. In contrast, at the far-west curtain, the shallowest receiver was recovered but the three deeper receivers were not. Most of the receiver stations that were not recovered were located by the acoustic control mechanism communicating with the mooring release mechanism, but the mooring did not release when the release code was sent to the transponder. After multiple unsuccessful attempts to release those receivers, the release mechanism was left in the 'open' position to allow for the possibility of subsequent release and the chance recovery of the equipment by other means. Several of the recovered moorings had serrations on the mooring line consistent with bite marks [Appendix E10 – Figure 7]. It is also possible these unrecovered receivers had been bitten free by sharks severing the mooring line above the release mechanism [see Appendix D for schematic].

Tagging

When conditions were controlled to maximise animal welfare (see Section 7.2.2) post capture mortality was zero for the 532 Southern Dogfish that were caught on the tagging trip [Appendix E5]. A total of 70 Southern Dogfish were tagged with acoustic transmitters and released at four locations within the central 30 miles of the closure (Figure 7.5): East curtain (38); east canyon habitat (11); central curtain (6); west curtain (15). The release depth was 320–520 m, apart from at the west site: 270–635 m. At the west curtain the male to female ratio was 1.1:1 but males dominated at the other sites, with ratios of 4.5–12:1.

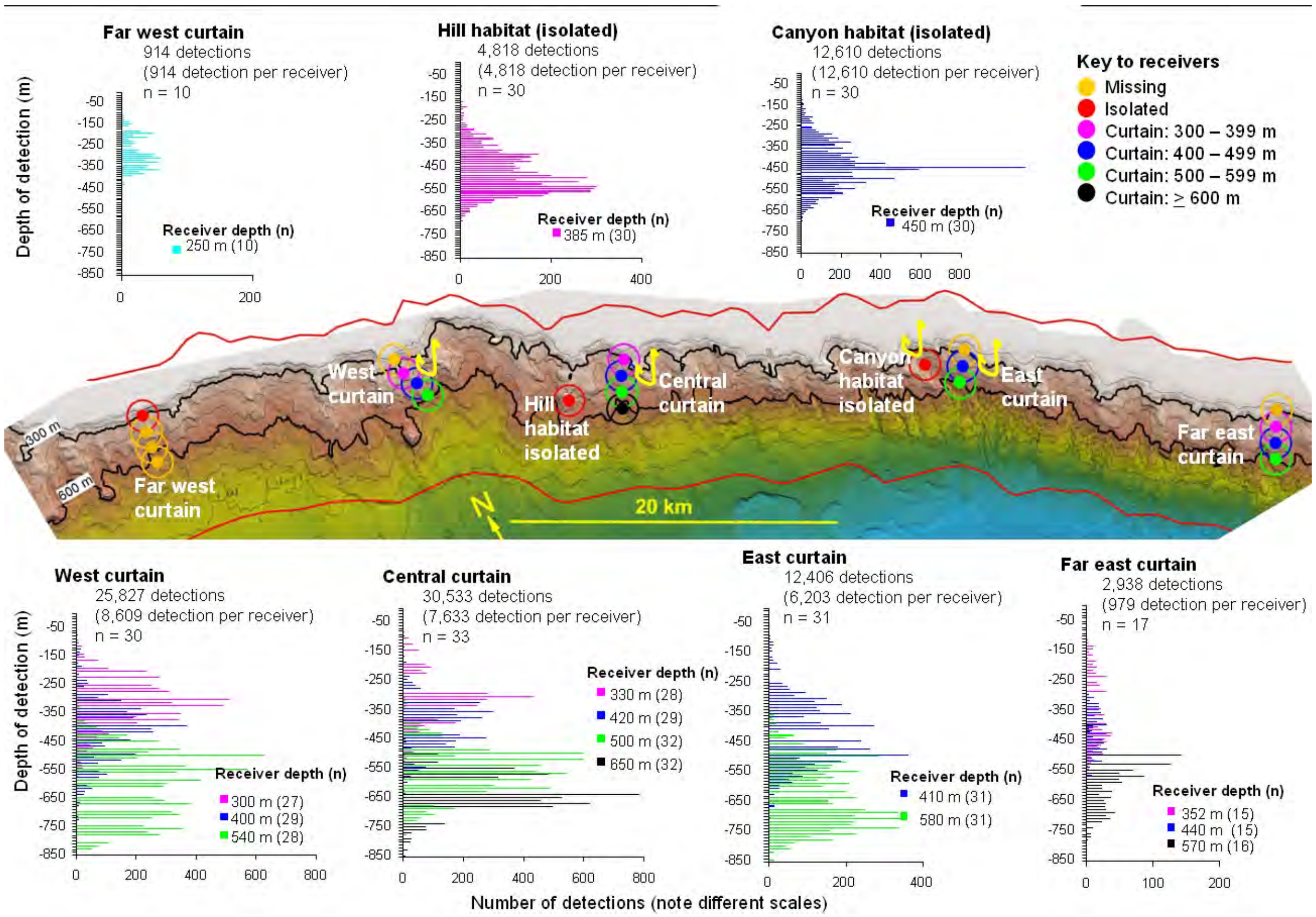

Figure 7.5 Central: map of the acoustic receiver array showing estimated detection range of each receiver (circles) and tag-release locations – fish hook symbols; ‘missing’ receivers indicate the locations where receivers had been deployed but not recovered; red line: closure boundary. Surrounding graphs show the number of detections by depth for each of the recovered receivers in the five curtains and at the ‘habitats’.

Survivorship

Of the 70 acoustic tagged sharks released most survived: 59 sharks were detected at least 27 times and by at least two receivers. Two sharks died during the experiment; the first in November 2009, and the second in April 2010. Eight tags were never detected. These sharks could have died or the tags failed. It is also possible (but less likely) the sharks may have survived but been resident between curtains with very small individual home ranges that do not extend to any of the curtains. Three other specimens were detected only once, on the release date. These 11 sharks were excluded from the analyses.

All 59 tags that were detected repeatedly (including the two that later died) showed changes in both depth and temperature indicating they represented sharks that were alive and moving (active). All temperature transmissions were < 16º C, indicating none of the active tags were inside endothermic (warm blooded) predators, thus we concluded that all the collected movement data represented the tagged Southern Dogfish.

Most (52/59) sharks were detected repeatedly in both the S09 and 09/10 deployments; average number of detections 2,224 ± 2,738 (range 27–17,495) by an average of 7.44 ± 3.58 receivers (range 2–15). These individuals were the focus of subsequent analyses. Five sharks, including one of the sharks that died, were only detected in the S09 deployment; these animals were excluded from further analyses.

The number of mortalities during the experiment was at least two (dead sharks) and possibly as high as 13 (dead + not detected + sharks only detected once), resulting in a range of 3–19% release mortality under controlled conditions subject to some uncertainty. However mortality rates under normal commercial conditions are likely to be higher because the safe handling of gulper sharks competes for time with processing commercial species. This is discussed further below (see Section 7.2.2).

Depth range and bathymetric range

The minimum recorded depth was 20 m and the deepest was 908 m (Table 7.1). This depth range is wider than expected. As the first four months of data were excluded from this analysis, shallow records cannot be attributed to release effects. Depth of detection was strongly correlated with depth of receiver and the standard deviations associated with depth of detection were ≤ 109 m (Figure 7.4 & Table 7.1). Thus, there were no significant differences between average detection depths and receiver depths, suggesting movement in the water column is mostly limited to within ~109 m of the bottom. However, at both of the habitat receivers and all but one of the curtains (far-east), detections within 100 m of the surface were recorded. As the 100 m contour is more than 50 NM away from the shallowest receivers and thus well outside their detection range, we conclude that some movement into the water column must have occurred.

At every recovered receiver, detections were recorded at least 90 m shallower than the bathymetric extent of the detection range predicted by range testing. Similarly at every recovered receiver apart from one, the maximum depth recorded was deeper than the maximum predicted by range testing. These deeper detections at least suggest that the detection range is larger than predicted and that further range testing is necessary.

The unexpectedly wide bathymetric range of Southern Dogfish has some implications for management. We recorded sharks at 908 m depth thus increasing the reported depth by 208 m. In areas where fishery closures are bounded at 700 m depth Southern Dogfish may move beyond this boundary, resulting in some exposure to fishing. At the shallower extent of the bathymetric range this risk is more difficult to evaluate as our receiver array did not cover bottom depths shallower than 250 m. We recorded sharks as shallow as 20 m but these animals must have been in the water column. The extent of such additional exposure will also vary with season, at least at southern latitudes. This is discussed further below (see Section 7.2.2).

Table 7.1 Correlation between depth of detection (*yellow shading*) and bathymetric range of receivers (*blue shading*). Minimum and maximum bathymetric (bottom) depths within range of the receiver determined from range testing (Appendix C, Figure 7.4); *difference = receiver depth - average detection depth.

Curtain	Depth receiver	Min.bath. depth.	Max.bath. depth.	Number of detections	Min depth detected	Max depth detected	Average detection depth	stdev	Difference*
Far-west	250	160	400	829	70	500	282	74	32
									0
West	300	250	500	7,744	54	619	311	78	11
West	400	300	580	5,516	70	760	412	100	12
West	540	420	720	12,611	91	896	604	109	64
									0
Hill habitat	385	480	620	4,733	54	735	480	91	95
									0
Central	330	160	450	5,563	41	590	301	78	-29
Central	420	220	500	5,366	50	710	400	83	-20
Central	500	400	600	9,573	66	834	553	80	53
Central	650	550	720	10,031	180	846	631	64	-19
									0
Canyon	450	300	550	12,525	50	731	441	84	-9
									0
East	410	300	600	5,396	20	760	421	104	11
East	580	450	820	7,022	210	908	625	106	45
									0
Far-east	352	300	550	507	200	632	434	80	82
Far-east	440	450	600	833	120	566	350	97	-90
Far-east	570	500	800	1,598	339	817	558	79	-12
Overall									11 ± 41

Along slope scale of home range

When the number of detections was standardised for number of receivers recovered, individual sharks were 5–14 times more likely to be detected near the centre of the array (west central and east curtains) than at the extremities (far-west and far-east curtains, Figures 6.2 and 7.5). Of the 52 sharks active in the 09/10 data, only 6 were detected at the far-west curtain and only 16 were detected at the far-east. Only one shark was detected at both the far-east and far-west curtains. These 21 sharks (40.4% of the total) are likely to have spent some time outside the study area but most (31/52) appear to be entirely resident.

Most sharks (38/52) were caught at multiple curtains (Figure 7.6). This indicates that for most individuals in the population, home range is greater than the typical distance between two curtains (c.a. 10 NM). A minority of 14 individuals were only detected at one curtain. Two of these of these were only detected at outer curtains and must have swum past one of the curtains near the release point undetected. Therefore it is assumed that 40/52 sharks swam past at least two curtains.

Eight of eleven active females (72%) were detected by at least two curtains. Most of these detections were near the centre of the array. Only one active female was detected at the far-west curtain and none were detected at the far-east curtain.

The number of sharks detected at the three central curtains was not correlated with the number of sharks released there. The number of sharks detected at the west, central, canyon and east locations were remarkably consistent: 30, 33, 30 and 31, respectively, whereas the number of sharks released at these locations varied significantly: 5, 6, 11, 39. This lack of correlation indicates the number of sharks detected at each curtain is independent of the number of sharks released there.

Although not formally part of this project, more than 1,300 conventional tags were opportunistically fitted to gulper sharks [Appendix E4, E5, E8 & E9]. The recapture rate has been low, with only 1% of individuals recaptured after up to 3 years at liberty (Table 7.2). Tagged sharks at liberty for more than one year moved further than sharks at liberty for shorter periods, although this relationship was not statistically significant (Figure 7.7). The data provide evidence that at least some Southern Dogfish are leaving the existing closures (Figures 7.8, 7.9, 7.10). The proportion of tagged Southern Dogfish captured leaving the smaller Port McDonnell closure (2.5%) was higher than the proportion leaving the larger GAB closure (1%) but again this difference was not statistically significant (Table 7.2). These comparisons highlight the limited statistical power of conventional tagging.

Diurnal and seasonal variation in temperature and depth

Individual gulper sharks showed distinct diurnal patterns moving towards the shallows at around 6 PM and descending at around 6 AM (Figure 7.11). During summer, when the night is shorter, sharks spent fewer hours in shallower waters, ascending later and descending earlier, compared to autumn and winter. Overall the average temperature range was narrow and remarkably consistent ranging from 9° C at night to 13° C during the day (Figure 7.12). During summer sharks encountered lower temperatures on average because they spent more time in deeper, cooler waters.

The practical implications of these diurnal and seasonal patterns for management are that Southern Dogfish will be more vulnerable to capture outside the closure in shallower waters at night, particularly during winter when nights are longer. In deeper waters outside the closure, vulnerability will be higher during the day, particularly in summer when, on average, decents are deeper.

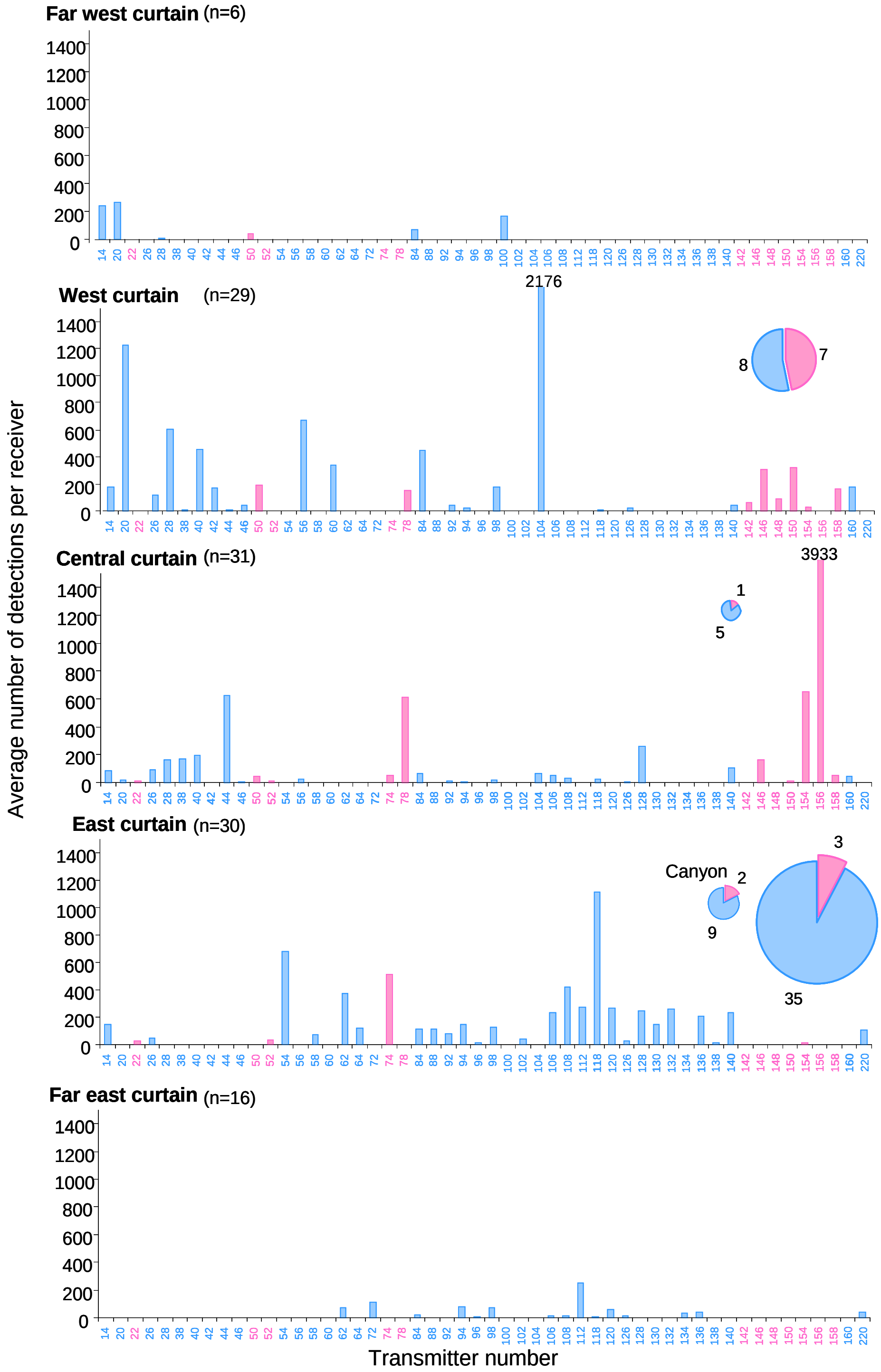

Figure 7.6 Number of detections per individual at each curtain, standardised for number of receivers recovered*:* detections: female – pink bar, male – blue bar. Pie-charts showing numbers and the ratio of female (pink) and male (blue) Southern Dogfish tagged and released at the central three curtains and at the Canyon habitat near the east curtain *(Transmitter 104 was detected 2176 times at the west curtain. Transmitter 156 was detected 3933 times at the central curtain).*

Table 7.2 Summary of the conventionally tagged gulper sharks.

Species	Tagged	Recaptured	Average days at liberty	Min–Max days at liberty	Average distance (Nautical miles)	Min–Max distance	Insights provided
Southern Dogfish	868*	10	390	213–653	34.6	2–98	No strong pattern of increasing distance with time. Even after nearly 2 years the greatest net distance travelled is less than 100 miles, most remain within 60 miles of capture/release location (Figure 7.7). Of the 597 sharks tagged within the GAB closures, 4 sharks (<1%) were recaptured by commercial fishers within 20 miles of the closure ends (Figure 7.8). Of the 200 sharks tagged at the Port MacDonnell site, 5 (2.5%) were recaptured by commercial fishers within 70 miles of the release point (Figure 7.9). The single shark recaptured on the east coast moved the furthest distance from east of Sydney to east of Ulladulla in 653 days (Figure 7.10).
Harrisson's Dogfish	309	1		83		0.2	This juvenile was recaptured East of Flinders Island near the release point after nearly 3 months of liberty.
Endeavour Dogfish	187	2	382	348–416	2.1	0.5–3.7	Over a period of ~1 year both these sharks were recaptured east of Coffs Harbour within just a few miles of capture/release location.
*597 (GAB closure), 200 (Port MacDonnell), 64 (East Coast), 7 (Bass Strait)							

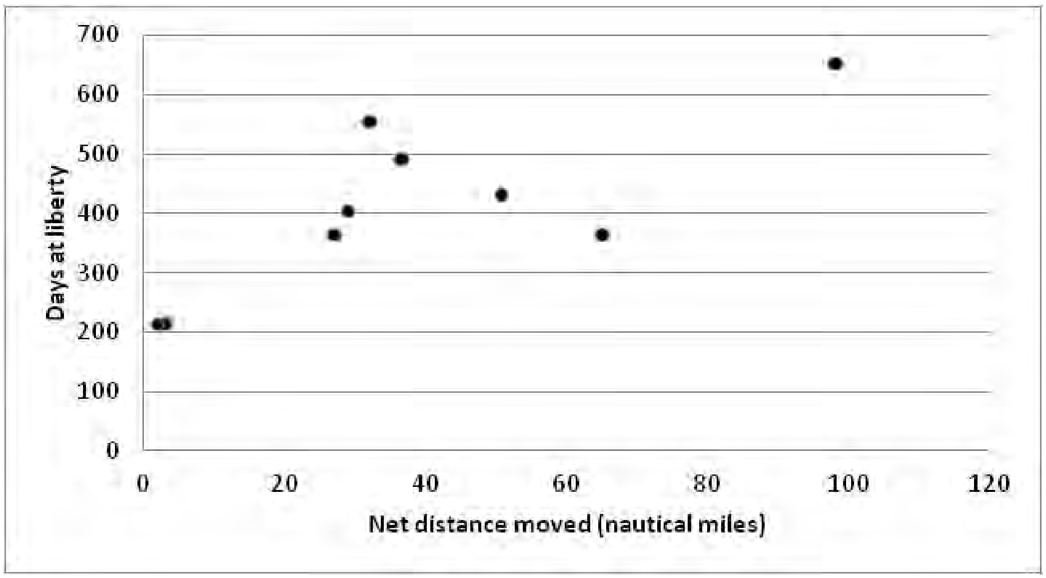

Figure 7.7 Time at liberty vs distance moved for recaptured conventionally tagged Southern Dogfish (*C. zeehaani*).

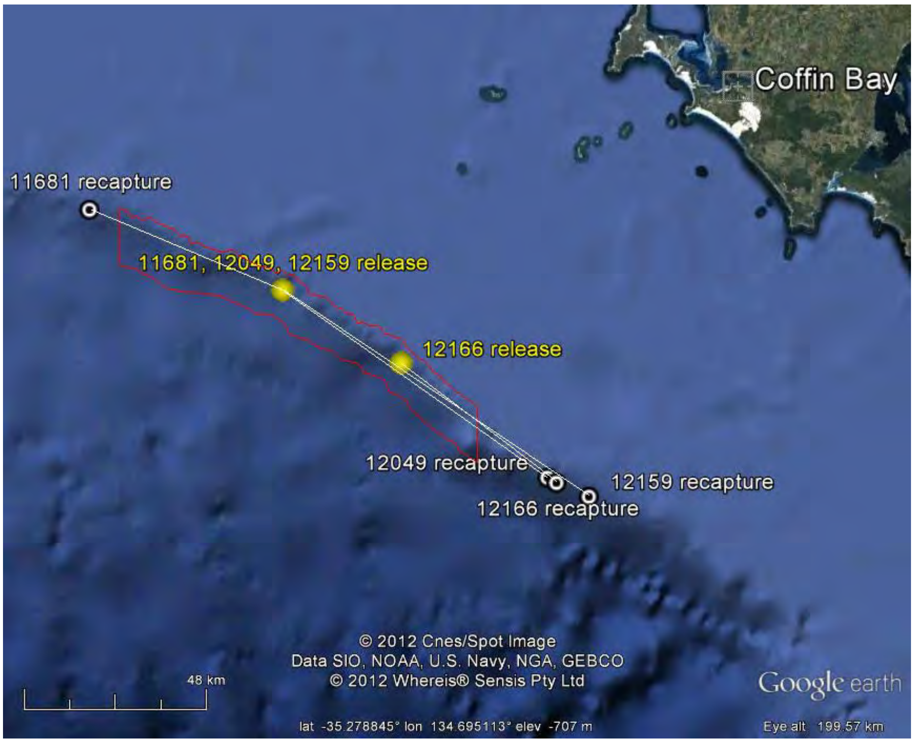

Figure 7.8 Net movement of conventionally tagged Southern Dogfish (*C. zeehaani*) released in the GAB closure. These four sharks were all recaptured by commercial fishing vessels. GAB closure is indicated as red polygon.

Figure 7.9 Net movement of conventionally tagged Southern Dogfish (*C. zeehaani*) released off Port MacDonnell (South Australia). These four sharks were all recaptured by commercial fishing vessels. Closure is indicated as red polygon.

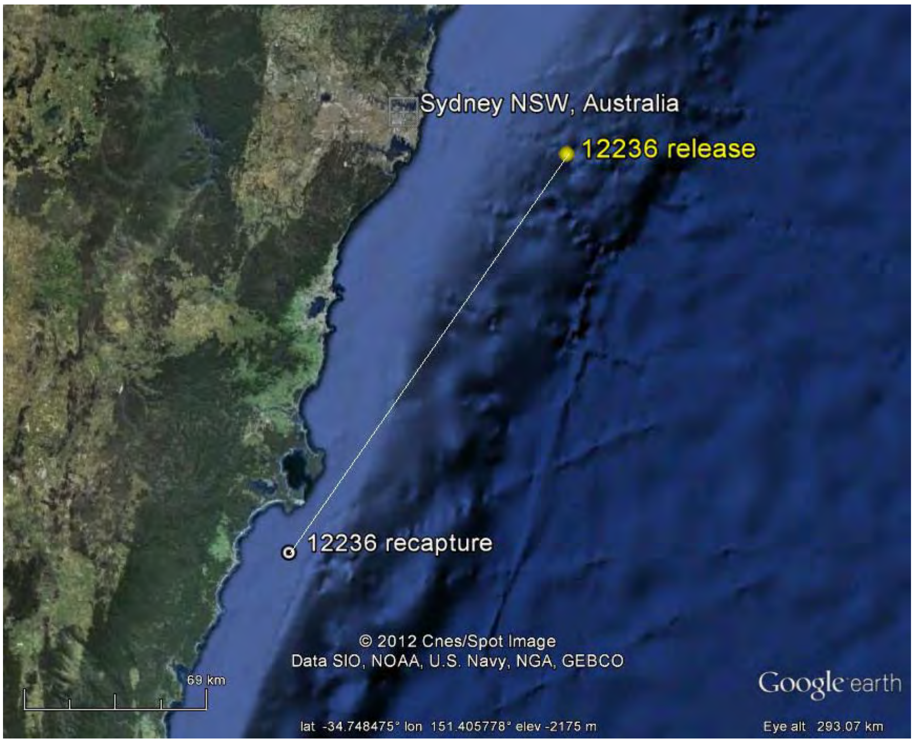

Figure 7.10 Net movement of a conventionally tagged Southern Dogfish (*C. zeehaani*) released east of Sydney (Browns Mountain) and recaptured east of Ulludulla. This shark was recaptured by a commercial fishing vessel.

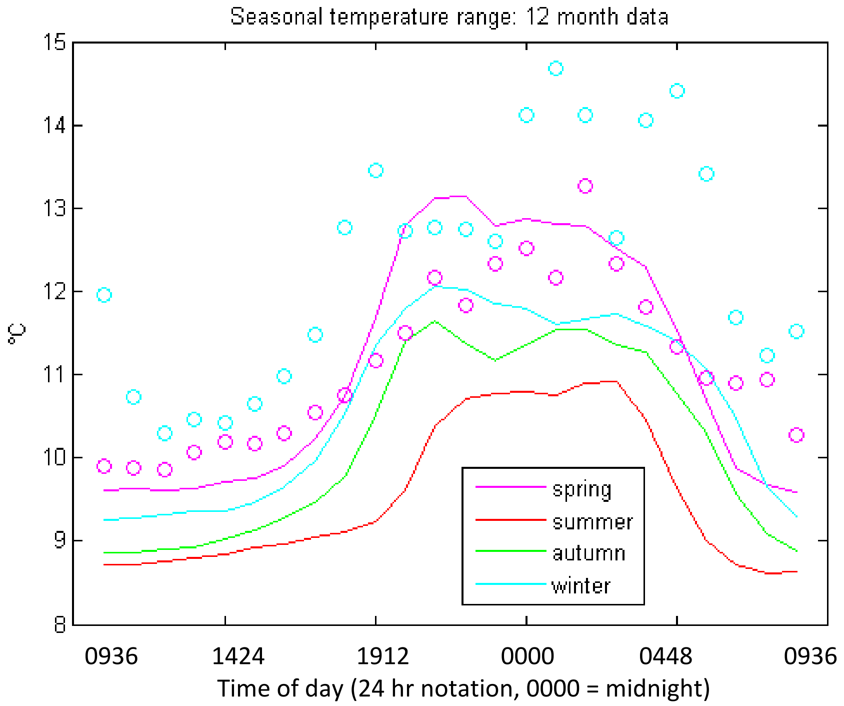

Figure 7.11 Seasonal differences in diurnal temperature patterns expressed over 24 hour period. Seasonal averages based on active sharks. Lines represent 09/10 data (n = 52), circles represent S09 data (n = 59).

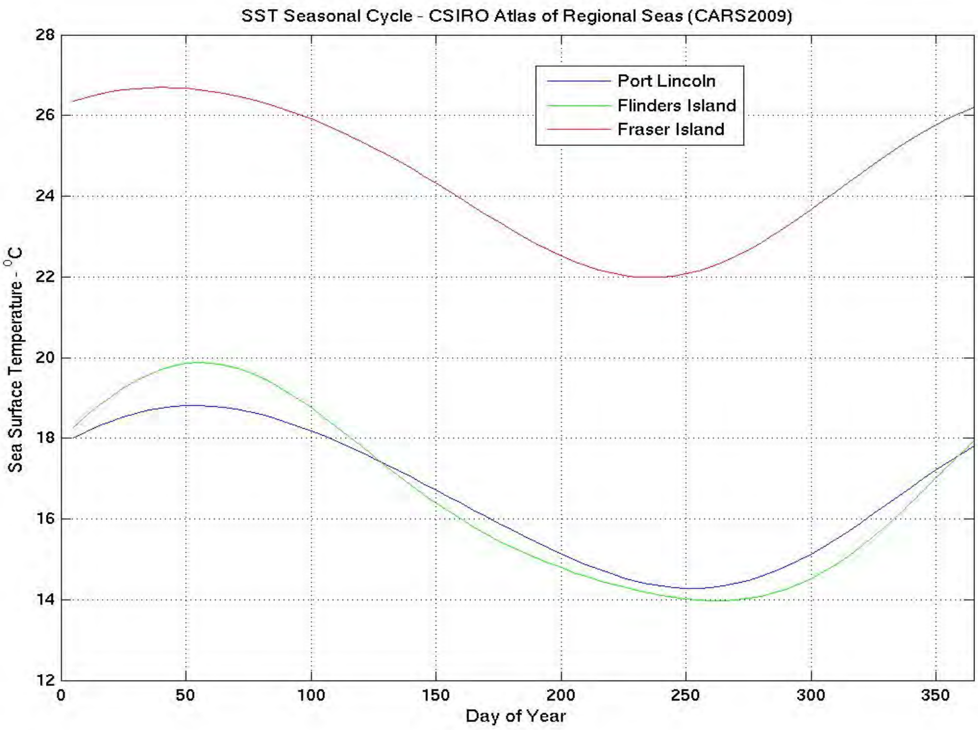

Figure 7.12 Sea Surface Temperature at three locations with gulper shark populations.

7.2.2 Discussion

Survivorship

The stress these sharks suffer due to the effects of pressure change during capture was clearly evident during the study. When catch rates were high, some individuals were placed temporarily in an aquarium where they floated upside down until they could be tagged. The observed behaviour suggests these individuals struggled to right themselves because they were excessively positively buoyant. The liver of deep-sea sharks is a major organ (18% of bodyweight in Southern Dogfish) that has a multi-functional role including buoyancy and energy storage (Pethybridge *et. al*. 2010) The composition of the liver varies between deepsea shark species linked to differences in ecology and habitat (Pethybridge *et al.,* 2010). In Australian gulper shark species the liver oil contains up to 82% squalene, a hydrocarbon that is a solid when compressed at depth, but expands to form a liquid at the surface (Phlegar, 1998; Pethybridge *et al*., 2010; Phlegar personal communication 2011, California State University). This expansion results in positive buoyancy in the liver at the surface. It seems likely that some of the dead and not detected sharks failed to overcome positive buoyancy and died before reaching the sea floor, although this remains uncertain.

Temperature shock is also likely to contribute to mortality. During the study this effect was minimised by tagging during winter in temperate regions and by avoiding the heat of the day. However, commercial operations are carried out under a range of conditions. Data from the CSIRO Atlas of Regional Seas (CARS) were used to explore the potential effects of temperature shock under a range of conditions (Figure 7.12). The average sea surface temperature in shelf waters off Port Lincoln in winter is around 14 degrees, which does not exceed the normal temperatures experienced by active gulper sharks (Figure 7.11). Similarly gulper sharks captured at Flinders Island (TAS) would not experience high temperatures if captured during winter. However gulper sharks in shelf regions off Port Lincoln and Flinders Island would experience temperatures outside their normal preferred range if captured at other times of the year. Similarly, gulper sharks from shelf waters off Fraser Island (QLD) would experience high temperatures well in excess of those preferred if captured at any time of the year.

These considerations are important for improving handling practices on commercial vessels. Any steps that can be taken to reduce the time taken to release sharks are likely to reduce the effects of pressure and temperature shock.

Depth range and bathymetric range

The observed minimum (20 m) and maximum (908 m) depths were both well outside the range of 210–700 recorded in the literature (Last and Stevens 2010). These results highlight the potential of acoustic telemetry to provide more detailed distributional information which is currently limited, hampering our ability to assess exposure risk due to fisheries for many vulnerable non target species (Daley *et al.*, 2007).

Along slope scale of home range

A key consideration for management is the appropriate geographic scale of the closure, which off the south coast of Australia is mainly constrained by longitudinal width. A fraction of the sharks acoustically tagged (23%) were only detected at one curtain suggesting their home range was less than 19 NM wide. Similarly a small number of conventionally tagged sharks were recaptured out of the closed area. Of these recaptured sharks 2/9 moved greater than 60 miles (Figure 7.7). This indicates that extending the closure along the slope would have additional positive benefits for ~20% of Southern Dogfish resident in the GAB closure.

Appropriate scale is sensitive to the precise nature of the management objective. If the management goal were to protect 75% of breeding females, then the appropriate along slope scale would be 30–40 miles (across three curtains), in areas where breeding females have been observed. It is only possible to attempt such precise estimates of suitable scale with detailed movement data collected from the area to be managed. Some qualitative predictions can be made about the distribution of other species of gulper sharks in other areas, but it is important to note that key factors affecting distribution are likely to vary between regions and species. On the east coast of Australia, extent of range and habitat is constrained by latitude, not longitude. Where a greater latitudinal range is available, sharks may undertake seasonal migrations to moderate the effects of environmental temperature.

To date there have been only three recaptures of gulper sharks off New South Wales: two Endeavour Dogfish released east of Coffs Harbour that were recaptured less than four miles from their release point after one year (one moving across the slope) and one Southern Dogfish released east of Sydney that was recaptured 98 miles south (off Ulludulla) after 653 days. However, these measurements need to be considered as indicators of the minimum scale of home range because conventional tagging often provides under-estimates. For example Southern Bluefin Tuna are consistently tagged and recaptured off Port Lincoln but telemetry data indicates they cross the Indian Ocean and return to the GAB between captures.

Diurnal and seasonal variation in temperature and depth

The observed seasonal variation in diurnal behaviour has not previously been recorded for gulper sharks. It is important to consider the extent that these results may or may not be applicable to other species or the same species in other areas before making prediction based on this study.

It is also important to consider possible regional differences on our ability to predict seasonal movements along the slope. On the south coast, along slope movement provides only small changes in latitude and therefore little scope to seek out higher temperatures during winter by migrating north. By contrast on the eastern seaboard along slope movements will be directly proportional to latitude. Market data provide some evidence that seasonal movements may be occurring for gulper shark species off northern NSW but this has not been attributed to a particular species (Daley *et al.*, 2002).

The pineal window (an area of skin above the brain on the dorsal surface of the snout) is remarkably un-pigmented in live Southern Dogfish. The pineal organ lies below this area. This organ is known to have a key role in day/night and seasonal rhythms of humans (Macchi and Bruce, 2004; Arendt and Skene 2005). Gruber *et al.*, (1975) demonstrated the pineal window in Lemon Sharks (*Negaprion brevirostris*) allows ambient light to filter through the skin and skull to stimulate the pineal organ directly. This organ is not as visible in other species of deepwater sharks but it is interesting to speculate as to how important changing light levels are for other deepwater sharks and other predators. The diet of Southern Dogfish is known to contain myctophids, a key food source representing millions of tonnes in the upper slope environment where vertically migrating prey are acutely attuned to changing light levels.

Conclusions

The across slope home range of Southern Dogfish in the GAB extends from at least the shelf edge down to the 900 m depth contour. Water column range extends to the surface, although vertical movements are infrequent. At time scales exceeding one year the along slope range of individuals including mature breeding females in the GAB closure is generally less than the width of the existing closure. The frequency of detections near the eastern and western margins of the closures is eight times lower than near the centre, indicating the edge effects of fishing to the east and west of the closure will be low. This is supported by low catch of conventionally tagged gulper sharks at the eastern and western ends. However, Southern Dogfish move towards the shallow and deeper margins of the closure on a daily basis. It is along these margins, which are 30 times longer than the eastern and western margins, where potential edge effects are greatest. These effects can be further evaluated by continued monitoring of fishing effort along the shallow margin in particular and by the development of individual based predictive models based on existing telemetry data that take into account alternative scenarios of fishing effort. Existing deepwater closures are likely to protect Southern Dogfish outside but near the deeper margin. Overall, the existing closure is likely to be effective for Southern Dogfish on the South Coast of Australia. The extent that these findings can be applied to Harrisson's Dogfish is constrained by two key uncertainties. Firstly there are no telemetry data for Harrisson's Dogfish to establish the daily movement patterns and secondly on the east coast, along slope range aligns with latitude therefore there is greater scope for seasonal movements along the slope to regulate body temperature. These uncertainties could be reduced by further telemetry studies of Harrisson's Dogfish off eastern Bass Strait.

7.3 Develop non-lethal methods for long term monitoring of gulper shark populations

This Section addresses Objective 3: *Develop non-lethal methods for long term monitoring of gulper shark populations.*

Long term monitoring of gulper shark populations is needed to assess the health of protected gulper shark populations, and evaluate performance of AFMA's management strategy for upper slope dogfish (the USDMS). Several fishery closures have been implemented to protect different species in different parts of their distributions.

7.3.1 Results and Discussion

Surveys

Three surveys testing the efficacy of BRUVS were completed – on the east coast during the 2009 *Diana* survey, off Western Australia in the Perth Canyon, and in the GAB 60 mile closure (see Table 7.3 and for full reports Appendices E4 & E7 and Williams, 2008]).

Table 7.3 A Table showing surveys that included BRUVS deployments as part of the projects evaluation of non-lethal long term monitoring methods. The number of deployments where gulpers were recorded is also shown.

Survey	Vessel	Sampling	Deployments	Number of deployments observing gulper sharks
East Coast gulper shark survey	FV *Diana*	Brisbane to Hobart 22 sites (300–600 m)	94	9
Perth Canyon	RV *Naturaliste*	Depth stratum, south eastern corner of canyon	66	10
CSIRO gulper shark pilot study survey	MNF *Southern Surveyor*	Depths (300–600 m), GAB 60 mile closure	35	3

Preliminary summary

Gulper sharks were recorded by the BRUVS on all three surveys, confirming the ability of the BRUVS method to detect all species of interest *in situ*. Four species were identified from the BRUVS footage: Endeavour Dogfish (*C. moluccensis*, east coast and Perth Canyon), Harrisson's Dogfish (*C. Harrissoni*, east coast), Southern Dogfish (*C. zeehaani*, GAB) and Western Gulper Shark (*C. westraliensis*, Perth

Canyon). BRUVS were deployed in conjunction with longline sets at 23 sites on the east coast survey to compare abundance estimates reached with either method. Initial summaries of these data indicate that, at several sites, BRUVS observed sharks where catch rates were highest – in particular at 31 Canyon and Byron Bank (Table 7.4).

Table 7.4 Summary of the number of gulper sharks caught by hook and line and the number of individuals (maximum & minimum) observed in BRUVS footage at each of the 23 sites on the 2009 east coast survey onboard the *FV Diana*.

Site	Total number caught by hook	max. BRUVS observations	min. BRUVS observation	Hooks set	BRUVS deployments
Border Bank	1			4500	4
Byron Bank	70	4	1	4500	4
South of Byron	64			4750	4
30 Canyon	21			3000	4
Coffs	99			4500	4
31 Canyon	144	15	2	4500	2
Port Macquarie	3			4500	0
Port Stevens	83			3308	2
Taupo Seamount	12			4993	10
Five Canyon	45	4	3	4500	8
North of Sydney closure	6			4500	4
Browns Mountain	100			4500	4
Ayres Rock	1	2	1	4500	4
Longnose Canyon	10			4500	4
Tuross Canyon	12			4500	4
Cape Howe	20			4500	4
Gipps MPA	2			4500	4
Everaad Canyon	2			4500	4
Seiners Canyon				4500	4
North Flinders	70	2	1	4500	4
Cape Barren	9	2	1	4500	4
Flinders MPA	6			4500	4
Freycinet MPA				4500	4
Totals	780	24	9	88051	94

Design, fabrication and testing of DeepBRUVS

To meet the need for a non-lethal long term monitoring method we recognized that the BRUVS as used for the surveys had limitations, i.e. it was only suitable for short-term deployments. With input from research scientists, electronics and design engineers, the DeepBRUVS concept was designed and subsequently fabricated in the CSIRO mechanical workshop facility [Marouchos *et al.*, 2011, see Appendix H] using CSIRO Capital Expenditure (CAPEX) funding. The DeepBRUVS has been designed to enable long term deployments (months) in gulper shark depths (up to 1000 m), with lighting and recording of up to 24 hours of high-definition HD video from calibrated stereo cameras, in pre-programmed intervals. DeepBRUVS has a bait dispensing mechanism to dispense a bait plume at pre-programmed times in synchrony with lighting and video recording. The DeepBRUVS uses the same acoustic release units that were used for acoustic moorings [Appendix D], so that weights are jettisoned on demand and the device floats to the surface for retrieval. This alleviates the need for long ropes to the surface and surface floats that are problematical for deployments in deepwater and strong currents. The DeepBRUVS platform is designed to accommodate additional sensors (e.g. CTD, current meter) for the collection of environmental data during deployments. It will be important to measure current strength to calibrate the effects of bait plume dispersal on observation rates.

A suitable and effective bait for use in the DeepBRUVS needs to attract fish with a plume resulting from a small volume and it needs to be stable (i.e. not degrade during deployments of weeks/months). It must also be of a suitable consistency to be dispensed via a motorized plunger in a cylinder (syringe like) which pushes the bait through a tube (bait boom) to release it in front of the cameras.

Some bait types (pellets, whole fish) were ruled-out as they would not dispense through the mechanism we had designed. Minced fish would spoil and the consistency would be difficult to maintain. Because the bait needs to be consistent between deployments, having a standard bait type is essential. Laboratory testing of fish oil showed it to be very buoyant and therefore unsuitable as it would quickly float away from the depth of interest. A fish meal product used in pelletized fish food for the aquaculture industry was sourced from Skretting Pty Ltd (an aquaculture fish-food manufacturing company). The fish meal is an anchovy product imported from South America. Initially this meal was mixed with fish oil for laboratory testing but the subsequent mix was too buoyant. The fish meal product was then mixed with water into a slurry consistency. This fish meal/salt water mix was tested in an aquarium at the Education Dept. Marine Studies Centre at Woodbridge, where we confirmed that fish were attracted to it, e.g. striped trumpeter rapidly gathered at the souce.

A field trial of the DeepBRUVS during April 2011 was completed over two days in Storm Bay, Tasmania. The testing was performed in 50 metres water depth and allowed for full system testing at sea. [Appendix E12]. It also allowed for the first *in-situ* testing of the fish-meal bait. During the field trial we noted that there was settling of the fish-meal particulates, exacerbated by the deck vibrations from the vessel's machinery making a portion of the mix into a thick and gritty paste which created excess friction in the bait cylinder and made it unworkable. We added more seawater to the mix and used the liquid portion of the mix (after the particulates settled) as the attractant. This fish-meal seawater solution was able to be dispensed and was observed on video at 50 m water depth to form a plume that hung in the water in front of the camera until it dispersed with the current. During the overnight deployment we observed a shark (*Squalus* sp.) and demersal fishes indicating the effectiveness of the bait solution to attract fish. A Motion Reference Unit (MRU) was added to the DeepBRUVS for these deployments and provided ascent and descent rates and pitch roll data during free-fall and ascent. The resultant data met specifications. We varied the payload of sacrificial weights to determine how the descent rate was affected. Once the weights were jettisoned, the positive buoyancy returned the unit to surface. Deployments and retrieval were achieved easily and safely using the vessel's articulated hydraulic lifting arm in calm sea conditions.

The field trials were successful in thoroughly testing the functionality of all components. Small modifications were noted that will enhance the operation of the DeepBRUVS. Several hours of collected video using various settings on cameras and lights, plus the programming of the recording bursts, provide useful feedback on the system's performance. The performance of the DeepBRUVS during field testing met expectations in all respects.

Key findings

Field surveys confirmed the ability of photographic methods to detect gulper sharks in their natural environment at ~300–600 m depths. Development of the new

DeepBRUVS survey tool (Marouchos *et al.*, 2011) provides the potential to collect quantitative, non-extractive and cost effective monitoring data on the status of gulper shark populations. Further work is required (1) to establish whether photographic summaries of species abundance, size structure and sex ratio can be calibrated to the same metrics measured by hook-and-line catch data, and (2) whether the tool will provide the means to robustly and cost-effectively monitor gulper shark populations.

7.4 Provide research to underpin the development of management responses

This Section deals with objective 4: *Provide early results (that integrate field results with existing knowledge) for evaluation by the EPBC listing (TSSC) process, and for an overarching implementation strategy to underpin the development of management responses*.

7.4.1 Results and Discussion

A key objective for the project was to provide timely scientific advice for evaluation by the EPBC listing (TSSC) process, and for the development of AFMA's overarching management response and implementation the Upper Slope Dogfish Management Strategy (USDMS). The heavy reliance on field data, and the need to integrate field results with existing knowledge, was a substantial challenge within the two year timeframe of the project.

Ultimately, six successful field surveys [Appendix E] provided data on the east and south coast distributions of gulper shark species and movement data on Southern Dogfish to inform the management processes. Distributional mapping was given strong support by operators in the trawl, auto-longline and minor line fisheries from the SESSF, northern NSW and southern Queensland, including by providing sea-going opportunities on their commercial vessels.

Early results, especially on gulper shark distribution, supported the Stage 1 implementation of AFMA's USDMS and the advice provided to the listing process. Project data supported CSIRO's (confidential) submission to the TSSC (see list of papers below). Subsequently, 36 candidate areas for protecting gulper sharks across temperate Australia were identified, including some that were proposed by the fishing industry. These were reviewed using survey data and short-listed to approximately six suitable and high priority options for area closures (Williams *et al.*, 2010; see Appendix F). Data from the acoustic tracking experiment in the GAB 60 mile closure were used in conjunction with the 'options' paper in a more detailed evaluation of specific options for each prospective individual area closure, and an closure network (Daley *et al.*, 2010; see Appendix G). The detailed evaluation used criteria based on Threatened Species Listing guidelines from the EPBC Act in a Management Strategy Evaluation format.

The closed area 'options' papers [Appendix F & G] were provided to all stakeholders and presented formally by the project team at SEMAC in September 2010. The rationale and options presented enabled a consensus view across stakeholders to be achieved, and underpinned the design of fishery closures for the Stage 2 implementation of the USDMS. Subsequently, the project has provided detailed mapping for the formal closure notifications, including input to arrangements for the Flinders Research Zone closure.

The project has also provided a detailed proposal for a long term monitoring strategy. This is needed to help gain Wildlife Trade Order (WTO) approval for the SESSF, and to address the Threatened Species Scientific Committee's (TSSC) advice that 'Conservation Dependent' listing of gulper sharks, depends in part, on the establishment of a monitoring program.

Communication and extension plan

The objectives of the communication and extension plans for this project were to inform conservation measures and updated management arrangements, and to maintain regular contact with stakeholders. Much of the project's communication has been through teleconferences with multiple stakeholders, and numerous telephone and email interactions with individual AFMA staff and industry members. These included, most recently (May 2011), a teleconference with AFMA, ABARES, DSEWPaC and an international independent science reviewer of the USDMS. We believe that communication has been effective at all levels from deckhands on the deck of fishing boats during field surveys (e.g. tag reporting), through to senior management levels (e.g. AFMA Commission, TSSC).

Here we list the key face-to-face meetings, and the project's written documents, as evidence of active, inclusive and effective communication by the project team:

Key face-to-face meetings:

- August 2009: presentation of CSIRO gulper shark pilot study (Williams, 2008) and FRDC project plans at AFMA's first meeting to discuss the draft Management Strategy for upper-slope dogfish in Melbourne (Alan Williams, Ian Knuckey)

- October 2009: reported results of survey to the Slope Research Assessment Group (SlopeRAG) in Hobart (Ross Daley)

- November 2009: presentation of scientific results on tagging and movement to the IMOS AATAMS acoustic telemetry workshop in Sydney (Alan Williams, Ross Daley)

- June 2010: presentation of project results to SETFIA in Melbourne (Alan Williams)

- June 2010: meetings with SESSF trawl and autoline industry members in Lakes Entrance to identify candidate areas for gulper closures (Alan Williams, Ross Daley)

- June 2010: meeting with SESSF trawl and autoline industry members in Hobart to identify candidate areas for gulper closures (Alan Williams, Ross Daley)

- June 2010: meetings with SESSF trawl and autoline industry members in Melbourne to identify candidate areas for gulper closures (Alan Williams, Ross Daley, Ian Knuckey)

- June 2010: presentation of project results to NSW/ Queensland minor-line industry representatives in Mooloolaba with respect to management options for remote seamounts (Alan Williams)

- June 2010: presentation of project results to AFMA and industry representatives in Canberra (Alan Williams, Ross Daley)

- August 2010: Meeting with NSW Fisheries regarding complementary State arrangements; 2-day workshop in Melbourne: development and evaluation of spatial management options

- September 2010: Presentation of results on gulper shark home range and movement to Offshore Trawl and Line Fisheries (OTLF) in Sydney (Ross Daley)

- September 2010: Presentation of management options at SEMAC, Canberra (Alan Williams, Ross Daley, Ian Knuckey)

- November 2010: presentation of issues and option for development of monitoring arrangements for gulper sharks to SlopeRAG in Hobart (Alan Williams, Ross Daley)

- December 2010: Presentation of results on gulper shark home range and movement to Ocean Trawl operators at Coffs Harbour (Ross Daley)

Key written documents:

1. A detailed submission to the TSSC, "Review of information relevant to the conservation of three Australian gulper shark species (Centrophoridae: *Centrophorus*): Harrisson's Dogfish, Southern Dogfish and Endeavour Dogfish" (confidential)

2. The 'closure options' discussion paper (Williams *et al.*, 2010 see Appendix F)

3. The 'individual area closures and closure network evaluation' discussion paper (Daley *et al.*, 2010 see Appendix G)

4. Detailed mapping for the formal closure notifications, including input to arrangements for the Flinders Research Zone closure

5. A formal response to the independent review of the USDMS and supporting science

6. A detailed proposal for a long term monitoring strategy

7.5 Collect data for other upper continental slope squalid sharks

7.5.1 Results and Discussion

This section addresses the Special Condition of the project: Collect and summarise data on distribution, size frequencies and sex ratios for Greeneye Spurdog *(Squalus chloroculus,)* and other dogfishes (Squalidae) from the upper continental slope.

Data on distribution, size structure, and sex ratios were collected for all squalid sharks, including various species of greeneye spurdogs (*Squalus* spp), on many of the voyages during the study. These data are described in the voyage reports and data for squalid on the upper slope are summarised below (Table 7.5). A total of 56 gummy sharks were collected for Jessica Boomer (a PhD student at Macquarie University) who is investigating levels of genetic connectivity and stock structuring around southern Australia; this material covers a key area (NSW) for which there were previously few samples. The project also identified that pupping areas are over hard bottom and provided other new insights about preferred habitat for *Centrophorus* species.

Table 7.5 Summary of distribution, size structure and sex ratio data collected for various species of greeneye spurdogs (*Squalus* spp) from the upper continental slope. ND = No Data.

	S. albifrons			*S. grahami*			*S.montalbani*			*S. chloroculus*		
Vessel and locality	*n*	**% Catch rate**	**Sex ratio M:F**	*n*	**% Catch rate**	**Sex ratio M:F**	*n*	**% Catch rate**	**Sex ratio M:F**	*n*	**% Catch rate**	**Sex ratio M:F**
***Diana* 01-09**												
Border Bank - Coffs	153	0.73	4:1	806	3.84	2:1	195	0.93	2:1	0		
31 Canyon - Pt Stevens	354	4.54	6:1	322	4.13	1.5:1	112	1.44	2:1	0		
Taupo seamount	127*	2.54	3:1	0						0		
5 Canyon - Longnose	26	0.19	1:2	358	2.65	1:2	157	1.16	1:1	0		
Tuross - Seiners Canyons	0			2	0.01	1:0	1	0.00	1:0	0		
N Flinders - Freycinet MPA	0			0			0			0		
***Sarda* 01-09**												
GAB Closure	0			0			0			476	3.97	1:3
West of Port Mac (GAB)	0			0			0			25	0.36	ND
***Sarda* 02-10**												
Everard Smith Canyon	0			0			0			2	0.00	ND
Babel - Cape Barren	0			0			0			3	0.01	ND

7.6 Data management

Strategies to inform data capture activities, and to set up suitable data flows within the project were formulated from the outset in a Data Management Plan. The considerations required to implement good data management practices were followed in this project. In brief, these were: that information on the sources of the data are preserved; that versions of the dataset are clearly identified; the data are, when appropriate, discoverable and accessible for re-use; that appropriate security measures are in place to prevent access to confidential data; and that those intending to be users of the data can determine whether it is suitable for their purpose.

There were some pre-existing data management tools, already used within CMAR, and these were available to support this process.

7.6.1 Results and discussion

Metadata and data stores
MarLIN was used to create the data descriptions for the project. These records are published in the ASDD and can be exported as ISO 19115 compliant records as required in the FRDC Guidelines. The granularity chosen for the metadata records was mainly on the basis of each survey, to track provenance and time of the raw datasets. There is a parent record to provide an overview of the project and describe outputs. All project metadata available to the public are seen through the following link:
http://www.marine.csiro.au/marq/edd_search1.quicksearch?query=gloproj&value=29

Catch data from the project reside in the CMAR Data Warehouse, an Oracle 10 database from which data can be served through the Data Trawler or through OGC web services.

Still images from the project are stored in the CMAR Data Centre image archive.

The VEMCO VUE databases contain raw data downloaded from the listening stations. They are found on the Divisional file system, as are acoustic multi-beam (EM300) data, GIS products and spatial analyses.

The BRUVS video footage and analyses are archived and currently available to UWA collaborators. The taxonomic specimens are curated at museums, while fish samples are held at the CMAR laboratories for analysis.

The Tag Database schema is a well developed and comprehensive repository for fish tags. Tools were built and schema development undertaken for loading and working with the project data. Processing was also undertaken to determine data quality, and other analyses were performed using Matlab.

There are two main means of publication of data products and dissemination of data from the data stores described above:

1. linked by URL through metadata records to the data
2. datasets, especially coverages (WMS) or features (WFS), can be made available through OGC web services using the CMAR Geoserver instance.

8. BENEFITS AND ADOPTION

The beneficiaries identified in the original application were Commonwealth Fishery (90%) and NSW Fishery (10%), but there is also a broader public benefit maintaining biodiversity on the upper continental slope off southern and eastern Australia. The private benefit for industry will be a higher likelihood of gulper sharks being listed at a level no higher than Conservation Dependent, and the likelihood of a lower proportion of the upper slope being closed to fishing. These competing objectives have a common element - maintenance of a healthy fishery ecosystem characterised by natural biodiversity that supports fishery production.

The research identified trade-offs between meeting the competing objectives of conservation and resource use. Spatial management was found to be a plausible solution to allow these objectives to be met separately. It details how these trade-offs can be minimised by selecting the most appropriate locations, closure sizes and configuration of closures to halt decline and support recovery.

The range of options for management and conservation were adopted as core elements of AFMA's Upper Slope Dogfish Management Strategy. The benefits of the research met the objectives of the research – to support the development of an effective fishery management strategy while simultaneously addressing requirements to mitigate impacts on gulper sharks. While the listing decision on Southern and Harrisson's Dogfish has yet to be made, the other species subject to threatened species nomination, Endeavour Dogfish has been determined not eligible.

9. FURTHER DEVELOPMENT

At the time of preparing this report, the management arrangements for the Flinders Research Zone have not been completed, but material supplied by this project (Appendix I) is contributing to that process.

An external independent review of AFMA's Upper Slope Dogfish Management strategy has recommended additional measures are needed to support recovery of gulper shark species (beyond mitigating fishing impacts on them). The recommendation, supported by the DSEWPaC and other federal departments with an interest in gulper shark conservation, is that a recovery strategy is based on a quantitative target with a limit reference point (emulating the management of fish stocks by the Harvest Strategy Policy). The feasibility of undertaking this work is being reviewed by an independent scientific working group – but it will depend heavily on data and methods established during this project.

The need to develop a monitoring program to measure performance of the Upper Slope Dogfish Management Strategy was articulated by the TSSC and is an element of the Wildlife Trade Operation conditions for the SESSF. This project has provided a detailed proposal for the monitoring program (as has been reviewed by stakeholders, rated as high priority by SEMAC, and supported as high priority by COMFRAB).

One key requirement for the monitoring program is to test BRUVS methods beyond the proof-of-concept stage. Dedicated sampling with DeepBRUVS tool is required to determine whether it can provide robust data on species abundance or relative abundance, size structure and sex ratio, and whether or not image-based estimates correlate well with hook-and-line catch data. The system has been designed to provide a cost effective option for monitoring in being able to be easily deployed and recovered from industry vessels, and have the ability to gather data during long deployments on the seabed. However, formal trials – including while collecting side-by-side catch data – have yet to be completed. A design for trials, including suitable locations, is documented within the monitoring proposal provided to AFMA.

10. PLANNED OUTCOMES

The project's outputs (products produced) have contributed to the planned outcomes as follows:

1. Interpreted results from a large volume of data generated by eight successful field surveys (that documented the east and south coast distributions of gulper shark species and movement data on Southern Dogfish) underpinned the design of fishery closures for the implementation of AFMA's Upper Slope Dogfish Management Strategy, and contributed substantially to CSIRO and industry submissions to influence the EPBC listing process for gulper sharks being undertaken by the Threatened Species Scientific Committee.

2. An effective and proactive stakeholder engagement and communication program enabled a consensus view about fishery closures to be achieved across fishery stakeholder groups.

3. A tool to provide long term non-extractive monitoring data, and a detailed proposal for a long term monitoring strategy will help gain Wildlife Trade Order (WTO) approval for the SESSF, and address the Threatened Species Scientific Committee's (TSSC) advice that 'Conservation Dependent' listing of gulper sharks depends, in part, on the establishment of a monitoring program.

11. CONCLUSION

This project aimed to provide the science knowledge required to underpin the development of management responses to conserve four species of deepwater sharks being managed under AFMA's Upper Slope Dogfish management Strategy, including three species of gulper sharks considered for threatened species listing under the EPBC listing (TSSC) process. The key knowledge gaps were the current distribution of gulper sharks in eastern Australia, and their rates and scales of movement to establish the efficacy of closed areas as a management tool. Further, the process of evaluating the status of these species required assessment of options for non-lethal and long term monitoring methods. This information was required for evaluation by the listing process, and the implementation strategy, in a short timeframe (2 years); hence there was a need to provide early results as the project progressed.

The project was successful in all respects, by providing the information needed to understand the current threat posed to gulper shark populations by fishing, doing so in a timely manner, and by communicating the results to a broad range of stakeholder groups. The options for spatial closures were presented in a way that highlighted the trade-offs between the competing objectives of resource use and conservation when dealing with vulnerable non-target species. They provided a mechanism to negotiate consensus outcomes to the competing objectives by showing how spatial management strategies could set aside separate areas to serve the different objectives. Trade-offs can be minimised by selecting the best locations and suitable size of closures to support objectives to halt decline and support recovery. There are no unique solutions because different stakeholders value the competing objectives differently. Tools and strategies for monitoring the recovery of gulper shark populations protected in spatial closures have been developed and pave the way to satisfy the listing process and fishery (WTO) assessment.

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APPENDIX A – INTELLECTUAL PROPERTY

No commercially valuable property arose from the research. No compelling reason was identified to restrict the distribution of results so these have been made publically available with no protection or confidentiality except where indicated.

APPENDIX B – STAFF LIST

Alan Williams, CSIRO Marine and Atmospheric Research, Hobart

Ross Daley, CSIRO Marine and Atmospheric Research, Hobart

Ian Knuckey, Fishwell Consulting, Queenscliff

Beth Gibson, Australian Fisheries Management Authority, Canberra

Pamela Brodie, CSIRO Marine and Atmospheric Research, Hobart

Franzis Althaus, CSIRO Marine and Atmospheric Research, Hobart

Bruce Barker, CSIRO Marine and Atmospheric Research, Hobart

Mark Green, CSIRO Marine and Atmospheric Research, Hobart

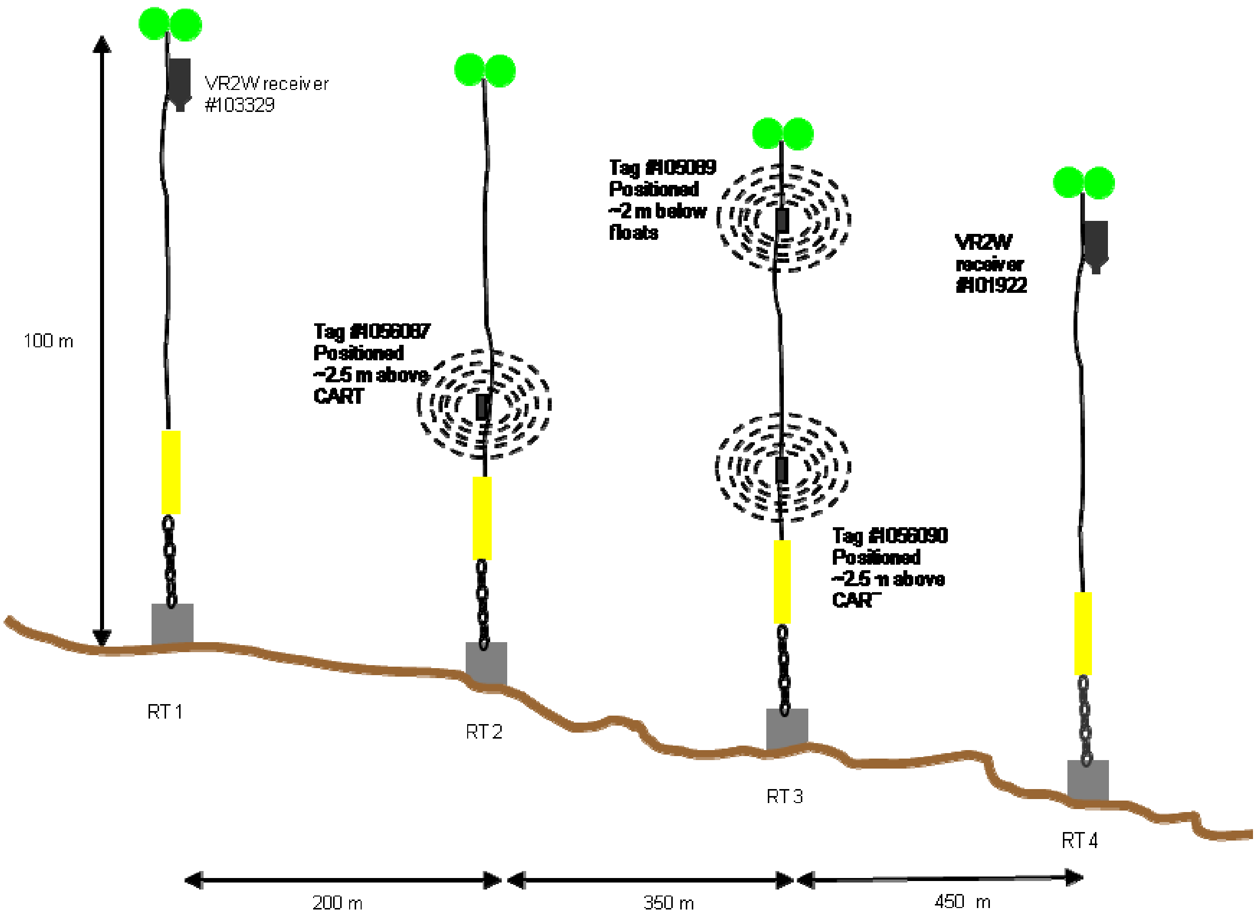
APPENDIX C – TECHNICAL DETAILS OF RANGE TESTING

Appendix C: Range test experiments carried out on board MNF Southern Surveyor during 2008

Static range testing

For the static range test, two tags (Vemco V16 69 khz, 4H battery, 10 sec interval) were positioned close to the seafloor on moorings and an additional tag was positioned higher in the water column (Figure C1). A series of VR2 acoustic receivers were deployed on moorings 100 metres above the sea floor so the tags could be tested for detection at ranges of 200, 450, 600 and 800 m. Data were downloaded after recovery of the moorings and the proportions of transmissions detected were calculated for each of the different ranges and depths.

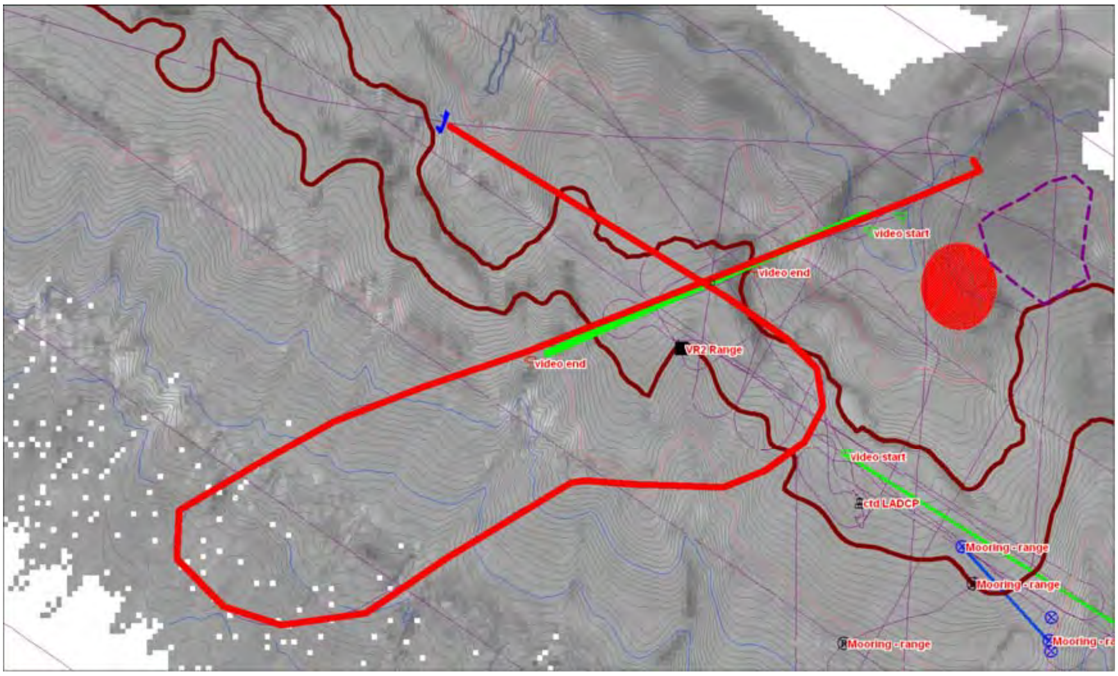
Figure C1. Configuration of tags and receivers moored for static range tests of acoustic tag undertaken by the MNF Southern Surveyor off Coffin Bay during 2008



Mobile range testing

A single VR2 acoustic receiver was moored 100 metres off the bottom attached to a Sonardyne beacon[1]. A single range testing tag (Vemco V16 69 khz, 4H battery, 10 sec interval) was suspended below the vessel using a tether and towed past the receiver. The approach was made in water of 327 m depth at a speed of 1.9 knots. The rate of detections increased to 3–4/minute (50–67%) at a range of 948 m from the receiver (time UTC 01:34:28). The departure was made in deeper water of 483 m depth, and faster at a speed of 2.3 knots. As the tag was towed away from the receiver the detection range was smaller and the detection rate fell below 50% at a distance of 540 m from the receiver. When the tow speed was increased to 3.4 knots the detection range fell to 460 m.

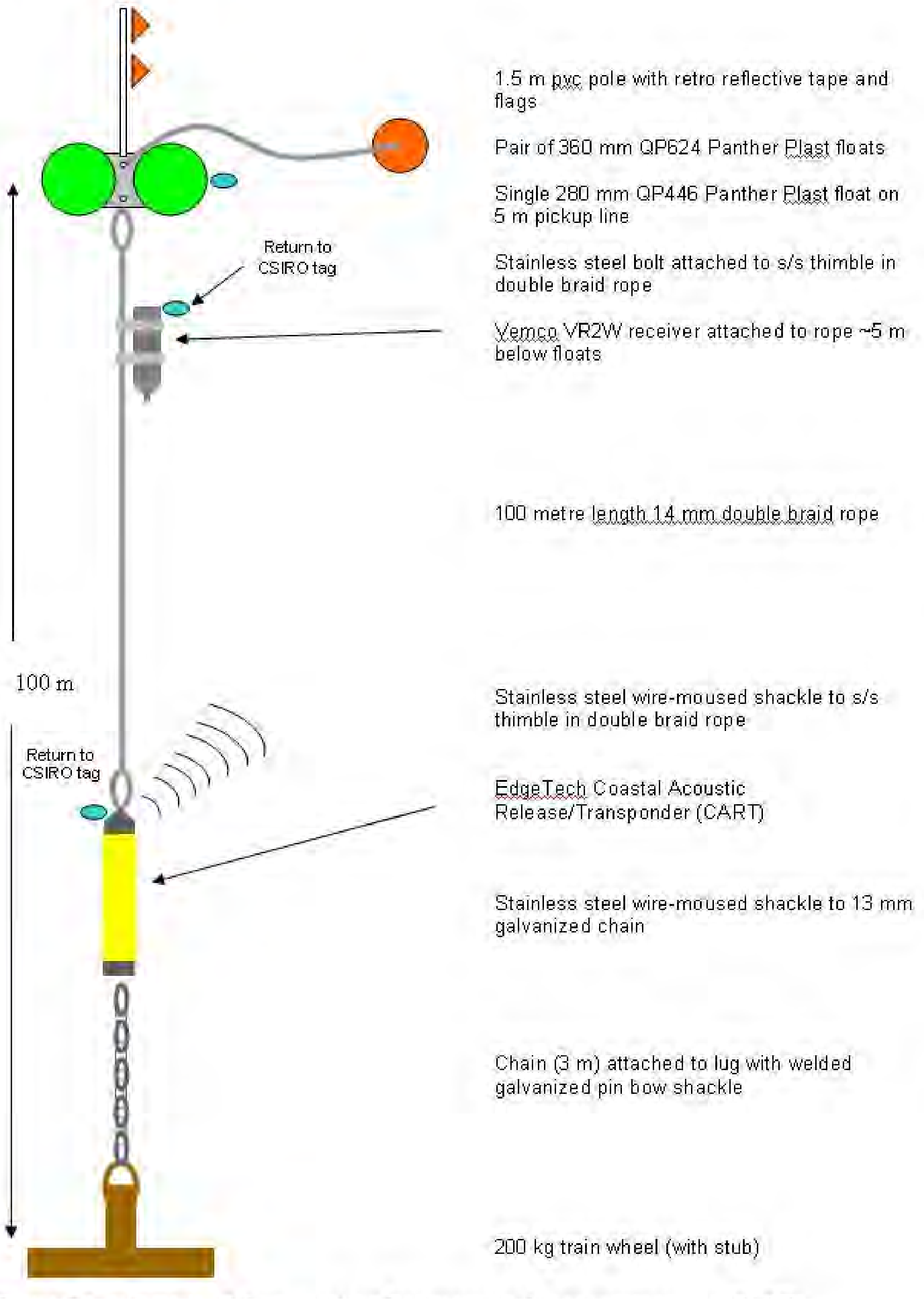
Figure C2: Path of towed range test of acoustic tag undertaken by the MNF Southern Surveyor off Coffin Bay during 2008. 300 and 600 m contours marked in red



[1] The Sonardyne beacon was used to get accurate distance measurements between the towed tag and the acoustic receiver.

APPENDIX D – TECHNICAL DETAILS OF MOORINGS

Technical Details of Moorings



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COASTAL ACOUSTIC RELEASE TRANSPONDER

FEATURES
- Active Bio-fouling prevention
- Easy maintenance
- Small lightweight package
- Medium load acoustic release
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- 1.5 years on alkaline batteries
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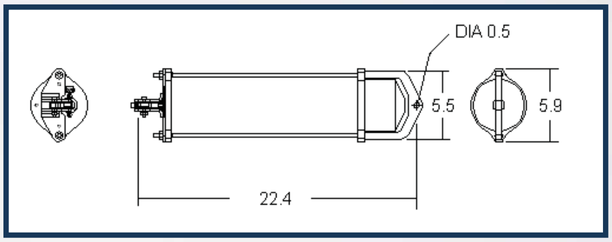
The CART Coastal Acoustic Release Transponder is a perfect system for deployments in coastal environments. The active bio-fouling prevention system is ideal for long term deployments where mechanisms can experience growth or sediment build up. The acoustic command structure is the same as used in all of our underwater equipment and is unsurpassed in multi-path environments.

CART

COASTAL ACOUSTIC RELEASE TRANSPONDER

KEY SPECIFICATIONS

MECHANICAL	
Release mechanism	Motor driven rotary type with thrust bearings
Release load rating	500 kg (1100 lbs)
Lifting load rating	750 kg (1650 lbs)
Depth rating	1000 meters (3300 ft)
Length	59.4 cm (23.4 in)
Diameter	Housing 11.5 cm (4.5 in) Supports 13.9 cm (5.5 in)
Weight in air	9.1 kg (20 lbs)
Weight in water	3.6 kg (8 lbs)
Exposed materials	Hard Coated Aluminum (housing etc) Stainless Steel (mechanism) Buna –N (O-rings) Acetyl and Nylon (isolation hardware)
ELECTRICAL	
Command frequencies	9.3 to 10.7 kHz
Command codes	BACS commands (ORE Offshore)
Transmit Source Level	192 dB re 1 micro Pascal
Receiver sensitivity	100 dB re-1uPascal-meter
Battery life	1.5 years and 40,000 replies at –5 degrees Celsius
Battery type	Welded alkaline pack



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The VR2W was designed using the same proven and reliable technology you've come to know and trust in all VEMCO receiving equipment. Affordable, compact, easy to use, long-lasting and flexible, the VR2W is ideal for research projects ranging from small river monitoring to freshwater lake studies to multi-researcher, multi-tracking operations in large oceanic systems.

VR2W Key Features

- Rapid upload speed using *Bluetooth*® wireless technology - after retrieving your VR2Ws, offload data quickly (100,000 bytes in ~8 seconds or roughly 10,000 detections) and from up to 7 receivers simultaneously
- Significant data storage capability - 8 MBytes (1-million detections)
- Field upgradable design allows the VR2W unit to be upgraded in the field with future coding scheme enhancements
- Safe, robust data storage capability - the VR2W always retains every detection in non-volatile memory so all data is saved even if the unit unexpectedly fails

Simple to Use. The VR2W records the identification number and time stamp from acoustic transmitters as a tagged animal travels within receiver range. Depth, temperature and other sensor data can also be collected. After removing your VR2Ws from the water, data is downloaded quickly and easily in the field without opening the case by using your PC with *Bluetooth*® wireless technology. The VR2W system uses VUE software that is compatible with Windows XP SP2, VISTA or Windows 7 operating systems.

Contact us for details about upgrading older receivers at a great discount (for a limited time only)

The VR2W uses greatly enhanced PC Software!

The VEMCO User Environment (VUE) PC Software for initialization, configuration and data upload from VEMCO receivers allows users to combine data from multiple receivers of varying types into a single integrated database.

The VR2W Comm Package includes everything you need to talk to your VR2W:

- VUE software
- Software manual
- Two VR2W Comm Keys
- Adapter for USB to *Bluetooth*® wireless technology

VUE will work with VR2W receivers and requires Windows XP SP2, VISTA or Windows 7 operating system. See VEMCO's website for more details.

VEMCO Division
AMIRIX Systems Inc.

211 Horseshoe Lake Drive
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The VR2W from VEMCO is a flexible, cost effective receiver for remote monitoring

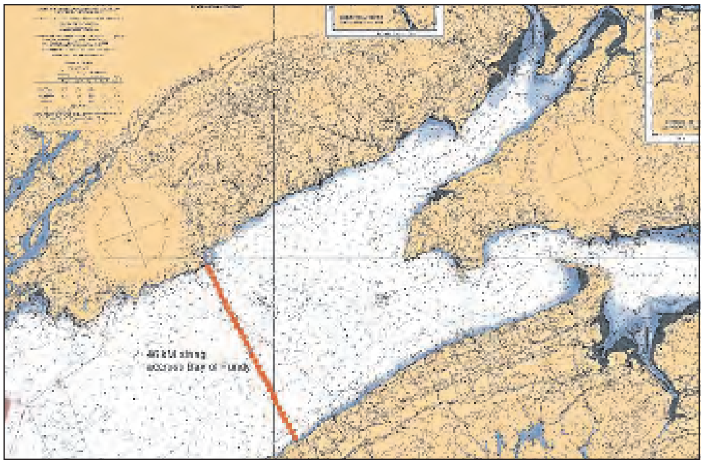
The VR2W is capable of identifying all VEMCO coded transmitters **and provides marine biologists with a flexible and reliable means of recording fish telemetry data.**

Compact. The VR2W consists of a hydrophone, receiver, ID detector, data logging memory, and battery all housed in a submersible case. The VR2W receiver's plastic high pressure case is lightweight and has a depth rating of 500 meters. The VR2W is easily moored or hidden underwater by a diver and can also be set up with an acoustic release system for highly inaccessible locations.

Proven Technology. The device has been used successfully in several studies including:

- The Pacific Ocean Shelf Tracking Project (POST) monitors the movement of marine animals through an array of listening stations set along the west coast of North America.
- Network of 250 receivers in the Bay of Fundy tracking the migratory patterns of several salmon groups.
- Ocean cod tracking off Nova Scotia using an array of 70 receivers.
- Fish passage monitoring at Tees River Barrage, UK.
- Endangered Giant Sea Bass monitoring off California.
- Lingcod site residency monitoring off Alaska.
- Monitoring of sturgeon, sharks and grouper species.

Flexible. The VR2W is ideal for acoustic telemetry projects ranging from small river monitoring to multi-researcher, multi-species tracking operations in large coastal areas. The receiver is effective at detecting all VEMCO 69 kHz tags including miniature and medium sized tags enabling a researcher to track a wide variety of fish species with the same receiver array.



VR2W Specifications	
Dimensions	308 mm long x 73 mm diameter
Weight	1190 g in air, 50 g in water
Power supply	1 - 3.6 V Lithium D cell battery
Battery life	Approximately 15 months
Maximum depth	500 metres
Receive frequency	69 kHz standard
Memory	8 MB non-volatile flash memory, 1-million detections
Attachment	Standard: Cable ties
Firmware	Field upgradeable receiver firmware
Software	Compatible with VEMCO User Environment (VUE) software
Transmitters	Logs and decodes ALL VEMCO coded transmitters
Code Maps	Support for all current and planned VEMCO Code Maps

Long Field Life. The low current draw VR2W will last up to 15 months on a Lithium D battery. Because non-volatile memory is used, the data remains intact even with the loss of battery power. Coded transmitters used with the VR2W enable researchers to conduct longer term studies. Many transmitters last several years giving the researcher the benefit of collecting many years of behavioural data from the same animal.

Global Compatibility. The global proliferation of VR2Ws along with the ability to decode all VEMCO tags (including Global tags introduced in 2010), allows researchers to collaborate by sharing receiver network arrays and infrastructure the world over.

For more information on the specific applications of VR2W technology or for technical details, contact VEMCO.

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APPENDIX E – VOYAGE REPORTS

Voyage report list

Sub Appendix	Vessel/month/year	Voyage objective
E1	*Diana*/Nov/2005	Survey
E2	*Bluefin*/Sep/2008	Survey
E3	*Lucky S*/Nov/2008	Moorings
E4	*Diana*/Sep/2009	Survey
E5	*Sarda*/Aug/2009	Tagging
E6	*Lucky S*/Nov/2009	Moorings
E7	*Naturaliste*/Mar/2010	BRUVS survey
E8	*Sarda*/Mar/2010	Survey
E9	*Sarda*/May/2010	Survey
E10	*Lucky S*/Nov/2010	Moorings
E11	*Bluefin*/Dec/ 2010	Survey
E12	*Challenger*/May/2011	BRUVS test

SUB-APPENDIX E1 – VOYAGE SUMMARY: FV '*DIANA*' 2005

SHIP **Name:** *Diana* **Call Sign:** 0855 **Type of ship:** Commercial fishing vessel - auto longliner
VOYAGE NO.: FV DIANA 2005-01 **VOYAGE NAME:** GAB Exploration
VOYAGE PERIOD: 14/7/2005 to 25/7/2005 *and* 27/7/2005 to 4/8/2005 **LEG 1:** Port Lincoln to Port Lincoln **LEG 2:** Port Lincoln to Port Lincoln
CHIEF SCIENTIST(S) Ross Daley
OBJECTIVES AND ACHIEVEMENT Objective. Broadly investigate the distribution, composition and relative abundance of deepwater chondrichthyans across the Great Australian Bight. **Achievement: Working in conjunction with AFMA observers aboard the trawler Riba 2 these two vessels recorded catch data for approximately 100 survey shots, covering areas from 129 to 136 degrees longitude.**

Diana 2005 – Voyage summary

Operation details

Date of operations: Winter 2005

The plan was for three boats to be involved with the survey:

Dianna	(Red boxes on the map)
Riba 2	(blue boxes)
Petuna Endeavour	(Green boxes)

In the end the Petuna Endeavour couldn't make it so the Riba 2 picked up that part of the survey. Figure 1 shows the area of operations and where each vessel collected data.

Each leg had two observers:

Diana:		Ross Daley-CMAR, Grant Johnson (ISMP/PIRVIC)
Riba 2	(blue boxes):	Lauchie Kranz (AFMA) and Justin Bell (PIRVic)
Riba 2	(green boxes):	2 x AFMA observers Nick and Craig

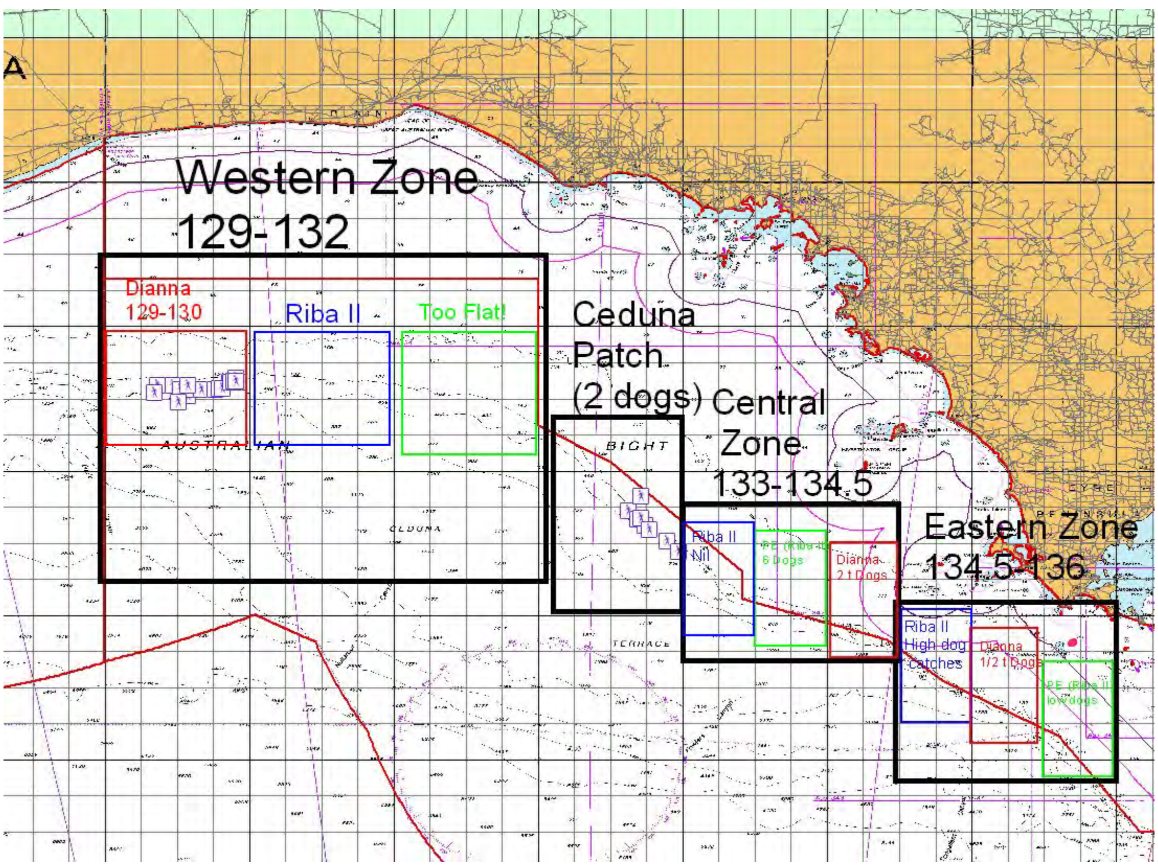


Figure 1. Survey area maps

Results

Dianna trips,
Grant Johnson and Ross Daley recorded the lat long and depth for each of 50 shots and identified, counted and estimated the weight of every fish that came over the side on 48 out of 50 shots observed. The other two shots were taken up with tagging sharks. All the station logs and catch comps and tag release data are recorded on two files:
Dianna Voyage 1.xls
Dianna Voyage 2.xls

Riba 2, Leg 1
Station logs and catch comps for target species only were recorded by Lachlan Kranz. The raw data was compiled with the ISMP data base. I checked with both Matt Koopman and Lauchlan Kranz on 23 November 2005 and they confirmed that AMFMA did not compile any catch data on discarded sharks during that voyage.

For 10 of approximately 50 shots, Justin Bell observed the shark and ray bycatch Table 1. Significant quantities of gulper shark (1.126/100 hooks, n=4) were caught in the eastern zone between 134.5-135. A small number of southern dogfish (0.043/hundred hooks) were recorded in the central zone between 133-133.5. There were no southern dogfish recorded in the western zone shots observed during this leg (n=2).

Other shark and ray species recorded in significant quantities were greeneye spurdog, whitefin swell shark, sawtail catshark, Bight skate, Lucifer's lantern shark and southern chimaera (Figure 2). Greeneye spurdogs and Bight skate were caught mainly on flat ground in the western zone.

Table 1: Shots observed by Justin Bell on Riba 2 leg 1

Fishing zone (guesses)	Length of shot observed (km)	Shot length (km)	Shot No.	No. hooks observed	No. hooks in shot	Spurdog	whitefin swell shark	Sawtail catshark	sharpnose 7-gill shark	**Southern dogfish**	Bight skate	School shark	Platypus shark	Blue shark	Lantern shark	Sawshark	Southern chimaera	Lemure ghostshark	Wide stingaree
West	8.256	8.256	6	5760	5760	855	110	222	1	0	84	0	0	0	0	0	1	0	0
West	4.128	4.128	shot 3	2880	2880	494	37	135	1	0	21	0	0	0	0	0	15	0	0
Central	4.128	4.128	20	2880	2880	47	3	47	0	0	1	0	0	0	0	2	1	1	0
Central	4.128	4.128	unknown	2880	2880	28	2	29	0	0	8	0	0	0	2	0	0	0	0
Central	4.128	4.128	21	2880	2880	283	48	29	0	3	6	0	0	0	0	0	1	0	0
Central	4.128	4.128	27	2880	2880	298	36	3	0	2	16	0	9	0	50	0	29	0	0
East	4.128	4.128	38	2880	2880	52	3	59	0	41	1	21	0	1	0	3	2	0	1
East	2.4768	6.88	42	1728	4800	135	17	87	0	12	3	0	0	0	3	0	3	0	0
East	4.128	4.128	43	2880	2880	119	28	169	0	65	8	0	0	0	2	0	4	0	0
East	5.504	6.88	50	3840	4800	576	85	127	0	5	11	0	0	3	0	0	1	1	0
				31488	35520														

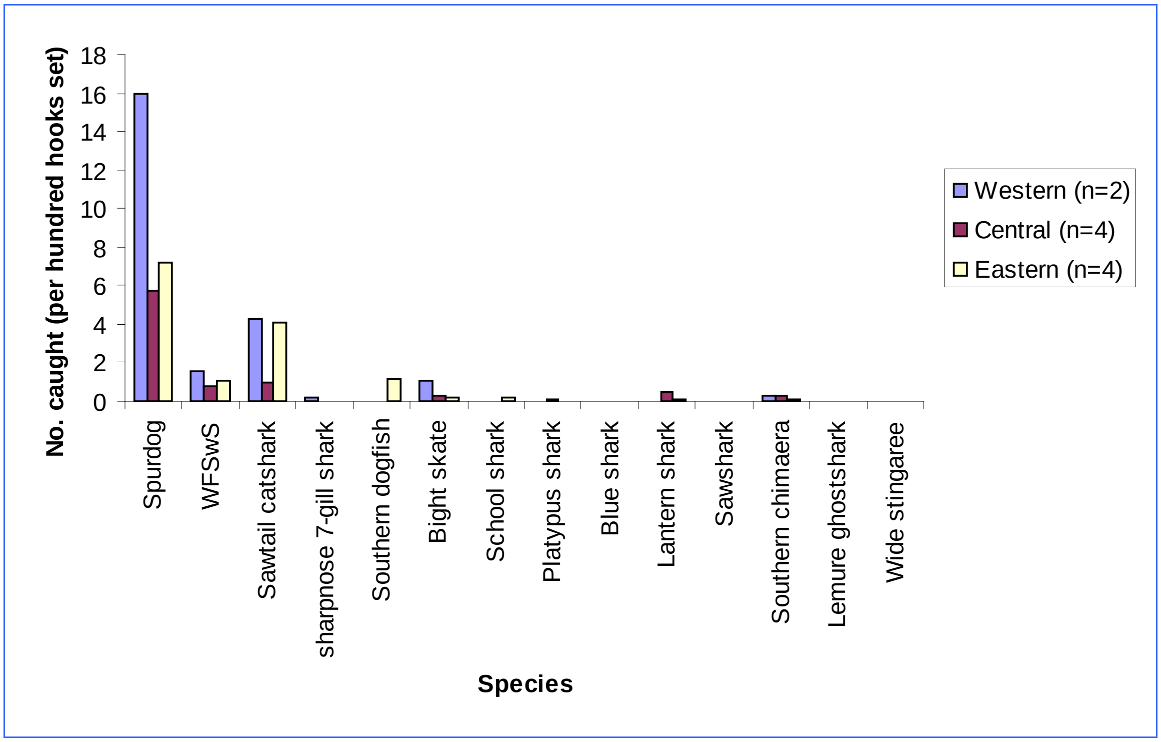


Figure 2: Catch rates of shark and ray bycatch taken on Riba 2 leg 1.

SUB-APPENDIX E2 – VOYAGE SUMMARY: AMC '*BLUEFIN*' 2008

SHIP **Name:** *Bluefin* **Call Sign:** **Type of ship:** Australian Maritime College training vessel
VOYAGE NO.: AMC BLUEFIN 2008-01 **VOYAGE NAME:** Flinders Island and SE Bass Strait
VOYAGE PERIOD: 15/9/2008 to 3/10/2008 **PORT OF DEPARTURE:** Beauty Point **PORT OF RETURN:** Beauty Point
CHIEF SCIENTIST(S) David Maynard (AMC), Ross Daley (CSIRO)
OBJECTIVES AND ACHIEVEMENT Objective. Collect information on distribution of Harrisson's Dogfish. **Achievement: This voyage was a training trip for students, who participated in a single demersal longline operation attempting to capture chondrichthyans.**

Voyage summary AMC Bluefin 2008

Between September 15 and October 3, 2008, CSIRO participated in a field survey on board the Australian Maritime College training vessel AMC *Bluefin*, operating in the waters around Flinders Island off southeastern Bass Strait. A single demersal longline with 700 hand baited hooks was deployed between 300 and 700 m inside the northern boundary of the Flinders Marine Protected area (Williams *et al.*, 2010). A single mature female Harrissons Dogfish was captured. A number of other chondrichthyans were tagged and released including several specimens that were subsequently recaptured. Further details of tags and recaptures are available from David Maynard at the Australian Maritime College.

SUB-APPENDIX E3 – VOYAGE REPORT: FV '*LUCKY S*' 2008

SHIP **Name:** *Lucky S* **Call Sign:** **Type of ship:** Fishing and general work vessel
VOYAGE NO.: LUCKY S 2008-01 **VOYAGE NAME:** Listening station mooring array recovery and redeployment
VOYAGE PERIOD: 21/11/2008 to 26/11/2008 **PORT OF DEPARTURE:** Port Lincoln **PORT OF RETURN:** Port Lincoln
CHIEF SCIENTIST(S) Bruce Barker
OBJECTIVES AND ACHIEVEMENT Objective. VR2W acoustic listening station moorings were originally fitted with 'burn wire' releases that had failed. This voyage was to attempt recovery of receivers using method for cutting supporting ropes and then redeploy receivers on mooring fitted with Coastal Acoustic Release Transponders (CARTs). **Achievement: Eleven of the 24 receivers were recovered on this trip with data recovered from 8 units. Twenty one new receivers were deployed in an array close to the original locations.**

Voyage Report – Spatial Closures Mooring Recovery

Project title:

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

Chartered vessel:

FV Lucky S, Port Lincoln SA
Owner Semi Skoljarev (SEKOL Tuna Farming Pty.Ltd., Port Lincoln SA)

Dates:

2nd to 12th November 2008

From:

Port Lincoln, South Australia

To:

Port Lincoln

Background

Areas of seabed in Commonwealth waters off temperate Australia are being closed to fishing as marine reserves are 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.

During a National Facility voyage during March 2008 (SS200803) listening station moorings were deployed within the spatial closures area. These were to be short term deployments and included a burn-wire, rope canister and surface floats to release on pre-programmed dates. At the same time sharks were caught (using bottom-set longlines) tagged and released from the SARDI research vessel RV Ngerin. Many of these animals were tagged with acoustic tags to trace their movements using the listening station array.

In July we again chartered the RV Ngerin to coincide with the mooring release dates, to retrieve the moorings. A thorough search for surface floats showed none had been released. A trawl tow (boards only) yielded the top portion of a mooring without the data recorder and confirmed that the burn-wire release hadn't fired. Subsequent checking by CSIRO electronics revealed the likelihood of a systematic fault for all units due to earth leakage around the posts supporting the sacrificial wire. Some weeks later we chartered a plane to check for surface floats in case any had released but none were spotted.

This voyage was planned to salvage the moorings by towing a long length of wire with grapples/ cutters to connect and cut the mooring below the VR2 data receivers. A couple of methods were tested off Hobart. We also planned to deploy a new listening station mooring array dependent on how many were salvaged and what the data showed.

Summary

CSIRO chartered the 29 m FV Lucky S for the recovery and deployment of listening station moorings in the spatial closures area off Port Lincoln. The ex Soela ctd winch (*egg survey winch*) was fitted to the deck of Lucky S (with ~3000 m ctd wire). The camera system gantry from the previous survey was left mounted on the stern of the vessel to use - with a sheave block - for towing the wire rope-cutter/grapple array. Initially the task was to retrieve as many as possible of the existing moorings with the failed burn-wire release mechanism.

The first tow and others were successful (figure 1) in cutting the mooring rope below the VR2 data recorder but several unsuccessful attempts followed for other moorings. Sometimes the mooring rope was cut above the data recorder and only the floats recovered. Refinement of technique resulted in the recovery of 9 VR2's (table 1, figure 2) by the end of the survey. Overall 5 moorings were cut above the recorder with only floats recovered.

Where the release canister and burn-wire release were retrieved, we were able to confirm the expected systematic failure of the burn-wire systems. We towed the cutter array at all mooring sites generally with several passes to try and snag the mooring. The badly corroded state of shackles suggests that some moorings had already lost the floats/release component presumably leaving the rope and VR2 on the bottom. This possibility explains our lack of success for some moorings particularly when our towing technique was refined and seemingly successful on intact moorings.
As the charter neared end and it was apparent that we wouldn't get many of the originals back, we setup for the deployment of the new mooring configurations incorporating new VR2's and Coastal Acoustic Release Transponders (CARTs) (figure 3, table 2).

Once each new mooring was deployed as closely to the given position as possible, the range (m) was determined for each by pinging the CART from 3 positions ~500 m distant and ~120 degrees opposing (fig 4). This slant range distance (table 3) will be used to accurately determine the actual position of each mooring on the seafloor.

Although not able to retrieve as many receivers as we might have hoped for initially, we are very pleased with the outcome of the voyage. We have receivers from eastern, central and western regions of the mooring array and data (~220,000 detections) from 3 species tagged with acoustic tags providing very useful information on movements plus confirmation that the sharks (particularly gulpers) survived and are moving

around the closure area. Additionally we were able to deploy 21 new moorings with receivers and acoustic releases into a new array with 4 ‘curtains’ providing greater spatial coverage to further enhance the study.

Voyage narrative

Friday 31st October
Load moorings gear

Saturday 1st November
Gear setup and preparation of acoustic releases (CARTS)

Sunday 2nd November
Continued the setup of mooring floats, lines etc. Departed Pt Lincoln ~1600 hours and steamed through the night to the closure area.

Monday 3rd November
At first light we deployed the cutter/weight array. Following a few adjustments we redeployed shooting for mooring no 15 and were successful in cutting the rope and retrieving the VR2W data receiver (#102602). Downloaded the data for 2896 detections. Moved to mooring #16 and had 4 attempts without result. Moved to #17 and had 3 attempts at snagging the mooring before evening. Wind freshened during the evening.

Tuesday 4th November
Strong wind and rough seas prevented any attempt to retrieve moorings. Dodged weather during the day whilst slowly steaming to Greenly Island where we anchored in the late afternoon whilst waiting for the weather to abate.
Sheltered in the lee of Greenly Island for the remainder of the night.

Wednesday 5th November
In the morning returned to the array as winds had abated, and began towing for moorings in marginal conditions with white caps and moderate seas. After 5 passes at mooring #8 the surface floats were spotted and retrieved with receiver #101998 (downloaded 69966 detections). Mooring #9 surfaced but without the data logger. Several attempts at snagging #10 were unsuccessful. Also tried for #6 but nil result.

Thursday 6th November
Towed for #1 for nil result. After towing for #2 the floats were spotted but without the receiver. Re tried #1 again but no result. Towing for #3 resulted in the floats and lots of rope surfacing but unfortunately no receiver. The same result for #12 again with no receiver. An attempt at #11 ended up in being pinned up followed by several more attempts. Tried #23 without luck. With darkness falling, a rapidly falling barometer and forecast change we steamed to Greenly during the night anchoring in the lee in the early hours of the morning.

Friday 7th November
Strong to gale force south westerly winds prevailed during the day as we remained anchored in the lee of Greenly Island.

Saturday 8th November
Steamed towards closure area during the morning but returned to Greenly Island to await abating sea conditions

Sunday 9th November
Left Greenly Island early in the morning for the western end of the listening station array. Towed cutter configuration for mooring #5 and successfully retrieved the floats and receiver #102597. Then successfully retrieved mooring #4 with floats and receiver #101925. Attempted more recoveries ahead of getting positions from Hobart for the new mooring array. Began deploying the new moorings and worked into the night to get 13 of the western end moorings deployed. Steamed to the east during the night.

Monday 10th November
Deployed moorings at the eastern end of the array in the morning.
Retrieved mooring #22 with receiver #101922 showing 1882 detections.
Mooring #21, retrieved with receiver #101994 but unable to read (no red light flashing). On checking found one terminal for the battery connection was bent and the unit wasn't powered and therefore not recording. Re tried snagging mooring #17 without success. Re tried snagging mooring #16 without success. Moved to #20 and were successful in retrieving the mooring block, receiver # 102596, all rope but no floats. Moved to the lost trap position and listened for tags using receiver # 101995 for ~50 minutes. Deployed the remainder of the moorings (no's 21, 16, 15 &14) in the evening.

Tuesday 11th November
Towed for mooring #19 and retrieved top floats only -no pickup float or release canister due to corroded shackles. Towed for #20 and retrieved top floats and plenty of rope but no receiver. On hauling up to check the cutters discovered more rope and a canister from #19. The receiver was also retrieved and was downloaded to reveal 96468 detections. Towed for # 7 and retrieved receiver #101923 revealing 25874 detections. Towed for #24 and cut off floats but no receiver. Towed for #23 without hook-up. Re tried for #6 but got nothing. Had 3 passes at hooking the lost smart trap from the March survey but again no luck. Departed the closure area and steamed to Pt Lincoln during the night.

Wednesday 12th November
Steamed to Pt Lincoln. Arrive at berth ~0800 hours. Decommission winch and other equipment. Crane winch off deck and remove all ropes, floats and associated gear.

Staff

Slavko Kolega	SEKOL	Skipper
Bruce Barker	CSIRO	Voyage leader
Mark Lewis	CSIRO	Moorings setup/deck operations
Scott Ryan	SEKOL	Engineer/deck
Adam Mullins	SEKOL	Deck
Shane Farrell	SEKOL	Deck

Acknowledgements

Mobilizing for this salvage voyage was possible with the help of several people. Thanks to CSIRO MT&E staff for the fabrication of components for the new moorings as well as making and testing the cutter plates. Thanks to Semi Soljarev for making the Lucky S available for the voyage and supplying a very willing and capable crew both on the boat, and at the SEKOL yard, to help in every aspect of execution. Thanks to Troy (SEKOL boilermaker) for welding work on the winch, the gantry and for making the train wheel mooring weights. Thanks to Slavko Kolega for organizing the train wheels, skippering the vessel and applying himself to the task of recovering the elusive moorings. Special thanks to the Lucky S crew who tirelessly, and enthusiastically spent countless hours scanning the ocean for buoys. Special thanks again to the deck crew who skilfully assisted with all deck operations. Thanks also to Dave Hughes of the CSIRO Moorings Group for providing tuition on the setup and use of the acoustic releases.

Table 1. Summary details of mooring retrievals and number of detections downloaded

Mooring #	VR2W Receiver #	Detections	Notes
15	102602	2896	
8	101998	69966	
5	102597	20480	
4	101925	4681	
22	101922	1882	
21	101994	--	No red light – not powered
20	102596	14071	No floats, all rope and mooring block
19	102607	93648	Dragged rope etc after only floats
7	101923	25874	
9	nil		Cut above VR2
2	nil		Cut above VR2
3	nil		Cut above VR2
12	nil		Cut above VR2
24	nil		Cut above VR2
*Anton Blass	101995	242	No new data – existing data from Mar 2008
*Lucky S	101995	nil	Deployed near lost trap (~50 mins)

Table 2. Summary of new listening station array depths, location, data logger and acoustic release details (the order reflects the chronological order in which the moorings were deployed).

Mooring #	**Depth (m)**	**Date deployed**	**Latitude (decimal degrees)**	**Longitude (decimal degrees)**	**CART serial #**	**VR2W receiver #**
13	650	9/11/2008	-35.1649	134.2984	32891	103331
12	500	9/11/2008	-35.1565	134.3039	32855	103315
11	420	9/11/2008	-35.1484	134.3096	32851	103316
10	330	9/11/2008	-35.1410	134.3170	32854	103327
9	430	9/11/2008	-35.1162	134.1606	32856	103317
8	540	9/11/2008	-35.0999	134.1855	32890	103332
7	400	9/11/2008	-35.0909	134.1832	32852	103333
6	300	9/11/2008	-35.0820	134.1789	32892	103326
5	230	9/11/2008	-35.0723	134.1783	32889	103330
4	660	9/11/2008	-35.0521	133.9980	32885	103328
3	570	9/11/2008	-35.0429	134.0000	32884	103334
2	400	9/11/2008	-35.0339	134.0024	32887	103321
1	250	9/11/2008	-35.0246	134.0060	32888	103320
20	570	10/11/2008	-35.3844	134.6761	32850	103329
19	440	10/11/2008	-35.3765	134.6818	32858	103324
18	352	10/11/2008	-35.3686	134.6879	32893	103325
17	295	10/11/2008	-35.3602	134.6945	32886	103322
21	450	10/11/2008	-35.2333	134.4973	32853	103318
16	580	10/11/2008	-35.2523	134.5121	32857	103323
15	410	10/11/2008	-35.2453	134.5196	32759	101924
14	300	10/11/2008	-35.2378	134.5267	32760	103319

** Nominal latitudes and longitudes as deployed - positions to be adjusted based on ranging CARTS (table 3) from 3 locations to accurately determine the position of the moorings on the seafloor.*

Table 3. Slant range distances as determined by pinging CARTs from 3 positions (fig 3) around each newly deployed mooring for the calculation of accurate positions of the mooring on the seafloor.

Mooring no	Mooring depth (m)	Range no	Range (m)	Longitude (decimal degrees)	Latitude (decimal degrees)
1	250	R1	558	134.008	-35.0284
		R2	456	134.002	-35.0222
		R3	604	134.011	-35.0216
2	400	R1	765	134.003	-35.0387
		R2	601	133.998	-35.0315
		R3	537	134.007	-35.0315
3	570	R1	791	134.001	-35.0469
		R2	675	133.995	-35.0405
		R3	609	134.004	-35.0408
4	660	R1	672	133.999	-35.0559
		R2	1066	133.994	-35.0499
		R3	985	134.003	-35.0498
5	230	R1	530	134.182	-35.0689
		R2	457	134.181	-35.076
		R3	593	134.173	-35.0705
6	300	R1	585	134.174	-35.0799
		R2	523	134.181	-35.0859
		R3	551	134.183	-35.0793
7	400	R1	632	134.178	-35.0895
		R2	573	134.185	-35.0946
		R3	635	134.188	-35.0884
8	540	R1	760	134.181	-35.0975
		R2	698	134.186	-35.104
		R3	743	134.19	-35.0968
9	430	R1	602	134.163	-35.1197
		R2	665	134.156	-35.1143
		R3	611	134.164	-35.1133
10	330	R1	482	134.319	-35.145
		R2	742	134.312	-35.1395
		R3	584	134.321	-35.1376
11	420	R1	665	134.304	-35.1476
		R2	616	134.313	-35.145
		R3	603	134.312	-35.1522
12	500	R1	674	134.299	-35.156
		R2	627	134.307	-35.1528
		R3	860	134.307	-35.1602
13	650	R1	880	134.292	-35.1651
		R2	842	134.3	-35.1607
		R3	826	134.303	-35.1683
14	300	R1	540	134.528	-35.2418
		R2	587	134.522	-35.2349
		R3	542	134.53	-35.235
15	410	R1	596	134.522	-35.2489
		R2	639	134.515	-35.243
		R3	662	134.523	-35.2422

Mooring no	Mooring depth (m)	Range no	Range (m)	Longitude (decimal degrees)	Latitude (decimal degrees)
16	580	R1	702	134.513	-35.2561
		R2	732	134.508	-35.2505
		R3	750	134.515	-35.2493
17	295	R1	492	134.695	-35.364
		R2	619	134.699	-35.3569
		R3	590	134.689	-35.3584
18	352	R1	575	134.69	-35.3727
		R2	595	134.683	-35.3671
		R3	607	134.691	-35.3654
19	440	R1	784	134.683	-35.3808
		R2	525	134.677	-35.3752
		R3	632	134.685	-35.3733
20	570	R1	644	134.671	-35.3829
		R2	882	134.677	-35.3885
		R3	740	134.679	-35.3815
21	450	R1	650	134.498	-35.2375
		R2	636	134.492	-35.2313
		R3	647	134.501	-35.2301

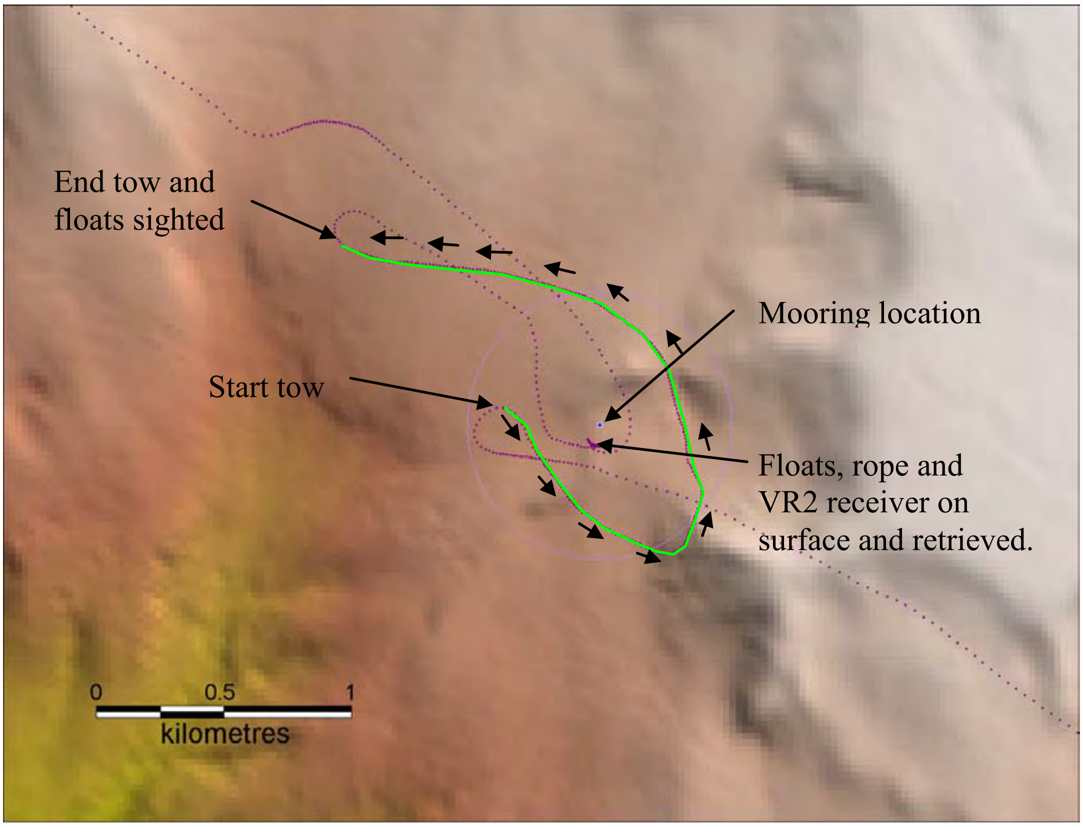


Figure 1. Showing the vessel track for mooring #22 in 450 metres water depth when the cutter array snagged the mooring near bottom, cut the rope and floats and receiver #101922 were retrieved.

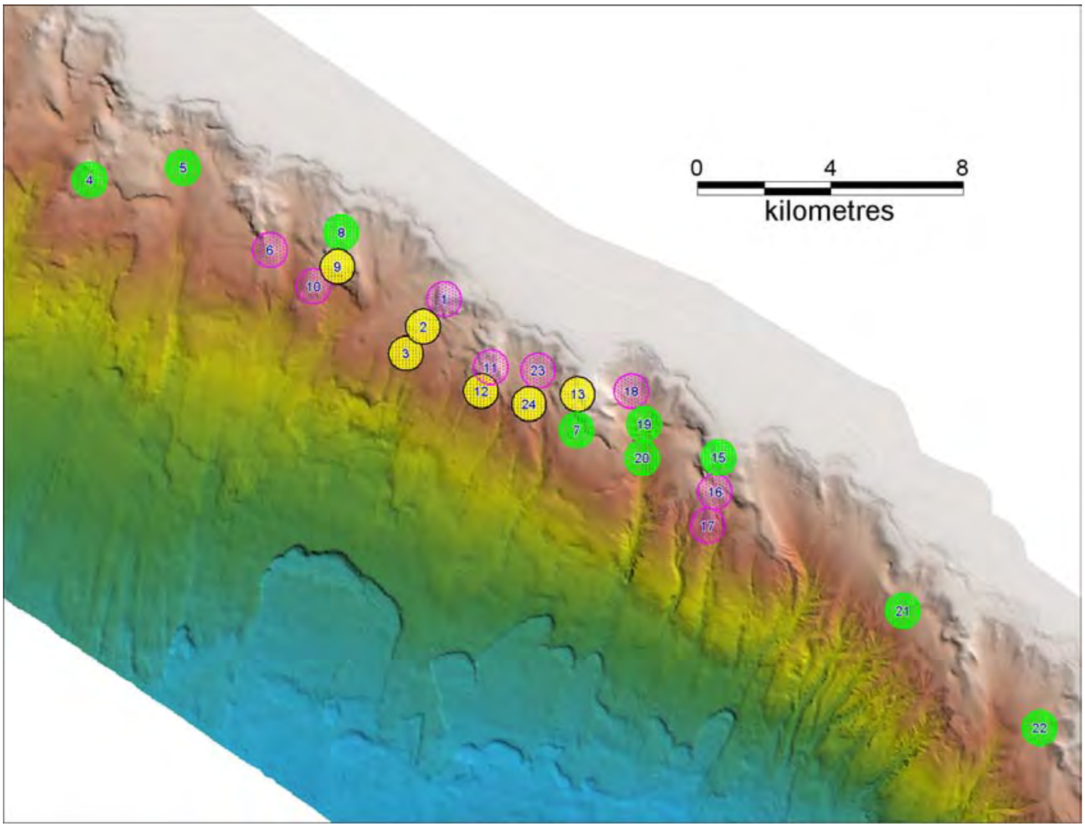


Figure 2. Retrieved VR2's - VR2 receiver retrieved green, – no success pink, – cut off above receiver yellow

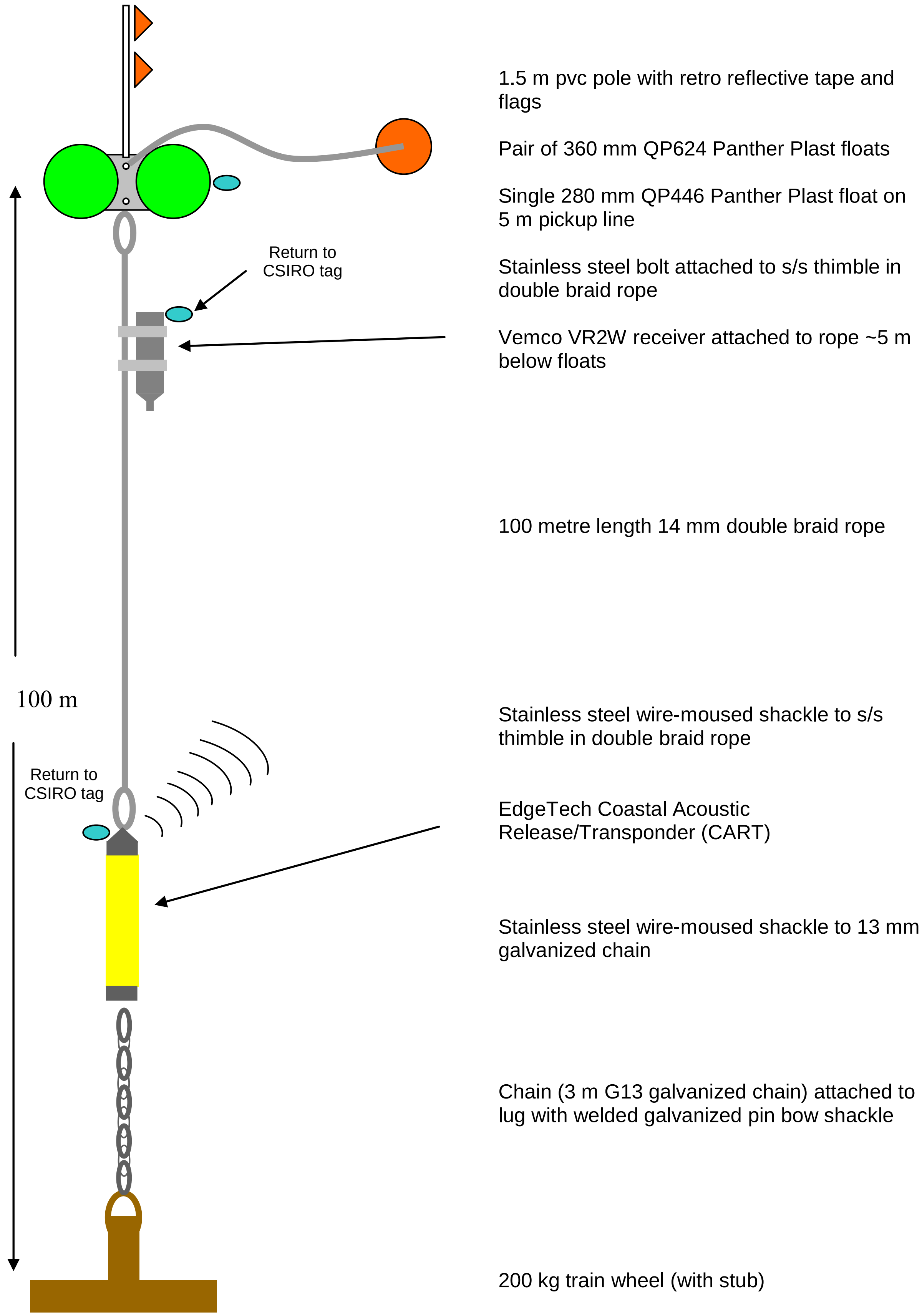


Figure 3. A schematic of the new subsurface mooring design incorporating CART acoustic release units as deployed from FV Lucky S during November 2008.

Figure 4. The vessel track (magenta dots) and locations for CART ranging (black crosses) as completed for each new mooring deployment. The red cross is the target location for deployment and the pink circle shows the ~500 m range of detection for the VR2. The ranging of the CARTS enables accurate determination of the location of the mooring on the sea floor with post processing.

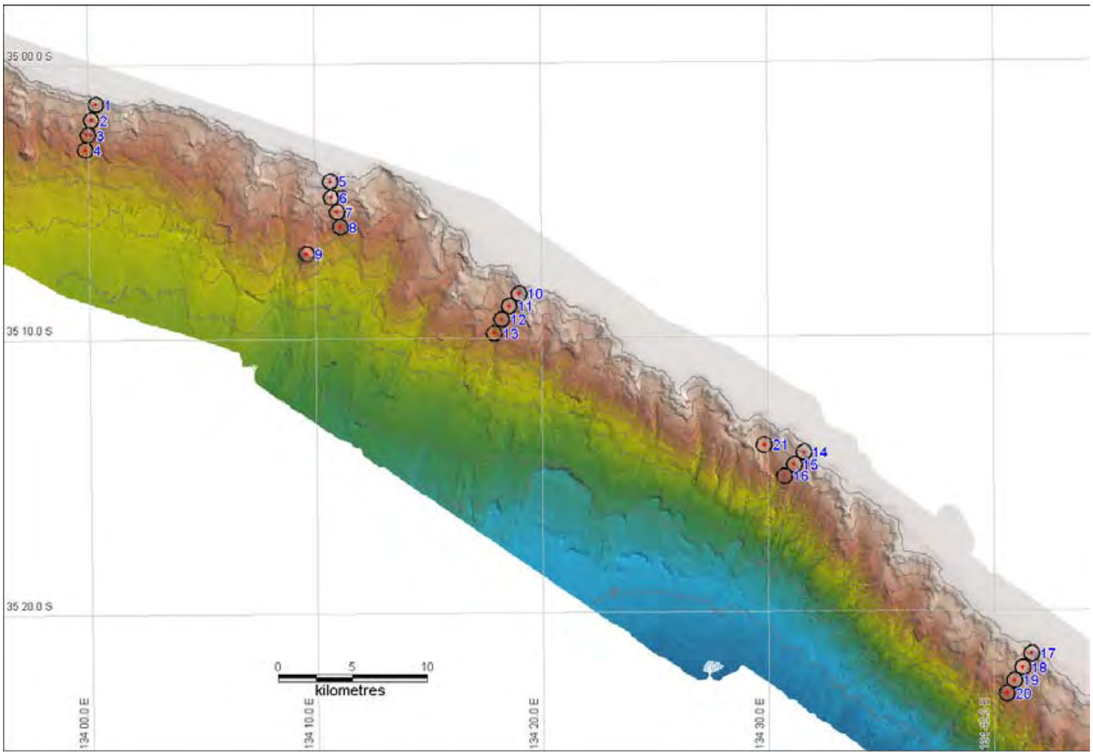


Figure 5. Locations of the new acoustic listening station mooring array as deployed during November from FV Lucky S. The new moorings include EdgeTech acoustic releases (CARTS) and VR2W receivers 100 m off bottom (fig 1).

SUB-APPENDIX E3

SUB-APPENDIX E4 – VOYAGE REPORT: FV ‘*DIANA*’ 2009

SHIP **Name:** *Diana* **Call Sign:** 0855 **Type of ship:** Commercial fishing vessel - auto longliner
VOYAGE NO.: FV DIANA 2009-01 **VOYAGE NAME:** East Coast Survey
VOYAGE PERIOD: 1/9/2009 to 16/9/2009 *and* 19/9/2009 to 7/10/2009 **LEG 1:** Brisbane to Sydney **LEG 2:** Sydney to Hobart
CHIEF SCIENTIST(S) Mark Green (leg 1) and Bruce Barker (leg 2)
OBJECTIVES AND ACHIEVEMENT Objective 1. Use auto-longline and drop-line (hook) fishing methods to sample ~ 20 locations between Brisbane and Hobart **Achievement: Total of 23 sites sampled with hooks in the 300–600 metre depth zone from Brisbane to NE Tasmania.** Objective 2. Collect catch composition (species, counts, catch-rate) data from each fishing operation. Validate catch of all dogfish species recorded with retained specimens (5) and photos for all locations. **Achievement: Catch composition recorded for every operation. Reference specimens retained and checked later for verification.** Objective 3. Record shot details for each fishing line set (location, depth, hooks set). **Achievement: Shot details recorded for every operation.** Objective 4. Deploy replicate Baited Remote Underwater Video Systems (BRUVS) at all sites. **Achievement: Total of 23 sites sampled with BRUVS in the 300–600 metre depth zone from Brisbane to NE Tasmania.**

Mapping Distribution and Movement of Gulper Sharks

East coast survey:
Locating and mapping
Centrophorus harrissoni

September 2009 - Voyage Report:
FV DIANA 01-2009

National Research FLAGSHIPS Wealth from Oceans
CSIRO
Australian Government Fisheries Research & Development Corporation

Project:

"*Mapping the distribution and movement of gulper sharks, and developing a non-extractive monitoring technique, to underpin a stock rebuild within a multi-sector fishery region off southern and eastern Australia*." (CSIRO and FRDC funded)

1. Background and scientific objectives

Gulper sharks (*Centrophorus* species of deepwater dogfish that occupy the upper slope and some offshore seamounts around southern and eastern Australia) represent one of the most urgent environmental challenges to the SESS fishery, and may even threaten its "license to operate". There are at least three species of gulper sharks impacted by fishing in SE Australia, including Harrisson's dogfish (*C. harrissoni*), southern dogfish (*C. zeehani*) and endeavour dogfish (*C. moluccensis*). Previous studies have shown that these species have been heavily depleted in areas where they have been fished (Graham et al. 1997; Andrew et al. 1997; Daley et al. 2002), in some areas down to less than 1% of initial population levels. Gulper sharks are susceptible to several methods of fishing including trawling, line fishing, and (deep set) gillnets. Moreover their biology makes them particularly susceptible to overfishing, with extremely low reproductive rates (Daley et al. 2002) and consequent long periods of recovery from overfishing. Concerns about overfishing of these species led to them being nominated for endangered species listing under the EPBC Act. A recent decision by the Threatened Species Scientific Committee (TSSC) has now seen them given a high priority for evaluation, with a decision on formal listing scheduled for September 2010. Several management measures have been put in place in recent years to help protect remaining populations of these species in SE Australia, including trip limits and specific closures in the GAB, eastern Tasmania, and near Wollongong. However with the exception of the GAB closure, it is not known whether these closures are actually protecting viable populations of gulper sharks, and even for the GAB it is not known whether the area closed is sufficiently large. There are clearly large gaps in understanding about the distribution and behaviour of these species, and the level of protection afforded by existing management measures, increasing the risk that they will be listed as conservation dependent or at an even higher category when the decision on listing is made.

Survey Objectives

This survey will contribute to two of the four project objectives:

1. Map the current distribution of gulper sharks (*Centrophorus spp.*) off eastern Australia between Brisbane and Hobart.

2. Provide early results to the Threatened Species Scientific Committee to assist in identifying areas where gulper sharks can be managed.

Voyage Objectives

1. Use auto-longline and drop-line (hook) fishing methods to sample ~ 20 locations between Brisbane and Hobart (Appendix 1). Effort will be concentrated in the 300-600 m depth range but some deeper locations will be sampled as *C. harrissoni* has been captured deeper.

2. Collect catch composition (species, counts, catch-rate) data from each fishing operation. Validate catch of all dogfish species recorded with retained specimens (5) and photos for all locations.

3. Record shot details for each fishing line set (location, depth, hooks set).

4. Deploy replicate Baited Remote Underwater Video Systems (BRUVS) at all sites (as a secondary objective to the first 3 objectives).

Secondary objectives

5. Collect up to 100 tissue samples from each dogfish species captured per voyage leg.

6. If time permits, fit conventional tags onto vigorous gulper sharks and release.

7. University of Connecticut: Collect cestode parasites from *Squalus* species.

2. Dates and timing of survey

Leg one
Depart Brisbane 1400 hours, Tuesday 1st September 2009
Dock Sydney 1630 hours, Wednesday 16th September 2009

Leg two
Depart Sydney 1600 hours, Saturday 19th September 2009
Dock Hobart 0800 hours, Wednesday 7th October 2009

3. Vessel details

CSIRO chartered F.V. Diana – a Hobart based fishing vessel - for this mapping survey. The Diana is equipped with auto longline gear and licensed to fish in Commonwealth, SE non-trawl waters and the high seas. The master and crew are experienced longline fishermen. The vessel was built in 2004 at Hobart Tasmania. The vessel is 22.8 metres in length, constructed of steel and powered by a single 3406 Caterpiller Marine (460 hp) main engine. Auxiliary power is supplied by smaller engines (3056 Caterpillers) for hydraulics, 240 volt power, refrigeration and ice making machines. The vessel has berths for up to 8 and is owned by Mr Will Mure (Mures Fishing) and operated by Mr Russell Potter (Skippers 2, MED 2) who has 7 years experience auto-longline and 13 years in all demersal line fishing in different parts of Australia.

4. Fishing equipment

Setting and hauling the longline used a Mustad Coastal auto-line system with automatic baiting of 2 hooks per second whilst steaming at 5 knots. The mainline used was 7mm Mustad roto line (swivelled) with snoods at 1.4 m intervals, and 300 mm snoods (1.8 mm monofilament, woven and braided snoods). The hooks used were 12/0 Mustad 'super baiters'. The line was anchored at each end with 50 kg steel weights, extra weights (and floats) were deployed along the line according to terrain and to fish either hard on the bottom or off the bottom. Lines and surface floats marked the start and end of the line and were used to retrieve the longline. Squid (sourced from New Zealand and Tasmania) was used as the bait.

5. Survey summary

The survey was completed over 37 days and split over 2 legs with port time in Sydney mid survey. This period included sampling at Taupo Seamount with five days added to the vessel charter to cover this. Several days were lost to bad weather during leg 2 when shelter was sought in Disaster Bay and Eden with impending storm force wind warnings. The steaming distance covered (Brisbane to Hobart via Taupo Seamount) was considerable (~2800 kilometres) and steaming between sites following retrieval of the gears and processing of the catch, to arrive on site in time for the master to survey the site and fine-tune the location of the sets for the following morning.

Throughout the survey 23 sites were sampled (fig 1). Typically sampling at each site comprised 3 longline sets (1500 hooks per set) and 4 BRUVS deployments (table 1). Overall there were 68 longline sets, 94 BRUVS deployments and 19 dropline sets (~140 hooks per set). The setting of gears commenced ~0430 hours and retrieval of the first set longline commenced ~0730 hours providing a soak time of at least 3 hours. Hauling and catch processing generally was generally completed early afternoon.

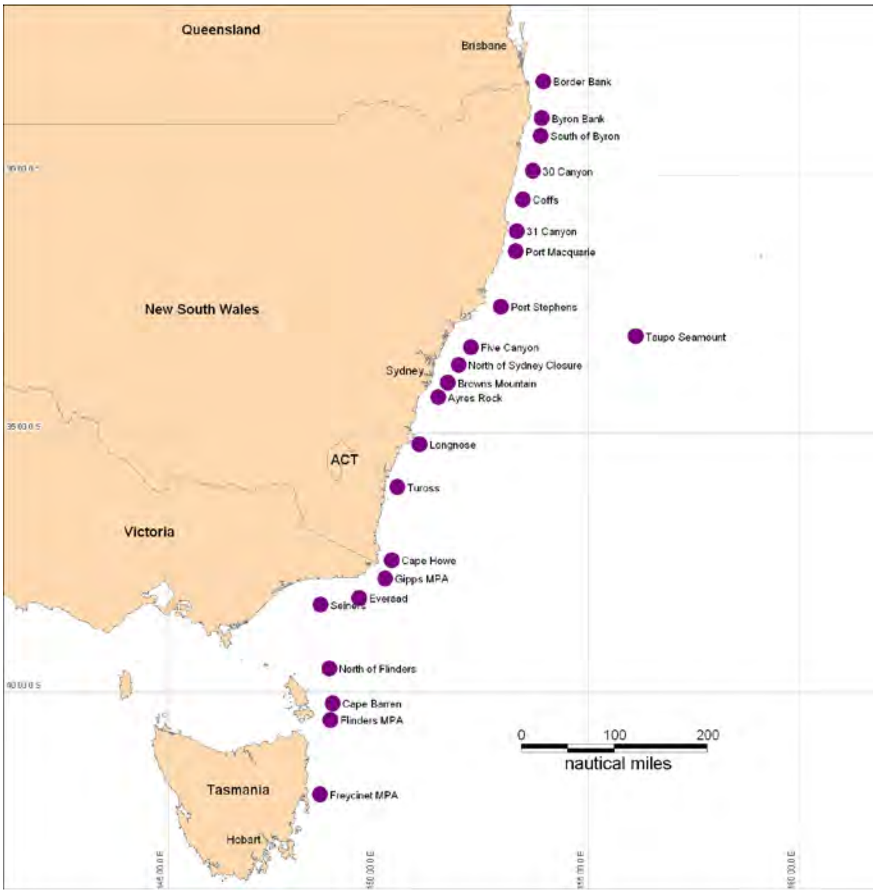


Fig 1 A map of all sampling sites completed during the survey.

Across the survey the total number of gulpers (*Centrophorus spp.*) caught was 780; with *C. harrissoni* (221), *C. moluccensis* (425), *C. zeehaani* (115), *C. squamosus* (18) and *C. niaukang* (1); most of which were measured, sexed, tagged (dorsal fin with Roto tag) and released (table 2, table 3). Some gulpers were kept for further taxonomic study. Small genetic tissue samples (tissue plug from dorsal fin tag hole) were collected for population genetic studies (table 4). Taxonomic samples for non-target species (including some sharks, skates and scale fish) were kept for further taxonomy work by scientists in Hobart. All of the catch was recorded with commercial species in particular counted and measured for length frequency data (table 5). Gonad staging data of female pink ling were collected from 86 fish from Everard Canyon with most stage 4 and 4+ (Fig 2).

Each BRUVS unit was baited using squid bait and deployed in the vicinity of the longline sets. In areas where there was considerable current the BRUVS were inclined to drag despite being heavily weighted. There were a few occasions where they became snagged when set on hard bottom; but all were retrieved and none lost throughout the survey. The BRUVS units provided stereo digital video with 2.5 hours recording per deployment. The video was downloaded to portable hard drive units with backups created as well. Preliminary viewing and data collection was started on board but most will be analysed by University WA staff back in the laboratory.

As per the vessel charter agreement, the catch and proceeds thereof belonged to CSIRO. At completion of leg 1 a small quantity of commercial scalefish (from Commonwealth Waters) was off-loaded in Sydney for market. At completion of the survey in Hobart the commercial catch from leg 2 (again only from Commonwealth waters) was sold (table 6). Scientific quota (AFMA permit) covered some quota species caught from Commonwealth waters. Our permit for fish caught in NSW waters only allowed a specified number to be kept for science and no commercial fishes could be marketed. Where there was no scientific quota or where the scientific quota was exceeded (e.g. ocean perch) - the catch was sold using Mures Fishing Co quota and the dollar-per-kilo cost of the quota was subtracted from the market price return.

The survey team was complemented by an AFMA staff member. Ms Sally Weekes *(Senior Management Officer, Fisheries Branch, Australian Fisheries Management Authority)* joined the vessel in Sydney for leg 2 and assisted processing (measuring and tagging) the catch. Sally's presence also allowed Sam McMillan (UWA) to spend more time viewing BRUVS footage during leg 2 rather than assisting with processing the catch.

A day-by-day voyage narrative is included in this voyage report.

6. Voyage Narrative

Tuesday 1st September

Load and depart from Raptis Seafoods wharf on Brisbane River 1400 hrs. Commence steaming around northern end of Moreton Island and then south towards first sampling station at Border Bank.

Wednesday 2nd September

Arrive at Border Bank 3 ~0500hrs, 3 hours earlier than anticipated due to 2 knot current running north to south. Master spent a bit of time running over the bottom to map out bottom to get best shot positions. Deployed 3 fleets of 1500 hooks each plus 4 camera operations (2 cameras at the end of Border Banks 1 and 2). Finished setting gear at 0830 hrs. Began hauling at 0930 and completed hauling the third fleet of hooks at approximately 1500 hrs. Only a single *Centrophorus moluccensis* captured on first shot. Most abundant was *Squalus albifrons*, some large "stingarees" (*Plesiobatus daviesi*), some blue eye, ocean perch and a few other scalefish in minor abundance. Overall, a low catch rate for everything. Steamed on to Byron Bank during evening. Arrived around 1900 hrs, steamed over ground to map out bottom and set shots up for next day.

Thursday 3rd September

Deployed 3 fleets of 1500 hooks each at the Byron Bank stations between 0416 and 0515 hrs. The shot at Byron Bank 3 was put in a bit to the east of the mark to get into the 300 – 600 metre depth (mark was in 200m). Two BRUVS units deployed between the hook fleets. Began hauling at 0700 and was completed by 1145. Note that because of current lines set Nth to Sth but hauled Sth to Nth. Recovered BRUVS between 1200 and 1330 then started steam to South of Byron stations.

Catch mostly elasmobranchs today. Thirty *C. moluccensis* on first fleet, 19 on second and 5 on third. Three *C. harrissoni* on first fleet (specimens retained). Lots of ghost shark (*Hydrolagus olgilbyi*) at these stations. Only a few Ocean perch, mostly over the hard bit of ground on the northern section of fleet 1 (operation 8). Collected biologicals from 25 specimens of *C. moluccensis* captured earlier today. A total of 50 genetic samples collected from *C. moluccensis*.

Two more BRUVS operations deployed close to first of South of Byron stations. These recovered at 1705. As the bottom is poorly marked on the swath the master spent a fair bit of time steaming over the station area to plan shots for tomorrow.

Friday 4th September

The weather picked up a bit overnight to a 30 knot north easterly making it a bit sloppy on the surface which pushed the boat along and made setting only possible with the weather (Nth to Sth). First fleet was put in a little further east (sloping but even bottom) of mark to get into right depth of about 500 metres. Second fleet set right across head of gully. When shooting the third fleet (shot 19) there was some problems shortly after starting and the gear had to be cut off and a new longline set The (reset) third fleet (now shot 20) was put in a little south and east of mark onto some reasonably flat bottom. On daybreak we pulled the aborted gear and set two BRUVS in similar position. Only 2 cameras set this morning as things will be a bit slower due to weather and time taken with aborted gear.

Finished hauling fleet 2 at 1022 then went and collected the deepest BRUVS unit which had been shifted about 1.5 km by currents and was drifting. We then completed hauling fleet 3 at 1245 and collected shallower BRUVS at 1320 hrs. Tide had carried southern end of fleet away from where it was set. Commenced steaming south to 30 Canyon site.

The first fleet produced 12 *C. harrissoni*, 15 *C. moluccensis,* 6 blue eye and some Ocean perch and a few other elasmobranchs spread fairly evenly over the shot. The second fleet had a low catch, dominated by small sharks (*Squalus albifrons* & *Etmopterus* spp.), mostly on the northern edge of the valley. The third fleet (much same as first fleet) had a lot of *C. moluccensis* and other sharks but no Harrissons, mostly in the northern 2/3 of the shot.

Arrived 30 Canyon site at 1800 hrs and began mapping out the bottom.

Saturday 5th September
Wind has eased a bit to around 15/20 knots south easterly and trough is moving away making it a bit nicer on surface. Based on effect of tide yesterday, the master suggests the current will carry the fishing line further south than originally set. Fleets set to take this into account. First fleet put in along steep edge and just above a small gutter feature in around 500 metres at 0400 hrs. Second fleet put in similar type of ground to first fleet, with southern end dipping down into head of small canyon. Third fleet put in on what looks like slightly less sloping bottom just above a big canyon head. Two BRUVS put in slightly shallower (to stop current dragging units away) in position between second and third fleets. Two more BRUVS similarly put in between fleets 1 and 2.

Finished hauling just after midday in fresh conditions and then went looking for the BRUVS which had drifted during the morning. Two were on their marks but the others had been carried south by the current up to 1.5 km away, despite a 25 knot southerly wind.

Fleet 1 produce six small *C. harrissoni* (46-55 cm) and fleet 2 produced a single adult male. The other catch was pretty much similar to the other days with the exception of a lot of *Hydrolagus ogilbyi on* the third fleet and a single specimen of *Centrophorus niaukung* (female, 150 cm) on the second. At around 1400 hrs we started punching south into the weather towards Coffs stations. Arrived Coffs 1700 and began mapping out bottom for shots tomorrow.

Sunday 6th September
First fleet put in crossing small valley feature around 450m either side and 570 m in the middle. Second fleet is on what looks like roughish, hard bottom (our bathymetry and backscatter) which maps out to be a fairly wide section of flat, smooth looking bottom ~ 450 m. Third fleet over a little bump @ 450 m and then dropping away to 535 m. Put two cameras in between fleets 1 and 2 to see how they would sit and so we can check on them after hauling first fleet. These were hauled after hauling first fleet (which had a massive tangle on northern end) and two more BRUVS put between fleet 2 and 3 then recovered after completing fishing.

Fifteen *C. harrissoni* were captured today (the first and last fish caught), 9, 2 and 4 on fleets 1, 2 and 3 respectively. A total of 84 *C. moluccensis* were also captured on the 3 fleets, most on the third. A lot of other sharks were also caught today, most notably 546 *Squalus grahami*. A few Ocean perch, some *Hydrolagus ogilbyi* and three blue eye comprised the commercial species. One *Plesiobatus daviesi* was captured, which apparently is the most southern record. Two specimens of a different skate, *Dipturas melanospilus,* appeared in the catch. Also a single specimen of *Etmopterus c.f. molleri,* which hasn't been caught so far.

After getting all gear on board we started steaming south at 1400 hrs towards the 31 Canyon stations. Arrived at site around 1800 and started mapping out the bottom.

Monday 7th September
First fleet down the side of small valley feature, 420 to 585 metres on softer bottom. Second fleet along contour in ~550 metres on semi-hard bottom. Third fleet across contour 530 to 430 metres on hard bottom. All these east of plan marks to get right depths. Two BRUVS were put in between fleet 1 and 2 but the weather and current were strong so we decided not to put any more in and check these after hauling the first fleet. As it turned out both cameras were dragged along, one ½ mile and the other 1.2 miles.

Strong currents and fresh northerly winds made locating floats difficult and all gear moved a long way during the morning. The mainline on fleet 3 broke during the haul and the gear was recovered from the other end. Lots of bent and missing hooks near the northern end suggesting very hard bottom.

Twenty one *C. harrissoni* were captured today, 13 on the third fleet. A total of 123 *C. moluccensis* were captured, 87 on the second fleet. Sixty gulper sharks were tagged today (including 19 Harrissons). Lots of other small sharks were also caught today. Tissue samples fixed in ethanol continue to be collected from Harrissons. Approximately 20 tissue samples were collected from each of the three main *Squalus* species, *S. grahami, S. albifrons* and *S. montalbani* and these put on ice in the fish room.

We arrived at the Port Macquarie stations about 1600 hrs and the master spent about 3 hours mapping out the bathymetry for shots tomorrow.

Tuesday 8th September
First fleet along the contour in 525 to 485 metres on patch of soft next to some hard bottom and near small rising feature. Second fleet in 590 – 470 metres over hard bottom and end of small rising feature. Third fleet in ~530 metres over long, thin rising feature (top 435 metres) which looks hard on backscatter. No cameras today due to strong currents and because steam down to next stations is around 60 miles.

Steaming up checking floats just after shooting and current had carried all shots a long way south already, though most look like they have “locked in” to the bottom. The northern end of fleet 1 is 1.3 miles south and the southern end is 1 mile south. Fleet 1 came up broken in the middle. Fleet 2 and 3 were both broken up with only about 750 hooks recovered from both, i.e. 2250 hooks lost with the main line.

One *C. harrissoni* and one *C. moluccensis* were was captured on fleet 1. Only 57 fish were caught on fleet 1. The combined catch from the remnants of fleets 2 & 3 was 21 fish. *Squalus albifrons* was the most abundant species today, with 7 of the 36 specimens being females, and 3 of these were mature. Today’s result represents “presence” for Harrisson’s gulper.

Heading south towards Catherine Hill Bay stations at 1100 hrs. Discussed with Ross on satellite phone and plan changed to head to Port Stephens stations.

Wednesday 9th September
Only two longline fleets set today as we are still unsure about the strength of the current. It appears a little slacker here. Both fleets on soft bottom on the ~500 metres contour. Gear in west of plan marks as these are too deep for the longline gear. First fleet put in along 500 metre depth contour on soft bottom. Second fleet aborted

aborted during deployment as a splice had not been made after about 400 hooks. Gear recovered[1] and second fleet reset along same bottom type and depth as fleet 1. After hauling both fleets two BRUVS put in just west of where fleet 2 was set. Four drop lines (~75 hooks) put into deeper water (640 - 690 m) just east of where fleet 2 was set (yellow diamond marks on maps).

A total of 46 *C. harrissoni* were captured today. Most (39) on the first fleet. The size ranged from 38 cm to 95 cm, with 12 specimens 50 cm or less in length. *Centrophorus moluccensis* was represented in the catch by 37 specimens, most on fleet 1. The rest of the days catch was dominated again by *S. grahami* and *S. albifrons* with a range of other elasmobranchs making up the total catch of 637 fish. The droplines did not catch anything.

After collecting all gear we started steaming east towards the Taupo seamount.

Thursday 10th September
Made first contact with depth 1500 metres at 1000 hrs, 160 metres (top of Taupo seamount) at 1015 hrs. Put in one camera on top and two drop lines along the eastern edge. Only one blue eye captured on one dropline. The rest of the time was spent mapping out the bottom to find some shots for tomorrow.

Friday 11th September
One fleet put in on a ledge along the north eastern edge of the seamount in ~330 metres. Six droplines put in laying alongside the edge (bottom ~500 m) just north of the longline. Two BRUVS were put in on the ledge and two more put in on the top. Later in the afternoon we put in two more droplines and two more BRUVS.

The longline was bitten or broken off after ~500 hooks were recovered. Despite searching the other end of the line could not be found. There was a lot of sharks on the hauled hooks; most of these (105) were *Squalus c.f. albifrons*, a bigger pointy nose variant of this species or perhaps a different species altogether. There were also four *C. harrissoni* on the line remnant, along with some blue eye, Bass groper and *S. c.f. megalops* (bigger than the inshore species). Two of the morning set droplines had no catch. Of the 31 fish on the other four morning set droplines, six were *C. harrissoni*. The rest of the catch on the droplines were mostly two species of *Etmopterus*, some blue eye, and a *Centroscymnus owstoni* . The two afternoon set droplines produced two *Etmopterus lucifer* and a pelagic armourhead (*Pseudopentaceros richardsoni*). One of the BRUVS recovered today was stuck hard on the bottom and eventually came up with a bent frame and some weights torn off. The frame was replaced with one of the spares.

The evening was spent mapping out the bottom to find some good and hopefully safe spots to put gear in tomorrow.

Saturday 12th September
The master got up extra early this morning and put in a “dummy line” to test the current direction prior to putting in the fishing gear. One fleet was put in along a wide ledge on the southern end of the seamount in 310 – 325 metres. Five[2] droplines were put in staggered along the steep edge at southern end. Four BRUVS put in similar depth and general location to longline.

[1] A rough count of hooks with bait on recovered line gave estimate of 2-3 hooks in 10 with no bait. ??
[2] Losing half of the longline yesterday means we don’t have enough big floats left to set 6 droplines today.

The longline was snagged on the bottom and both ends recovered but only 1/3 of the mainline was recovered. Two *C. harrissoni* were captured on about 500 hooks. The 5 droplines were all snagged on the bottom and managed to catch a few blue eye, some king terakahi and one *Squalus c.f. albifrons*. Two droplines caught nothing and 1 was broken after about 40 hooks. The seafloor on top of the seamount appears to be very hard and full of snags.

We unsuccessfully dragged the bottom with some weights for one hour hoping the snag up the lost middle section of the longline. At 1200 hrs we started steaming west for the Five Canyon site.

Sunday 13th September
Arrived Five Canyon site 1400 hrs and put four BRUVS in roughly the middle of the overall area. While the BRUVS were deployed, the master marked out part of the site for tomorrows longlines. BRUVS were recovered at after 1600 hrs. Some *Squalus* spp. sharks seen on video and bottom looks like soft sediments.

Monday 14th September
First fleet starting near edge of canyon and running along ~520 metre contour on gentle slope. Second fleet running along 560 metre contour on gentle slope. Third fleet running across (down into) fourth canyon, ~430 metres either side and 630 in deep. One BRUVS put into canyon, the other three on the slope. All soft bottom in this area.

Five *C. harrissoni* were captured today on the first two fleets, none on the third. Thirty five *C. moluccensis* were also caught, along with five *C. zeehanni* (first time captured this survey). The most dominant species were Ocean perch (302), *Squalus grahami* (212) and gummy shark (82, also first time captured this survey). The rest of the catch was a mixture of the species already caught with the additions of a single Briar shark (2.7 metres long, immature female), a foul-hooked thresher shark (not landed), some different skates and 2 hagfish. We also caught four species of *Etmopterus*!

After hauling the cameras we started steaming for the North of Sydney Closure site, arriving around 1600 hrs. The master marked out some depths for tomorrows shots.

Tuesday 15th September – North of Sydney closure
First fleet along 590 metre contour on soft, slightly sloping bottom. Second and third fleet set obliquely, 590 – 530 metres on same bottom type. Four BRUVS set across depth range 430 – 530 metres.

Very small and low abundance catches today. However, one *C. harrissoni* was captured on the third fleet. Four *C. zeehanni* and one *C. moluccensis* were also captured today. The most abundant species was Ocean perch then *S. montalbani*. Two species of *Etmopterus,* a *Deania quadrispinosa*, a gummy shark, some skates, a seven gill shark, a pink ling, some other *Squalus* spp. and some hagfish were also in the catch. Apart from hooks near the floats, a lot of the hooks had no bait and had hagfish slime on them, suggesting these creatures cleaned up a lot of baits. The BRUVS showed lots of hagfish attacking the bait bag.

After recovering the BRUVS at 1230 hrs we began steaming slowly towards the Browns Mountain site. We arrived at this site ~1500 hrs and started mapping out the bottom, dodging the five small recreational boats fishing on waters over the peak.

Wednesday 16th September - Browns Mountain.
First fleet in on flat area just to north of mountain, ~530 metres. Second fleet on eastern edge of main rise. Third fleet southwest of main mountain in reserve, 485 to 450 metres. Two BRUVS were set in the closure area near fleet 3, one set between fleets 1 and 2 and one positioned right on top of the mountain. Ocean perch was the dominant species captured (193 specimens) followed by *S. montalbani* (115). Three species of gulper shark were captured, *C. zeehaani* (88), *C. moluccenis* (9) and *C. harrissoni* (3). Among the other catch was 4 mandarin sharks, *Cirrhigaleus australis* and 2 blue eye (one very small).

After completing the haul we collected the BRUVS and steamed for Sydney harbour. Berthed alongside at the Piermont Fishermans Wharf at 1630 hours.

Thursday 17th September
In port (Sydney) reprovisioning and preparing for leg 2. Replaced lost gear

Friday 18th September
In port finalizing preparations

Saturday 19th September
Departed Sydney 1600 hours and steamed to Ayres Rock site. We found that the top of Ayres Rock was generally too deep so surveyed inshore of the feature on hard ground at the appropriate depth.

Sunday 20th September
Three fleets of hooks (3 x 1500 hooks) were set. Shot 106 was across areas of higher and low backscatter on gently sloping bottom. Shot 107 mostly on an area of gently sloping harder bottom. Shot 108 on generally low backscatter soft and gently sloping bottom. BRUVS were deployed along a line between longline shots 107 and 108 and covering the depths the longline sets traversed. The catch at this site was dominated by swell sharks (180), and dogfishes *S. grahami* (88), *S. megalops* (61)) with only one gulper (*C. harrissoni*) landed. Once the catch was recorded etc and the BRUVS retrieved we steamed south to the next site. We surveyed the site during the late evening hours in preparation for the next mornings sampling.

Monday 21st September
Shot 113 was on an area of low backscatter to the south of the canyon, 114 traversed the canyon with generally low backscatter but some indication of hardness. Shot 115 was to the north of the canyon on generally low backscatter. Two BRUVS were set to the north of the canyon and the other two to the south of the canyon at the Longnose Canyon site. The catch at Longnose was dominated by swell sharks (217) and ocean perch (112). The catch of gulpers included *C. harrissoni* (3), *C. zeehani* (6) and *C. moluccensis* (1).

Tuesday 22nd September
Shot 120 was on hard ground to the north of the main canyon but coinciding with a shallower canyon feature. Shot 121 was on low backscatter bottom on gently sloping bottom. Shot 122 transversed the head of the Tuross Canyon. The BRUVS were set in a line north of the canyon. Strong currents limited where we could safely deploy the BRUVS. The catch at the Tuross site was dominated by swell sharks (110) and ocean perch (125) with some pink ling (25) . The shark catch included *C. squamosus* (10), *S. megalops* (19), *C. harrissoni* (1) and *C. zeehani* (3). We steamed south to the next site (Tathra Canyon) during the late afternoon. It was obvious the weather was building to a change and the forecast was ominous with storm warnings for our area of operation and dust settling on the vessel whilst we

were offshore. We decided that we should head for shelter ahead of the forecast 40-50 knot winds so set a course towards Disaster Bay.

Wednesday 23rd September
Arrive Disaster Bay ~0600 hours after steaming from the Tathra Canyon site following storm wind warnings for this area. Anchored for the day in the south west corner of Disaster Bay. As predicted very windy conditions prevailed throughout the day.

Thursday 24th September
Remained anchored at Disaster Bay for most of the day with an easing of the winds during the afternoon. Departed the Disaster Bay anchorage at about 1600 hours and steamed to the Cape Howe site which we surveyed in preparation for the next mornings sampling.

Friday 25th September
This site generally consists of moderately hard ground with 'canyon features' at the southern end. Shot 127 was across a canyon and shots 128 and 129 to the north on gently sloping and undulating bottom. The BRUVS were set with two south on the harder ground and on the ridge of the canyons. two to the north adjacent to the longlines and in similar depths. Whilst hauling shot 127 the longline became pinned to the bottom and broke. We attempted to haul from the other end and it eventually pulled free but with the loss of ~900 hooks. The catch from the Cape Howe site was dominated by ocean perch (283), ribaldo (78) and ling (56). The catch of gulpers included *C. zeehani* (7), *C. harrissoni* (3) and *C. squamosus* (10).
We steamed to the Gippsland MPA site during the afternoon and proceeded to survey in preparation for sampling the next morning. Again the forecast was not good with storm warnings and 8 meter seas predicted. Later in the evening conditions worsened and we decided to steam back to Eden for shelter as it was considered too risky to go to Lakes Entrance and negotiate the bar-way in the prevailing conditions.

Saturday 26th September
We arrived at Eden during the early hours (~0215 hours) and berthed at the fisherman's wharf. As predicted the wind increased from early morning and remained strong to gale force all day.

Sunday 27th September
We remained berthed at Eden for the day with 50+ knot wind and rain squalls scudding across the bay.

Monday 28th September
In Eden again today with the hope of sailing in the evening but the forecast remained poor and the wind maintained at 30-35 knots all afternoon. Following the updated forecast in the late afternoon we decided it would be unwise to head out into the sea conditions that would have built and been maintained throughout the day.

Tuesday 29th September
We remained berthed at Eden for the day with weather conditions easing during the day. Departed Eden ~1600 hours and steamed to the Gippsland MPA site into a southerly sea.

Wednesday 30th September
The three longline sets at the Gippsland MPA site traversed moderately hard and sloping terrain where the backscatter map showed evidence of ridges of hardness. *Note that these shots were inshore of but adjacent to the current Gippsland MPA*

boundary. Two BRUVS were set adjacent and slightly deeper than shot 134 with the other two units slightly shallower and adjacent to the northern longline (shot 136). The catch was dominated by ocean perch (164), ribaldo (129) and ling (50) with a few blue eye (15) and swell sharks (23). Only two gulper sharks (*Centrophorus zeehaani*) were landed at this site. Following the retrieval of the four BRUVS we steamed eastwards to the Everard Canyon site. The master was familiar with the canyon but his knowledge was mainly at the head of the canyon and further north than our proposed sampling sites. He felt that we could expect large catches of ling at the head of the canyon at this time of the year. We proceeded to map the site in preparation for the next mornings setting of gear.

Thursday 1st October
At Everard Canyon longline shot 141 was mostly on low backscatter steeply sloping terrain, shot 142 across high backscatter steeply sloping and shot 143 on mostly low backscatter moderately sloping terrain. Two BRUVS sets were on high backscatter areas and two on low backscatter ground. Overall the catch was dominated by ocean perch (180), pink ling (149) and swell sharks (64). Only two gulpers *(Centrophorus harrissoni)* were landed. We staged the ling ovaries for maturity and also retained gonad material for later inspection as there was interest in determining whether the ling were of a spawning aggregation. The BRUVS were retrieved and we steamed to the next site (Seiners Canyon) where several hours were spent mapping the head of the canyon in preparation for the next days shots. Pre-existing swath data didn't extend to the head of this canyon the overall distribution of hard and soft ground was unknown.

Friday 2nd October
As per the general instruction (industry tip) for the Seiners Canyon site we set the longlines at the head of the canyon on what appeared to be relatively soft bottom. The BRUVS were set in a line adjacent to the deeper end of the longline shots. The longline catch was dominated by pink ling (491) with generally less diversity in the catch than at other sites. The catch included ocean perch (23), a few skates (12), ocean perch (23), swell sharks (4), gummy sharks (2) and little else. No gulper sharks were landed at this site although it was a site provided by industry as being a likely location to catch them. Perhaps with so many ling the gulpers didn't get a chance to take the baits? At one stage during the hauling we had to pause whilst the deck was cleared of the large catch of ling many of which were large. Many of the ling were inspected to gauge sexual maturity and closeness to spawning. The BRUVS were retrieved and we proceeded to steam to the next site where we arrived late in the evening and mapped the ground in preparation for next mornings sets.

Saturday 3rd October
The North Flinders site backscatter map showed extensive areas of high backscatter. Longline shot 155 traversed some high backscatter patches, shots 156 and 157 were mostly on the extensive hard ground patches. Two BRUVS were set near the significant canyon feature to the south and where there was a transition from hard to soft ground (near longline 157) and the other two set on an extensive patch of moderately hard ground to the north of longline 156. Notably the catch from this site yielded 70 gulpers (*Centrophorus harrissoni*) with 30 caught on shot 155, 37 on shot 156 and 3 on shot 157. Otherwise the catch was dominated by ocean perch (301), swell sharks (152), blue eye (50), ling (35), ribaldo (29) and lantern sharks (48). Following the haul of the longlines the BRUVS were retrieved and we steamed south to the Cape Barren site.

Sunday 4th October
The first longline set (shot 161) at the Cape Barren site was just to the north of a canyon on mixed backscatter bottom, shot 162 was just to the south of the canyon and shot 163 was further south and across a ridge showing areas of high backscatter. The four BRUVS were deployed between shots 162 and 163 on an area showing mixed hardness. The catch was dominated by ocean perch (137) and pink ling (131) with some blue eye (52) and swell sharks (58). Nine gulper sharks (*Centrophorus harrissoni*) were landed. Following retrieval of the BRUVS we steamed south to the next sampling site.

Monday 5th October
During the early hours of the morning we had problems with the vessels mapping and navigation system due to a computer failure. We were forced to set the gear without the mapping of the previous evening and relied on the swath bathymetry map for positions. This resulted in the gear being set later in the morning than usual and in slightly deeper waters. The deepness of the set was compounded by the unpredictability of the tidal set which carried the lines into deeper water. Consequently the catch reflected the deeper set with ribaldo (541) dominating and other deep water species evident (oreo dory, kitefin and briar sharks and whiptails). Otherwise there was the usual dominant species with pink ling (52), ocean perch (77), swell sharks (19). The BRUVS were retrieved and we steamed south to the final sampling site for the survey within the Freycinet MPA.

Tuesday 6th October
During the night the weather conditions worsened due to strong southerly winds and with seas building. We set the longlines and BRUVS on generally gently sloping bottom with some signs of hardness. It soon became apparent that the current from the south was strong and the gear was dragging. There were substantial tangles in the longlines and a couple of the BRUVS dragged. We expect that the generally low catch rates for the longline sets were the result of the tangles and the gear dragging. Russell also noted that he generally finds that catches are down when currents are strong. The small catch overall was dominated by ocean perch (23), pink ling (22) and ribaldo (25). No gulpers were landed. The BRUVS were retrieved and as noted some had moved significant distances throughout the set. This completed the sampling and we commenced the steam to Hobart.

Wednesday 7th October
Steamed throughout the night and berthed at the Hobart CSIRO wharf at 0800 hours to unload personnel, samples and equipment. The commercial catch was offloaded at the main wharf to be sold.

7. Acknowledgements

Special thanks to the Mr Russell Potter (master), Gerald, Kyle, Dan and Bern (crew) for running the vessel and fishing operations in a professional manner and also for being a willing and happy team throughout a long survey. We also thank Mr Will Mure (Director Mures Fishing Company) for the charter the vessel and also being flexible enough to allow the charter to continue for extra days to enable completion of the work. We thank FRDC for the funding of this survey through the project.

8. Staff

Mr Mark Green	CSIRO	Voyage leader (leg 1)
Mr Bruce Barker	CSIRO	Voyage leader (leg 2)
Ms Sally Weekes	AFMA	Observer (leg 2)
Dr Ken Graham	Consultant	Taxonomy
Mr Sam McMillan	University of WA	Baited camera system (BRUVS)
Mr Russell Potter	FV Diana	Master
Mr Gerald Knight	FV Diana	Mate
Mr Daniel Wignal	FV Diana	Deck
Mr Kyle Brown	FV Diana	Deck
Mr Bernard Hill	FV Diana	Deck (leg 2)

Table 1. A summary table showing the number BRUVS deployed per site and the approximate number of hours of video collected.

Site name	**BRUVS Operations**	**BRUVS Hours @2.5 per set**
Border Bank	4	10
Byron Bank	4	10
South of Byron	4	10
30 Canyon	4	10
Coffs	4	10
31 Canyon	2	5
Port Macquarie	0	0
Port Stevens	2	5
Taupo seamount	10	25
Five Canyon	8	20
North of Sydney closure	4	10
Browns Mountain	4	10
Ayers Rock	4	10
Longnose Canyon	4	10
Tuross Canyon	4	10
Cape Howe	4	10
Gipps MPA	4	10
Everard Canyon	4	10
Seiners Canyon	4	10
North of Flinders	4	10
Cape Barren	4	10
Flinders Closure	4	10
Freycinet MPA	4	10
Total	**94**	**235**

Table 2. Summary numbers of *Centrophorus sp.* caught

Site	Centrophorus harrissoni	Centrophorus moluccensis	Centrophorus niaukang	Centrophorus squamosus	Centrophorus zeehaani
Border Bank		1			
Byron Bank	3	67			
South of Byron	12	52			
30 Canyon	7	13	1		
Coffs	15	84			
31 Canyon	21	123			
Port Macquarie	1	2			
Port Stevens	46	37			
Taupo Seamount	12				
Five Canyon	5	35			5
North of Sydney closure	1	1			4
Browns Mountain	3	9			88
Ayres Rock	1				
Longnose Canyon	3	1			6
Tuross Canyon	1			8	3
Cape Howe	3			10	7
Gipps MPA					2
Everard Canyon	2				
Seiners Canyon					
North Flinders	70				
Cape Barren	9				
Flinders MPA	6				
Freycinet MPA					
Totals	**221**	**425**	**1**	**18**	**115**

Table 3. The number of fin tags (Roto) deployed on gulper sharks throughout the survey

	C. moluccensis	*C. harrissoni*	*C. zeehaani*
Female	122	48	27
Male	65	35	37
Totals	187	83	64

Table 4. The number of flesh samples collected from dogfishes for genetics studies

Species	Samples held			
	EtOH Lab	**EtOH Sea**	**Frozen**	**Total**
Centrophorus harrissoni	20	87		107
Centrophorus moluccensis	13	81		94
Centrophorus squamosus	9			9
Centrophorus zeehaani	3	35		38
Squalus albifrons	61		21	82
Squalus grahami	57		24	81
Squalus montalbani	151		25	176
Total	**314**	**203**	**70**	587

Table 5 A list of all sampling sites throughout the survey with supporting information re date, time, gear, latitude, longitude and depth.

Site name	Date	Time (hhmm)	Op#	Type	Hooks set	Start set position Latitude	Longitude	Depth (m)	End set position Latitude	Longitude	Depth (m)
Border Bank	2-Sep	0640	**1**	Longline	1500	-28.1709	153.9418	420	-28.1849	153.9312	350
Border Bank	2-Sep	0659	**2**	BRUVS		-28.1927	153.9303	350			
Border Bank	2-Sep	0708	**3**	BRUVS		-28.1984	153.9327	360			
Border Bank	2-Sep	0727	**4**	Longline	1500	-28.2242	153.9103	320	-28.2408	153.9008	470
Border Bank	2-Sep	0747	**5**	BRUVS		-28.2447	153.8965	580			
Border Bank	2-Sep	0755	**6**	BRUVS		-28.2389	153.893	470			
Border Bank	2-Sep	0813	**7**	Longline	1500	-28.2787	153.8828	400	-28.294	153.8924	455
Byron Bank	3-Sep	0415	**8**	Longline	1500	-28.9116	153.8872	440	-28.9293	153.8861	470
Byron Bank	3-Sep	0437	**9**	Longline	1500	-28.9434	153.8847	470	-28.9618	153.8836	460
Byron Bank	3-Sep	0501	**10**	Longline	1500	-28.9809	153.8831	440	-28.9979	153.8867	440
Byron Bank	3-Sep	0534	**11**	BRUVS		-28.9711	153.8841	465			
Byron Bank	3-Sep	0541	**12**	BRUVS		-28.9729	153.8802	380			
Byron Bank	3-Sep	0605	**13**	BRUVS		-28.9375	153.8856	480			
Byron Bank	3-Sep	0611	**14**	BRUVS		-28.9374	153.8807	270			
Sth of Byron	4-Sep	1504	**15**	BRUVS		-29.1636	153.872	475			
Sth of Byron	4-Sep	1508	**16**	BRUVS		-29.1613	153.8701	440			
Sth of Byron	4-Sep	0409	**17**	Longline	1500	-29.1688	153.8802	500	-29.1861	153.8755	480
Sth of Byron	4-Sep	0433	**18**	Longline	1500	-29.1891	153.8578	370	-29.2093	153.8535	420
Sth of Byron	4-Sep	0458	**19**	Longline	aborted	-29.2165	153.8677	565	-29.2223	153.8675	abort
Sth of Byron	4-Sep	0511	**20**	Longline	1500	-29.2298	153.8672	480	-29.2455	153.6528	490
Sth of Byron	4-Sep	0640	**21**	BRUVS		-29.2222	153.8681	505			
Sth of Byron	4-Sep	0647	**22**	BRUVS		-29.2229	153.8643	440			
30 Canyon	5-Sep	0404	**23**	Longline	1500	-29.9288	153.681	480	-29.9433	153.6713	465
30 Canyon	5-Sep	0429	**24**	Longline	1500	-29.9638	153.6619	470	-29.9787	153.6497	500
30 Canyon	5-Sep	0452	**25**	Longline		-29.9886	153.6422	480	-29.9979	153.6289	440
30 Canyon	5-Sep	0523	**26**	BRUVS		-29.9823	153.6409	380			
30 Canyon	5-Sep	0531	**27**	BRUVS		-29.9766	153.6434	360			
30 Canyon	5-Sep	0549	**28**	BRUVS		-29.9531	153.6605	400			
30 Canyon	5-Sep	0555	**29**	BRUVS		-29.9493	153.6623	400			
Coffs	6-Sep	0426	**30**	Longline	1500	-30.4259	153.4342	440			
Coffs	6-Sep	0450	**31**	Longline	1500	-30.4632	153.4307	450	-30.4814	153.4379	470
Coffs	6-Sep	0520	**32**	Longline	1500	-30.5105	153.4232	455	-30.5269	153.4206	535

Site name	Date	Time (hhmm)	Op#	Type	Hooks set	Start set position Latitude	Start set position Longitude	Start set position Depth (m)	End set position Latitude	End set position Longitude	End set position Depth (m)
Coffs	6-Sep	0617	**33**	BRUVS		-30.4515	153.4311	440			
Coffs	6-Sep	0625	**34**	BRUVS		-30.4517	153.428	430			
Coffs	6-Sep	0930	**35**	BRUVS		-30.4888	153.4306	460			
Coffs	6-Sep	0937	**36**	BRUVS		-30.4921	153.4277	450			
31 Canyon	7-Sep	0425	**37**	Longline	1500	-31.0779	153.312	420	-31.0956	153.3023	585
31 Canyon	7-Sep	0453	**38**	Longline	1500	-31.1097	153.3305	550	-31.1301	153.3305	510
31 Canyon	7-Sep	0515	**39**	Longline	1500	-31.1444	153.3337	530	-31.1596	153.3216	430
31 Canyon	7-Sep	0601	**40**	BRUVS		-31.1198	153.3218	460			
31 Canyon	7-Sep	0607	**41**	BRUVS		-31.1201	153.3178	440			
Pt Macquarie	8-Sep	0412	**42**	Longline		-31.4013	153.2876	525	-31.4214	153.2848	485
Pt Macquarie	8-Sep	0432	**43**	Longline		-31.4337	153.2808	490	-31.4559	153.2707	470
Pt Macquarie	8-Sep	0455	**44**	Longline		-31.4672	153.2753	530	-31.4881	153.2719	500
Pt Stephens	9-Sep	0500	**45**	Longline	1500	-32.5064	152.9199	510	-32.5221	153.9104	500
Pt Stephens	9-Sep	0523	**46**	Longline	aborted	-32.5395	152.9013	515			
Pt Stephens	9-Sep	0611	**47**	Longline	1500	-32.5385	152.902	515	-32.5562	153.8913	515
Pt Stephens	9-Sep	1145	**48**	BRUVS		-32.5412	152.8895	420			
Pt Stephens	9-Sep	1150	**49**	BRUVS		-32.5404	152.8936	445			
Pt Stephens	9-Sep	1200	**50**	Dropline	75	-32.5466	152.9094	640			
Pt Stephens	9-Sep	1203	**51**	Dropline	77	-32.548	152.9122	660			
Pt Stephens	9-Sep	1208	**52**	Dropline	74	-32.5552	152.9132	695			
Pt Stephens	9-Sep	1211	**53**	Dropline	82	-32.5554	152.9093	660			
Taupo Sm	10-Sep	1027	**54**	BRUVS		-33.1281	156.1272	145			
Taupo Sm	10-Sep	1059	**55**	Dropline	95	-33.109	156.0962	570			
Taupo Sm	10-Sep	1102	**56**	Dropline	97	-33.1116	156.0943	560			
Taupo Sm	11-Sep	0410	**57**	Longline	1500	-33.1121	156.2884	345	-33.1262	156.2906	330
Taupo Sm	11-Sep	0437	**58**	Dropline	153	-33.1058	156.2873	575			
Taupo Sm	11-Sep	0445	**59**	Dropline	125	-33.1022	156.2829	500			
Taupo Sm	11-Sep	0450	**60**	Dropline	115	-33.0987	156.281	510			
Taupo Sm	11-Sep	0455	**61**	Dropline	152	-33.0943	156.2804	505			
Taupo Sm	11-Sep	0500	**62**	Dropline	132	-33.0902	156.2805	525			
Taupo Sm	11-Sep	0505	**63**	Dropline	123	-33.0862	156.2784	500			
Taupo Sm	11-Sep	0514	**64**	BRUVS		-33.0895	156.2668	310			
Taupo Sm	11-Sep	0520	**65**	BRUVS		-33.0918	156.2625	295			
Taupo Sm	11-Sep	0534	**66**	BRUVS		-33.0997	156.2311	133			
Taupo Sm	11-Sep	0537	**67**	BRUVS		-33.1015	156.2277	135			

						Start set position			End set position		
Site name	Date	Time (hhmm)	Op#	Type	Hooks set	Latitude	Longitude	Depth (m)	Latitude	Longitude	Depth (m)
Taupo Sm	11-Sep	1431	**68**	Dropline	154	-33.3559	156.1212	490			
Taupo Sm	11-Sep	1437	**69**	Dropline	149	-33.3576	156.1167	600			
Taupo Sm	11-Sep	1445	**70**	BRUVS		-33.3493	156.116	335			
Taupo Sm	12-Sep	0355	**71**	Longline	1500	-33.3449	156.1252	325	-33.3337	156.1106	
Taupo Sm	12-Sep	0429	**72**	Dropline	143	-33.3555	156.1306	405			
Taupo Sm	12-Sep	0433	**73**	Dropline	155	-33.355	156.1334	400			
Taupo Sm	12-Sep	0437	**74**	Dropline	122	-33.3552	156.137	420			
Taupo Sm	12-Sep	0442	**75**	Dropline	130	-33.357	156.1406	460			
Taupo Sm	12-Sep	0447	**76**	Dropline	148	-33.3569	156.1454	520			
Taupo Sm	12-Sep	0500	**77**	BRUVS		-33.3395	156.1338	310			
Taupo Sm	12-Sep	0506	**78**	BRUVS		-33.3353	156.1277	305			
Taupo Sm	12-Sep	0512	**79**	BRUVS		-33.3288	156.1209	310			
Taupo Sm	12-Sep	0517	**80**	BRUVS		-33.3249	156.1174	305			
Five Canyon	13-Sep	1409	**81**	BRUVS		-33.3185	152.2091	440			
Five Canyon	13-Sep	1413	**82**	BRUVS		-33.3225	152.2084	460			
Five Canyon	13-Sep	1418	**83**	BRUVS		-33.3268	152.2083	485			
Five Canyon	13-Sep	1423	**84**	BRUVS		-33.3298	152.2034	475			
Five Canyon	14-Sep	0416	**85**	Longline	1500	-33.3155	152.2192	560	-33.3291	152.2096	511
Five Canyon	14-Sep	0438	**86**	Longline	1500	-33.3407	152.2053	560	-33.3512	152.1926	550
Five Canyon	14-Sep	0501	**87**	Longline	1500	-33.3587	152.1704	480	-33.3678	152.155	445
Five Canyon	14-Sep	0524	**88**	BRUVS		-33.3577	152.1578	480			
Five Canyon	14-Sep	0533	**89**	BRUVS		-33.3487	152.1768	435			
Five Canyon	14-Sep	0540	**90**	BRUVS		-33.3456	152.1886	485			
Five Canyon	14-Sep	0547	**91**	BRUVS		-33.3521	152.1838	500			
Nth Sydney cl.	15-Sep	0428	**92**	Longline		-33.6542	151.9564	590	-33.6663	151.9469	590
Nth Sydney cl	15-Sep	0450	**93**	Longline		-33.679	151.9361	590	-33.6832	151.9204	530
Nth Sydney cl	15-Sep	0513	**94**	Longline		-33.6997	151.9213	595	-33.2041	151.9046	530
Nth Sydney cl	15-Sep	0536	**95**	BRUVS		-33.6944	151.8888	430			
Nth Sydney cl	15-Sep	0542	**96**	BRUVS		-33.6949	151.8965	460			
Nth Sydney cl	15-Sep	0549	**97**	BRUVS		-33.6942	151.905	495			
Nth Sydney cl	15-Sep	0555	**98**	BRUVS		-33.6929	151.9131	530			
Browns Mt	16-Sep	0411	**99**	Longline		-34.0066	151.6804	525	-34.0194	151.6701	530
Browns Mt	16-Sep	0425	**100**	Longline		-34.0293	151.6672	540	-34.0427	151.6615	580
Browns Mt	16-Sep	0501	**101**	Longline		-34.0435	151.6295	485	-34.0526	151.6144	450
Browns Mt	16-Sep	0525	**102**	BRUVS		-34.0395	151.6213	430			

Site name	Date	Time (hhmm)	Op#	Type	Hooks set	Start set position Latitude	Start set position Longitude	Start set position Depth (m)	End set position Latitude	End set position Longitude	End set position Depth (m)
Browns Mt	16-Sep	0530	**103**	BRUVS		-34.0389	151.6247	445			
Browns Mt	16-Sep	0545	**104**	BRUVS		-34.0243	151.6676	520			
Browns Mt	16-Sep	0555	**105**	BRUVS							
Ayers Rock	20-Sep	0430	**106**	Longline	1500	-34.283	151.465	586	-34.289	151.449	475
Ayers Rock	20-Sep	0450	**107**	Longline	1500	-34.303	151.443	485	-34.311	151.428	440
Ayers Rock	20-Sep	0515	**108**	Longline	1500	-34.33	151.433	540	-34.341	151.42	505
Ayers Rock	20-Sep	0540	**109**	BRUVS		-34.327	151.415	430			
Ayers Rock	20-Sep	0545	**110**	BRUVS		-34.325	151.424	470			
Ayers Rock	20-Sep	0550	**111**	BRUVS		-34.32	151.431	490			
Ayers Rock	20-Sep	0600	**112**	BRUVS		-34.319	151.439	520			
Longnose Canyon	21-Sep	0410	**113**	Longline	1500	-35.241	150.971	450	-35.226	150.987	510
Longnose Canyon	21-Sep	0432	**114**	Longline	1500	-35.219	150.984	430	-35.201	150.989	385
Longnose Canyon	21-Sep	0458	**115**	Longline	1500	-35.206	150.996	500	-35.189	150.008	520
Longnose Canyon	21-Sep	0525	**116**	BRUVS		-35.192	150.999	440			
Longnose Canyon	21-Sep	0530	**117**	BRUVS		-35.194	151	470			
Longnose Canyon	21-Sep	0555	**118**	BRUVS		-35.223	150.982	460			
Longnose Canyon	21-Sep	0600	**119**	BRUVS		-35.222	150.983	460			
Tuross Canyon	22-Sep	0410	**120**	Longline	1500	-36.026	150.475	500	-36.041	150.47	515
Tuross Canyon	22-Sep	0430	**121**	Longline	1500	-36.049	150.463	510	-36.065	150.452	505
Tuross Canyon	22-Sep	0450	**122**	Longline	1500	-36.07	150.435	370	-36.088	150.431	450
Tuross Canyon	22-Sep	0530	**123**	BRUVS		-36.065	150.447	450			
Tuross Canyon	22-Sep	0535	**124**	BRUVS		-36.062	150.449	440			
Tuross Canyon	22-Sep	0540	**125**	BRUVS		-36.057	150.451	430			
Tuross Canyon	22-Sep	0550	**126**	BRUVS		-36.052	150.453	430			
Cape Howe	25-Sep	0420	**127**	Longline	1500	-37.486	150.315	480	-37.471	150.322	550
Cape Howe	25-Sep	0440	**128**	Longline	1500	-37.459	150.325	480	-37.443	150.329	480
Cape Howe	25-Sep	0500	**129**	Longline	1500	-37.431	150.331	475	-37.414	150.334	500
Cape Howe	25-Sep	0525	**130**	BRUVS		-37.415	150.331	450			
Cape Howe	25-Sep	0530	**131**	BRUVS		-37.42	150.329	450			
Cape Howe	25-Sep	0545	**132**	BRUVS		-37.461	150.33	555			
Cape Howe	25-Sep	0555	**133**	BRUVS		-37.472	150.328	570			
Gipps MPA	30-Sep	0425	**134**	Longline	1500	-37.838	150.14	500	-37.828	150.157	550
Gipps MPA	30-Sep	0450	**135**	Longline	1500	-37.816	150.168	500	-37.807	150.182	450
Gipps MPA	30-Sep	0510	**136**	Longline	1500	-37.805	150.194	510	-37.793	150.206	515
Gipps MPA	30-Sep	0530	**137**	BRUVS		-37.791	150.201	485			

Site name	Date	Time (hhmm)	Op#	Type	Hooks set	Start set position Latitude	Longitude	Depth (m)	End set position Latitude	Longitude	Depth (m)
Gipps MPA	30-Sep	0335	**138**	BRUVS		-37.794	150.194	440			
Gipps MPA	30-Sep	0600	**139**	BRUVS		-37.832	150.162	530			
Gipps MPA	30-Sep	0605	**140**	BRUVS		-37.835	150.159	530			
Everard Canyon	1-Oct	0410	**141**	Longline	1500	-38.164	149.514	430	-38.173	149.526	460
Everard Canyon	1-Oct	0425	**142**	Longline	1500	-38.181	149.536	460	-38.192	149.548	510
Everard Canyon	1-Oct	0455	**143**	Longline	1500	-38.211	149.564	480	-38.224	149.577	485
Everard Canyon	1-Oct	0525	**144**	BRUVS		-38.203	149.561	470			
Everard Canyon	1-Oct	0530	**145**	BRUVS		-38.205	149.556	515			
Everard Canyon	1-Oct	0540	**146**	BRUVS		-38.187	149.549	400			
Everard Canyon	1-Oct	0545	**147**	BRUVS		-38.185	149.546	420			
Seiners Canyon	2-Oct	0410	**148**	Longline	1500	-38.327	148.639	540	-38.312	148.637	445
Seiners Canyon	2-Oct	0440	**149**	Longline	1500	-38.324	148.633	580	-38.309	148.632	415
Seiners Canyon	2-Oct	0505	**150**	Longline	1500	-38.326	148.628	470	-38.309	148.625	380
Seiners Canyon	2-Oct	0530	**151**	BRUVS		-38.333	148.628	450			
Seiners Canyon	2-Oct	0540	**152**	BRUVS		-38.334	148.633	510			
Seiners Canyon	2-Oct	0550	**153**	BRUVS		-38.334	148.64	590			
Seiners Canyon	2-Oct	0555	**154**	BRUVS		-38.332	148.646	500			
N Flinders	3-Oct	0415	**155**	Longline	1500	-39.516	148.816	450	-39.53	148.829	460
N Flinders	3-Oct	0445	**156**	Longline	1500	-39.556	148.84	570	-39.574	148.846	*500
N Flinders	3-Oct	0515	**157**	Longline	1500	-39.607	148.851	480	-39.624	148.85	510
N Flinders	3-Oct	0540	**158**	BRUVS		-39.626	148.849	480			
N Flinders	3-Oct	0545	**159**	BRUVS		-39.625	148.84	450			
N Flinders	3-Oct	0600	**160**	BRUVS		-39.596	148.847	480			
N Flinders	3-Oct	0605	**161**	BRUVS		-39.593	148.849	510			
Cape Barren	4-Oct	0415	**162**	Longline	1500	-40.193	148.921	475	-40.205	148.905	460
Cape Barren	4-Oct	0435	**163**	Longline	1500	-40.205	148.905	580	-40.237	148.915	460
Cape Barren	4-Oct	0500	**164**	Longline	1500	-40.625	148.915	480	-40.282	148.912	510
Cape Barren	4-Oct	0530	**165**	BRUVS		-40.259	148.911	430			
Cape Barren	4-Oct	0535	**166**	BRUVS		-40.257	148.916	515			
Cape Barren	4-Oct	0540	**167**	BRUVS		-40.255	148.908	425			
Cape Barren	4-Oct	0545	**168**	BRUVS		-40.253	148.913	490			
Flinders Closure	5-Oct	0425	**169**	Longline	1500	-40.5	148.89	520	-40.508	148.872	500
Flinders Closure	5-Oct	0500	**170**	Longline	1500	-40.559	148.869	580	-40.568	148.855	530
Flinders Closure	5-Oct	0530	**171**	Longline	1500	-40.587	148.853	490	-40.602	148.844	*500
Flinders Closure	5-Oct	0555	**172**	BRUVS		-40.584	148.862	580			

Site name	Date	Time (hhmm)	Op#	Type	Hooks set	Start set position Latitude	Longitude	Depth (m)	End set position Latitude	Longitude	Depth (m)
Flinders Closure	5-Oct	0600	**173**	BRUVS		-40.584	148.858	470			
Flinders Closure	5-Oct	0605	**174**	BRUVS		-40.585	148.849	460			
Flinders Closure	5-Oct	0610	**175**	BRUVS		-40.586	148.847	450			
Freycinet MPA	6-Oct	0425	**176**	Longline	1500	-41.921	148.626	440	-41.933	148.629	460
Freycinet MPA	6-Oct	0500	**177**	Longline	1500	-41.965	148.632	460	-41.975	148.632	485
Freycinet MPA	6-Oct	0525	**178**	Longline	1500	-42	148.618	460	-42.013	148.62	470
Freycinet MPA	6-Oct	0555	**179**	BRUVS		-41.992	148.623	475			475
Freycinet MPA	6-Oct	0600	**180**	BRUVS		-41.99	148.627	490			490
Freycinet MPA	6-Oct	0605	**181**	BRUVS		-41.988	148.632	495			495
Freycinet MPA	6-Oct	0610	**182**	BRUVS		-41.985	148.628	445			445

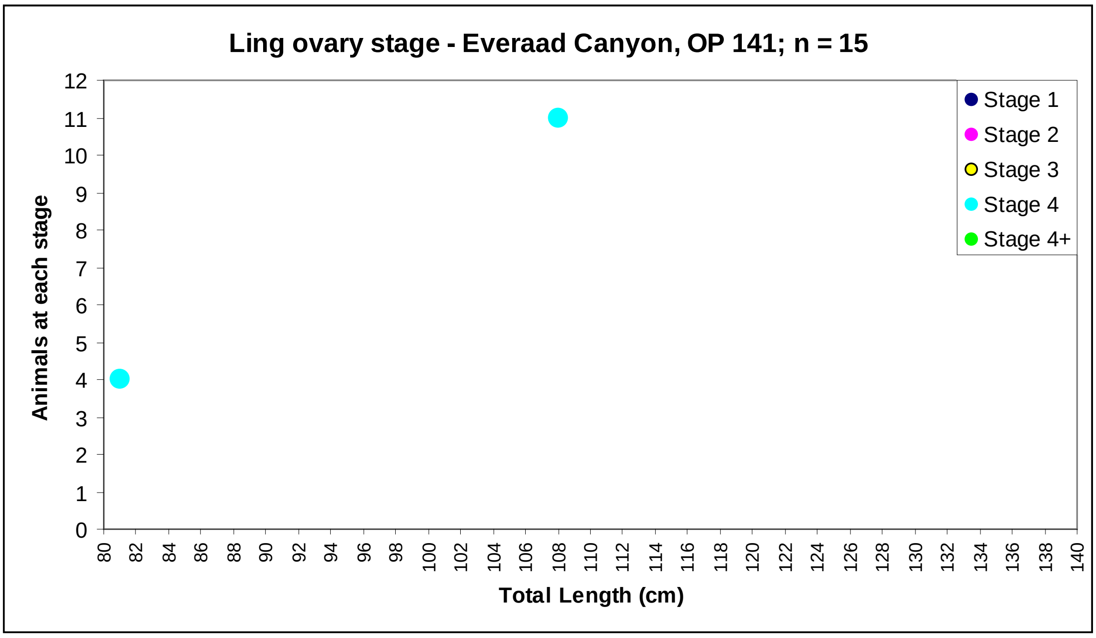
Table 6 A table of the catch species and number at each site.

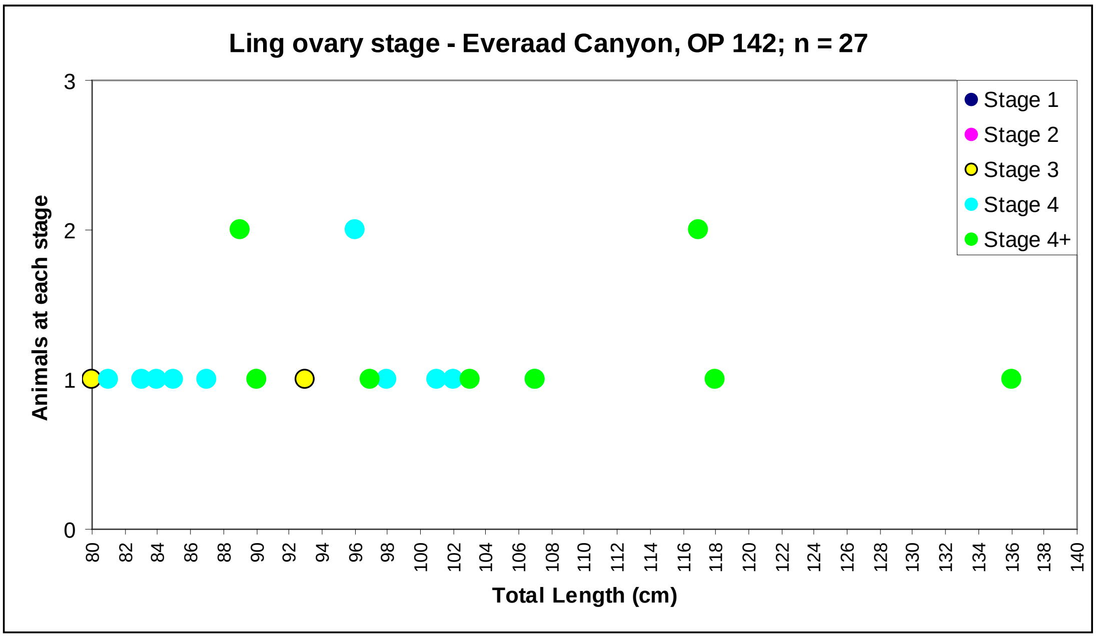
Species	**Border Bank**	**Byron Bank**	**South of Byron**	**30 Canyon**	**Coffs**	**31 Canyon**	**Port Macquarie**	**Port Stevens**	**Taupo Seamount**	**Five Canyon**	**North of Sydney closure**	**Browns Mountain**	**Ayres Rock**	**Longnose Canyon**	**Tuross Canyon**	**Cape Howe**	**Gipps MPA**	**Everard Canyon**	**Seiners Canyon**	**Cape Barren**	**North Flinders**	**Flinders MPA**	**Freycinet MPA**	**Totals**
?Coloconger sp.						1																		1
?Lepidion sp.	2		1																					3
Alopias supercilliosus										1														1
Apogonops anomalus				1																				1
Bassanago sp.										2					6		3	7		13	8	28	2	69
Beryx decadactylus	1																9	1		1	6			18
Beryx splendens									1												8			9
Brama																				2		2		4
Branchiostegus cf serratus	1																							1
Centrophorus harrissoni		3	12	7	15	21	1	46	12	5	1	3	1	3	1	3		2		9	70	6		221
Centrophorus moluccensis	1	67	52	13	84	123	2	37		35	1	9		1										425
Centrophorus niaukang				1																				1
Centrophorus squamosus															8	10								18
Centrophorus zeehaani										5	4	88		6	3	7	2							115
Centroscymnus owstoni									1															1
Cephaloscyllium albipinnum														2	55	8	16	64	2	58	152	19	8	384
Cephaloscyllium laticeps																	7		2					9
Cephaloscyllium variegatum		1	10	3	3	9	2	1		8		36	180	215	55						2			525
Chimaera fulva																		2		2	10	20	5	39
Cirrhigaleus australis	2		2									4			2									10
Coelorinchus australis																			2	6			1	9

Species	Border Bank	Byron Bank	South of Byron	30 Canyon	Coffs	31 Canyon	Port Macquarie	Port Stevens	Taupo Seamount	Five Canyon	North of Sydney closure	Browns Mountain	Ayres Rock	Longnose Canyon	Tuross Canyon	Cape Howe	Gipps MPA	Everard Canyon	Seiners Canyon	Cape Barren	North Flinders	Flinders MPA	Freycinet MPA	Totals
Coelorinchus matamua																						1		1
Coelorinchus maurofasciatus										1		6			2	19	7	5		30	13	15	1	99
Dalatias licha																	1			1	1	5		8
Deania calcea																						7		7
Deania quadrispinosa											1				1		2	1			1			6
Dipturus acrobelus										1														1
Dipturus canutus										18	4	5		8	7	35	8	2	11	10	8		3	119
Dipturus confusus																				2			3	5
Dipturus grahami	1	21	7	22	8	1		5		10		2	5											82
Dipturus gudgeri								1		3		1		1		4	1	8	1	11	3	2	1	37
Dipturus melanospilus					2			6																8
Echinorhinus cookei										1														1
Epigonus denticulatus											1													1
Eptatretus cirrhatus										2	6	1	2					1						12
Etmopterus bigelowi		9	13						6	7	18	2	41			4								100
Etmopterus cf pusilluscheck			9					4		4														17
Etmopterus lucifer									12	3	6					1				18	48	7	6	101
Etmopterus molleri					1	6		16		2		8	15											48
Etmopterus sp. (check)		32																						32
Figaro boardmani		33	26	23	25	56	8	48							1		3			12		1	1	237
Galeorhinus galeus																	1			1	1			3
Genypterus blacodes										3	1	1		10	25	56	50	149	491	131	35	52	22	1026
Helicolenus barathri	53	17	40	8	24	18	2	2	1	302	55	193	13	112	125	283	164	180	23	137	301	77	23	2153

Species	Border Bank	Byron Bank	South of Byron	30 Canyon	Coffs	31 Canyon	Port Macquarie	Port Stevens	Taupo Seamount	Five Canyon	North of Sydney closure	Browns Mountain	Ayres Rock	Longnose Canyon	Tuross Canyon	Cape Howe	Gipps MPA	Everard Canyon	Seiners Canyon	Cape Barren	North Flinders	Flinders MPA	Freycinet MPA	Totals
Heptranchias perlo		4	1	3	1			1			1	1												12
Hoplichthys haswelli						1								1										2
Hydrolagus cf ogilbyi	2	162	17	122	12	8	1	37		15		4	1	2			2	1		3			2	391
Hyperoglyphe antarctica	33		7		3		1		15	6		2		4	4	3	15			52	50	7	3	205
Lepidoperca magna							1																	1
Lepidopus caudatus																					1			1
Lepidorhynchus denticulatus												3				1	1	1		1		5		12
Macruronus novaezelandiae																		1				1		2
Malacocephalus laevis			2	1						6	1		1											11
Mora moro									1					1		78	129	9		17	29	541	25	830
Mustelus antarcticus										82	1								2				1	86
Nemadactylus macropterus																				7			1	8
Nemadactylus n.sp.									7															7
Neocyttus rhomboidalis																						27		27
Paraulopus sp.	1	1	1			1	2																	6
Pentaceros decacanthus	1									1														2
Plesiobatis daviesi	11				1			4																16
Polymixia sp.	1																							1
Polyprion americanus	1	1	1						1							1								5
Prionace glauca																				1				1
Proscymnodon plunketi																				2		3		5
Pseudopentaceros richardsoni									1															1
Pterygotrigla andertoni	2	1																						3

Species	Border Bank	Byron Bank	South of Byron	30 Canyon	Coffs	31 Canyon	Port Macquarie	Port Stevens	Taupo Seamount	Five Canyon	North of Sydney closure	Browns Mountain	Ayres Rock	Longnose Canyon	Tuross Canyon	Cape Howe	Gipps MPA	Everard Canyon	Seiners Canyon	Cape Barren	North Flinders	Flinders MPA	Freycinet MPA	Totals
Rexea solandri			1													6				1				8
Sphoeroides pachygaster	4																							4
Squalus acanthias																				4				4
Squalus albifrons	18	16	65	4	50	133	53	168		19		2	5											533
Squalus cf. albifrons									127															127
Squalus cf. megalops									7															7
Squalus grahami	1	118	35	106	546	66	3	253		212	3	53	88	2	1	1								1488
Squalus megalops					10							1	61	2	19			5		66			2	166
Squalus montalbani		15	6	78	96	102	2	8		19	13	115	10					1						465





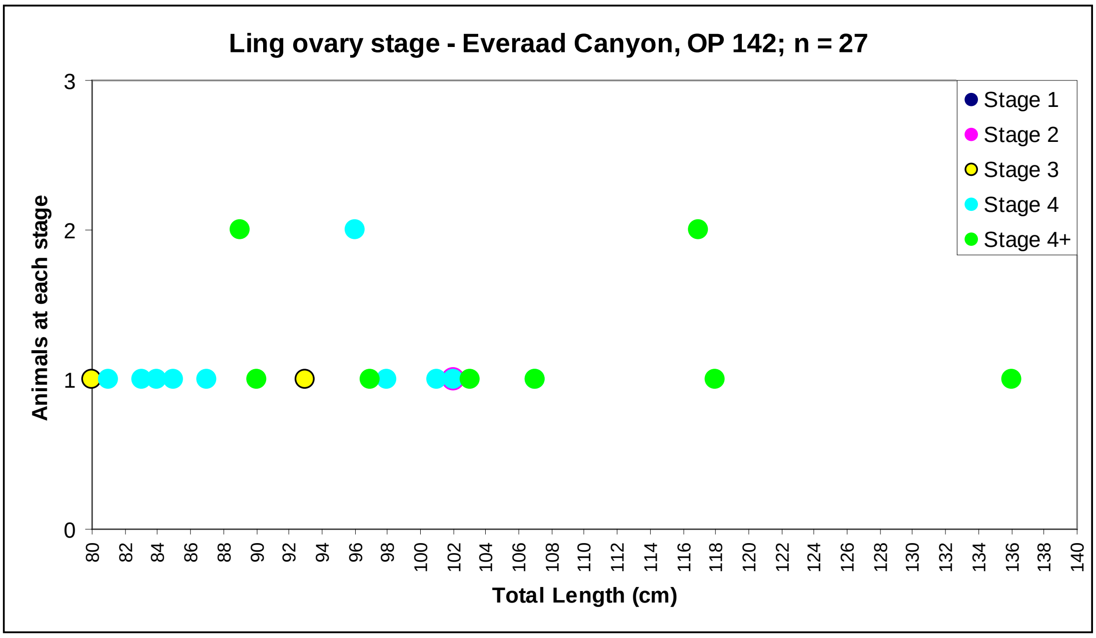


Figure 2. A figure to show the results of staging the ovaries of mature female pink ling caught in Everard Canyon

Table 6. The return from commercial fishes caught in Commonwealth waters and sold with the proceeds returned to the project budget offset the cost of charter.

Species	Weight (kg)	Market Price/kg	Quota	Quota cost	Full amount	Less quota costs	Notes
Blue eye	36	$12.00	sci quota		$432.00	$432.00	
Blue eye	85.5	$11.00	sci quota		$940.50	$940.50	
Blue eye	8.5	$11.00	sci quota		$93.50	$93.50	
Blue eye	22	$11.00	sci quota		$242.00	$242.00	
Hapuka	9	$12.00	non quota		$108.00	$108.00	
Tiki (morwong)	7	$3.00	quota	$0.30	$21.00	$18.90	
Alfonsino	38	$3.00	non quota		$114.00	$114.00	
Blue eye	330	$8.00	sci quota		$2,640.00	$2,640.00	
Blue grenadier	7	$2.50	sci quota		$17.50	$17.50	
Gemfish	1	$2.50	sci quota		$2.50	$2.50	
Morwong	8	$3.00	quota	$0.30	$24.00	$21.60	
Ocean perch **	657	$3.00	quota	$0.30	$1,971.00	$1,803.90	100 kg at $3.00 and 557 kg at $2.70
Pink ling	2778	$6.00	sci quota		$16,668.00	$16,668.00	
Ribaldo	902	$3.00	quota	$0.20	$2,706.00	$2,525.60	
Ghost shark	44	$1.50	quota	$0.40	$66.00	$48.40	
Oreo dory	29	$2.50	quota	$0.50	$72.50	$58.00	
Blue shark	13	$1.00	non quota		$13.00	$13.00	
						$25,747.40	
**exceeded sci quota							
					Costs	$211.31	Commission, market dues etc
						$25,536.09	
						$2,553.61	Less discretionary amount (10%) to Mures
					Total	**$22,982.48**	Amount to be paid to CSIRO by Mures

Appendix

Meta data

1. Voyage report

Diana12009_VoyageReport_Master

2. Marlin record (in progress)

See East Coast Gulper Survey - autolongliner FV Diana 01/2009

3. Survey data

A scanned copy of original data sheets as they came off the boat.
See:
Leg1 Catchcomp datasheets.pdf
Leg2 Catchcomp datasheets.pdf
Leg1 tag datasheets.pdf
Leg2 tag datasheets.pdf

See
S:\Sustainable Marine Ecosystems in SE\Spatial closures project\Voyage_DIANA_09\Diana_survey_results_data

All *operation, catch, tagging, length frequency, ling gonad staging and genetics sample data* contained in DianaOpsDetails_MASTER.xls

S:\Sustainable Marine Ecosystems in SE\Spatial closures project\Voyage_DIANA_09**Voyage report new working**

GIS Mapping
S:\Sustainable Marine Ecosystems in SE\Spatial closures project\Voyage_DIANA_09\Mapping\Ops_Di200901_legs1_2.TAB

4. BRUVS Specifications

Frame material	12 mm bar
Height	700 mm
Width	890 mm
Length	1300 mm
Weight of frame	40 kg
Extra weights	8 x 2.5 kg

Cameras	2 per unit
Sony CX-7	Stereo configuration
Recording mode	High definition (HD) 16:9 high quality
Memory card capacity	16 GBytes
Recording time	~2.5 hours
Lights	Blue LED
Synchronization	Pre deployment using flashing LED
Camera separation	See camera calibration files
Inclination	See camera calibration files
Bait bag	Mesh bag attached to pole at front
Mooring line	14 mm float line
Floats	1 x large (vol) Polyform inflatable buoy 1 x dan pole with flag

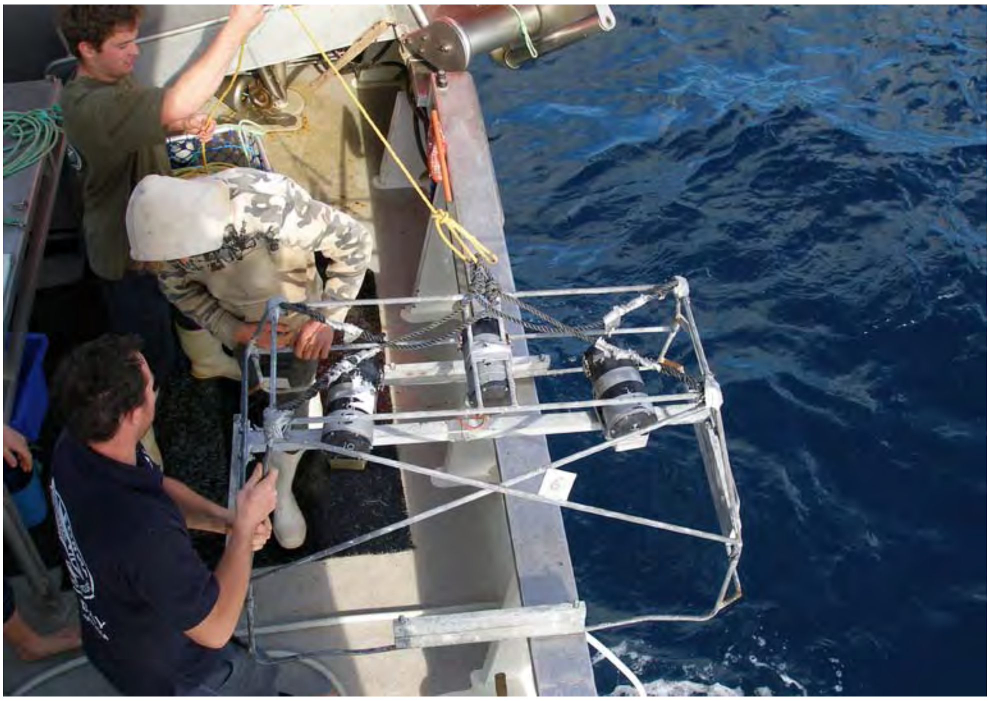


Figure 3. A stereo-camera BRUVS unit prepared and ready for deployment.

SUB-APPENDIX E4

SUB-APPENDIX E5 – VOYAGE REPORT: FV '*SARDA*' 2009

SHIP **Name:** *Sarda* **Call Sign:** 0737 **Type of ship:** Commercial fishing vessel - auto longliner
VOYAGE NO.: FV SARDA 2009-01 **VOYAGE NAME:** Acoustic tag deployment yoyage, Great Australian Bight
VOYAGE PERIOD: 8/8/2009 to 14/8/2009 **PORT OF DEPARTURE:** Port Lincoln **PORT OF RETURN:** Port Lincoln
CHIEF SCIENTIST(S) Bruce Barker
OBJECTIVES AND ACHIEVEMENT Objective 1. Place V16 acoustic tags on up to 60 vigorous Southern Dogfish, 20 Greeneye Dogfish and 20 Whitefin Swellshark and release them as close to the capture point as is practical. **Achievement: V16 tags were placed onto 70 Southern Dogfish, 20 Greeneye Dogfish and 10 Whitefin Swellshark. These were all released along the track of fishing operations.** Objective 2. Place conventional tags on additional sharks captured in vigorous state and release them where practical. **Achievement: Conventional tags were placed onto 462 Southern Dogfish, 430 Greeneye Dogfish and 40 Whitefin Swellshark. These were all released along the track of fishing operations.** Objective 3. Monitor the condition of sharks fitted with acoustic tags following release using a VR2W listening station. **Achievement: Listening station was in water during tagging/release operations. Sharks were detected on bottom following release.** Objective 4. Collect data on the bathymetric, depth and habitat preferences of Southern Dogfish and other species as well as environmental data (depth and temperature). **Achievement: The deployment of V16TP (acoustic tags fitted with temperature and pressure sensors) onto 100 vigorous animals within the VR2W sensor array within the 60 mile closure gives us the opportunity to collect considerable data on Southern Dogfish and other shark species.** Objective 5. If conditions are suitable and time permits, recover two VR2W listening station moorings, download data and redeploy. **Achievement: VR2W sensors number 11 and 15 were recovered, downloaded and redeployed on the last day of operations.**

Mapping Distribution and Movement of Gulper Sharks

Acoustic tag deployment voyage, Great Australian Bight: August 2009 - Voyage Report: FV SARDA 1-09

National Research FLAGSHIPS Wealth from Oceans

CSIRO

Australian Government Fisheries Research & Development Corporation

Project:

"*Mapping the distribution and movement of gulper sharks, and developing a non-extractive monitoring technique, to underpin a stock rebuild within a multi-sector fishery region off southern and eastern Australia*." (CSIRO and FRDC funded)

1. Scientific objectives

1. Fit acoustic tags to Southern Dogfish (*Centrophorus zeehaani*) to track their movements within a fishery closed area southwest of Port Lincoln

2. Fit acoustic tags to comparative species: Greeneye Dogfish (*Squalus chloroculus*) and Whitefin Swellshark (*Cephaloscyllium albipinnum*) to track their movements within the fishery closed area.

3. Fit conventional tags to the three species mentioned above to examine their movements outside fishery closed areas.

2. Summary of achievements against Voyage Objectives

Objective 1. Place V16 acoustic tags on up to 60 vigorous Southern Dogfish, 20 Greeneye Dogfish and 20 Whitefin Swellshark and release them as close to the capture point as is practical.
Achievement: V16 tags were placed onto 70 Southern Dogfish, 20 Greeneye Dogfish and 10 Whitefin Swellshark. These were all released along the track of fishing operations.

Objective 2. Place conventional tags on additional sharks captured in vigorous state and release them where practical.
Achievement: Conventional tags were placed onto 462 Southern Dogfish, 430 Greeneye Dogfish and 40 Whitefin Swellshark. These were all released along the track of fishing operations.

Objective 3. Monitor the condition of sharks fitted with acoustic tags following release using a VR2W listening station.
Achievement: Listening station was in water during tagging/release operations. Sharks were detected on bottom following release.

Objective 4. Collect data on the bathymetric, depth and habitat preferences of Southern Dogfish and other species as well as environmental data (depth and temperature).
Achievement: The deployment of V16TP (acoustic tags fitted with temperature and pressure sensors) onto 100 vigorous animals within the VR2W sensor array within the 60 mile closure gives us the opportunity to collect considerable data on Southern Dogfish and other shark species.

Objective 5. If conditions are suitable and time permits, recover two VR2W listening station moorings, download data and redeploy.
Achievement: VR2W sensors number 11 and 15 were recovered, downloaded and redeployed on the last day of operations.

3. Dates and timing of survey

Depart Port Lincoln 1140 hours, Saturday 8th August 2009
Return Port Lincoln 0700 hours Friday 14th August 2009

4. Vessel details

CSIRO chartered F.V. Sarda – a Lakes Entrance based fishing vessel - for this tagging survey. The Sarda is equipped with auto longline gear and licensed to fish in Commonwealth waters. The master and crew are experienced longline fisherman. The vessel was built in 1974 at Williamstown Victoria. The vessel is 20 meter in length, constructed of steel and powered by a single 871 GM (265 hp) main engine. Auxiliary power is supplied by smaller engines for hydraulics, 240 volt power and refrigeration (brine tanks and freezer). The vessel has berths for up to 7 and is owned and operated by Mr Chris Currie (Bluebeards Seafoods) who has 25+ years of drop and longline fishing experience for both demersal and pelagic fishes in different parts of Australia.

5. Fishing equipment

Setting and hauling the longline used a Mustad Coastal auto-line system with automatic baiting of 2 hooks per second whilst steaming at 5 knots. The mainline used was 7mm Mustad roto line (swivelled) with snoods at 1.4 m intervals, and 400 mm snoods (1.8 mm monofilament). The hooks used were 12/0 Mustad ‘super baiters’. The line was anchored at each end with 60 kg steel weights, extra weights (and floats) were deployed along the line according to terrain and to fish either hard on the bottom or off the bottom. Lines and surface floats marked the start and end of the line and were used to retrieve the longline. Jack Mackeral (sourced from Korea) was used as the bait.

The line was typically in the water for about 3 hours before hauling.
In the evenings Charlie Huveneer (SARDI shark biologist) put out a berley trail to attract sharks. He aimed to catch a mako shark on a hook and line, bring it on board, tag it with a satellite tag and release.

6. Voyage Narrative

Saturday 8th

Steamed to the closure area to the southwest of Port Lincoln and arrived in the early hours of Sunday 9th.

Sunday 9th

At about 0430 we started the set of 2 fleets of 2000 hooks (2 x 2000 hooks) in the eastern portion of the listening station array. The line (fleet #1) was hauled resulting in a large catch of gulpers (128), green eyed dogfish (96) and swell sharks (16) with a mixture of blue-eye, gemfish, ling, ribaldo and knifejaw also landed. With this large catch of gulpers and many appearing to be in good condition, we deployed 38 of the acoustic tags. Other gulpers and green eyed dogfish were tagged with conventional fin tags (Jumbo and Roto) with smaller animals tagged using dart tags. Fleet #2 was hauled and again a large number of gulpers (98), green eyed dogfish (187) and swell sharks (34) were landed and tagged. Of the swell sharks, 5 were tagged using acoustic tags.

Monday 10th

We moved westward (past line 4 of the listening array) and set a single line (fleet #3) of 2000 hooks. The catch consisted of 38 gulpers, 64 green eyed dogfish and 3 swell sharks with some ribaldo, blue-eye, ling, ocean perch, knifejaw and gemfish. Acoustic tags were deployed on 11 more of the larger gulpers and 10 tags implanted in green eyed dogfish. Three more swell sharks were tagged with fin mounted acoustic tags as well.

Tuesday 11th

We moved further west towards line 3 of the listening array considering it beneficial to catch and tag animals from different areas of the listening array. Fleet #4 was set with 2000 hooks. The resulting catch of sharks was relatively small with only 1 gulper, 23 green eyed dogfish and 2 swell sharks landed. This haul did have more blue-eye and a mixture of the usual fish species. The gulper shark was tagged with an acoustic tag and the 2 swell sharks also tagged with acoustic tags. With the small catch we decided to set another line of 1000 hooks (fleet 5) nearby. The catch consisted of 5 gulpers, 22 green eyed dogfish, and 7 more swell sharks. Acoustic tags were deployed on 5 of the gulper sharks and 5 of the green eyed dogfish (internally).

Wednesday 12th

Again we moved westwards past the next line of the listening array and set 3000 hooks (fleet #6). The catch was large with 196 gulpers, 84 green eyed dogfish and 12 swell sharks landed and tagged. Because the catch contained a significant number of large mature female gulpers we decided to deploy all of our remaining acoustic tag allocation (for gulpers) at this location. We also implanted the remaining allocation of tags in green eyed dogfish. At the shallower end of this set there were quite a few piked dogfish (*Squalus megalops*). Some were tagged with dart tags. This was our final longlining set with all acoustic tags deployed.

Thursday 13th
Retrieved listening station mooring #11, downloaded data and redeployed in the same position. Once released, the mooring floats surfaced about 3.5 minutes later – mooring depth 420 m. We steamed to the next array line to the east and retrieved mooring #15 and again downloaded data and redeployed in the same position. We then moved to the adjacent shelf edge to attempt to berley up a mako shark for Charlie's satellite tag but this was unsuccessful. Continued to steam back to Port Lincoln during the night.

Friday 14th
Berthed at Port Lincoln at 0700 hours packed gear for freight and departed for Adelaide ~ midday.

7. Acknowledgements

Many thanks to the Master and crew of fishing vessel Sarda who provided a happy and safe work area for this research voyage. Chris Currie deserves special mention for his ability to find an abundant supply of our target species. Many thanks to Charlie Huveneers for his tireless efforts with tagging, providing some stimulating conversation during the trip and providing entertainment in the form of capturing a mako shark.

8. Staff

Mr Bruce Barker	CSIRO	Voyage leader
Mr Mark Green	CSIRO	Tagging
Dr Charlie Huveneer	SARDI	Tagging
Mr Chris Currie	FV Sarda	Master
Mr Jim Culliber	FV Sarda	Mate/Deck/cook
Mr Jimmy Wickham	FV Sarda	Deck
Mr Laurie Pullbrook	FV Sarda	Deck

Table 1 Details of fishing positions

Operation/Fleet number	Start set position Latitude	Longitude	Depth (m)	End set position Latitude	Longitude	Depth (m)	No of hooks set
1	-35.262	134.527	490	-35.282	134.553	430	2000
2	-35.246	134.527	382	-35.270	134.549	407	2000
3	-35.219	134.462	320	-35.238	134.492	386	2000
4	-35.147	134.313	400	-35.170	134.331	488	2000
5	-35.159	134.336	444	-35.171	134.338	520	1000
6	-35.073	134.188	270	-35.108	134.225	635	3000

Table 2 Details of target species caught

Operation/ fleet #	No hooks set	Gulpers	Green eye	Swell sharks	Piked dogfish
1	2000	128	96	16	
2	2000	98	187	34	
3	2000	38	64	3	
4	2000	1	23	2	3
5	1000	5	22	7	2
6	3000	196	84	12	20

Table 3 Details of release positions of tagged fish

Operation/ fleet #	Release position (~centre of set) Latitude	Longitude
1	-35.2715	134.5397
2	-35.2576	134.5373
3	-35.2279	134.4766
4	-35.157	134.3214
5	-35.1641	134.337
6	-35.0903	134.206

Table 4 Tag tally

	Conventional	Acoustic	Mean length (cm)
Greeneye ♀	108	7	68
Greeneye ♂	322	13	73
Total Greeneyes	*430*	*20*	
Gulper ♀	152	13	93
Gulper ♂	310	57	85
Total Gulpers	*462*	*70*	
Swell ♀	38	8	98
Swell ♂	2	2	97
Total Swells	*40*	*10*	
Total	**932**	**100**	

Note- 10 of the internally tagged greeneyes also had conventional tags fitted, so all up 1022 target sharks were tagged. We also tagged 26 Piked Spurdogs.

Table VR2W data

Listening station no	Depth (m)	CART serial #	VR2W #	No of detections
11	420	32851	103316	6612
15	410	32759	101924	124765
Onboard*	5		103316	209

** VR2W # 103316 was deployed on a line over the side of the vessel whilst we released tagged sharks and for a short time after in several locations to monitor the descent of the sharks to their usual depth.*

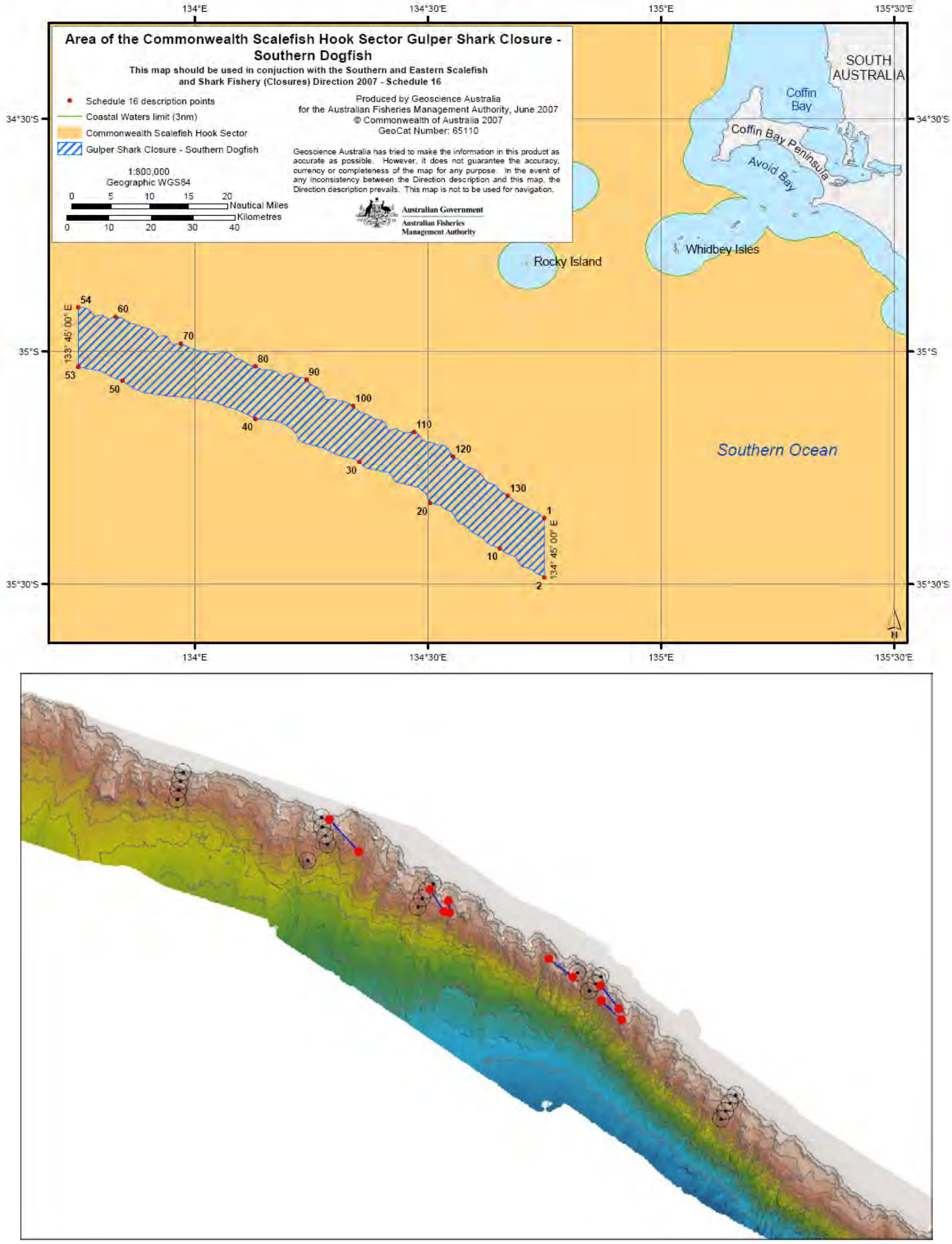


Figure 1 Top: location of survey area in the GAB; Bottom: diagram showing position of longline shots (blue lines and red dots) and acoustic receivers (black circles) within the GAB 60-mile closure

APPENDIX

Data acquittal

Tag data (shark length, sex, tag type, tag number)

A scanned copy of original data sheets as they came off the boat
SARDA_tagging_datasheets_August2009.pdf
In S:\Sustainable Marine Ecosystems in SE\Spatial closures project\SARDA_09

The tagging data with errors corrected in file
Shark tagging data SARDA August 2009.xls
In S:\Sustainable Marine Ecosystems in SE\Spatial closures project\GAB 60-mile survey\GULPER_TAGGING\Tag_release_data\FV_SARDA_TAG_RELEASE_DATA_2009
Note that this spreadsheet contains a Documentation sheet that lists the corrections made to data.

Mapping files

LonglineSets_Master in S:\Sustainable Marine Ecosystems in SE\Spatial closures project\SARDA_09\maps

VR2W data read

Files placed in
S:\Sustainable Marine Ecosystems in SE\Spatial closures project\GAB 60-mile survey\GULPER_TAGGING\Vemco_ReceiverLogs\SARDA_ReceiverLogs_2009.

Listening station/ mooring #11 2009-08-13 00:35:23 VR2W-103316 <B>Data Upload</B> ***VR2W_103316_20090813_1.vrl***

Listening station/ mooring #15 2009-08-13 03:22:53 VR2W-101924 <B>Data Upload</B> ***VR2W_101924_20090813_1.vrl***

Temporary listening station hung over side of fishing vessel during operations
VR2W_103316_20090813_1.vrl

Voyage report

In file S:\Sustainable Marine Ecosystems in SE\Spatial closures project\SARDA_09

Tag recaptures

Squalus chloroculus, Male, tag# 181315 (yellow spaghetti), captured fleet 2 on 09/08/09, no length recorded (we thought this was a keen recapture from fleet 1 so didn’t measure; lesson learnt). Originally tagged Ngerin and released 10/03/08, measured 68 cm. Returned alive.

Squalus chloroculus, Male, Tag# 181434 (yellow spaghetti), captured fleet 5 on 11/08/09, measured 74 cm. Originally tagged same trip on fleet 1, measured 74.5 cm. Returned alive.

Squalus chloroculus, Female, Tag# 181484 (yellow spaghetti), captured fleet 3 on 10/08/09, measured 73 cm. Originally tagged Ngerin and released 07/03/08, measured 68 cm. Returned alive.

Centrophorus zeehaani, Male, Tag# E4856 (yellow roto), captured fleet 6 on 12/08/09, measured 86 cm. Originally tagged Dianna and release 30/07/05, measured 86 cm. Returned alive.

SUB-APPENDIX E6 – VOYAGE REPORT: FV '*LUCKY S*' 2009

SHIP **Name:** *Lucky S* **Call Sign:** **Type of ship:** Fishing and general work vessel
VOYAGE NO.: FV LUCKY S 2009-01 **VOYAGE NAME:** Listening station mooring array recovery and redeployment
VOYAGE PERIOD: 21/11/2009 to 26/11/2009 **PORT OF DEPARTURE:** Port Lincoln **PORT OF RETURN:** Port Lincoln
CHIEF SCIENTIST(S) Bruce Barker
OBJECTIVES AND ACHIEVEMENT Objective. Recover acoustic receivers from the survey array in the GAB 60 mile closure. Download data and redeploy receivers on new moorings. **Achievement: All receivers recovered, downloaded, re-batteried and re-deployed. Two additional receivers included in areas of interest.**

Mapping Distribution and Movement of Gulper Sharks

Voyage Report:

Listening station mooring array recovery and redeployment FV Lucky S, November 2009

National Research FLAGSHIPS Wealth from Oceans CSIRO

Australian Government Fisheries Research & Development Corporation

Project title

"*Mapping the distribution and movement of gulper sharks, and developing a non-extractive monitoring technique, to underpin a stock rebuild within a multi-sector fishery region off southern and eastern Australia*." (CSIRO and FRDC funded)

Chartered vessel:

FV Lucky S, Port Lincoln SA
Contact Semi Skoljarev (Sekol Tuna Farming Pty.Ltd., Port Lincoln SA)

Dates:

21st to 26th November 2009

From:

Port Lincoln, South Australia

To:

Port Lincoln

Background

Areas of seabed in Commonwealth waters off temperate Australia are being closed to fishing as marine reserves are 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.

An array of moorings with listening devices to track sharks that have been tagged with coded acoustic tags has been in place within the fishery closure area off Port Lincoln since April 2008. The moorings were retrieved and redeployed in November 2008. In August 2009 a fishing vessel equipped with auto longline gear, was chartered to catch and tag more of the sharks of interest (gulpers, green eyed dogfish and swell sharks). During that survey 2 moorings were retrieved and redeployed.

This survey aimed to retrieve all of the moorings in the array, service the components and download data from the receivers and then redeploy them mostly into their original positions. We also planned to deploy an extra 6 moorings in locations determined by the data retrieved.

Survey summary

CSIRO chartered the 29 m FV Lucky S for the recovery and re deployment of listening station moorings in the spatial closures area off Port Lincoln. These were the moorings using acoustic release units (CART's) deployed from the Lucky S in November 2008 (fig. 1).

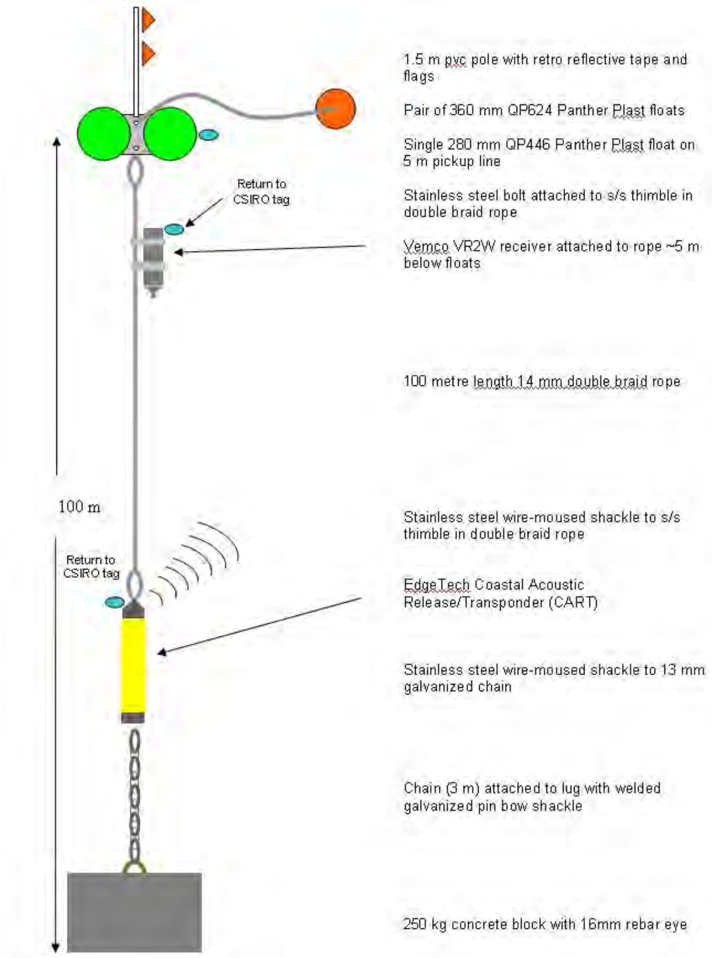


Figure 1. A schematic of the subsurface mooring incorporating CART acoustic release units as re deployed from FV Lucky S during November 2009.

The method to interrogate, release and retrieve each mooring was to position the vessel close to the position where deployed, lower the hydra-phone of the deck communications unit over the side and then communicate with the release by coded acoustic signals. Initially the CART was enabled and then a range check was done. Enabling the release confirmed the status and indicated whether it was upright or horizontal, open or closed. The release command was sent and a reply code indicated that the release had been activated. We then noted the range to see whether is was surfacing (by a decreasing range). In most cases this procedure was straight forward and successful with the mooring releasing and surfacing close to the vessel. Because the floats, rope and release unit were not heavy the released mooring was easily retrieved by hand.
We started the retrieval at the eastern end of the array and worked our way to the west. There were several moorings that failed to surface although we were receiving all the right codes from the release unit (table 1). We did note that there was some corrosion on the release mechanism (fig. 2) to varying degrees on the CART units and reasoned that this could have been contributing to the mechanism not letting go although opened. Some moorings had a small amount of bio-fouling with hydroids

and ascidians; an animal colonizing the release part of the CART could also contribute to it not opening.

Figure 2. One of the CART units showing the corrosion on the release mechanism that may have been contributing to the release failure of some of the other moorings.

A couple of mooring ropes were compromised being chewed/cut by a shark and as noted with mooring #1 can be cut right through. We were lucky to recover this mooring having found, upon initial interrogation, the release was horizontal and therefore with nothing attached. It was only the sharp eyes of the skipper who spotted the floats > 0.7 nm mile (1300 m) away that avoided the loss of the receiver data. The rope was severed (fig. 3) and fortunately for us this had apparently happened within hours of our arrival at the mooring site. Another rope was compromised ~30% also by shark bite.

Figure 3. The 14mm double braid mooring rope severed by a shark resulting in the mooring drifting free.

The receiver data was downloaded for each mooring and the number of detections noted (fig 4). The number of detections is also tabulated in table 1. A preview of the detection data reveals that there have been at least 15 gulpers, 8 green-eyed dogfish and 5 swell sharks detected and moving within the array of listening stations.

To further test the range of acoustic tags (a range test was performed during the initial spatial closures survey – SS200803) we deployed 2 moorings with receivers and 2 moorings with range test tags providing a static test of a range of detection distances. We also did a dynamic range test by suspending a range test tag and data logger below the vessel and drifting towards and then away from a listening station mooring. Unfortunately little data was obtained from the range test tags suggesting they either didn't activate with the removal of the magnet battery switch or the batteries were exhausted.

Following retrieval of all moorings we had 22 CART's at our disposal for redeployment (6 new and 16 original). This provided enough to reinstate the mooring array and add 2 new hard habitat locations (fig. 4) but not replacing #9. All of the original CART units were cleaned, new batteries installed, flushed with nitrogen and re-armed with new release links. We also renewed the zinc anode with anodes from the Lucky S.

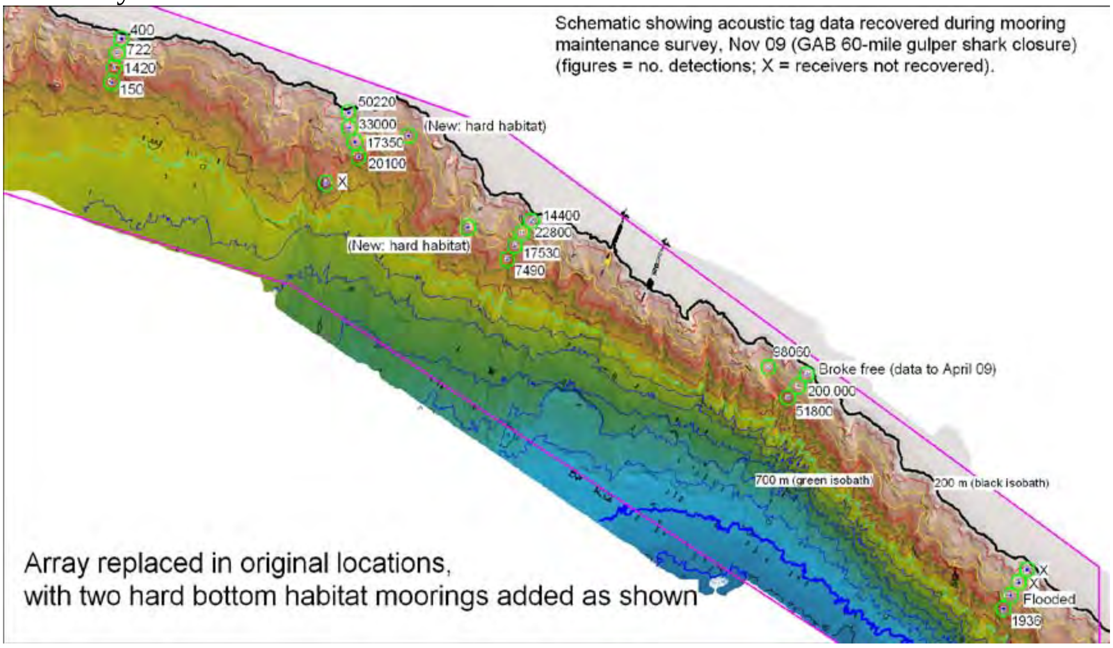


Figure 4. Schematic showing acoustic tag data collected during the survey at the various mooring positions as overlain on the swath bathymetry map.

All receivers (VR2W's) had batteries renewed, data downloaded and backed-up and then cleared of original data. This step also included updating the UTC time from the computer.

To redeploy the moorings we streamed the floats, receiver unit and rope behind the vessel whilst steaming slowly to the position. The CART was attached to the concrete mooring-block chain in readiness for deployment. The hydraulic articulated crane (Hiab) was used to lift the mooring block over the side and a Sea Catch release was used to safely release the mooring when ready (fig. 5).

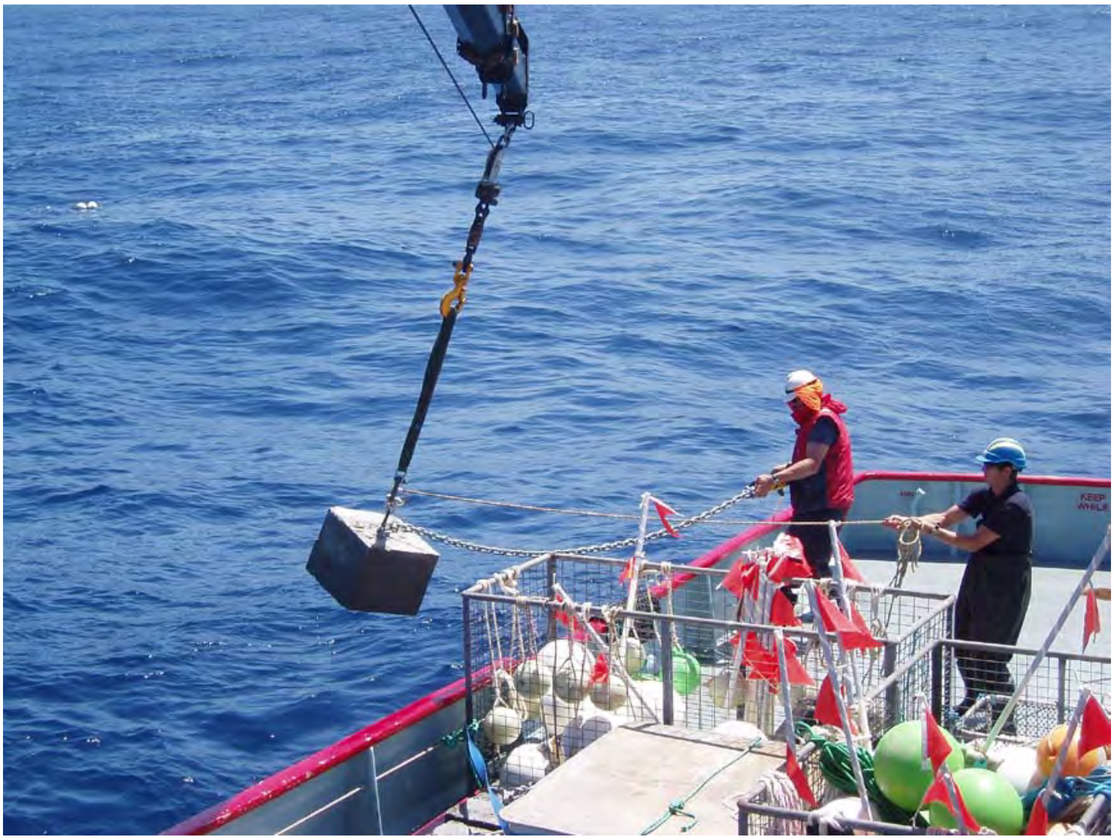


Figure 5. The concrete mooring block suspended over the side just prior to releasing. The mooring floats, receiver and rope already streamed, the acoustic release is held and dropped over the side as the block is released.

Ancillary Project

Mr Paul Rogers of SARDI was invited to come on the Lucky S to catch and tag mako sharks. As the mooring recovery and redeployment work took place during daylight hours only, there was ample time for fishing and tagging during the night. Details of the tagging project follow.

SARDI AQUATIC SCIENCES PROJECT:

Investigating the movement dynamics of shortfin mako sharks (*Isurus oxyrinchus*) in the Southern and Indian Oceans: Identification of critical foraging habitats and migration paths

BACKGROUND:

Shortfin mako sharks (*Isurus oxyrinchus*) are 'top' predators in oceanic and shelf ecosystems. Shortfin makos were listed as Vulnerable by the International Union of Conservation of Nature in February 2007. Subsequently, they were listed by the Convention on Migratory Species in 2009, and are currently on the DEWHA Finalized Priority Assessment List in October 2009. Despite the listings and conservation concern, there are currently no species-specific management arrangements aimed at limiting the mortality of this species as a result of industrial fishing in any Australian State, Commonwealth, or adjacent High Seas jurisdiction.

Our satellite tracking project has shown that since March 2008, some individuals have travelled >20,000 km and range across multiple management jurisdictions, whereas others have shown a higher degree of site fidelity. Because mako sharks break the surface most days, the 'invisible pathways' in the ocean that are revealed using dorsal-fin mounted satellite tags now represent a key component in the future management and conservation of this species.

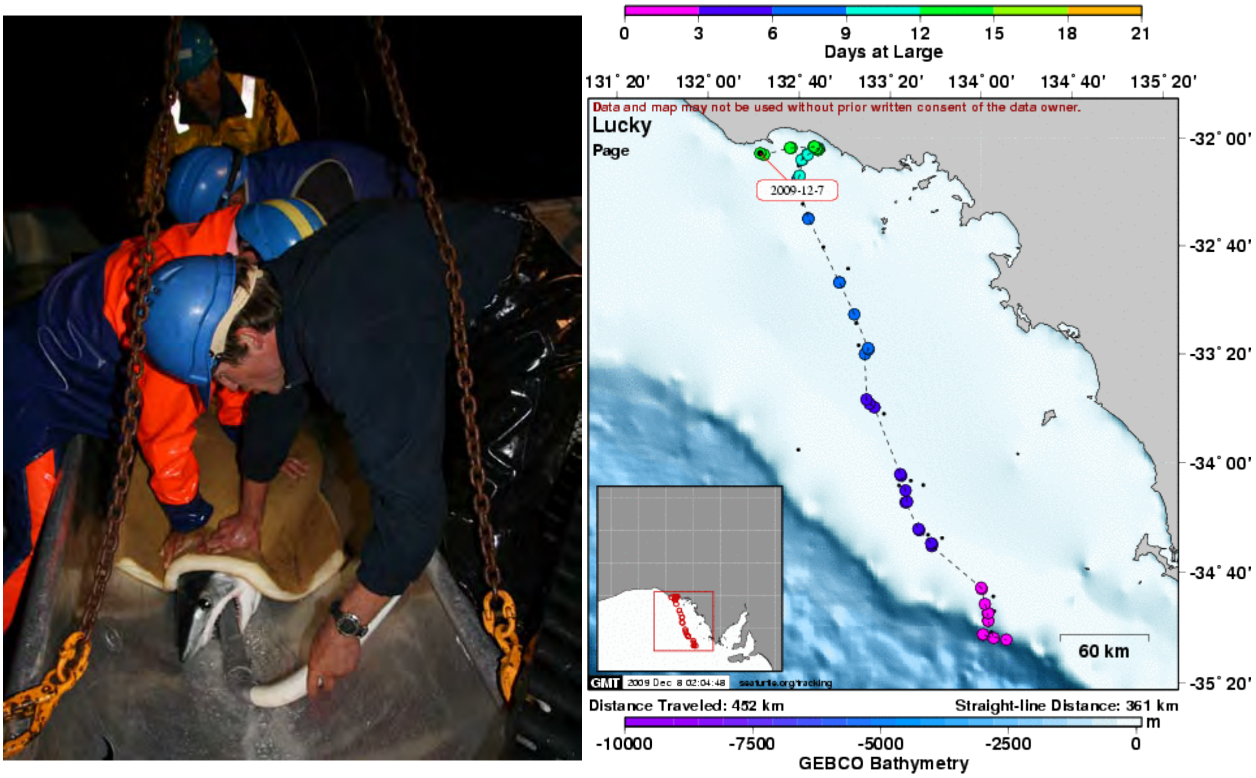
OBJECTIVES:

The broad objective of this project is to investigate the movement dynamics, critical foraging habitats and migration paths of shortfin mako sharks in the Southern and Indian Oceans.

RESULTS:

On 23/11/09, five juvenile shortfin makos between ~1.3 and 1.7 m, TL were captured using a floating surface line while drifting near the shelf slope ~30 miles SW of Rocky Island in the eastern Great Australian Bight. The four smallest sharks (~1.3–1.4 m, TL) were tagged using spaghetti ID tags and released. The 1.7 m juvenile male was selected to be the most suitable for satellite tagging. The shark was lifted aboard using a purpose-built aluminium cradle (Fig. 1 (a)), restrained using a wetted foam mattress and its' gills were aerated using a deck-hose. A Wildlife Computers™ Spot satellite tag was fixed to the second dorsal fin using stainless steel bolts and washers.

The shark was then measured by total length, sexed and released within five minutes of capture in excellent condition.
Since being tagged at S35° 00.258, E134° 04.422, the Spot tag on ‘Lucky the Mako’ has provided 53 GPS locations via the ARGOS satellite network (Fig. 1(b)) and the shark has travelled ~431 (straight-line) km to an area near Fowlers Bay.
The daily travels of the shortfin mako shark that was satellite tagged on this survey can now be viewed at: http://www.seaturtle.org/tracking/?project_id=308



(a) (b)
Figure 6 (a) The shortfin mako being maintained in the cradle during the capture and tagging process (b) Satellite tag track of the shortfin mako shark tagged during the CSIRO gulper shark acoustic data download cruise in the Great Australian Bight during November 2009.

MISCELLANEOUS:

Paul would like to extend thanks to Mark Lewis, Bruce Barker and Ross Daly (CSIRO, Hobart) for allowing him join the cruise and for their assistance during the satellite tag deployment. The crew, skipper and onshore support staff of the Lucky-S also provided valuable assistance, and helped with logistics in Port Lincoln which was greatly appreciated. Thanks also to Graham Tapley for providing bait, berley and an on-deck storage bin.

Contact :

Mr Paul Rogers
Research Scientist (PhD candidate)
Flinders University & SARDI Aquatic Sciences
Threatened Endangered and Protected Species SubProgram
2 Hamra Ave, West Beach, SA, 5024
Phone mobile: 0428113236, office: 08 82075487

Voyage narrative

Friday 20th November
Load and prepare moorings gear

Saturday 21st November
Departed Pt Lincoln ~1600 hours and steamed through the night to the closure area. There was a 20-30 knot breeze from the southwest making for an uncomfortable night whilst steaming to the study area.

Sunday 22nd November
Sea conditions continued to be less than ideal but not too rough for sighting the surfacing moorings and being able to retrieve them. Began the retrieval of the mooring array from the eastern end with mooring #20. It released and was spotted near to the vessel. The mooring was retrieved and receiver data downloaded. Moved to mooring #19 and it was released and retrieved to find the receiver had water in it. We weren't able to re power with a fresh battery so kept for electronics technicians in Hobart to see if the data could be recovered. Mooring #18 wouldn't release after several attempts. The coded acoustic reply indicated that the release unit (CART) was upright and operating as it should but the mooring didn't surface. We moved to mooring #17 and it also failed to surface following release. We returned to the site of #14 – the mooring that had washed up on the shore at King Island – and confirmed that the CART was still attached to the mooring. We proceeded to release and retrieve moorings #15, 16, 21, 13, 12, 11 and 10 during the afternoon. Paul Rogers of SARDI decided to wait for conditions to abate before attempting to berley sharks for tagging.

Monday 23rd November
Continued working from east to west to retrieve the moorings from the array. Mooring #9 failed to surface and we tried the backup deck release unit and hydra-phone but still no result. Moorings #8, 7 and 6 were retrieved but #5 also failed to release although all the right response codes from the CART were received.
We then proceeded to deploy a line of 4 moorings for a static range test of the range tags. The two end moorings with acoustic receivers (VR2W's) and the two moorings with range test tags. We moved west to the next line of moorings to attempt a range test with a tag whilst suspending it near bottom and drifting towards the deepest mooring. Moorings #4, 3, 2 were retrieved and we then found that the CART on mooring #1 was horizontal indicating that the top part of the mooring had gone! The skipper of the vessel (Slavko who had been noted for his sharp spotting skills) saw something resembling the mooring floats in the distance. We steamed over to it and retrieved the floats, receiver and most of the rope for mooring #1. It was >0.7 nm away from the original position and the rope severely damaged/cut enough to have parted. During the evening we replaced the batteries in the receivers and cleaned the CART release mechanism in preparation for redeployment. Paul began putting a berley trail out to attract sharks and before long 4 small mako sharks had been attracted to the vessel, caught and tagged. Later in the evening a larger mako was landed, tagged with a satellite tag and released in good condition. It was named Lucky.

Tuesday 24th November
The greater part of the morning was spent servicing the CART units. This included replacement of the batteries, adding a new zinc anode, arming with the release link and flushing with nitrogen. Once completed, we proceeded with deploying the moorings starting with the line to the west and moving eastward. Moorings #1, 2, 3 and 4 were deployed. We then retrieved the 4 moorings for the static range testing. We revisited the location for mooring #5 and were able to get it to release so it was retrieved. We subsequently redeployed this mooring at the same location. Mooring #'s 6, 7 and 8 were deployed. We then returned to the position for mooring #9 to see if it could be released but again it wouldn't let go. Mooring #'s 22 and 23 were then deployed – these were new *hard bottom habitat* positions. We started the drift and berley trail to attract mako sharks. Again several mako sharks were attracted to the bait.

Wednesday 25th November
We proceeded to deploy moorings # 10, 11, 12, 21, 14, 15 and 16. We repeated attempts to release #'s 17 and 18 but without result. Mooring #'s 19, 20, 18 and 17 were deployed during the afternoon. We started on our way back to Port Lincoln steaming through the night.

Thursday 26th November
Arrived at Port Lincoln early in the morning and started packing and off-loading all equipment at first light.

Staff

Bruce Barker	CSIRO	Voyage leader
Mark Lewis	CSIRO	Moorings setup/deck operations
Paul Rogers	SARDI	Mako shark tagging
Slavko Kolega	Sekol	Skipper
Scott Ryan	Sekol	Engineer/deck
Chris Meletti	Sekol	Deck

Acknowledgements

Special thanks to the skipper and crew of the Lucky S for their assistance. Thanks to Con Karaberidis for coordinating the use of the vessel and crew and also to those at the Sekol yard who assisted with delivery of our gear to the vessel and a last-minute welding job. Thanks also to Mr Shane Farrell who made the mooring blocks. Thanks also to the CSIRO Moorings Group for lending us 6 extra CART's in time for the survey.

Table 1. The number of detection from each mooring receiver

Mooring site#	VR2W#	CART #	Detections
1	103320	32853	401
2	103321	32851	722
3	103334	32885	1422
4	103328	32759	150
5	103330	32855	50223
6	103326	32858	32998
7	103333	32884	17347
8	103332	32854	20103
9	103317	*32856*	not recovered
10	103327	32892	14435
11	103316	32889	22798
12	103315	33713	17536
13	103331	33722	7490
14	--	--	broke free – found King Is
15	101924	32890	236537
16	103323	32852	51878
17	101998	*33715*	not recovered
18	102597	*33723*	not recovered
19	101922	32891	Flooded VR2W
20	103329	33721	1936
21	103318	33717	98060
		TOTAL	**475976 detections**

Table 2. Summary of listening station array depths, location, receiver (VR2W) and acoustic release details (the order reflects the chronological order in which the moorings were deployed) during November 2009.

Mooring #	Depth (m)	Date deployed	Latitude (decimal degrees)	Longitude (decimal degrees)	CART serial #	VR2W receiver #
1	250	24/11/2009	-35.0246	134.0060	32853	103320
2	400	24/11/2009	-35.0339	134.0024	32851	103321
3	570	24/11/2009	-35.0429	134.0000	32885	103334
4	660	24/11/2009	-35.0521	133.9980	32759	103328
5	230	24/11/2009	-35.0723	134.1783	32855	103330
6	300	24/11/2009	-35.0820	134.1789	32858	103326
7	400	24/11/2009	-35.0909	134.1832	32884	103333
8	540	24/11/2009	-35.0999	134.1855	32854	103332
9	No mooring re deployed at this habitat site				- -	- -
22	450	24/11/2009	-35.0873	134.2240	32888	101925
23	385	24/11/2009	-35.1449	134.2689	32850	102607
10	330	25/11/2009	-35.1410	134.3170	32892	103327
11	420	25/11/2009	-35.1484	134.3096	32889	103316
12	500	25/11/2009	-35.1565	134.3039	33713	103315
13	650	25/11/2009	-35.1649	134.2984	33722	103331
21	450	25/11/2009	-35.2333	134.4973	33717	103318
14	300	25/11/2009	-35.2378	134.5267	32857	102593
15	410	25/11/2009	-35.2453	134.5196	32890	101924
16	580	25/11/2009	-35.2523	134.5121	32852	103323
19	440	25/11/2009	-35.3765	134.6818	32891	101922
20	570	25/11/2009	-35.3844	134.6761	33721	103329
18	352	25/11/2009	-35.3686	134.6879	33723	102597
17	295	25/11/2009	-35.3602	134.6945	33715	101998

Data Acquittal

Mapping files

L:\MooringRecovery Nov2009\New array_VR2 locations.TAB

Voyage report

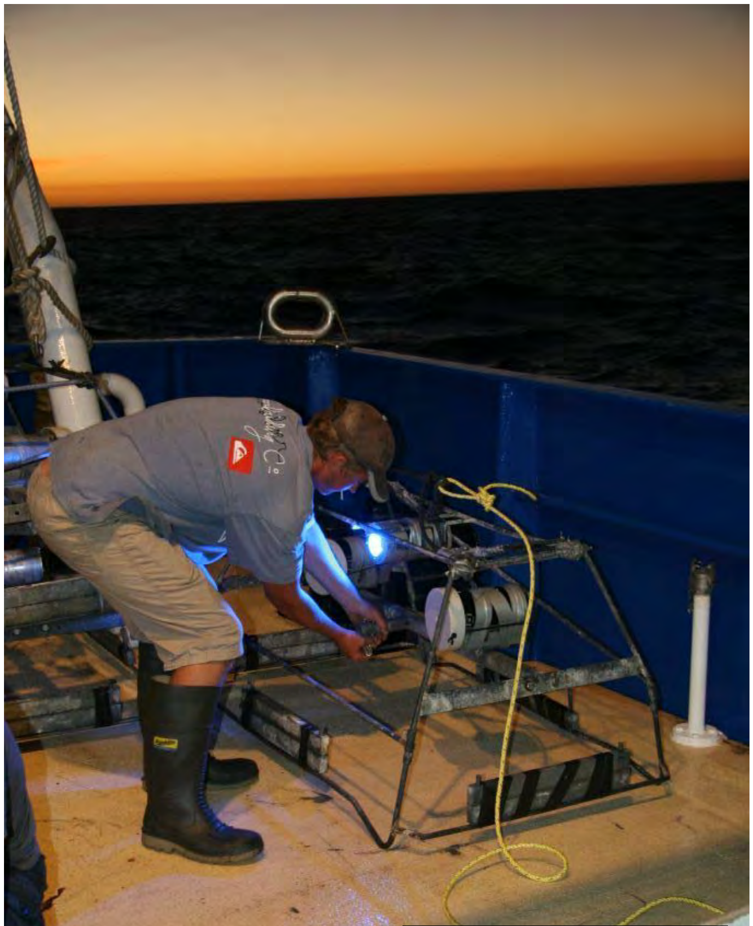
Data from receivers

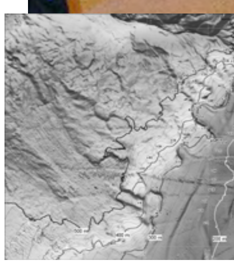
S:\Sustainable Marine Ecosystems in SE\Spatial closures project\GULPER_TAGGING\VemcoData_bases\DEEP_SHARK_MASTER.vdb

SUB-APPENDIX E6

SUB-APPENDIX E7 – VOYAGE REPORT: RV '*NATURALISTE*' 2010

SHIP **Name:** *Naturaliste* **Call Sign:** **Type of ship:** Research vessel
VOYAGE NO.: RV NATURALISTE 2010-01 **VOYAGE NAME:** Baited remote underwater video system and fishing survey – Perth Canyon, Western Australia
VOYAGE PERIOD: 9/3/2010 to 19/3/2010 **PORT OF DEPARTURE:** Fremantle **PORT OF RETURN:** Fremantle
CHIEF SCIENTIST(S) Euan Harvey
OBJECTIVES AND ACHIEVEMENT Objective. Extend and complement work already done to map the distribution of gulper sharks and to further test the effectiveness of a non-extractive monitoring technique using Baited Remote Underwater Video System (BRUVS). **Achievement: Sixty six BRUVS deployments in 200–550 metres resulting in 180 hours of stereo video. Additional fishing with long-lines and drop-lines resulted in capture of a single *Centrophorus* specimen (partially eaten and dead). BRUVS data to be assessed after voyage.**





Mapping Distribution and Movement of Gulper Sharks

Baited Remote Underwater Video System and Fishing Survey – Perth Canyon WA. March 2010

Voyage Report: RV Naturaliste 1/2010

Bruce Barker

Project:

"Mapping the distribution and movement of gulper sharks, and developing a non-extractive monitoring technique, to mitigate the risk to the species within a multi-sector fishery region of southern and eastern Australia." (CSIRO and FRDC funded)

Vessel:

RV Naturaliste

Date:

9–19 March 2010

Ports:

Fremantle to Fremantle

Introduction:

The aim of this survey was to extend and complement work already done to map the distribution of gulper sharks and to further test the effectiveness of a non-extractive monitoring technique using Baited Remote Underwater Video System (BRUVS). Co-investigator Dr Euan Harvey arranged the charter of WA Fisheries research vessel RV Naturaliste for 10 days to survey the canyon feature off Perth WA (Perth Canyon). WA Fisheries were also interested in using the BRUVS in deepwater to gain a better understanding of the deepwater scalefish communities of that area. Additionally WA Fisheries researchers were keen to utilize the charter to catch scalefish for biological sampling. This complemented our need to verify the species observed with the BRUVS by providing live samples. WA Fisheries supplied gear to enable longline/dropline fishing and staff to identify and process any catch.

Vessel details:

RV Naturaliste
Launched September 2001
Length: 22.68 metres
max range: 2,500 nautical miles
Power: 500 hp Cummins KTA 19 engine & two generating sets
Crew: 5, 6 scientist berths
Displacement 165 tonnes
Capacity: 29,000 litres fuel; 13,000 litres water

Sampling equipment:

10 BRUVS units – stereo HD flashcard video cameras, light emitting diodes (LED) light, LED synchronization dial, BRUVS frame and weights, float lines, surface floats, bait (squid and pilchard).
Video data download and storage – 4 laptops, external hard drives (12 x 1 terra bytes), card readers, batteries and chargers.

Fishing equipment – 10 mm rope, hooks (circle hooks, 3 sizes), clip-on snoods, weights, surface lines and floats, bait (squid, pilchards, mullet).

Results summary:

The area chosen for the survey was at the southeastern portion of the canyon head of the Perth canyon. It appears unlikely that this area would have been impacted by trawl. It contained features with some ridges and a steep and hard bank. The survey area was reasonably close to Rottnest Island which minimized daily steaming time (figures 1 and 2). The sampling design focussed on the upper-slope depths between 200 and 600 meters. Sampling was stratified: 200–250, 300–350, 400–450 and 500–550 m. The swath bathymetry and backscatter maps were used to inform site selection. Operation details (site location, depth and time) are summarized in table 1.

BRUVS

- 66 BRUVS deployments across the selected depth stratum.
- ~ 180 hours stereo video collected.

The soak time for the BRUVS was ~3 hours but was reduced to ~2 hours during the survey to make best use of available time. Preliminary review of videos for each shot confirmed cameras and lighting etc were working well and that fish and sharks were being attracted to the baits at all sites and had been recorded to video. Closer scrutiny and analysis of the videos will confirm the identification of the shark species recorded but a preliminary inspection suggests the majority appeared to be green eyed dogfish. Some of the BRUVS tipped over on the bottom due to drag on the surface line and more weights were added. We also expect that some may have dragged along the bottom with the strong southerly current and this could have contributed to some becoming pinned to the bottom and difficult to retrieve. We were fortunate to retrieve all units with the only loss being one sacrificial base frame and a camera getting flooded.

Depth stratum (m)	BRUVS deployments
200–250	20
300–350	19
400–450	18
500–550	9
Total BRUVS set	66

Fishing – bottom set baited hooks

Baited hooks (longline – 99 hooks, dropline – 2 x 30 hooks)

- 3 x longline sets (loss of all hooks on one occasion and 75% on the other due to the gear being caught on the bottom).
- 7 x dropline sets.
- 1 gulper landed – dead and retained - male 805 mm (total length), op# 42, 418 m water depth, (species to be confirmed).
- several green eyed dogfish caught (id to be confirmed).
- assorted scale-fish including ocean perch, blue eye, knifejaw, leatherjackets and snapper, gurnard perch.

Overall catches from the baited hooks were small. Two out of three shots of the longline resulted in lost gear due to snagging. It is likely that the longline dragged along the bottom and this contributed to it being pinned-up and subsequent loss of gear for the 2nd and 3rd sets. We then reconfigured to set drop lines with 30 hooks on each. These were also prone to dragging and the loss of the weight (connected by a weak link). The bottom hooks tended to catch the most fish but overall catches were very small. All fish were measured and biological samples of most specimens were kept by WA Fisheries. Several green eyed dogfish and the one gulper shark were frozen and identification will be confirmed in Hobart.

Voyage Narrative:

Tuesday 9th

Loading gear etc and departed Fremantle at 1600 hours. Steamed to Rottnest Island to anchor.

Wednesday 10th

Steamed out to Perth Canyon to arrive on site at first light. Set 10 BRUVS units in 200–250 meters water depth. Set the longline (99 hooks) in ~220 m and then started the haul of the BRUVS following ~3 hour deployments. The BRUVS showed mostly knifejaw, leatherjackets and snapper with some sharks.

Re-deployed 10 BRUVS again. Hauled the longline and steamed back to an anchorage at Rottnest Island having left the BRUVS deployed overnight. The longline yielded snapper, leatherjackets, a gurnard and several green eyed dogfish. A male and a female were kept as samples for later identification. Corey was taken ashore and returned to Perth to attend a course.

Thursday 11th

The longline was set in 300–350 m water depth.

Hauled previous days set of BRUVS and redeployed 10 units. Struggled to retrieve a few of the BRUVS but all were eventually retrieved with the loss of the sacrificial base of the frame of one unit. We then attempted to retrieve the longline but both ends were hooked up on the bottom and were eventually broken off (100 hooks and ropes lost). We then reviewed mapping data which, confirmed that the set had been on apparently soft substrate (swath backscatter) and on only gently sloping terrain, therefore it is suprising that gear was lost. We suspect that the longline had dragged somewhat from the position where it was set and became fouled on hard terrain/structure. Lost all of the longline. Retrieved BRUVS and steamed to Rottnest Is.

Friday 12th

Set 9 BRUVS in 400–450 m water depth and then set the longline adjacent to and in slightly deeper water to the BRUVS but still within the 400–450 m stratum. Hauled the BRUVS and then hauled the longline but again it was snagged and broke off with only 20 hooks retrieved. Hauling from the other end of the longline failed to retrieve it. Several green eyes and one damaged (chewed) dead gulper were caught. The gulper and a male and female green eye were retained as samples for later identification. Steamed to the anchorage at Rottnest Island. Corey re-joined the survey along with Claire Wellington (a Phd student from UWA) whilst Ben Carlish left.

Saturday 13th

Departed anchorage at the usual time of 0400 hours and steamed to the study area where we deployed the 9 BRUVS in 500–550 m water depth (deepest planned set). Following the lost longline gear of previous days two droplines rigged were deployed instead with 30 hooks on each. The droplines only yielded a blue eye and an ocean perch. We then proceed to locate the BRUVS for retrieval but found it difficult to see the floats. It became apparent that there was a strong set (current) to the south and it was enough to drag most if not all the surface floats under at times. Eventually we found and retrieved all the BRUVS much to the teams relief. On review of the videos some of the BRUVS units were overturned by the drag on the surface float lines. Extra weights were added to the frames.

Sunday 14th

Set the 2 droplines in 400–450 m water depth and then set the 9 BRUVS in the same depth stratum. Hauled dropline #1 for a small catch consisting of several green eyed dogfish and a redfish. Initially we couldn't locate the floats for the other dropline but eventually located it ~3 nm south of it's original set location. It had obviously dragged to shallower than set and we retrieved 2 green eyed dogfish and 3 snapper. We did another short dropline deployment but didn't catch anything. Returned to Rottnest Is anchorage and Clare went ashore to return to Perth.

Monday 15th

Set the 9 BRUVS and then set the two droplines. Dropline #1 had no catch and the other with several green eyed dogfish and 1 ocean perch. Retrieved the BRUVS and steamed to Fremantle as the forecast for the next couple of days wasn't favorable with strong winds from the south predicted. Berthed at Fremantle ~1700 hours.

Tuesday 16th
In port

Wednesday 17th
Departed Fremantle for Rottnest Is ~1400 hours and anchored off Rottnest. Sam McMillan (UWA) replaced Euan Harvey, Cory Wakefield didn't rejoin the survey

Thursday 18th
Strong winds from the south, no gear set.

Friday 19th
Steamed out to the study area early in the morning to assess conditions. Given the predicted strong winds and the already lumpy seas decided it unwise to set the gear as the risk of gear loss was high. Steamed to Fremantle.

Staff:

Dr Euan Harvey (voyage leader)	UWA
Mr Bruce Barker	CSIRO
Dr Corey Wakefield	WA Fisheries
Mr Dion Boddington	WA Fisheries
Mr Ben Carlish (communications)	WA Fisheries
Ms Claire Wellington	UWA
Mr Sam McMillan	UWA

RV Naturaliste crew

Mr Andy Prindiville (master)	WA Fisheries
Mr Tim Shepherd (mate)	WA Fisheries
Mr Richard Maddever(engineer/deck)	WA Fisheries
Mr Kim Hillier (cook/deck)	WA Fisheries
Mr Andrew Kusse (deck)	WA Fisheries

Acknowledgements:
We would like to thank WA Fisheries for making the RV Naturaliste available for the charter. Thanks to Andy Prindiville (master) and crew (Tim, Richie, Kim and Andrew) for leading deck operations and providing a happy, safe and clean working environment. Special thanks to Kim Hillier for keeping everyone on board well fed. Thanks to UWA staff whom (through Dr Euan Harvey) assisted mobilization for the survey, preparing and providing the BRUVS equipment and participating in the survey and camera calibrations. Thanks also to Ben Carlish for providing images used on the cover of this report and to Dion Boddington for assisting in the dispatch of frozen samples freighted to Hobart.

Table 1 Details of gear deployments during the survey

Operation	BRUVS_no	Code	Longitude	Latitiude	Time deploy WA local time	Date WA local	Depth	Notes
1	1	RC01	115.231	-31.970	05:52:00	10/03/10	202	BRUVS set
2	2	RC02	115.231	-31.973	06:00:00	10/03/10	204	BRUVS set
3	3	RC03	115.230	-31.977	06:05:00	10/03/10	203	BRUVS set
4	4	RC04	115.228	-31.981	06:14:00	10/03/10	212	BRUVS set
5	5	RC05	115.225	-31.986	06:21:00	10/03/10	212	BRUVS set
6	6	RC06	115.222	-31.991	06:30:00	10/03/10	212	BRUVS set
7	7	RC07	115.221	-31.995	06:39:00	10/03/10	210	BRUVS set
8	8	RC08	115.219	-32.000	06:49:00	10/03/10	206	BRUVS set
9	9	RC09	115.217	-32.004	06:58:00	10/03/10	215	BRUVS set
10	10	RC10	115.216	-32.008	07:11:00	10/03/10	213	BRUVS set
11	-	Longline	115.205	-32.018	07:50:00	10/03/10	224	long line start
12	11	RC11	115.214	-32.012	11:20:00	10/03/10	212	BRUVS set and left overnight
13	12	RC12	115.211	-32.015	11:26:00	10/03/10	210	BRUVS set and left overnight
14	13	RC13	115.208	-32.019	11:32:00	10/03/10	213	BRUVS set and left overnight
15	14	RC14	115.205	-32.023	11:39:00	10/03/10	210	BRUVS set and left overnight
16	15	RC15	115.202	-32.032	11:46:00	10/03/10	210	BRUVS set and left overnight
17	16	RC16	115.202	-32.036	11:53:00	10/03/10	216	BRUVS set and left overnight
18	17	RC17	115.201	-32.040	11:59:00	10/03/10	216	BRUVS set and left overnight
19	18	RC18	115.197	-32.046	12:05:00	10/03/10	215	BRUVS set and left overnight
20	19	RC19	115.195	-32.050	12:13:00	10/03/10	210	BRUVS set and left overnight
21	20	RC20	115.198	-32.056	12:20:00	10/03/10	215	BRUVS set and left overnight
22	-	Longline	115.200	-32.006	05:30:00	11/03/10	310	Longline start
23	21	RC21	115.222	-31.973	08:49:00	11/03/10	333	BRUVS set
24	22	RC22	115.221	-31.978	08:59:00	11/03/10	300	BRUVS set
25	23	RC23	115.222	-31.983	09:04:00	11/03/10	300	BRUVS set
26	24	RC24	115.220	-31.986	09:11:00	11/03/10	311	BRUVS set
27	25	RC25	115.215	-31.987	09:18:00	11/03/10	319	BRUVS set
28	26	RC26	115.212	-31.990	09:23:00	11/03/10	324	BRUVS set
29	27	RC27	115.210	-31.995	09:30:00	11/03/10	328	BRUVS set
30	28	RC28	115.208	-31.999	09:35:00	11/03/10	300	BRUVS set
31	29	RC29	115.204	-32.002	09:45:00	11/03/10	300	BRUVS set
32	30	RC30	115.197	-32.012	09:58:00	11/03/10	335	BRUVS set
33	31	RC31	115.216	-31.973	05:35:00	12/03/10	418	BRUVS set
34	32	RC32	115.215	-31.978	05:44:00	12/03/10	410	BRUVS set
35	33	RC33	115.213	-31.982	05:52:00	12/03/10	429	BRUVS set
36	34	RC34	115.209	-31.981	05:59:00	12/03/10	430	BRUVS set
37	35	RC35	115.203	-31.982	06:04:00	12/03/10	429	BRUVS set
38	36	RC36	115.202	-31.986	06:11:00	12/03/10	440	BRUVS set
39	37	RC37	115.197	-31.988	06:15:00	12/03/10	409	BRUVS set
40	38	RC38	115.192	-31.991	06:27:00	12/03/10	419	BRUVS set
41	39	RC39	115.191	-31.996	06:33:00	12/03/10	424	BRUVS set
42	-	Longline	115.190	-32.004	07:04:00	12/03/10	418	Longline start
43	40	RC40	115.192	-31.986	05:38:00	13/03/10	502	BRUVS set
44	41	RC41	115.212	-31.972	05:48:00	13/03/10	510	BRUVS set
45	42	RC42	115.209	-31.976	05:57:00	13/03/10	502	BRUVS set

Operation	BRUVS_no	Code	Longitude	Latitiude	Time deploy WA local time	Date WA local	Depth	Notes
46	43	RC43	115.202	-31.977	06:07:00	13/03/10	525	BRUVS set
47	44	RC44	115.198	-31.979	06:15:00	13/03/10	540	BRUVS set
48	45	RC45	115.197	-31.984	06:25:00	13/03/10	521	BRUVS set
49	46	RC46	115.187	-31.988	06:32:00	13/03/10	509	BRUVS set
50	47	RC47	115.183	-31.991	06:41:00	13/03/10	500	BRUVS set
51	48	RC48	115.181	-31.995	06:52:00	13/03/10	518	BRUVS set
52	-	Dropline	115.195	-32.007	07:40:00	13/03/10	386	Dropline set
53	-	Dropline	115.193	-32.001	07:50:00	13/03/10	380	Dropline set
54	-	Dropline	115.202	-32.018	05:47:00	14/03/10	247	Dropline set
55	-	Dropline	115.187	-32.019	06:00:00	14/03/10	354	Dropline set
56	49	RC49	115.192	-32.005	06:13:00	14/03/10	406	BRUVS set
57	50	RC50	115.184	-32.013	06:27:00	14/03/10	415	BRUVS set
58	51	RC51	115.180	-32.018	06:34:00	14/03/10	414	BRUVS set
59	52	RC52	115.172	-32.021	06:43:00	14/03/10	408	BRUVS set
60	53	RC53	115.167	-32.026	06:53:00	14/03/10	410	BRUVS set
61	54	RC54	115.163	-32.031	07:02:00	14/03/10	413	BRUVS set
62	55	RC55	115.157	-32.034	07:16:00	14/03/10	420	BRUVS set
63	56	RC56	115.162	-32.047	07:28:00	14/03/10	420	BRUVS set
64	57	RC57	115.161	-32.053	07:35:00	14/03/10	447	BRUVS set
65	-	Dropline	115.147	-32.065	12:45:00	14/03/10	347	Dropline set
66	58	RC58	115.194	-32.003	05:38:00	15/03/10	308	BRUVS set
67	59	RC59	115.193	-32.007	05:44:00	15/03/10	305	BRUVS set
68	60	RC60	115.197	-32.012	05:51:00	15/03/10	334	BRUVS set
69	61	RC61	115.193	-32.017	05:58:00	15/03/10	314	BRUVS set
70	62	RC62	115.184	-32.021	06:06:00	15/03/10	305	BRUVS set
71	63	RC63	115.183	-32.028	06:13:00	15/03/10	315	BRUVS set
72	64	RC64	115.177	-32.031	06:21:00	15/03/10	322	BRUVS set
73	65	RC65	115.173	-32.034	06:27:00	15/03/10	321	BRUVS set
74	66	RC66	115.170	-32.039	06:35:00	15/03/10	325	BRUVS set
75	-	Dropline	115.172	-32.051	06:58:00	15/03/10	308	Dropline set
76	-	Dropline	115.170	-32.058	07:10:00	15/03/10	332	Dropline set

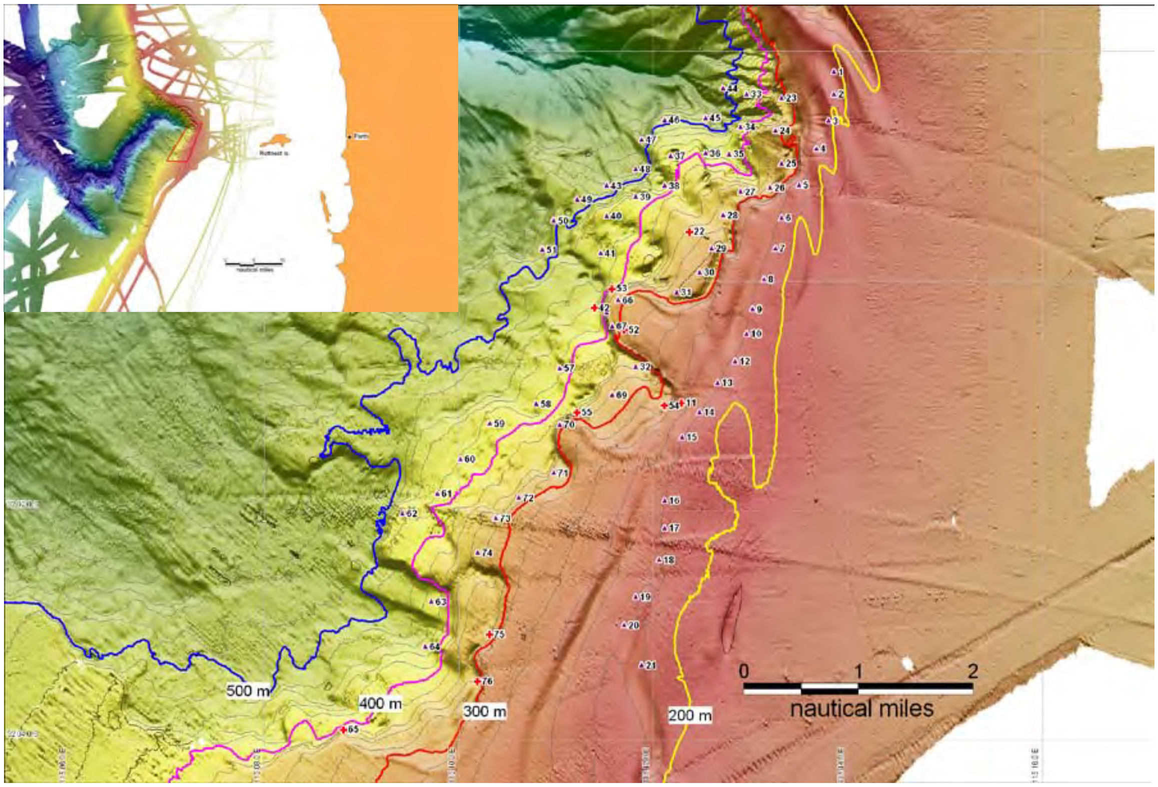


Figure 1. A map showing the sampling sites (BRUVS and fishing) at the southeastern end of the canyon and the sampling area (red polygon on inset) in relation to the coast and the canyon greater. Contours (as labeled) are shown overlain on sun-illuminated swath bathymetry as mapped using the multi-beam swath mapper on National Facility Research Vessel Southern Surveyor.

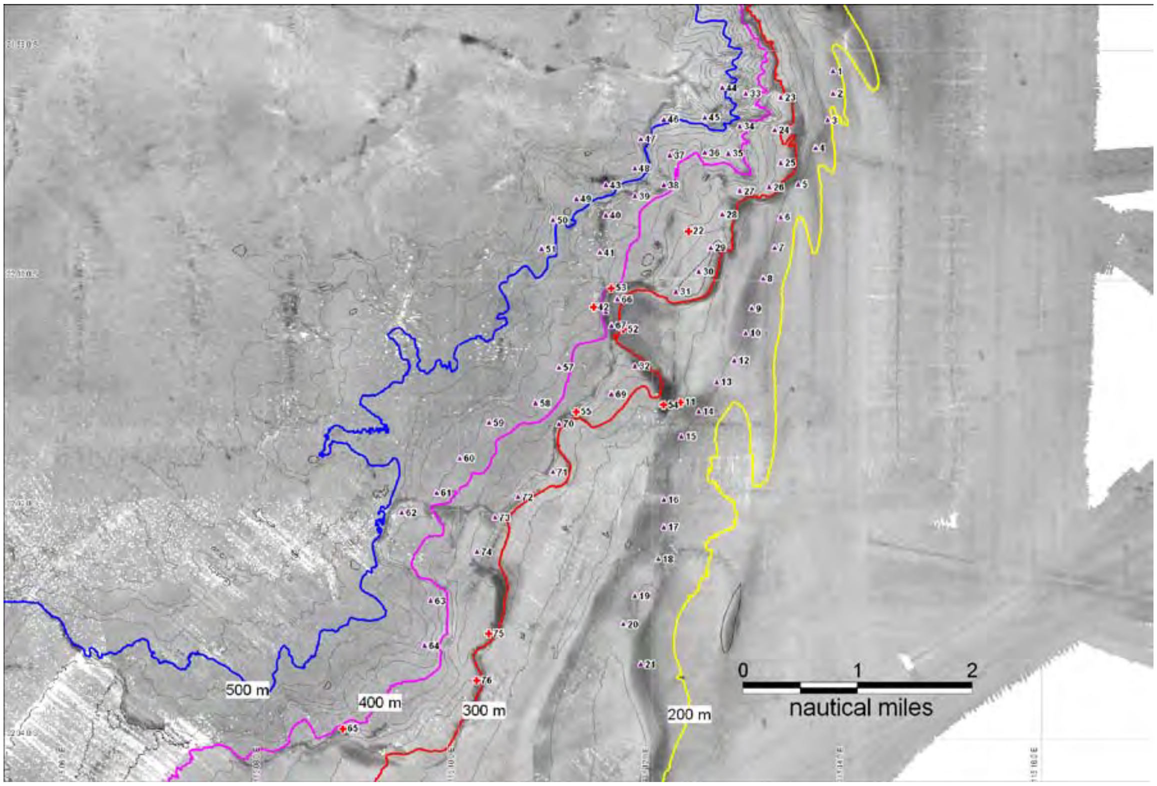


Figure 2. A map showing the sites sampled using the BRUVS and baited lines overlaid on a backscatter (hardness) map from the multi-beam swath mapper where the darker shading (dark grey areas) indicate harder bottom.

SUB-APPENDIX E8 – VOYAGE REPORT: FV '*SARDA*' 2010-01

SHIP **Name:** *Sarda* **Call Sign:** 0737 **Type of ship:** Commercial fishing vessel - auto longliner
VOYAGE NO.: FV SARDA 2010-01 **VOYAGE NAME:** Eastern site survey, Great Australian Bight
VOYAGE PERIOD: 17/3/2010 to 20/3/2010 **PORT OF DEPARTURE:** Portland **PORT OF RETURN:** Portland
CHIEF SCIENTIST(S) Mark Green
OBJECTIVES AND ACHIEVEMENT Objective 1. Confirm species of shark caught are in-fact *Centrophorus* spp. **Achievement: *Centrophorus* species identified as *C. zeehaani*. Photos taken and 3 specimens collected (2 male, 1 female) for collection material and potentially genetics.** Objective 2. Collect sex ratio and size structure (length/frequency) data (*Centrophorus* spp only). **Achievement: Length and sex recorded for all *Centrophorus* specimens captured except two that dropped off.** Objective 3. Collect size at maturity data from males and any dead females. **Achievement: Only two male gulper sharks captured with incompletely calcified claspers; size recorded. No specimens of female dissected as they were all in good condition and returned to sea alive.** Objective 4. Collect catch composition data, focus on elasmobranches but scale fish if possible. **Achievement: Catch composition recorded for all operations.** Objective 5. Collect information on population distribution (geographic extent) and information on the bottom types over fished areas. **Achievement: All four operations conducted at slightly different locations and with a variety of bottom topographical features. Catch from each operation recorded independently for comparison.** Objective 6. Fit conventional tags to any species of gulper shark encountered **Achievement: Two hundred specimens of *C. zeehaani* were marked with Jumbo Rototags fitted to the dorsal fin.**

Mapping Distribution and Movement of Gulper Sharks

Eastern site survey, Great Australian Bight: March 2010 - Voyage Report: FV SARDA 1-10

National Research FLAGSHIPS
Wealth from Oceans
CSIRO

Australian Government
Fisheries Research & Development Corporation

Project:

"*Mapping the distribution and movement of gulper sharks, and developing a non-extractive monitoring technique, to underpin a stock rebuild within a multi-sector fishery region off southern and eastern Australia*." (CSIRO and FRDC funded)

1. Scientific objectives

1. Confirm species of shark caught are in-fact *Centrophorus* spp.
2. Collect sex ratio and size structure (length/frequency) data (*Centrophorus* spp only).
3. Collect size at maturity data from males and any dead females.
4. Collect catch composition data, focus on elasmobranches but scale fish if possible.
5. Collect information on population distribution (geographic extent) and information on the bottom types over fished areas.
6. Fit conventional tags to any species of gulper shark encountered

2. Summary of achievements against Voyage Objectives

<u>Objective 1.</u>
***Achievement: Centrophorus* species identified as *C. zeehaani.* Photos taken and 3 specimens collected (2 male, 1 female) for collection material and potentially genetics.**

<u>Objective 2.</u>
***Achievement:* Length and sex recorded for all *Centrophorus* specimens captured except the two that dropped of on fleet 1.**

<u>Objective 3.</u>
***Achievement:* Only two male gulper sharks captured with incompletely calcified claspers; size recorded. No specimens of female dissected as they were all in good condition and returned to sea alive.**

<u>Objective 4.</u>
***Achievement:* Catch composition recorded for all operations, see table 5.**

<u>Objective 5.</u>
***Achievement:* All four operations conducted at slightly different locations and with a variety of bottom topographical features. Catch from each operation recorded independently for comparison.**

<u>Objective 6.</u>
***Achievement:* Two hundred specimens of *C. zeehaani* were marked with Jumbo Rototags fitted to the dorsal fin.**

3. Dates and timing of survey

Depart Portland 1800 hours, Wednesday 17th March 2010
Return Portland 1815 hours Friday 20th March 2010

4. Vessel details

CSIRO chartered F.V. Sarda – a Lakes Entrance based fishing vessel - for this tagging survey. The Sarda is equipped with auto longline gear and licensed to fish in Commonwealth waters. The master and crew are experienced longline fisherman. The vessel was built in 1974 at Williamstown Victoria. The vessel is 20 meter in length, constructed of steel and powered by a single 871 GM (265 hp) main engine. Auxiliary power is supplied by smaller engines for hydraulics, 240 volt power and refrigeration (brine tanks and freezer). The vessel has berths for up to 7 and is owned and operated by Mr Chris Currie (Bluebeards Seafoods) who has 25+ years of drop and longline fishing experience for both demersal and pelagic fishes in different parts of Australia.

5. Fishing equipment

Setting and hauling the longline used a Mustad Coastal auto-line system with automatic baiting of 2 hooks per second whilst steaming at 5 knots. The mainline used was 7mm Mustad roto line (swivelled) with snoods at 1.4 m intervals, and 400 mm snoods (1.8 mm monofilament). The hooks used were 12/0 Mustad 'super baiters'. The line was anchored at each end with 60 kg steel weights, extra weights (and floats) were deployed along the line according to terrain and to fish either hard on the bottom or off the bottom. Lines and surface floats marked the start and end of the line and were used to retrieve the longline. Jack Mackeral (sourced from Triabunna) was used as the bait.

The line was typically in the water for between 2–4 hours before commencement of hauling.

The gulper sharks captured were removed from the hook by the crew and not allowed to pass through the 'rollers' in order to prevent jaw damage. Other sharks did go through the rollers.

6. Voyage Narrative

Wednesday 17th

Steamed westerly from Portland and arrived at the survey site in the early hours of Thursday 18th.

Thursday 18th

At about 0600 hrs we started setting the first of 2 fleets (each with 2000 hooks). The first fleet was set along a very steep edge above the canyon feature, the second across the head of the small canyon. Deployment was completed by 0700 hrs. Hauling fleet 1 commenced at 0920 hrs and was completed by 1030 hrs. A total of 20 *Centrophorus zeehaani* were captured; 2 of these dropped off the line, the others were tagged with Roto tags fitted to the dorsal fin. Hauling fleet 2 commenced at 1130 hrs and was completed by 1330 hrs. A total of 228 *C. zeehaani* were captured with 182 of these being tagged (exhausting the supply of tags) and released during this busy fishing operation. Most of these animals were male but a small patch of females tended to be in the middle section of operation set in deeper water. A third fleet of 2000 hooks was set slightly to the west of the canyon feature at around 1500 hrs in depths corresponding to where the females were captured on fleet 2, though in a slightly different location. Only 5 *C. zeehaani* were captured on this operation, 2 of them female. Most sharks captured appeared to be in good condition with most observed swimming slowly down when returned to the sea. On all operations the complete catch was recorded and all gulper sharks were measured (total length) and the sex recorded.

Friday 19th

As the charter was for 2 days only, meaning we had to be back in port at ~1800 hrs this day (and estimated steaming time is about 8–9 hrs) we set a single fleet of 1000 hooks in a depth of about 500 metres along the inside of the canyon. A total of 25 *C. zeehaani* were captured and returned to the sea after length and sex being recorded. Catch composition was also recorded. At around 0940 hrs fishing operations were complete and we commenced the steam back to Portland. We arrived at the wharf area and ropes on at 0630 hrs.

It is worth noting that during the tagging operations a record was made of each gulper shark that had a jaw broken from a previous fishing capture. A total of 13 fish from the 200 tagged had jaw damage from a previous capture (see figure 2). Three of these were female.

7. Acknowledgements

Many thanks to the Master and crew of fishing vessel Sarda who once again have provided a happy and safe work area for this research voyage. Chris Currie deserves special mention for his ability to find an abundant supply of our target species.

8. Staff

Mr Mark Green	CSIRO	Voyage leader
Mr Scott Cooper	CSIRO	Science data
Mr Chris Currie	FV Sarda	Master
Mr Jim Culliber	FV Sarda	Mate/Deck/cook
Mr Will Andrews	FV Sarda	Deck
Mr Laurie Pullbrook	FV Sarda	Deck

Table 1 Details of fishing positions

Operation/Fleet number	Start set position Latitude	Longitude	Depth (m)	End set position Latitude	Longitude	Depth (m)	No of hooks set
1	-38.133	140.238	336	-38.118	140.211	388	2000
2	-38.125	140.203	393	-38.109	140.176	452	2000
3	-38.086	140.141	443	-38.116	140.145	600	2000
4	-38.118	140.187	492	-38.133	140.193	470	1000

Table 2 Details of main elasmobranch species caught

Operation/Fleet number	No hooks set	Gulpers	Green eye	Swell sharks	Sawtail catshark	Piked dogfish
1	2000	20		9	80	32
2	2000	228	9	4	26	8
3	2000	5	15	1	20	1
4	1000	25	1	9		1

Table 3 Details of release positions of tagged fish

Operation/ fleet number	Release position (~centre of set) Latitude	Longitude
1	-38.125	140.222
2	-38.117	140.188

Note – animals only tagged on Op 1 & 2

Table 4 Tag tally

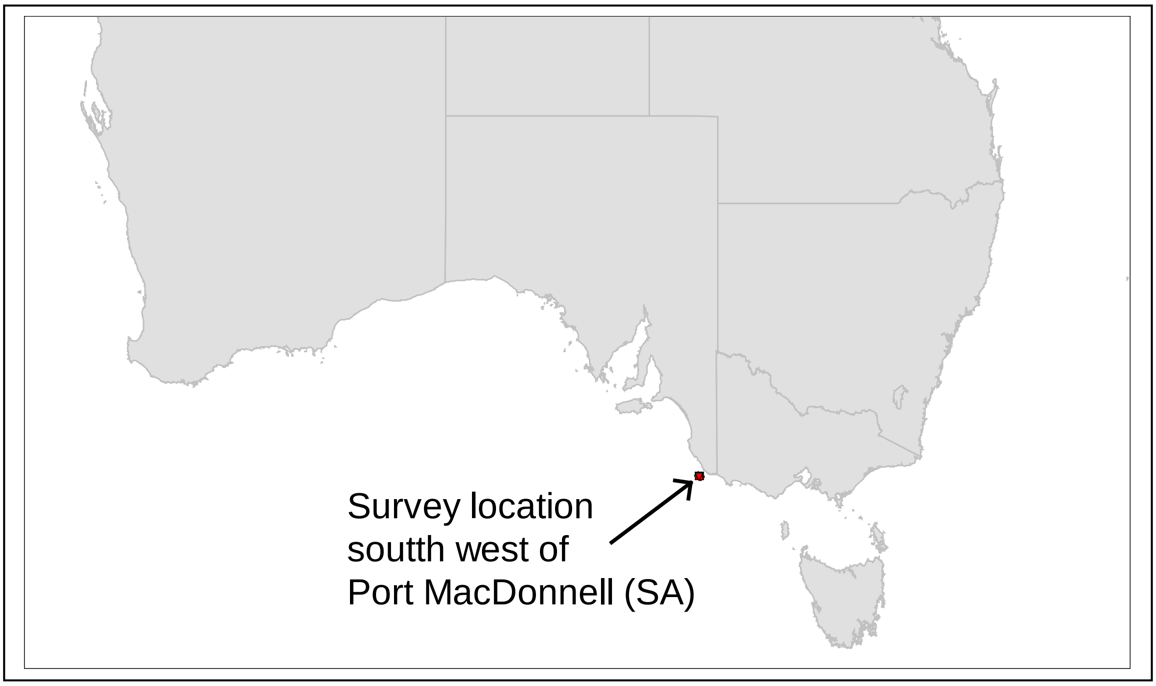
	Conventional	Mean length (cm)
Gulper ♀	26	100
Gulper ♂	174	87
Total	**200**	

Table 5. Catch composition

Common name	Scientific name	Shot 1	Shot 2	Shot 3	Shot 4	**Total**
Southern Dogfish	*Centrophorus zeehaani*	20	228	5	25	278
Piked Spurdog	*Squalus megalops*	32	8	1	1	42
Greeneye Spurdog	*Squalus chloroculus*		9	15	1	25
Whitefin Swellshark	*Cephaloscyllium albipinium*	9	4	1	9	23
Gummy Shark	*Mustelus antarcticus*	5				5
Sawtail Catshark	*Figaro boardmani*	80	26	20		126
Bight Skate	*Dipturas gudgeri*	4	1			5
Grey Skate	*Dipturas canutus*	1	8	3		12
Pygmy thornback skate	*Deneraja flindersi*	1				1
Shortfin eel	*Anguilla australis australis*	3	15	29	15	62
Banded rattail	*Coelorinchus fasciatus*	10	2			12
Cucumber fish	*Paraulopus nigripinnis*	1				1
Hapuka	*Polyprion oxygeneios*	5	4			9
Pink ling	*Genypterus blacodes*	28	21	2	10	61
Ocean perch	*Helicolenus percoides*	22	58	53	26	159
Jackass morwong	*Nemadactylus macropterus*	9				9
Blue-eye trevalla	*Hyperoglyphe antarctica*	4	6	2		12
Blue grenadier	*Macruronus novaezelandiae*		3			3
Gemfish	*Rexea solandri*		1			1
Ribaldo cod	*Mora Moro*			18	1	19
Ray's bream	*cf Brama brama*			2		2
Totals		**234**	**394**	**151**	**88**	**867**

Table 6. Tag detai

count	Length (cm)	Sex (M/F/U)	Tag No.	count	Length (cm)	Sex (M/F/U)	Tag No.	count	Length (cm)	Sex (M/F/U)	Tag No.	count	Length (cm)	Sex (M/F/U)	Tag No.	count	Length (cm)	Sex (M/F/U)	Tag No.
1	104	F	12401	**41**	82	M	12441	**81**	89	M	12481	**121**	84	F	12321	**161**	87	M	12361
2	89	M	12402	**42**	88	M	12442	**82**	89	M	12482	**122**	110	F	12322	**162**	104	F	12362
3	82	M	12403	**43**	84	M	12443	**83**	86	M	12483	**123**	71	F	12323	**163**	87	M	12363
4	87	M	12404	**44**	85	M	12444	**84**	92	M	12484	**124**	86	M	12324	**164**	91	M	12364
5	100	F	12405	**45**	87	M	12445	**85**	80	M	12485	**125**	88	M	12325	**165**	87	M	12365
6	91	M	12406	**46**	88	M	12446	**86**	87	M	12486	**126**	85	M	12326	**166**	85	M	12366
7	90	M	12407	**47**	89	M	12447	**87**	85	M	12487	**127**	90	F	12327	**167**	88	M	12367
8	82	M	12408	**48**	91	M	12448	**88**	90	M	12488	**128**	103	F	12328	**168**	86	M	12368
9	84	M	12409	**49**	89	M	12449	**89**	88	M	12489	**129**	89	M	12329	**169**	86	M	12369
10	89	M	12410	**50**	86	M	12450	**90**	84	M	12490	**130**	90	M	12330	**170**	106	F	12370
11	89	M	12411	**51**	87	M	12451	**91**	86	M	12491	**131**	87	M	12331	**171**	88	M	12371
12	83	M	12412	**52**	87	M	12452	**92**	85	M	12492	**132**	104	F	12332	**172**	89	M	12372
13	89	M	12413	**53**	85	M	12453	**93**	90	M	12493	**133**	87	M	12333	**173**	89	M	12373
14	87	M	12414	**54**	91	M	12454	**94**	85	M	12494	**134**	86	M	12334	**174**	86	M	12374
15	84	M	12415	**55**	92	M	12455	**95**	107	F	12495	**135**	93	M	12335	**175**	86	M	12375
16	86	M	12416	**56**	88	M	12456	**96**	88	M	12496	**136**	86	M	12336	**176**	79	M	12376
17	89	M	12417	**57**	87	M	12457	**97**	103	F	12497	**137**	84	F	12337	**177**	90	M	12377
18	88	M	12418	**58**	86	M	12458	**98**	88	M	12498	**138**	88	M	12338	**178**	87	M	12378
19	88	M	12419	**59**	90	M	12459	**99**	88	M	12499	**139**	86	M	12339	**179**	88	M	12379
20	94	M	12420	**60**	80	M	12460	**100**	101	F	12500	**140**	85	M	12340	**180**	85	M	12380
21	90	M	12421	**61**	84	M	12461	**101**	91	M	12301	**141**	104	F	12341	**181**	88	M	12381
22	84	M	12422	**62**	83	M	12462	**102**	83	M	12302	**142**	85	M	12342	**182**	88	M	12382
23	86	M	12423	**63**	94	M	12463	**103**	89	M	12303	**143**	105	F	12343	**183**	88	M	12383
24	87	M	12424	**64**	87	M	12464	**104**	86	M	12304	**144**	95	F	12344	**184**	87	M	12384
25	87	M	12425	**65**	85	M	12465	**105**	102	F	12305	**145**	85	M	12345	**185**	85	M	12385
26	86	M	12426	**66**	90	M	12466	**106**	89	M	12306	**146**	85	M	12346	**186**	83	M	12386
27	91	M	12427	**67**	90	M	12467	**107**	88	M	12307	**147**	84	M	12347	**187**	88	M	12387
28	89	M	12428	**68**	89	M	12468	**108**	88	M	12308	**148**	91	M	12348	**188**	87	M	12388
29	88	M	12429	**69**	87	M	12469	**109**	86	M	12309	**149**	88	M	12349	**189**	89	M	12389
30	89	M	12430	**70**	89	M	12470	**110**	90	F	12310	**150**	91	M	12350	**190**	88	M	12390
31	87	M	12431	**71**	89	M	12471	**111**	86	M	12311	**151**	86	M	12351	**191**	103	F	12391
32	88	M	12432	**72**	89	M	12472	**112**	89	M	12312	**152**	87	M	12352	**192**	84	M	12392
33	87	M	12433	**73**	87	M	12473	**113**	87	M	12313	**153**	90	M	12353	**193**	100	F	12393
34	86	M	12434	**74**	84	M	12474	**114**	89	M	12314	**154**	87	M	12354	**194**	86	M	12394
35	90	M	12435	**75**	83	M	12475	**115**	86	M	12315	**155**	86	M	12355	**195**	102	F	12395
36	88	M	12436	**76**	87	M	12476	**116**	105	F	12316	**156**	104	F	12356	**196**	85	M	12396
37	87	M	12437	**77**	105	F	12477	**117**	87	M	12317	**157**	94	M	12357	**197**	90	M	12397
38	87	M	12438	**78**	83	M	12478	**118**	91	M	12318	**158**	90	M	12358	**198**	105	F	12398
39	87	M	12439	**79**	93	M	12479	**119**	86	M	12319	**159**	85	M	12359	**199**	86	M	12399
40	88	M	12440	**80**	92	M	12480	**120**	85	M	12320	**160**	87	M	12360	**200**	90	M	12400



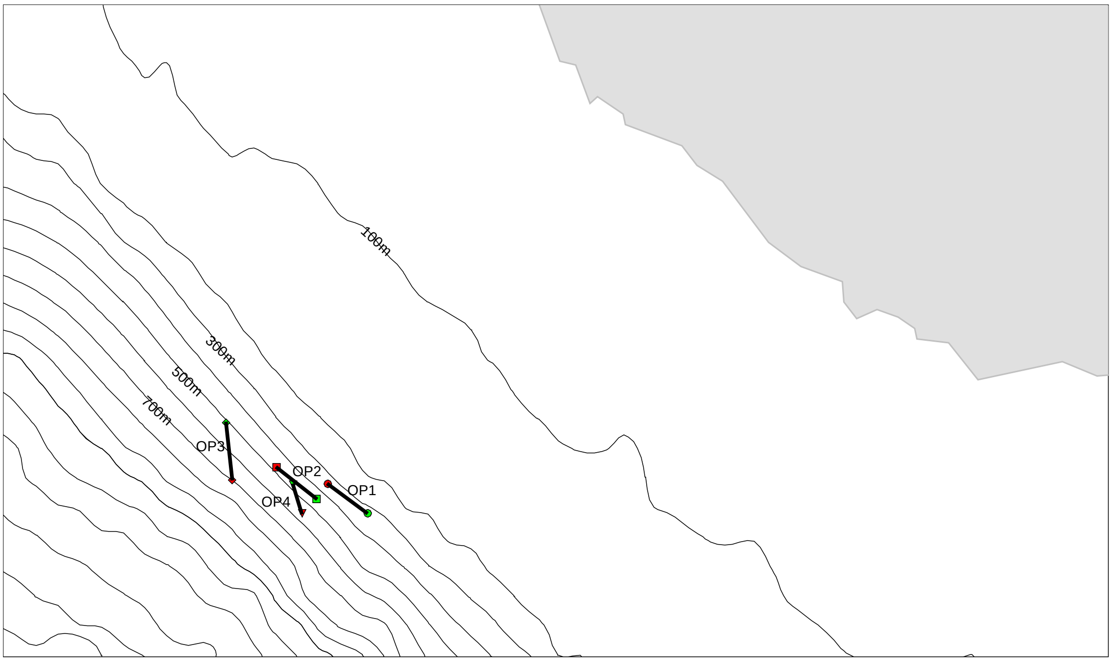


Figure 1 Top: Location of survey area on the edge of the GAB. Bottom: Location of fishing operations on depth gradient. Note the canyon feature is not shown on these topographic lines and depths are indicative only.

Figure 2 Jaw damage from previous capture/s. Some healing evident but there appears to be relatively fresh damage and also the puncture from this capture where the hook was removed by hand (arrow), suggesting animal captured at least 3 times.

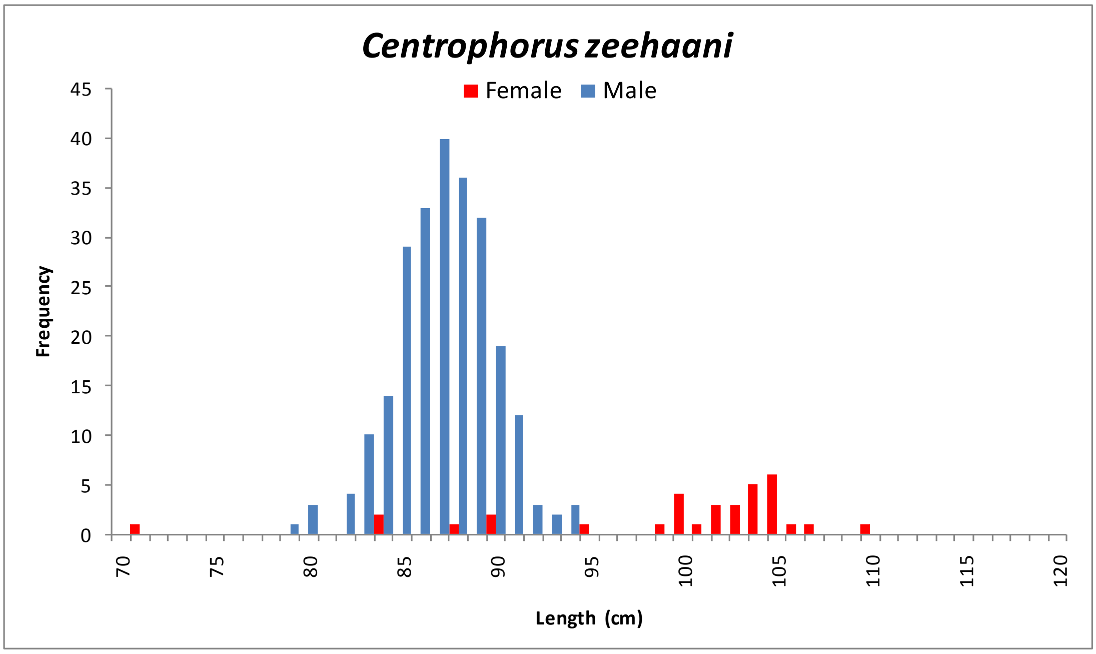


Figure 3 Length vs Frequency for Southern dogfish captured on all the operations.

APPENDIX

Data acquittal

Tag data (shark length, sex, tag type, tag number)

A scanned copy of original catch comp data sheets (as they came off the boat) in file:
Catchcompscan_SARDA 01-10.pdf
In:
S:\Sustainable Marine Ecosystems in SE\Spatial closures project\Yoyage_SARDA_01-10\Data_report_Sarda01-2010

The tagging data with errors corrected in file
Shark tagging data and all other data in file:
Data SARDA 01-10.xlsx
In:
S:\Sustainable Marine Ecosystems in SE\Spatial closures project\Yoyage_SARDA_01-10\Data_report_Sarda01-2010

Original hardcopy of tagging and length/sex data do not scan well as the pencil used is too light. These are filed with the original catch composition data sheets and given to Ross Daley.

Mapping files

All map products are in:
S:\Sustainable Marine Ecosystems in SE\Spatial closures project\Yoyage_SARDA_01-10\Data_report_Sarda01-2010

Voyage report

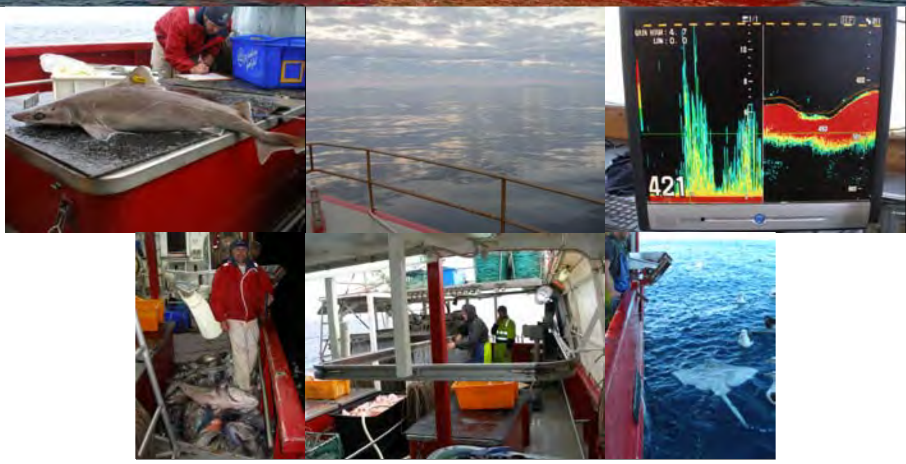
In file:
S:\Sustainable Marine Ecosystems in SE\Spatial closures project\Yoyage_SARDA_01-10\Data_report_Sarda01-2010

Images

Photos taken on Marks Olympus camera are in:
S:\Sustainable Marine Ecosystems in SE\Spatial closures project\Yoyage_SARDA_01-10\Images Sarda01-1.

SUB-APPENDIX E9 – VOYAGE REPORT: FV '*SARDA*' 2010-02

SHIP **Name:** *Sarda* **Call Sign:** 0737 **Type of ship:** Commercial fishing vessel - auto longliner
VOYAGE NO.: FV SARDA 2010-02 **VOYAGE NAME:** Bass Strait Survey
VOYAGE PERIOD: 20/5/2010 to 25/5/2010 *and* 27/5/2010 to 6/6/2010 **LEG 1:** Lakes Entrance to Lakes Entrance **LEG 2:** Lakes Entrance to St Helens (TAS)
CHIEF SCIENTIST(S) Mark Green
OBJECTIVES AND ACHIEVEMENT Objective 1. Confirm species of shark caught are in-fact *Centrophorus* spp. and distinguish between *C. zeehaani* and *C. harrissoni*. **Achievement: A total of 202 *Centrophorus spp.* were identified at various locations across Bass Strait. Of these, seven were identified as *C. zeehaani*, 191 were identified as *C. harrissoni* and 4 were not identified to species as they dropped off the line (see Table 1). Photos taken for reference of most specimens.** Objective 2. Collect sex ratio and size structure (length/frequency) data (*Centrophorus* spp only). **Achievement: Length and sex recorded for all landed *Centrophorus* specimens.** Objective 3. Collect size at maturity data from males and any dead females. **Achievement: Twenty seven male *C. harrissoni* gulper sharks captured with incompletely calcified claspers. No specimens of female dissected as they were all in good condition and returned to sea alive (see Section 9 for detail).** Objective 4. Collect catch composition data, focus on elasmobranches but scale fish if possible. **Achievement: Catch composition recorded for all operations.** Objective 5. Collect information on population distribution (geographic extent) and information on the bottom types over fished areas. **Achievement: Thirty three operations conducted in waters on continental slope across eastern Bass Strait and in waters north east of Flinders Island group. Position data plotted into maps with bathymetric data.** Objective 6. Fit conventional tags to any species of gulper shark encountered **Achievement: Seven specimens of *C. zeehaani* and 186 specimens of *C. harrissoni* were fin tagged (dorsal) with Jumbotags and Rototags. One *C. harrissoni* was tagged with a dart tag alongside the dorsal fin.**



Mapping Distribution and Movement of Gulper Sharks

Bass Strait Survey: May–June 2010
Voyage Report
FV SARDA 2-10

Mark Green and Scott Cooper

National Research FLAGSHIPS Wealth from Oceans CSIRO

Australian Government Fisheries Research & Development Corporation

Project:

"Mapping the distribution and movement of gulper sharks, and developing a non-extractive monitoring technique, to mitigate the risk to the species within a multi-sector fishery region off southern and eastern Australia." (CSIRO and FRDC funded)

1. Scientific objectives

1. Confirm species of shark caught are in-fact *Centrophorus* spp. and distinguish between *C. zeehaani* and *C. harrissoni*.
2. Collect sex ratio and size structure (length/frequency) data (*Centrophorus* spp only).
3. Collect size at maturity data from males and any dead females.
4. Collect catch composition data, focus on elasmobranches but scale fish if possible.
5. Collect information on population distribution (geographic extent) and information on the bottom types over fished areas.
6. Fit conventional tags to any species of gulper shark encountered

2. Summary of achievements against Voyage Objectives

Objective 1.
Achievement: **A total of 202 *Centrophorus spp.* were identified at various locations across Bass Strait. Of these, seven were identified as *C. zeehaani*, 191 were identified as *C. harrissoni* and 4 were not identified to species as they dropped off the line (see Table 1). Photos taken for reference of most specimens.**

Objective 2.
Achievement: **Length and sex recorded for all landed *Centrophorus* specimens**

Objective 3.
Achievement: **Twenty seven male *C. harrissoni* gulper sharks captured with incompletely calcified claspers. No specimens of female dissected as they were all in good condition and returned to sea alive (see Section 9 for detail).**

Objective 4.
Achievement: **Catch composition recorded for all operations (see Appendix 2).**

Objective 5.
Achievement: **Thirty three operations conducted in waters on continental slope across eastern Bass Strait and in waters north east of Flinders Island group. Position data plotted into maps with bathymetric data (see Figures 3 and 4).**

Objective 6.
***Achievement:* Seven specimens of *C. zeehaani* and 186 specimens of *C. harrissoni* were fin tagged (dorsal) with Jumbotags and Rototags. One *C. harrissoni* was tagged with a dart tag alongside the dorsal fin (see Appendix 3).**

3. Dates and timing of survey

Leg 1.

Sail Lakes Entrance (VIC) 1545 hours, Wednesday 20th May 2010.
Dock Lakes Entrance (VIC) 0045 hours, Tuesday 25th May 2010.

Leg 2.

Sail Lakes Entrance (VIC) 1500 hours, Thursday 27th May 2010.
Dock St Helens (TAS) 0600 hours, Saturday 6th June 2010.

4. Vessel details

CSIRO scientists were invited to join F.V. Sarda, a Lakes Entrance based fishing vessel, to collect data during commercial fishing operations in areas of interest. The Sarda is equipped with auto longline gear and licensed to fish in Commonwealth waters. The Master and Mate are experienced longline fisherman. Some of the crew were recently recruited but quickly gained deck skills at sea. The 20 m steel vessel was built in 1974 at Williamstown Victoria. It is powered by a single 871 GM (265 hp) main engine. Auxiliary power is supplied by smaller engines for hydraulics, 240 volt power and refrigeration (brine tanks and freezer). The vessel has berths for up to 7 and is owned and operated by Mr Chris Currie (Bluebeards Seafoods) who has 25+ years of drop and longline fishing experience for both demersal and pelagic fishes in different parts of Australia.

5. Fishing equipment

Setting and hauling the longline used a Mustad Coastal auto-line system with automatic baiting of 2 hooks per second whilst steaming at 5 knots. The mainline used was 7mm Mustad roto line (swivelled) with snoods at 1.4 m intervals, and 400 mm snoods (1.8 mm monofilament). The hooks used were 12/0 Mustad ‘super baiters’. The line was anchored at each end with 60 kg steel weights, extra weights (and floats) were deployed along the line according to terrain and to fish either hard on the bottom or off the bottom. Lines and surface floats marked the start and end of the line and were used to retrieve the longline. Jack Mackerel (sourced from Triabunna and Taiwan) was used as the bait.

The fishing line was in the water for an average soak time of 8 hours before commencement of hauling. The range of soak times was 2.5–13.45 hours.

The gulper sharks captured were carefully removed from the hook by the crew and not allowed to pass through the ‘rollers’ in order to reduce jaw damage. Other sharks and scale fish did go through the rollers.

6. Voyage Narrative

Leg 1

20 May Depart Lakes Entrance at 1545 hrs
Set course for Seiners Horseshoe.

21 May. Seiners Horseshoe.
Operations 1–3, each of 3000 hooks. Finish setting 0630 hrs. Commenced hauling 0900 hrs. Operation 1 pinned up to start with, broke off after ~300 hooks so we picked up other end of set and hauled. This too was pinned up but let go and was ok until nearly the end when it pinned up again and we broke off 200-300 hooks. Operations 2 and 3 had more floats put on line to keep it off the rough bottom and came up a lot better. Completed hauling 1730 hrs. Catch dominated by Ribaldo, Ocean perch and Pink Ling. Catch considered poor commercial quantity. Two adult *Centrophorus zeehaani* in days catch.

22 May. South Mackerel Canyon.
Operations 4–6, each of 3000 hooks, set along steep sides of canyon. Some steepish bumps showing up on vessel sounder along track of sets. Finish setting 0630 hrs. Commenced hauling at 0915 hrs; completed hauling 1640 hrs. Catch dominated by Pink ling, Swell shark and Ocean perch. Two *C. harrissoni* and one *C. zeehaani* in days catch.

23 May. Everard Canyon.
Operations 7–10, three of 3000 and one of 2000 hooks all along eastern side of canyon. Catch dominated by Pink ling, Ocean perch, Swell shark, Spurdogs and some Blue-eye. Two *C. harrissoni* in days catch. The last set produced a Prickly shark and a Black shark, which had not been caught so far.

24 May. Middle Bight.
Operations 11–13, two of 4000 and one of 3000 hooks. The first two set parallel on eastern side of shallow canyon. The third set west of the canyon, along the slope over “broken” bottom. Looked like 20 m high bumps on sounder followed by flat and then up sharp edge. First and second set dominated by Pink ling, Ribaldo, Ocean perch and including eight *C. harrissoni* adults. The third set dominated by Pink ling, Ocean perch and Swell shark.

25 May Return Lakes Entrance..
Over the barway at 0030 hrs and ropes on wharf at 0045 hrs.

Leg 2

27 May. Depart Lakes Entrance at 1500 hrs.
Set course for Smithy's Corner (named after founder fisherman Schmidt).

28 May. Smithy's Corner.
Operations 14–17, each of 3000 hooks. Op14 set along northern side very steep sided canyon in slight gutter feature. Op 15 set along NW side of canyon running along depth gradient. Op 16 set along top of steep ridge; corresponding to proposed CSIRO position 2. Op 17 set along top of wider ridge, shallow to deep; corresponding to proposed CSIRO position 4. Catch on first and second operations dominated by Pink Ling, Ocean Perch and Spikey Dogfish; third operation included some Ribaldo, Hapuka and morwong with few Dogfish; fourth operation dominated by Spikey Dogfish, Ribaldo and Ocean Perch. One *C. harrissoni* captured on first operation, two on the third and one unknown Centrophorus sp (breakoff) on the fourth.

29–30 May. Killiecrankie Bay.
Laying up out of heavy easterly weather.

31 May. Babel.
Single operation 18 consisted of 3000 hooks, along depth gradient between two small canyon features; set just north and similar depths as "high Diana catch" shot. Set in early afternoon. Completed haul 1810, a few Pink ling and Blue eye, Ocean Perch plus a small number of Rays Bream. One *C. harrissoni* in catch, tagged and released.

1 June. Babel.
Operations 19–22, each of 3000 hooks. First operation just south and in similar depth range as the "high Diana catch" shot. Second operation was replicate of "high Diana catch" shot, corresponding to proposed CSIRO position 8. Third operation was along southern side of steep, small canyon; corresponding to CSIRO position 7 (called "Alan's" shot by Chris). Fourth operation starting southern side of top end same canyon, down into a gutter along top of canyon and running up northern side. Catch on first and second operations dominated by swell shark with ling and ocean perch next most abundant. A total of 63 (20 + 43) gulper sharks on these two sets (2 *C. zeehaani* and the rest *C. harrissoni*); one of these was a recaptured (tagged) juvenile *C. harrissoni*. This shark re-released alive. The third operation was dominated by spikey dogfish and ocean perch, with 11 *C. harrissoni* all at the extreme SW end. The fourth operation dominated by ribaldo and ocean perch with no gulpers at all.

2 June. Flinders
Operations 23–25, each of 3000 hooks. First operation across (down and up) canyon head. Second operation parallel to first but a bit deeper. Third operation further south similarly across (down and up) the head of a smaller canyon feature; this one weighted and bubbled for blue-eye. Catch on first operation dominated by Ling and Spikey dogfish with three *C. harrissoni* and one *C. zeehaani* on line. Second operation dominated by Spikey dogfish, then

Ribaldo and Ling, also with three *C. harrissoni* and one *C. zeehaani* on line. Third operation most abundant was Ocean perch, with Swell shark, Blue-eye and Ribaldo equally abundant. Interestingly eight *C. harrissoni* were captured on this line, even though it was set with weights and floats specifically to target Blue-eye. An interpretation of this pattern is that weights kept a fair proportion of the line on the bottom, as also supported by the high proportion of Ocean perch in the catch.

3 June. Flinders.

Operations 26–29, two of 4000, one of 3000 and one of 2000 hooks. First operation of 3000 hooks along slope just south of small canyon fished yesterday. Second operation of 4000 hooks across and down into (734 m) head of small canyon feature and then up along edge of ledge on southern side. Third operation of 3000 hooks set along slope over uneven ground, bubbled and weighted for Blue-eye. Fourth operation of 2000 hooks along contours on northern side of small canyon feature; this one weighted and bubbled for Blue-eye. Catch on first operation mainly Ribaldo with Ling, Ocean perch, Lantern sharks and Ray's bream. The catch on the second operation comparatively large and mostly Ribaldo, Ling, Brier shark (99 specimens) and Swell shark, but also lots of Ocean perch, spikey dogfish and Blue-eye. A single *Centrophorus squamosus* (Leafscale gulper shark) was captured on the second operation. We originally thought this may be a Taiwan gulper which would have been well out of its supposed range but later examination of the denticles under a microscope in the laboratory confirmed it as *C. squamosus*. There were some large pieces of coral (Figures 6-11) that came up on the hooks on this operation. Most abundant on the third operation was Ocean perch and Swell shark but also substantial catch of Gemfish (70) and Blue-eye (60); also of note a few very large Hapuka. The fourth operation produced a very 'clean' commercial catch of Blue-eye (194) and Gemfish (52) with only a few other species captured, and only six specimens of the non-commercial Swell shark and four Lantern shark. A total of 11 *C. harrissoni* plus one unknown *Centrophorus* sp (drop off) on all these operations.

4 June. Cape Barren.

Operations 30–33, three of 3000 and one of 2000 hooks. First operation of 3000 hooks across the 'Gulper spit 1' location; set north to south across spit between two small canyon features at 40º 06"; corresponding to the proposed CSIRO shot 10. Second operation of 3000 hooks set in ESE direction across the 'Between spits' location; corresponding to the proposed CSIRO shot 11. This set obliquely across proposed shot line to fit in 3000 hooks, across dip at head of canyon (480 m) and then over southern knoll and down slope to 545 m. Third operation of 2000 hooks set with weights and floats for Blue-eye; running SW up the slope over some bumpy features. Fourth operation of 3000 hooks set along contours of the steep northern edge of canyon feature at 'Chris gulper spit two' location; corresponding to proposed CSIRO shot 12. The catch of *C. harrissoni* was 74 on the first two operations and additional 6 specimens captured on the second two. After completing the haul at 1915 hrs a course was set for the port of St Helens.

5 June. St Helens, Tasmania.

Crossed the bar-way without incident at 0430 but became stuck in shallow channel at Pelican Point for an hour, eventually getting into deeper water at 0540. Docking at the fishermans wharf at 0600 hrs.

7. Acknowledgements

Many thanks to the Master and crew of fishing vessel Sarda who once again have provided a happy and safe work area. We especially thank Chris Currie for inviting CSIRO to participate in these commercial fishing operations so that we can collect important scientific data related to the gulper sharks.

8. Staff

Mr Mark Green	CSIRO	Voyage leader/cook
Mr Scott Cooper	CSIRO	Science data (Leg 2 only)
Mr Chris Currie	FV Sarda	Master
Mr Howard Bott	FV Sarda	Mate/Deck
Mr Ryan Coles	FV Sarda	Deck
Mr Tom Culpitt	FV Sarda	Deck
Mr Tom Nickless	FV Sarda	Deck (Leg 1 only)
Mr Trent McNamara	FV Sarda	Deck (Leg 1 only)
Mr Claude “Tex” Taylor	FV Sarda	Deck (Leg 2 only)

9. Discussion of preliminary scientific information

All the tagged sharks were returned to the water immediately after tagging to a position between the start and end positions of the fishing line. For the purposes of the tag database these will be recorded as the mid-point.

Twenty seven male *C. harrissoni* were captured with incompletely calcified claspers, an indication of reaching maturity. Most of these (24) had completely un-calcified claspers and measured 50–84 cm; those with semi-calcified claspers (3) measured 84–90 cm. This is similar to the results for first maturity reported by Daley *et al.* (1998) who found length at first maturity to be between 80 and 85 cm.

A total of 107 Brier shark, *Deania calcea* were captured on operations 23, 24, 26 & 27 in the Flinders region. Most of these (99) were captured on operation 27. All of the females captured had up to 16 large, developing (yellow-yolked) ova in the uterus. Daley *et al.* (1998) noted that few female *D. calcea* in their samples were in breeding condition, indicating that existing data is incomplete regarding breeding cycle and that generally there is a poor understanding of the location of breeding females. This investigation suggests the slope in the Flinders region appears to be important to *D. calcea* for reproduction. It is worth noting that operation 27 was the only one that resulted in multiple specimens of large corals being brought to the surface on the fishing equipment (see figures 6–11), suggesting good quality benthic habitat at this location.

A total of 50 Longsnout Dogfish, *Deania quadrispinosa*, were captured on 16 of the operations spread across the entire area of this investigation.

A single specimen of *C. harrissoni* was recaptured with Rototag A0615. This animal was first captured in September 2009 from the Diana during a research voyage. This immature male specimen was first measured at 62 cm and was re-measured at 64 cm. Some fouling on tag was noted (Figure 1). It was released again and swam away.

Quite a few gulper sharks captured had evidence of previous capture. This took the form of relatively minor damage such as healed hook wounds, or in some cases serious damage to the lower jaw (Figure 2). Of 167 gulper sharks for which this data was recorded, 38 had been previously captured. This means that at least 22% of these sharks had survived at least one previous capture.

It is important to note that sites off Flinders Island showed differences in sex ratios for Harrisson's Dogfish with the southern site dominated by females.

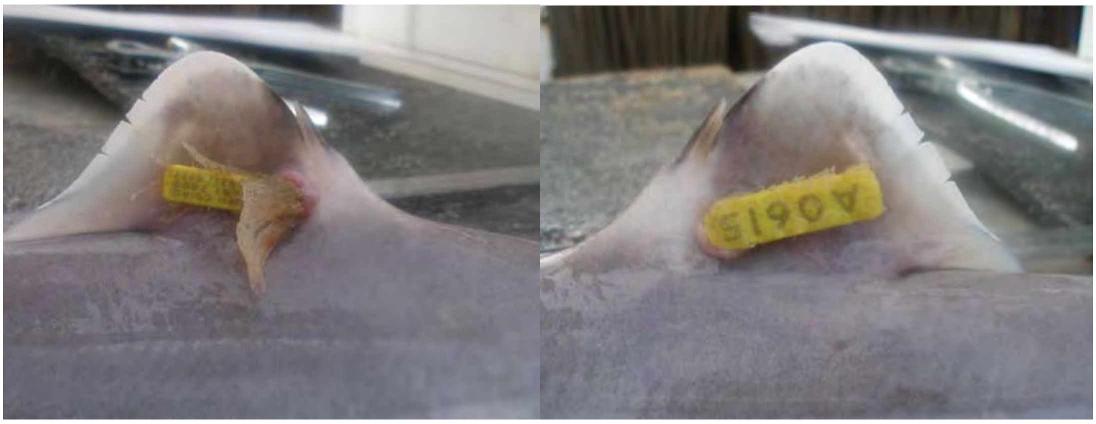


Figure 1. The recaptured *C. harrissoni* showing bio-fouling on the tag.

Figure 2. Some examples of lower jaw damage from previous capture. Note that the bottom right image is an animal first captured and tagged on a previous research trip (September 2009) where gulper sharks were de-hooked by hand.

Table 1. Catch details of *Centrophorus* spp.

Operation #	Location	Scientific name	count
1	Seiners Horseshoe	*Centrophorus zeehaani*	1
2	Seiners Horseshoe	*Centrophorus zeehaani*	1
4	South Mackeral Canyon	*Centrophorus zeehaani*	1
5	South Mackeral Canyon	*Centrophorus harrissoni*	2
7	Everard Canyon	*Centrophorus harrissoni*	1
8	Everard Canyon	*Centrophorus harrissoni*	1
11	Middle Bight	*Centrophorus harrissoni*	3
12	Middle Bight	*Centrophorus harrissoni*	5
14	Smithy's corner	*Centrophorus harrissoni*	1
16	Smithy's corner	*Centrophorus harrissoni*	2
17	Smithy's corner	*Centrophorus sp.*	1
18	Babel	*Centrophorus harrissoni*	1
19	Babel	*Centrophorus harrissoni*	20
20	Babel	*Centrophorus harrissoni*	41
20	Babel	*Centrophorus zeehaani*	2
21	Babel	*Centrophorus harrissoni*	11
23	Flinders	*Centrophorus harrissoni*	3
23	Flinders	*Centrophorus zeehaani*	1
24	Flinders	*Centrophorus harrissoni*	3
24	Flinders	*Centrophorus zeehaani*	1
25	Flinders	*Centrophorus harrissoni*	8
26	Flinders	*Centrophorus harrissoni*	2
26	Flinders	*Centrophorus sp.*	1
27	Flinders	*Centrophorus harrissoni*	6
28	Flinders	*Centrophorus harrissoni*	3
30	Cape Barren	*Centrophorus harrissoni*	22
31	Cape Barren	*Centrophorus harrissoni*	50
31	Cape Barren	*Centrophorus sp.*	2
32	Cape Barren	*Centrophorus harrissoni*	4
33	Cape Barren	*Centrophorus harrissoni*	2

Table 2. Details of fishing positions

Op #	End	Set Time	Haul Time	Hooks	Depth (m)	Lat DD.ddddd	Lon DDD.ddddd
1	Start	0359	0856	3000	594	-38.38042	148.62225
1	Finish	0429	1136		537	-38.39102	148.62862
2	Start	0508	1241	3000	643	-38.39002	148.61313
2	Finish	0535	1422		408	-38.39790	148.56635
3	Start	0559	1543	3000	367	-38.41170	148.56655
3	Finish	0659	1737		330	-38.37103	148.55033
4	Start	0406	0915	3000	308	-38.53600	148.48255
4	Finish	0440	1100		482	-38.52458	148.53495
5	Start	0440	1158	3000	416	-38.51123	148.54602
5	Finish	0504	1337		411	-38.47445	148.56540
6	Start	0556	1430	3000	407	-38.48490	148.56437
6	Finish	0625	1640		517	-38.46028	148.60840
7	Start	0359	0850	3000	381	-38.19443	149.57612
7	Finish	0407	1120		397	-38.17205	149.53240
8	Start	0507	1210	3000	401	-38.20250	149.57503
8	Finish	0534	1359		479	-38.18333	149.53558
9	Start	0555	1500	3000	538	-38.16947	149.49917
9	Finish	0627	1720		325	-38.13117	149.47210
10	Start	0651	1816	2000	529	-38.14825	149.45353
10	Finish	0711	1953		440	-38.12208	149.44218
11	Start	0354	0855	4000	432	-38.30003	149.12942
11	Finish	0434	1122		378	-38.27640	149.06732
12	Start	0455	1147	4000	453	-38.27962	149.06070
12	Finish	0536	1436		592	-38.31815	149.11732
13	Start	0635	1607	3000	391	-38.30250	148.99273
13	Finish	0745	1800		445	-38.32192	148.94780
14	Start	0345	0841	3000	516	-38.71763	148.47035
14	Finish	0416	1050		309	-38.71512	148.42522
15	Start	0443	1150	3000	324	-38.72515	148.38248
15	Finish	0511	1415		300	-38.75727	148.35285
16	Start	0548	1520	3000	528	-38.79167	148.40867
16	Finish	0618	1800		323	-38.83303	148.38958
17	Start	0652	1850	3000	234	-38.84767	148.44713
17	Finish	0719	2120		647	-38.81098	148.46653
18	Start	1342	1620	3000	591	-39.48805	148.82563
18	Finish	1408	1805		549	-39.45233	148.81712
19	Start	0434	0900	3000	487	-39.58585	148.84702
19	Finish	0500	1200		457	-39.55423	148.82760
20	Start	0516	1340	3000	498	-39.55917	148.83390
20	Finish	0547	1600		561	-39.50127	148.81780
21	Start	0621	2005	3000	604	-39.43287	148.80517
21	Finish	0700	2215		328	-39.46182	148.76517
22	Start	0716	1925	3000	411	-39.45042	148.76748
22	Finish	0743	1715		472	-39.41333	148.78940
23	Start	0422	0910	3000	325	-39.63073	148.74833
23	Finish	0453	1115		299	-39.66853	148.78287
24	Start	0534	1200	3000	300	-39.62900	148.76408
24	Finish	0605	1400		272	-39.66947	148.79557
25	Start	0639	1505	3000	528	-39.70805	148.85988
25	Finish	0710	1710		453	-39.75260	148.85300
26	Start	0411	0910	3000	580	-39.73480	148.86017
26	Finish	0442	1130		549	-39.77892	148.87572
27	Start	0503	1235	4000	468	-39.77265	148.85803
27	Finish	0559	1625		398	-39.82402	148.82373
28	Start	0624	1735	3000	412	-39.82297	148.85472
28	Finish	0655	1925		440	-39.85973	148.88630
29	Start	0715	2030	2000	412	-39.85947	148.88193
29	Finish	0731	2225		417	-39.87005	148.85445
30	Start	0438	0900	3000	379	-40.07757	148.87830
30	Finish	0506	1100		371	-40.11383	148.88793
31	Start	0525	1150	3000	336	-40.12917	148.87355
31	Finish	0555	1407		545	-40.13718	148.92603
32	Start	0620	1800	2000	424	-40.17333	148.91333
32	Finish	0638	1915		311	-40.18945	148.90290
33	Start	0706	1527	3000	599	-40.18565	148.93333
33	Finish	0739	1725		418	-40.21357	148.88618

Table 3. Summary of species caught

Scientific name	Common name	Total
Amblyraja hyperborea	Boreal Skate	174
Anguilla australis	Shortfin eel	63
Beryx decadactylus	Imperador	71
Beryx splendens	Alfonsino	4
Brama brama	Ray's Bream	50
Centrophorus harrissoni	Harrisson’s gulper shark	191
*Centrophorus squamosus**	Leafscale gulper shark*	1
Centrophorus sp.	Unknown gulper shark	4
Centrophorus zeehaani	Southern gulper shark	7
Centroscymnus owstoni	Owston's Dogfish	5
Cephaloscyllium albipinnum	Whitefin Swellshark	1347
Cephaloscyllium laticeps	Draughtboard Shark	37
Chimaera fulva	Southern Chimaera	37
Chlopsidae	Moray eel	1
Coelorinchus fasciatus	Banded whiptail	130
Dalatias licha	Black Shark	4
Deania calcea	Brier shark	107
Deania quadrispinosa	Longsnout Dogfish	50
Dipturus canutus	Grey Skate	191
Dipturus confusus	Longnose Skate	11
Dipturus gudgeri	Bight Skate	14
Echinorhinus cookei	Prickly shark	1
Eptatretus cirrhatus	Broadgilled Hagfish	3
Etmopterus baxteri	Southern Lantern shark	2
Etmopterus lucifer	Blackbelly Lanternshark	265
Etmopterus pucillus	Smooth/Slender Lanternshark	1
Figaro boardmani	Sawtail Catshark	356
Genypterus blacodes	Pink Ling	2557
Helicolenus percoides	Ocean Perch	2306
Heptranchias perlo	Sharpnose Sevengill Shark	43
Hydrolagus lemures	Blackfin Ghostshark	51
Hyperoglyphe antarctica	Blue-eye Trevalla	764
Lepidorhynchus denticulatus	Toothed whiptail	6
Macruronus novaezelandiae	Blue grenadier	39
Mora moro	Ribaldo	1222
Mustelus antarcticus	Gummy Shark	21
Nemadactylus macropterus	Jackass morwong	77
Paraulopus nigripinnis	Cucumber fish	3
Physiculus luminosa	Luminescent Cod	1
Platycephalus richardsoni	Tiger Flathead	5
Polyprion americanus	Bass Groper	2
Polyprion oxygeneios	Hapuka	56
Prionace glauca	Blue shark	1
Proscymnodon plunketi	Plunket's shark	6
Rexea solandri	Gemfish	267
Spiniraja whitleyi	Melbourne skate	7
Squalus chloroculus	Greeneye dogshark	6
Squalus megalops	Spikey Dogfish	1398
Synaphobranchus sp.	Cut-throat eel	3
Zameus squamulosus	Velvet dogfish	17
	Total	**11985**

* Confirmed in laboratory, previously thought to be C. niaukang.

Table 4. Suggested fishing positions by CSIRO

Highlighted cells are positions actually fished.

		Start		End			
Area	CSIRO Ref	Lat	Long	Lat	Long	Rationale	Notes
Smithy's	1	-38.786697	148.372010	-38.802117	148.328688	Exploratory shot in potential closure	N end; rough
Smithy's	2	-38.792202	148.408149	-38.821759	148.393398	Exploratory shot in potential closure	Middle spit
Smithy's	3	-38.789015	148.434701	-38.809299	148.419212	Exploratory shot in potential closure	Middle spit
Smithy's	4	-38.822918	148.430644	-38.851025	148.412574	Exploratory shot in potential closure	S spit
Smithy's	5	-38.809588	148.466784	-38.841173	148.451295	Exploratory shot in potential closure	S spit
Finger 3	6	-39.249164	148.738655	-39.289112	148.698365	Mature fish this far north?	Canyon edge - desirable, but distant from Babel
Babel	7	-39.429306	148.807631	-39.461765	148.759605	N of high Diana catch	extend over canyon edge at N
Babel	8	-39.498717	148.817301	-39.544159	148.832772	High Diana catch	Replicate sample; expected hi catch
Babel	9	-39.606329	148.844053	-39.630298	148.787970	S of high Diana catch	extend over canyon edge at S
Cape Barren	10	-40.103692	148.874870	-40.104686	148.917051	Chris gulper spit 1	Expectation of gulpers
Cape Barren	11	-40.142847	148.883983	-40.144040	148.926165	Between spits	
Cape Barren	12	-40.193332	148.921217	-40.214201	148.889451	Chris gulper spit 2	Expectation of gulpers

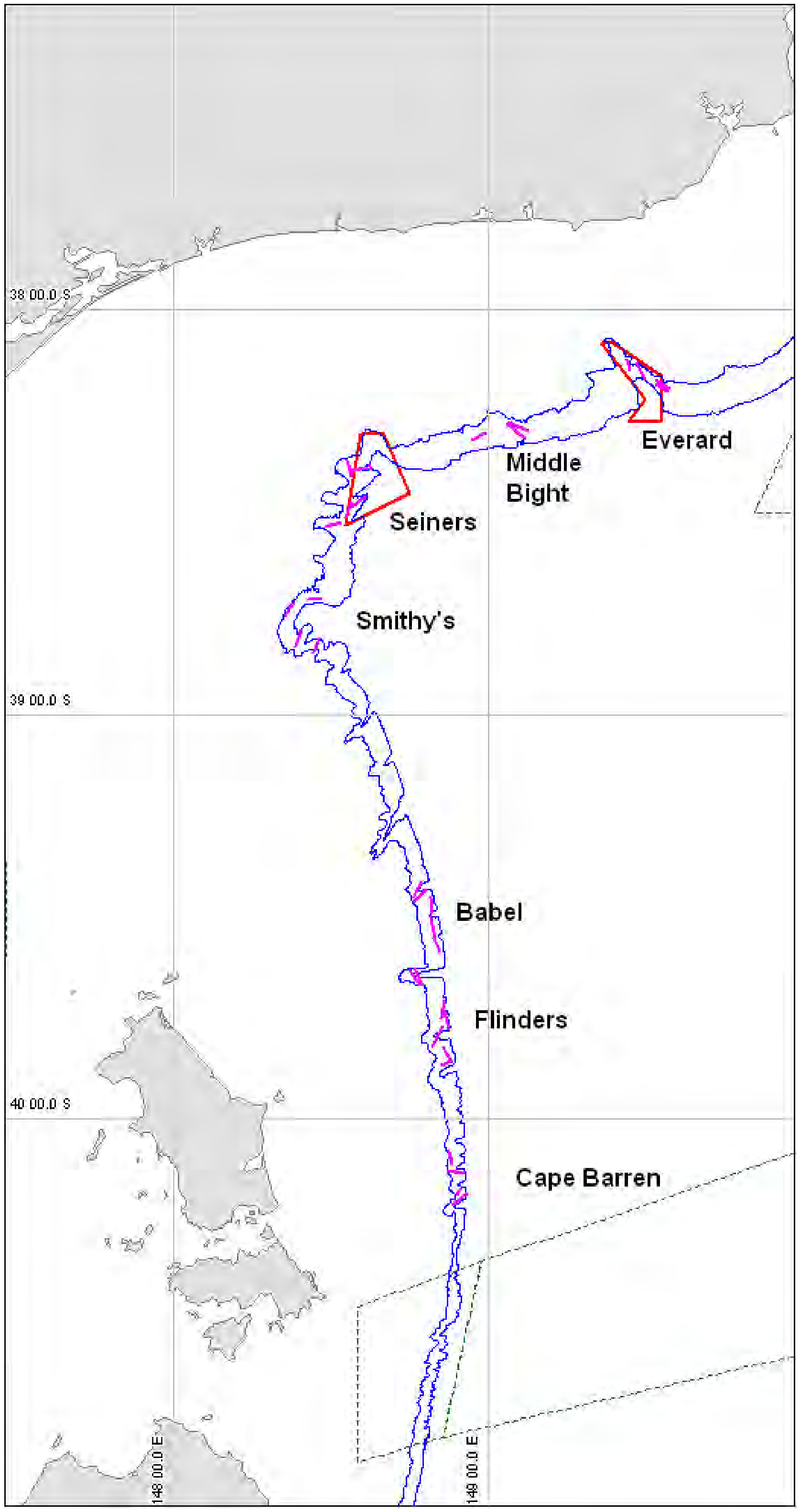
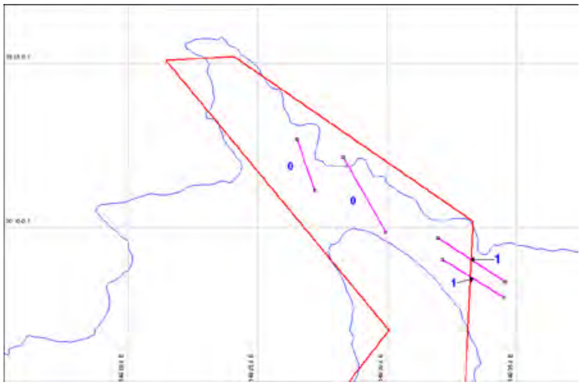
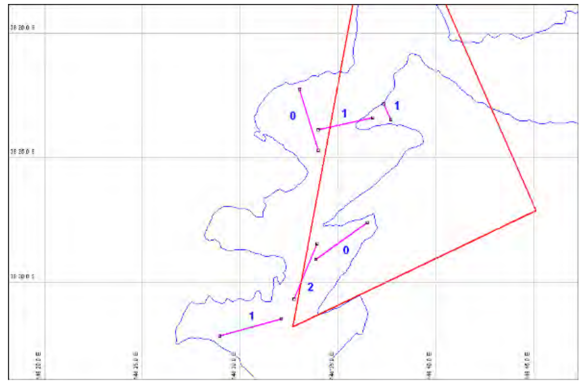


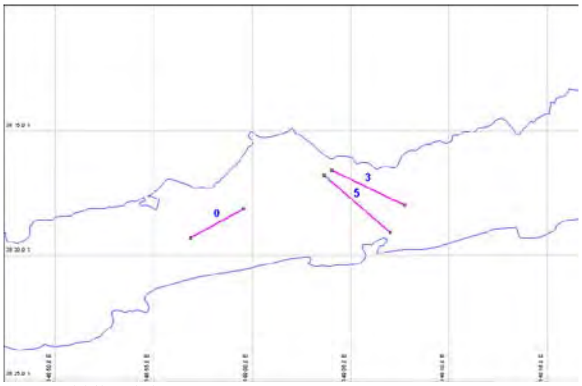
Figure 3. Location of surveyed areas, Leg 1 in waters of NE Bass Strait and Leg 2 starting at Smithy's and continuing south to NE of Flinders Island. Fishing main-line sets indicated as purple lines, 300 and 600 metre depth contours shown as blue lines. Ling closures indicated as red lines, MPA's indicated as dashed green lines.



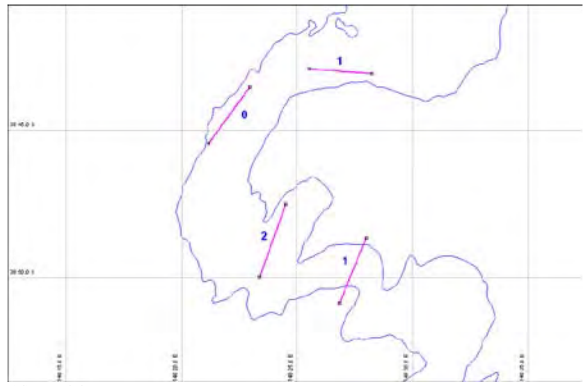
(a) Everard Canyon



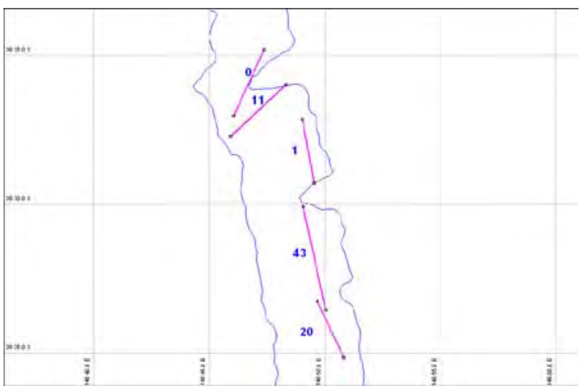
(b) Seiners Canyon and South Mackeral Canyon



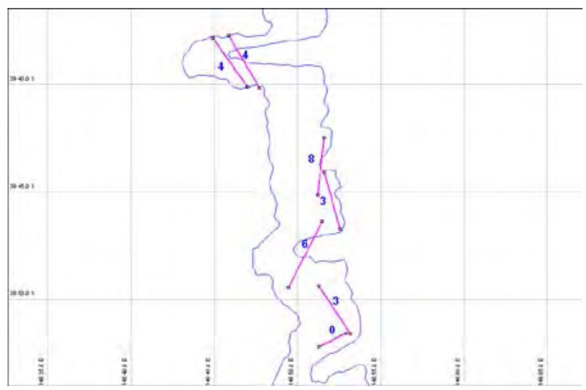
(c) Middle Bight



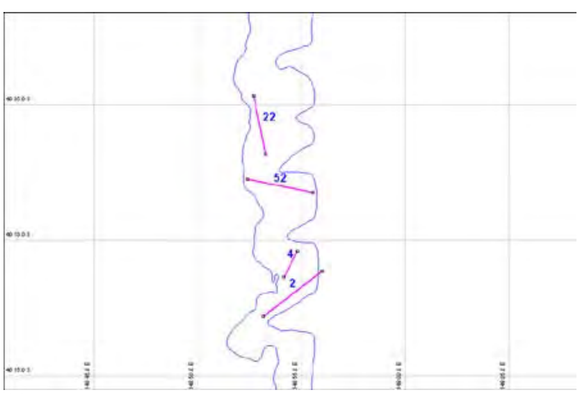
(d) Smithy's Corner



(d) Babel



(f) Flinders



(g) Cape Barren

Figure 4 (a–g). Catch and location of *Centrophorus* spp for all the operations. Fishing line sets indicated as purple lines, 300 and 600 metre depth contours shown as blue lines. Ling closures indicated as red lines.

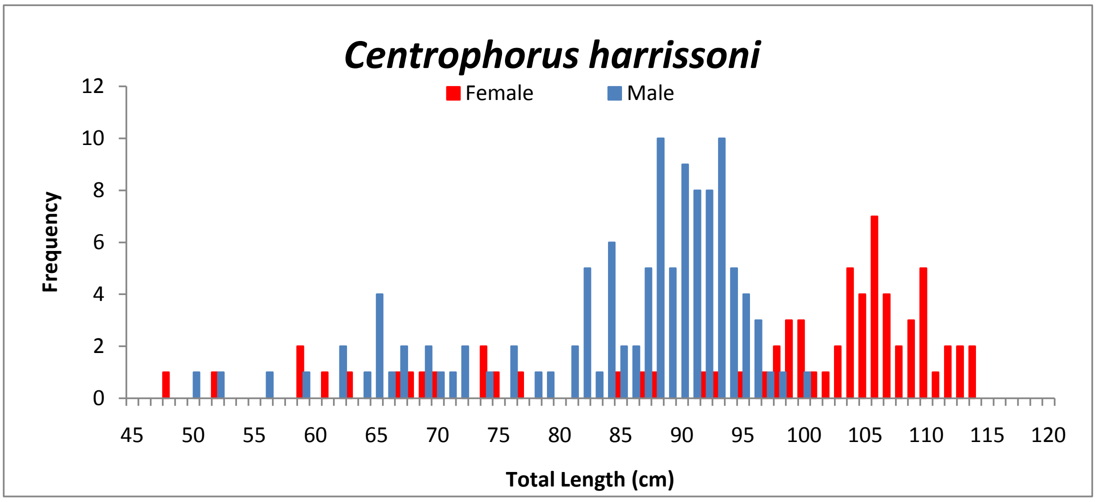


Figure 5. Length vs Frequency for Harrisson's Dogfish captured on all the operations.

Figure 6. Hard coral from Operation 27. One specimen.

Figure 7. Hard coral from Operation 27. One specimen.

Figure 8. Black coral from Operation 27. Two specimens

Figure 9. Soft coral from Operation 27. Two specimens.

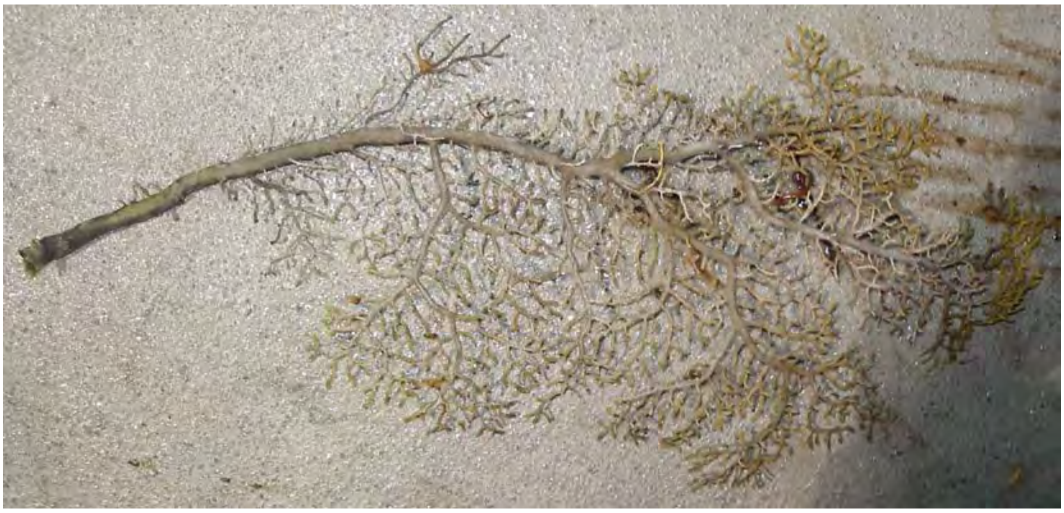


Figure 10. Hard coral from Operation 27. One specimen.

Figure 11. Hard coral from Operation 27. One specimen.

APPENDIX 1

Data acquittal

Tag data (shark length, sex, tag type, tag number)

A scanned copy of original catch comp data sheets (as they came off the boat) in file:
Catchcompscan_SARDA_02-10.pdf
In:
S:\Sustainable Marine Ecosystems in SE\Spatial closures project\Voyage_SARDA_02_2010\Data_report_Sarda_02-2010

The tagging data with errors corrected in file
Shark tagging data and all other data in file:
Data_Master_SARDA 02-10.xlsx
In:
S:\Sustainable Marine Ecosystems in SE\Spatial closures project\Voyage_SARDA_02_2010\Data_report_Sarda_02-2010

Original hardcopy of tagging and length/sex data do not scan well as the pencil used is too light. These are filed with the original catch composition data sheets and given to Ross Daley.

Mapping files

All map products are in:
S:\Sustainable Marine Ecosystems in SE\Spatial closures project\Voyage_SARDA_02_2010.

Voyage report

Sarda02-2010_Voyagereport_FINAL.doc
In file:
S:\Sustainable Marine Ecosystems in SE\Spatial closures project\Voyage_SARDA_02_2010\Data_report_Sarda_02-2010

Images

Photos taken on Marks Olympus camera are in:
S:\Sustainable Marine Ecosystems in SE\Spatial closures project\Voyage_SARDA_02_2010\Data_report_Sarda_02-2010\Images.

APPENDIX 2.

Details of catch composition for each operation.

Operation #	Scientific name	Common name	count
1	*Helicolenus percoides*	Ocean Perch	77
	Mora moro	Ribaldo	63
	Genypterus blacodes	Pink Ling	62
	Coelorinchus fasciatus	Banded whiptail	26
	Dipturus canutus	Grey Skate	10
	Etmopterus lucifer	Blackbelly Lanternshark	9
	Anguilla australis	Shortfin eel	4
	Dipturus gudgeri	Bight Skate	2
	Chimaera fulva	Southern Chimaera	2
	Lepidorhynchus denticulatus	Toothed whiptail	2
	Rexea solandri	Gemfish	1
	Centroscymnus owstoni	Owston's Dogfish	1
	Centrophorus zeehaani	Southern gulper shark	1
2	*Mora moro*	Ribaldo	124
	Genypterus blacodes	Pink Ling	42
	Helicolenus percoides	Ocean Perch	18
	Cephaloscyllium albipinnum	Whitefin Swellshark	17
	Dipturus canutus	Grey Skate	13
	Etmopterus lucifer	Blackbelly Lanternshark	12
	Coelorinchus fasciatus	Banded whiptail	11
	Macruronus novaezelandiae	Blue grenadier	4
	Centroscymnus owstoni	Owston's Dogfish	4
	Amblyraja hyperborea	Boreal Skate	2
	Rexea solandri	Gemfish	2
	Anguilla australis	Shortfin eel	2
	Hyperoglyphe antarctica	Blue-eye Trevalla	1
	Deania quadrispinosa	Longsnout Dogfish	1
	Centrophorus zeehaani	Southern gulper shark	1
3	*Genypterus blacodes*	Pink Ling	106
	Helicolenus percoides	Ocean Perch	95
	Cephaloscyllium albipinnum	Whitefin Swellshark	27
	Rexea solandri	Gemfish	12
	Amblyraja hyperborea	Boreal Skate	11
	Dipturus canutus	Grey Skate	11
	Mora moro	Ribaldo	11
	Squalus megalops	Spikey Dogfish	9
	Nemadactylus macropterus	Jackass morwong	6
	Figaro boardmani	Sawtail Catshark	6
	Amblyraja hyperborea	Boreal Skate	5
	Hyperoglyphe antarctica	Blue-eye Trevalla	4
	Heptranchias perlo	Sharpnose Sevengill Shark	4
	Coelorinchus fasciatus	Banded whiptail	1
	Coelorinchus fasciatus	Banded whiptail	1
	Cephaloscyllium laticeps	Draughtboard Shark	1

3	*Beryx decadactylus*	Imperador	1
	Spiniraja whitleyi	Melbourne skate	1
	Anguilla australis	Shortfin eel	1
	Chimaera fulva	Southern Chimaera	1
4	*Genypterus blacodes*	Pink Ling	190
	Helicolenus percoides	Ocean Perch	58
	Squalus megalops	Spikey Dogfish	31
	Amblyraja hyperborea	Boreal Skate	15
	Dipturus canutus	Grey Skate	14
	Cephaloscyllium albipinnum	Whitefin Swellshark	12
	Coelorinchus fasciatus	Banded whiptail	10
	Dipturus gudgeri	Bight Skate	7
	Rexea solandri	Gemfish	3
	Figaro boardmani	Sawtail Catshark	3
	Deania quadrispinosa	Longsnout Dogfish	2
	Hydrolagus lemures	Blackfin Ghostshark	1
	Cephaloscyllium laticeps	Draughtboard Shark	1
	Heptranchias perlo	Sharpnose Sevengill Shark	1
	Anguilla australis	Shortfin eel	1
	Centrophorus zeehaani	Southern gulper shark	1
5	*Cephaloscyllium albipinnum*	Whitefin Swellshark	137
	Genypterus blacodes	Pink Ling	75
	Helicolenus percoides	Ocean Perch	37
	Squalus megalops	Spikey Dogfish	37
	Dipturus canutus	Grey Skate	9
	Heptranchias perlo	Sharpnose Sevengill Shark	8
	Rexea solandri	Gemfish	6
	Figaro boardmani	Sawtail Catshark	5
	Hyperoglyphe antarctica	Blue-eye Trevalla	3
	Nemadactylus macropterus	Jackass morwong	3
	Dipturus gudgeri	Bight Skate	2
	Centrophorus harrissoni	Harrisson’s gulper shark	2
	Hydrolagus lemures	Blackfin Ghostshark	1
	Eptatretus cirrhatus	Broadgilled Hagfish	1
	Deania quadrispinosa	Longsnout Dogfish	1
6	*Genypterus blacodes*	Pink Ling	160
	Helicolenus percoides	Ocean Perch	143
	Cephaloscyllium albipinnum	Whitefin Swellshark	125
	Mora moro	Ribaldo	35
	Dipturus canutus	Grey Skate	14
	Amblyraja hyperborea	Boreal Skate	6
	Hyperoglyphe antarctica	Blue-eye Trevalla	5
	Anguilla australis	Shortfin eel	3
	Rexea solandri	Gemfish	2
	Polyprion americanus	Bass Groper	1
	Hydrolagus lemures	Blackfin Ghostshark	1
	Squalus chloroculus	Greeneye dogshark	1

6	*Beryx decadactylus*	Imperador	1
	Squalus megalops	Spikey Dogfish	1
7	*Genypterus blacodes*	Pink Ling	135
	Helicolenus percoides	Ocean Perch	118
	Squalus megalops	Spikey Dogfish	88
	Cephaloscyllium albipinnum	Whitefin Swellshark	46
	Figaro boardmani	Sawtail Catshark	24
	Hyperoglyphe antarctica	Blue-eye Trevalla	13
	Rexea solandri	Gemfish	7
	Dipturus canutus	Grey Skate	7
	Coelorinchus fasciatus	Banded whiptail	4
	Hydrolagus lemures	Blackfin Ghostshark	4
	Eptatretus cirrhatus	Broadgilled Hagfish	1
	Centrophorus harrissoni	Harrisson's gulper shark	1
8	*Helicolenus percoides*	Ocean Perch	121
	Cephaloscyllium albipinnum	Whitefin Swellshark	110
	Genypterus blacodes	Pink Ling	93
	Squalus megalops	Spikey Dogfish	40
	Hyperoglyphe antarctica	Blue-eye Trevalla	20
	Figaro boardmani	Sawtail Catshark	10
	Dipturus canutus	Grey Skate	5
	Mora moro	Ribaldo	4
	Rexea solandri	Gemfish	3
	Coelorinchus fasciatus	Banded whiptail	1
	Hydrolagus lemures	Blackfin Ghostshark	1
	Amblyraja hyperborea	Boreal Skate	1
	Centrophorus harrissoni	Harrisson's gulper shark	1
	Anguilla australis	Shortfin eel	1
	Chimaera fulva	Southern Chimaera	1
9	*Genypterus blacodes*	Pink Ling	159
	Figaro boardmani	Sawtail Catshark	60
	Helicolenus percoides	Ocean Perch	56
	Squalus megalops	Spikey Dogfish	43
	Hyperoglyphe antarctica	Blue-eye Trevalla	22
	Cephaloscyllium albipinnum	Whitefin Swellshark	8
	Rexea solandri	Gemfish	5
	Nemadactylus macropterus	Jackass morwong	3
	Macruronus novaezelandiae	Blue grenadier	2
	Dipturus canutus	Grey Skate	2
	Beryx decadactylus	Imperador	2
	Coelorinchus fasciatus	Banded whiptail	1
	Cephaloscyllium laticeps	Draughtboard Shark	1
10	*Helicolenus percoides*	Ocean Perch	110
	Genypterus blacodes	Pink Ling	49
	Hyperoglyphe antarctica	Blue-eye Trevalla	29
	Figaro boardmani	Sawtail Catshark	15
	Mora moro	Ribaldo	12

10	*Rexea solandri*	Gemfish	10
	Nemadactylus macropterus	Jackass morwong	8
	Macruronus novaezelandiae	Blue grenadier	7
	Coelorinchus fasciatus	Banded whiptail	4
	Cephaloscyllium albipinnum	Whitefin Swellshark	4
	Dalatias licha	Black Shark	1
	Etmopterus lucifer	Blackbelly Lanternshark	1
	Hydrolagus lemures	Blackfin Ghostshark	1
	Echinorhinus cookei	Prickly shark	1
	Squalus megalops	Spikey Dogfish	1
11	*Genypterus blacodes*	Pink Ling	110
	Mora moro	Ribaldo	84
	Helicolenus percoides	Ocean Perch	77
	Cephaloscyllium albipinnum	Whitefin Swellshark	21
	Figaro boardmani	Sawtail Catshark	19
	Dipturus canutus	Grey Skate	13
	Dipturus confusus	Longnose Skate	9
	Heptranchias perlo	Sharpnose Sevengill Shark	7
	Etmopterus lucifer	Blackbelly Lanternshark	6
	Anguilla australis	Shortfin eel	6
	Rexea solandri	Gemfish	4
	Centrophorus harrissoni	Harrisson's gulper shark	3
	Chimaera fulva	Southern Chimaera	2
	Coelorinchus fasciatus	Banded whiptail	1
	Macruronus novaezelandiae	Blue grenadier	1
	Spiniraja whitleyi	Melbourne skate	1
12	*Genypterus blacodes*	Pink Ling	139
	Helicolenus percoides	Ocean Perch	88
	Cephaloscyllium albipinnum	Whitefin Swellshark	58
	Figaro boardmani	Sawtail Catshark	44
	Dipturus canutus	Grey Skate	16
	Heptranchias perlo	Sharpnose Sevengill Shark	13
	Amblyraja hyperborea	Boreal Skate	11
	Centrophorus harrissoni	Harrisson's gulper shark	5
	Dipturus confusus	Longnose Skate	2
	Anguilla australis	Shortfin eel	2
	Coelorinchus fasciatus	Banded whiptail	1
	Rexea solandri	Gemfish	1
	Chimaera fulva	Southern Chimaera	1
13	*Genypterus blacodes*	Pink Ling	96
	Helicolenus percoides	Ocean Perch	94
	Cephaloscyllium albipinnum	Whitefin Swellshark	71
	Dipturus canutus	Grey Skate	10
	Figaro boardmani	Sawtail Catshark	5
	Hyperoglyphe antarctica	Blue-eye Trevalla	3
	Heptranchias perlo	Sharpnose Sevengill Shark	2
	Squalus megalops	Spikey Dogfish	2

13	*Rexea solandri*	Gemfish	1
	Anguilla australis	Shortfin eel	1
14	*Genypterus blacodes*	Pink Ling	157
	Helicolenus percoides	Ocean Perch	42
	Squalus megalops	Spikey Dogfish	31
	Coelorinchus fasciatus	Banded whiptail	9
	Amblyraja hyperborea	Boreal Skate	7
	Rexea solandri	Gemfish	7
	Cephaloscyllium albipinnum	Whitefin Swellshark	5
	Dipturus canutus	Grey Skate	4
	Mora moro	Ribaldo	3
	Macruronus novaezelandiae	Blue grenadier	2
	Deania quadrispinosa	Longsnout Dogfish	2
	Hyperoglyphe antarctica	Blue-eye Trevalla	1
	Mustelus antarcticus	Gummy Shark	1
	Centrophorus harrissoni	Harrisson's gulper shark	1
	Chimaera fulva	Southern Chimaera	1
15	*Squalus megalops*	Spikey Dogfish	169
	Genypterus blacodes	Pink Ling	107
	Helicolenus percoides	Ocean Perch	41
	Cephaloscyllium laticeps	Draughtboard Shark	21
	Nemadactylus macropterus	Jackass morwong	18
	Mustelus antarcticus	Gummy Shark	17
	Hydrolagus lemures	Blackfin Ghostshark	9
	Figaro boardmani	Sawtail Catshark	7
	Coelorinchus fasciatus	Banded whiptail	6
	Polyprion oxygeneios	Hapuka	6
	Dipturus canutus	Grey Skate	5
	Amblyraja hyperborea	Boreal Skate	4
	Cephaloscyllium albipinnum	Whitefin Swellshark	4
	Spiniraja whitleyi	Melbourne skate	3
	Deania quadrispinosa	Longsnout Dogfish	2
	Rexea solandri	Gemfish	1
	Chlopsidae	Moray eel	1
16	*Mora moro*	Ribaldo	41
	Helicolenus percoides	Ocean Perch	38
	Genypterus blacodes	Pink Ling	26
	Polyprion oxygeneios	Hapuka	15
	Nemadactylus macropterus	Jackass morwong	15
	Figaro boardmani	Sawtail Catshark	15
	Hydrolagus lemures	Blackfin Ghostshark	10
	Amblyraja hyperborea	Boreal Skate	10
	Cephaloscyllium laticeps	Draughtboard Shark	7
	Coelorinchus fasciatus	Banded whiptail	5
	Squalus megalops	Spikey Dogfish	4
	Hyperoglyphe antarctica	Blue-eye Trevalla	3
	Paraulopus nigripinnis	Cucumber fish	3

16	*Dipturus canutus*	Grey Skate	3
	Macruronus novaezelandiae	Blue grenadier	2
	Centrophorus harrissoni	Harrisson's gulper shark	2
	Cephaloscyllium albipinnum	Whitefin Swellshark	2
	Etmopterus lucifer	Blackbelly Lanternshark	1
	Squalus chloroculus	Greeneye dogshark	1
17	*Squalus megalops*	Spikey Dogfish	205
	Mora moro	Ribaldo	147
	Helicolenus percoides	Ocean Perch	98
	Genypterus blacodes	Pink Ling	46
	Cephaloscyllium albipinnum	Whitefin Swellshark	12
	Platycephalus richardsoni	Tiger Flathead	5
	Amblyraja hyperborea	Boreal Skate	4
	Dipturus canutus	Grey Skate	3
	Figaro boardmani	Sawtail Catshark	3
	Cephaloscyllium laticeps	Draughtboard Shark	2
	Rexea solandri	Gemfish	2
	Polyprion oxygeneios	Hapuka	2
	Hydrolagus lemures	Blackfin Ghostshark	1
	Hyperoglyphe antarctica	Blue-eye Trevalla	1
	Etmopterus pucillus	Smooth Lanternshark	1
	Centrophorus sp.	Unknown gulper shark	1
18	*Helicolenus percoides*	Ocean Perch	118
	Etmopterus lucifer	Blackbelly Lanternshark	28
	Cephaloscyllium albipinnum	Whitefin Swellshark	20
	Hyperoglyphe antarctica	Blue-eye Trevalla	14
	Anguilla australis	Shortfin eel	10
	Genypterus blacodes	Pink Ling	9
	Coelorinchus fasciatus	Banded whiptail	7
	Brama brama	Ray's Bream	6
	Beryx decadactylus	Imperador	4
	Mora moro	Ribaldo	4
	Chimaera fulva	Southern Chimaera	2
	Amblyraja hyperborea	Boreal Skate	1
	Dipturus canutus	Grey Skate	1
	Centrophorus harrissoni	Harrisson's gulper shark	1
	Deania quadrispinosa	Longsnout Dogfish	1
	Lepidorhynchus denticulatus	Toothed whiptail	1
19	*Cephaloscyllium albipinnum*	Whitefin Swellshark	180
	Genypterus blacodes	Pink Ling	77
	Helicolenus percoides	Ocean Perch	68
	Etmopterus lucifer	Blackbelly Lanternshark	26
	Centrophorus harrissoni	Harrisson's gulper shark	20
	Amblyraja hyperborea	Boreal Skate	14
	Coelorinchus fasciatus	Banded whiptail	13
	Deania quadrispinosa	Longsnout Dogfish	9
	Dipturus canutus	Grey Skate	5

19	*Mora moro*	Ribaldo	5
	Chimaera fulva	Southern Chimaera	4
	Rexea solandri	Gemfish	2
	Figaro boardmani	Sawtail Catshark	2
	Anguilla australis	Shortfin eel	2
20	*Cephaloscyllium albipinnum*	Whitefin Swellshark	110
	Helicolenus percoides	Ocean Perch	85
	Genypterus blacodes	Pink Ling	77
	Centrophorus harrissoni	Harrisson's gulper shark	41
	Etmopterus lucifer	Blackbelly Lanternshark	18
	Deania quadrispinosa	Longsnout Dogfish	7
	Chimaera fulva	Southern Chimaera	5
	Dipturus canutus	Grey Skate	4
	Coelorinchus fasciatus	Banded whiptail	3
	Mora moro	Ribaldo	3
	Figaro boardmani	Sawtail Catshark	3
	Heptranchias perlo	Sharpnose Sevengill Shark	3
	Hyperoglyphe antarctica	Blue-eye Trevalla	2
	Amblyraja hyperborea	Boreal Skate	2
	Anguilla australis	Shortfin eel	2
	Centrophorus zeehaani	Southern gulper shark	2
	Dalatias licha	Black Shark	1
	Hydrolagus lemures	Blackfin Ghostshark	1
21	*Squalus megalops*	Spikey Dogfish	187
	Helicolenus percoides	Ocean Perch	75
	Cephaloscyllium albipinnum	Whitefin Swellshark	44
	Figaro boardmani	Sawtail Catshark	19
	Centrophorus harrissoni	Harrisson's gulper shark	11
	Genypterus blacodes	Pink Ling	7
	Mora moro	Ribaldo	4
	Mustelus antarcticus	Gummy Shark	3
	Dipturus canutus	Grey Skate	2
	Chimaera fulva	Southern Chimaera	2
	Coelorinchus fasciatus	Banded whiptail	1
	Dipturus gudgeri	Bight Skate	1
	Dalatias licha	Black Shark	1
	Etmopterus lucifer	Blackbelly Lanternshark	1
	Amblyraja hyperborea	Boreal Skate	1
	Cephaloscyllium laticeps	Draughtboard Shark	1
	Deania quadrispinosa	Longsnout Dogfish	1
	Brama brama	Ray's Bream	1
	Heptranchias perlo	Sharpnose Sevengill Shark	1
	Anguilla australis	Shortfin eel	1
22	*Mora moro*	Ribaldo	139
	Helicolenus percoides	Ocean Perch	94
	Squalus megalops	Spikey Dogfish	56
	Genypterus blacodes	Pink Ling	25

22	*Cephaloscyllium albipinnum*	Whitefin Swellshark	22
	Etmopterus lucifer	Blackbelly Lanternshark	21
	Hyperoglyphe antarctica	Blue-eye Trevalla	16
	Figaro boardmani	Sawtail Catshark	13
	Beryx decadactylus	Imperador	10
	Anguilla australis	Shortfin eel	10
	Brama brama	Ray's Bream	5
	Macruronus novaezelandiae	Blue grenadier	4
	Dipturus canutus	Grey Skate	4
	Amblyraja hyperborea	Boreal Skate	3
	Chimaera fulva	Southern Chimaera	3
	Rexea solandri	Gemfish	2
	Beryx splendens	Alfonsino	1
	Coelorinchus fasciatus	Banded whiptail	1
	Hydrolagus lemures	Blackfin Ghostshark	1
	Eptatretus cirrhatus	Broadgilled Hagfish	1
	Deania quadrispinosa	Longsnout Dogfish	1
	Heptranchias perlo	Sharpnose Sevengill Shark	1
	Lepidorhynchus denticulatus	Toothed whiptail	1
23	*Genypterus blacodes*	Pink Ling	159
	Squalus megalops	Spikey Dogfish	130
	Helicolenus percoides	Ocean Perch	40
	Mora moro	Ribaldo	35
	Etmopterus lucifer	Blackbelly Lanternshark	33
	Cephaloscyllium albipinnum	Whitefin Swellshark	19
	Amblyraja hyperborea	Boreal Skate	18
	Hyperoglyphe antarctica	Blue-eye Trevalla	9
	Dipturus canutus	Grey Skate	9
	Figaro boardmani	Sawtail Catshark	6
	Coelorinchus fasciatus	Banded whiptail	4
	Hydrolagus lemures	Blackfin Ghostshark	3
	Centrophorus harrissoni	Harrisson's gulper shark	3
	Deania quadrispinosa	Longsnout Dogfish	3
	Rexea solandri	Gemfish	2
	Polyprion oxygeneios	Hapuka	2
	Nemadactylus macropterus	Jackass morwong	2
	Dipturus gudgeri	Bight Skate	1
	Deania calcea	Brier shark	1
	Cephaloscyllium laticeps	Draughtboard Shark	1
	Beryx decadactylus	Imperador	1
	Chimaera fulva	Southern Chimaera	1
	Centrophorus zeehaani	Southern gulper shark	1
	Etmopterus baxteri	Southern Lantern shark	1
24	*Squalus megalops*	Spikey Dogfish	207
	Mora moro	Ribaldo	82
	Genypterus blacodes	Pink Ling	73
	Helicolenus percoides	Ocean Perch	29
	Etmopterus lucifer	Blackbelly Lanternshark	25

24	*Cephaloscyllium albipinnum*	Whitefin Swellshark	17
	Macruronus novaezelandiae	Blue grenadier	15
	Figaro boardmani	Sawtail Catshark	11
	Rexea solandri	Gemfish	9
	Deania quadrispinosa	Longsnout Dogfish	6
	Hyperoglyphe antarctica	Blue-eye Trevalla	5
	Coelorinchus fasciatus	Banded whiptail	3
	Centrophorus harrissoni	Harrisson’s gulper shark	3
	Deania calcea	Brier shark	2
	Dipturus canutus	Grey Skate	2
	Nemadactylus macropterus	Jackass morwong	2
	Lepidorhynchus denticulatus	Toothed whiptail	2
	Dalatias licha	Black Shark	1
	Hydrolagus lemures	Blackfin Ghostshark	1
	Amblyraja hyperborea	Boreal Skate	1
	Cephaloscyllium laticeps	Draughtboard Shark	1
	Proscymnodon plunketi	Plunket's shark	1
	Anguilla australis	Shortfin eel	1
	Chimaera fulva	Southern Chimaera	1
	Centrophorus zeehaani	Southern gulper shark	1
	Etmopterus baxteri	Southern Lantern shark	1
25	*Helicolenus percoides*	Ocean Perch	100
	Cephaloscyllium albipinnum	Whitefin Swellshark	49
	Hyperoglyphe antarctica	Blue-eye Trevalla	44
	Mora moro	Ribaldo	42
	Beryx decadactylus	Imperador	21
	Genypterus blacodes	Pink Ling	21
	Etmopterus lucifer	Blackbelly Lanternshark	12
	Rexea solandri	Gemfish	9
	Centrophorus harrissoni	Harrisson’s gulper shark	8
	Amblyraja hyperborea	Boreal Skate	5
	Figaro boardmani	Sawtail Catshark	4
	Dipturus canutus	Grey Skate	3
	Brama brama	Ray's Bream	3
	Beryx splendens	Alfonsino	2
	Coelorinchus fasciatus	Banded whiptail	2
	Polyprion oxygeneios	Hapuka	2
	Deania quadrispinosa	Longsnout Dogfish	2
	Heptranchias perlo	Sharpnose Sevengill Shark	2
	Dipturus gudgeri	Bight Skate	1
	Prionace glauca	Blue shark	1
	Physiculus luminosa	Luminescent Cod	1
26	*Mora moro*	Ribaldo	104
	Genypterus blacodes	Pink Ling	63
	Helicolenus percoides	Ocean Perch	54
	Etmopterus lucifer	Blackbelly Lanternshark	47
	Brama brama	Ray's Bream	35
	Hyperoglyphe antarctica	Blue-eye Trevalla	12

26	*Anguilla australis*	Shortfin eel	10
	Chimaera fulva	Southern Chimaera	6
	Coelorinchus fasciatus	Banded whiptail	5
	Deania calcea	Brier shark	5
	Rexea solandri	Gemfish	5
	Deania quadrispinosa	Longsnout Dogfish	5
	Cephaloscyllium albipinnum	Whitefin Swellshark	4
	Dipturus canutus	Grey Skate	3
	Centrophorus harrissoni	Harrisson's gulper shark	2
	Proscymnodon plunketi	Plunket's shark	2
	Macruronus novaezelandiae	Blue grenadier	1
	Amblyraja hyperborea	Boreal Skate	1
	Beryx decadactylus	Imperador	1
	Centrophorus sp.	Unknown gulper shark	1
27	*Mora moro*	Ribaldo	255
	Genypterus blacodes	Pink Ling	105
	Deania calcea	Brier shark	99
	Cephaloscyllium albipinnum	Whitefin Swellshark	86
	Helicolenus percoides	Ocean Perch	58
	Squalus megalops	Spikey Dogfish	51
	Hyperoglyphe antarctica	Blue-eye Trevalla	35
	Etmopterus lucifer	Blackbelly Lanternshark	18
	Zameus squamulosus	Velvet dogfish	17
	Rexea solandri	Gemfish	14
	Amblyraja hyperborea	Boreal Skate	11
	Dipturus canutus	Grey Skate	6
	Centrophorus harrissoni	Harrisson's gulper shark	6
	Figaro boardmani	Sawtail Catshark	6
	Deania quadrispinosa	Longsnout Dogfish	5
	Anguilla australis	Shortfin eel	5
	Chimaera fulva	Southern Chimaera	5
	Beryx decadactylus	Imperador	4
	Diastobranchus capensis	Basketwork eel	3
	Squalus chloroculus	Greeneye dogshark	2
	Proscymnodon plunketi	Plunket's shark	2
	Coelorinchus fasciatus	Banded whiptail	1
	Polyprion oxygeneios	Hapuka	1
	Centrophorus squamosus	Leafscale gulper shark	1
28	*Helicolenus percoides*	Ocean Perch	98
	Cephaloscyllium albipinnum	Whitefin Swellshark	79
	Rexea solandri	Gemfish	70
	Hyperoglyphe antarctica	Blue-eye Trevalla	60
	Figaro boardmani	Sawtail Catshark	36
	Squalus megalops	Spikey Dogfish	30
	Genypterus blacodes	Pink Ling	9
	Beryx decadactylus	Imperador	8
	Nemadactylus macropterus	Jackass morwong	6
	Hydrolagus lemures	Blackfin Ghostshark	4

28	*Dipturus canutus*	Grey Skate	3
	Polyprion oxygeneios	Hapuka	3
	Centrophorus harrissoni	Harrisson's gulper shark	3
	Coelorinchus fasciatus	Banded whiptail	2
	Etmopterus lucifer	Blackbelly Lanternshark	2
	Beryx splendens	Alfonsino	1
	Amblyraja hyperborea	Boreal Skate	1
	Heptranchias perlo	Sharpnose Sevengill Shark	1
29	*Hyperoglyphe antarctica*	Blue-eye Trevalla	194
	Rexea solandri	Gemfish	52
	Helicolenus percoides	Ocean Perch	15
	Cephaloscyllium albipinnum	Whitefin Swellshark	6
	Etmopterus lucifer	Blackbelly Lanternshark	4
	Hydrolagus lemures	Blackfin Ghostshark	2
	Polyprion oxygeneios	Hapuka	2
	Beryx decadactylus	Imperador	2
	Nemadactylus macropterus	Jackass morwong	2
	Genypterus blacodes	Pink Ling	2
	Squalus megalops	Spikey Dogfish	2
30	*Genypterus blacodes*	Pink Ling	37
	Squalus megalops	Spikey Dogfish	29
	Centrophorus harrissoni	Harrisson's gulper shark	22
	Figaro boardmani	Sawtail Catshark	18
	Amblyraja hyperborea	Boreal Skate	14
	Polyprion oxygeneios	Hapuka	11
	Helicolenus percoides	Ocean Perch	7
	Hyperoglyphe antarctica	Blue-eye Trevalla	6
	Nemadactylus macropterus	Jackass morwong	6
	Cephaloscyllium albipinnum	Whitefin Swellshark	5
	Hydrolagus lemures	Blackfin Ghostshark	3
	Rexea solandri	Gemfish	3
	Spiniraja whitleyi	Melbourne skate	2
	Dipturus canutus	Grey Skate	1
31	*Genypterus blacodes*	Pink Ling	106
	Hyperoglyphe antarctica	Blue-eye Trevalla	87
	Centrophorus harrissoni	Harrisson's gulper shark	50
	Helicolenus percoides	Ocean Perch	45
	Squalus megalops	Spikey Dogfish	36
	Amblyraja hyperborea	Boreal Skate	18
	Cephaloscyllium albipinnum	Whitefin Swellshark	14
	Figaro boardmani	Sawtail Catshark	10
	Rexea solandri	Gemfish	6
	Coelorinchus fasciatus	Banded whiptail	3
	Dipturus canutus	Grey Skate	2
	Beryx decadactylus	Imperador	2
	Deania quadrispinosa	Longsnout Dogfish	2
	Centrophorus sp.	Unknown gulper shark	2

31	*Cephaloscyllium laticeps*	Draughtboard Shark	1
	Squalus chloroculus	Greeneye dogshark	1
	Polyprion oxygeneios	Hapuka	1
	Nemadactylus macropterus	Jackass morwong	1
32	*Hyperoglyphe antarctica*	Blue-eye Trevalla	95
	Helicolenus percoides	Ocean Perch	82
	Cephaloscyllium albipinnum	Whitefin Swellshark	25
	Genypterus blacodes	Pink Ling	22
	Mora moro	Ribaldo	20
	Beryx decadactylus	Imperador	11
	Amblyraja hyperborea	Boreal Skate	8
	Rexea solandri	Gemfish	7
	Hydrolagus lemures	Blackfin Ghostshark	6
	Dipturus canutus	Grey Skate	5
	Coelorinchus fasciatus	Banded whiptail	4
	Centrophorus harrissoni	Harrisson's gulper shark	4
	Figaro boardmani	Sawtail Catshark	3
	Macruronus novaezelandiae	Blue grenadier	1
	Polyprion oxygeneios	Hapuka	1
	Squalus megalops	Spikey Dogfish	1
	Anguilla australis	Shortfin eel	1
	Squalus chloroculus	Greeneye dogshark	1
	Nemadactylus macropterus	Jackass morwong	1
33	*Hyperoglyphe antarctica*	Blue-eye Trevalla	80
	Helicolenus percoides	Ocean Perch	27
	Rexea solandri	Gemfish	19
	Genypterus blacodes	Pink Ling	13
	Polyprion oxygeneios	Hapuka	10
	Figaro boardmani	Sawtail Catshark	9
	Squalus megalops	Spikey Dogfish	8
	Cephaloscyllium albipinnum	Whitefin Swellshark	8
	Mora moro	Ribaldo	5
	Nemadactylus macropterus	Jackass morwong	4
	Beryx decadactylus	Imperador	3
	Dipturus canutus	Grey Skate	2
	Centrophorus harrissoni	Harrisson's gulper shark	2
	Polyprion americanus	Bass Groper	1
	Etmopterus lucifer	Blackbelly Lanternshark	1
	Hydrolagus lemures	Blackfin Ghostshark	1

APPENDIX 3.

Tag details - key: Cz = *Centrophorus zeehaani*, Ch = *Centrophorus harrissoni*, Sc = *Squalus chloroculus*, R = Rototag, J = Jumbotag, D = Dart tag. Shaded cells are recaptured animal, re-released at capture location.

Count	Op #	Species	Sex	Length (cm)	Tag type	Tag #	Count	Op #	Species	Sex	Length (cm)	Tag type	Tag #	Count	Op #	Species	Sex	Length (cm)	Tag type	Tag #	Count	Op #	Species	Sex	Length (cm)	Tag type	Tag #
1	1	Cz	M	88	J	12503	26	19	Ch	M	97	J	12528	51	20	Ch	F	74	J	12552	76	20	Ch	F	68	R	A0634
2	2	Cz	M	90	J	12504	27	19	Ch	M	84	J	12529	52	20	Ch	M	89	J	12553	77	20	Ch	M	67	R	A0635
3	4	Cz	M	93	J	12505	28	19	Ch	M	92	J	12530	53	20	Ch	F	67	J	12554	78	20	Ch	M	65	R	A0636
4	5	Ch	M	92	J	12506	29	19	Ch	M	91	J	12531	54	20	Ch	M	95	J	12555	79	20	Ch	M	52	R	A0637
5	5	Ch	F	48	D	183008	30	19	Ch	M	79	J	12532	55	20	Ch	M	72	J	12556	80	20	Ch	M	62	R	A0638
6	6	Sc	M	90	J	12507	31	19	Ch	M	93	J	12533	56	20	Ch	M	76	J	12557	81	21	Ch	M	89	J	12572
7	7	Ch	M	84	J	12508	32	19	Ch	M	96	J	12534	57	20	Ch	M	84	J	12558	82	21	Ch	M	92	J	12573
8	8	Ch	M	87	J	12509	33	19	Ch	M	88	J	12535	58	20	Ch	M	90	J	12559	83	21	Ch	M	93	J	12574
9	11	Ch	M	88	J	12510	34	19	Ch	M	70	J	12536	59	20	Ch	M	88	J	12560	84	21	Ch	M	100	J	12575
10	11	Ch	M	87	J	12511	35	19	Ch	M	95	J	12537	60	20	Ch	M	72	J	12561	85	21	Ch	M	90	J	12576
11	11	Ch	F	77	J	12512	36	19	Ch	M	93	J	12538	61	20	Ch	M	71	J	12562	86	21	Ch	F	61	R	A0621
12	12	Ch	M	86	J	12513	37	19	Ch	M	91	J	12539	62	20	Ch	F	70	J	12563	87	21	Ch	F	52	R	A0622
13	12	Ch	M	87	J	12514	38	19	Ch	M	87	J	12540	63	20	Ch	M	65	J	12564	88	21	Ch	M	56	R	A0623
14	12	Ch	M	88	J	12515	39	19	Ch	M	88	J	12541	64	20	Ch	M	69	J	12565	89	21	Ch	F	59	R	A0639
15	12	Ch	M	83	J	12516	40	19	Ch	M	62	R	A0619	65	20	Ch	F	75	J	12566	90	21	Ch	M	69	R	A0640
16	12	Ch	M	84	J	12517	41	20	Ch	M	91	J	12542	66	20	Ch	M	84	J	12567	91	23	Ch	M	91	J	12577
17	14	Ch	M	89	J	12518	42	20	Ch	M	93	J	12543	67	20	Ch	M	90	J	12568	92	23	Ch	M	91	J	12578
18	16	Ch	M	82	J	12519	43	20	Ch	M	94	J	12544	68	20	Ch	M	96	J	12569	93	23	Cz	M	84	J	12579
19	16	Ch	M	89	J	12520	44	20	Ch	M	93	J	12545	69	20	Ch	M	90	J	12570	94	23	Ch	M	93	J	12580
20	18	Ch	M	94	J	12521	45	20	Cz	F	74	J	12546	70	20	Ch	M	93	J	12571	95	24	Ch	M	94	J	12581
21	19	Ch	M	85	J	12522	46	20	Cz	F	68	J	12547	71	20	Ch	M	64	R	A0615	96	24	Ch	M	81	J	12582
22	19	Ch	M	93	J	12523	47	20	Ch	M	88	J	12548	72	20	Ch	M	59	R	A0620	97	24	Cz	M	85	J	12583
23	19	Ch	M	95	J	12525	48	20	Ch	M	90	J	12549	73	20	Ch	M	66	R	A0631	98	24	Ch	M	96	J	12584
24	19	Ch	M	92	J	12526	49	20	Ch	M	82	J	12550	74	20	Ch	F	59	R	A0632	99	25	Ch	M	90	J	12585
25	19	Ch	F	69	J	12527	50	20	Ch	M	65	J	12551	75	20	Ch	M	65	R	A0633	100	25	Ch	M	76	J	12586

APPENDIX 3 continued.

Count	Op #	Species	Sex	Length (cm)	Tag type	Tag #	Count	Op #	Species	Sex	Length (cm)	Tag type	Tag #	Count	Op #	Species	Sex	Length (cm)	Tag type	Tag #	Count	Op #	Species	Sex	Length (cm)	Tag type	Tag #
101	25	Ch	M	74	J	12587	126	30	Ch	F	NR	J	12812	151	31	Ch	F	104	J	12837	176	31	Ch	M	82	J	12862
102	25	Ch	M	82	J	12588	127	30	Ch	F	109	J	12813	152	31	Ch	M	84	J	12838	177	31	Ch	F	63	J	12863
103	25	Ch	M	93	J	12589	128	30	Ch	F	111	J	12814	153	31	Ch	F	108	J	12839	178	31	Ch	F	103	J	12864
104	25	Ch	M	92	J	12590	129	30	Ch	F	114	J	12815	154	31	Ch	F	105	J	12840	179	31	Ch	F	100	J	12865
105	25	Ch	M	91	J	12591	130	30	Ch	M	88	J	12816	155	31	Ch	F	107	J	12841	180	31	Ch	F	74	J	12866
106	25	Ch	M	91	J	12592	131	30	Ch	F	106	J	12817	156	31	Ch	F	92	J	12842	181	31	Ch	F	112	J	12867
107	26	Ch	M	92	J	12593	132	30	Ch	F	105	J	12818	157	31	Ch	F	100	J	12843	182	31	Ch	F	101	J	12868
108	26	Ch	M	98	J	12594	133	30	Ch	F	110	J	12819	158	31	Ch	F	107	J	12844	183	31	Ch	F	103	J	12869
109	27	Ch	M	88	J	12595	134	30	Ch	F	112	J	12820	159	31	Ch	F	85	J	12845	184	31	Ch	F	106	J	12870
110	27	Ch	M	78	J	12596	135	30	Ch	F	99	J	12821	160	31	Ch	F	98	J	12846	185	31	Ch	F	110	J	12871
111	27	Ch	M	87	J	12597	136	30	Ch	M	89	J	12822	161	31	Ch	F	107	J	12847	186	31	Ch	M	67	J	12872
112	27	Ch	M	90	J	12598	137	30	Ch	F	114	J	12823	162	31	Ch	F	109	J	12848	187	31	Ch	F	113	J	12873
113	27	Ch	M	94	J	12599	138	30	Ch	F	104	J	12824	163	31	Ch	F	108	J	12849	188	31	Ch	F	104	J	12874
114	27	Ch	M	91	J	12600	139	30	Ch	F	105	J	12825	164	31	Ch	M	90	J	12850	189	31	Ch	F	102	J	12875
115	28	Ch	M	92	J	12801	140	31	Ch	F	113	J	12826	165	31	Ch	F	106	J	12851	190	32	Ch	F	99	J	12876
116	28	Ch	M	94	J	12802	141	31	Ch	M	86	J	12827	166	31	Ch	F	94	J	12852	191	32	Ch	M	91	J	12877
117	28	Ch	M	88	J	12803	142	31	Ch	F	110	J	12828	167	31	Ch	F	105	J	12853	192	32	Ch	M	82	J	12878
118	30	Ch	M	91	J	12804	143	31	Ch	F	98	J	12829	168	31	Ch	F	107	J	12854	193	32	Ch	M	50	R	A0624
119	30	Ch	F	104	J	12805	144	31	Ch	F	110	J	12830	169	31	Ch	F	109	J	12855	194	33	Ch	M	95	J	12879
120	30	Ch	M	85	J	12806	145	31	Ch	M	90	J	12831	170	31	Ch	F	97	J	12856	195	33	Ch	M	88	J	12880
121	30	Ch	F	104	J	12807	146	31	Ch	F	87	J	12832	171	31	Ch	M	93	J	12857							
122	30	Ch	F	106	J	12808	147	31	Ch	F	100	J	12833	172	31	Ch	F	110	J	12858							
123	30	Ch	F	99	J	12809	148	31	Ch	M	81	J	12834	173	31	Ch	F	106	J	12859							
124	30	Ch	F	106	J	12810	149	31	Ch	F	106	J	12835	174	31	Ch	F	88	J	12860							
125	30	Ch	F	93	J	12811	150	31	Ch	M	92	J	12836	175	31	Ch	F	95	J	12861							

SUB-APPENDIX E10 – VOYAGE REPORT: FV '*LUCKY S*' 2010

SHIP **Name:** *Lucky S* **Call Sign:** **Type of ship:** Fishing and general work vessel
VOYAGE NO.: FV LUCKY S 2010-01 **VOYAGE NAME:** Listening station mooring array recovery
VOYAGE PERIOD: 31/10/2010 to 3/11/2010 **PORT OF DEPARTURE:** Port Lincoln **PORT OF RETURN:** Port Lincoln
CHIEF SCIENTIST(S) Bruce Barker
OBJECTIVES AND ACHIEVEMENT Objective 1. Final retrieval of all the VR2W receivers in the array. **Achievement: Seventeen receivers were recovered. Four acoustic release units failed to function and receivers not recovered from these moorings.** Objective 2. Deploy and retrieve 4 short term moorings with VR2W receivers for an acoustic tag 'range testing' experiment. **Achievement: Short term moorings deployed, range testing completed and these receivers recovered.**

Mapping Distribution and Movement of Gulper Sharks

Voyage Report

Listening station mooring array recovery, FV Lucky S, November 2010

Voyage Summary

Listening Station Mooring Recovery

FV Lucky S November 2010

Departure: Port Lincoln 31st October 1800 hours
Arrival: Port Lincoln 3rd November 0800 hours

Background

Areas of seabed in Commonwealth waters off temperate Australia are being closed to fishing as marine reserves are 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.

An array of moorings with listening devices to track sharks that have been tagged with coded acoustic tags has been in place within the fishery closure area off Port Lincoln since April 2008. The moorings were retrieved and redeployed in November 2008. In August 2009 a fishing vessel equipped with auto longline gear, was chartered to catch and tag more of the sharks of interest (gulpers, green eyed dogfish and swell sharks). During that survey 2 moorings were retrieved and redeployed. Later in 2009 FV Lucky S was chartered to retrieve the moorings, download data, service and re battery components (VR2W's and CART's) and deploy again.

This survey aimed to retrieve all of the moorings in the array ~ 12 months later, download data from the receivers and return all gear to Hobart as it was the end of the data gathering phase of the project. We also planned to deploy and retrieve four short-term moorings for a tag range-testing experiment.

Survey summary

CSIRO chartered the 29 m FV Lucky S for the recovery of listening station moorings in the spatial closures area off Port Lincoln. Although our departure was delayed by weather, the survey was completed as planned. Of the 22 moorings, we successfully retrieved 17 (figs. 1 and 2). Data from the VR2W receivers was downloaded with a

total of ~909,000 detections and 9,540,000 pings (table 1). Of the retrieved loggers, 2 of the VR2W units apparently failed with no sign of the red flashing indicator light. Of the five moorings that didn't surface, indications when interrogated – via the CART coded acoustic return signal – were that 4 moorings were intact with the acoustic release unit in an upright (correct) position and that the release command was received and enacted upon but the gear didn't release. At one mooring location there wasn't any reply signal from the CART unit.
Having retrieved 4 moorings at the beginning of the survey, the equipment was reconfigured to be deployed again as part of the tag range-test experiment. Range test tags were placed on 2 moorings (fig. 6) and receivers (VR2W's) at either end (figs. 3 and 4). Once the rest of the moorings had been retrieved on day 3 we retrieved these moorings before steaming back to Port Lincoln.
Several of the mooring lines were damaged (fig. 7) from bites to the rope. Varying levels of damage were sustained but in most cases the damage wasn't enough to risk the mooring holding.
The survey went smoothly with all work undertaken safely and without incident. The vessel provides a good platform for off-shore operations. The master and crew were skilled and helpful.

Voyage Narrative

Sunday 31st October

Following several days of delayed departure due to the delayed arrival of equipment on transit from Hobart (24 hours) and several days unsuitable weather and with frontal systems approaching, we departed Port Lincoln ~ 1800 hour and steamed throughout the night during the to the study area.

Monday 1st November

We arrived on site early in the morning to begin retrieval of the listening station moorings. The moorings had been deployed ~12 months previous (November 2009). The first mooring was retrieved quickly and easily and we continued with others throughout the day. The mooring hardware was mostly clean i.e. minimal fouling and with minimal visible corrosion. The mooring ropes (12 mm double braid) were also in good condition with only a few showing minor signs of fish/shark bites to compromise the rope. Having retrieved eight moorings we then prepared four moorings for a tag range-test experimental setup. These were deployed in an area central to the study area on moderately sloping bottom. We continued to retrieve moorings to the west and successfully retrieved another eight moorings and with two others failing to surface. We finished work for the day and drifted during the night.

Tuesday 2nd November

We repositioned early in the morning to pick up the remaining four moorings to the west. Unfortunately we were unable to retrieve three out of the four. The coded acoustic reply signal from two of them indicated the CART was upright and therefore the mooring was intact but it was not releasing. There was no signal from the other suggesting either that the mooring wasn't there anymore or that the CART was in-operable due to malfunction, flattened battery or flooding. Although we revisited each after an hour or more to try again, there was no change. We then steamed east to pick up the tag range test mooring array and these four moorings were successfully retrieved. We commenced the steam back to Port Lincoln steaming through the night.

Wednesday 3rd November

During the early hours of the morning we approached Port Lincoln and tied up at the main wharf for unloading at first light. Our equipment was off-loaded and taken to the SEKOL yard to be packed in crates for transport back to Hobart.

Staff

Slavko Kolega (master)	SEKOL
Bruce Barker (voyage leader)	CSIRO
Mark Green (deck operations)	CSIRO
Scott Ryan (engineer, deck crew)	SEKOL
Chris Meletti (deck crew)	SEKOL

Acknowledgements

Special thanks to the skipper and crew of the Lucky S for ably running the vessel and assisting with the retrieval and deployment of our moorings. Thanks also to Semi Skoljarev (vessel owner) for making the vessel available and to the support staff at the SEKOL yard for assistance with freight and gear storage.

Data Acquittal

VRL files:
S:\Sustainable Marine Ecosystems in SE\Spatial closures project\GULPER_TAGGING\Vemco_ReceiverLogs\LuckyS_Nov2010\ReceiverLogs
RLD files:
S:\Sustainable Marine Ecosystems in SE\Spatial closures project\GULPER_TAGGING\Vemco_ReceiverLogs\LuckyS_Nov2010\ReceiverLogs
Data from VR2W's housed in the Access database *Tag Database.mdb*
Survey details: S:\Sustainable Marine Ecosystems in SE\Spatial closures project\Voyage_LuckyS_mooring Recovery Oct 2010\ MooringRecoveryNov2010_survey detail.xlsx
Survey Images: S:\Sustainable Marine Ecosystems in SE\Spatial closures project\Voyage_LuckyS_mooring Recovery Oct 2010\Images

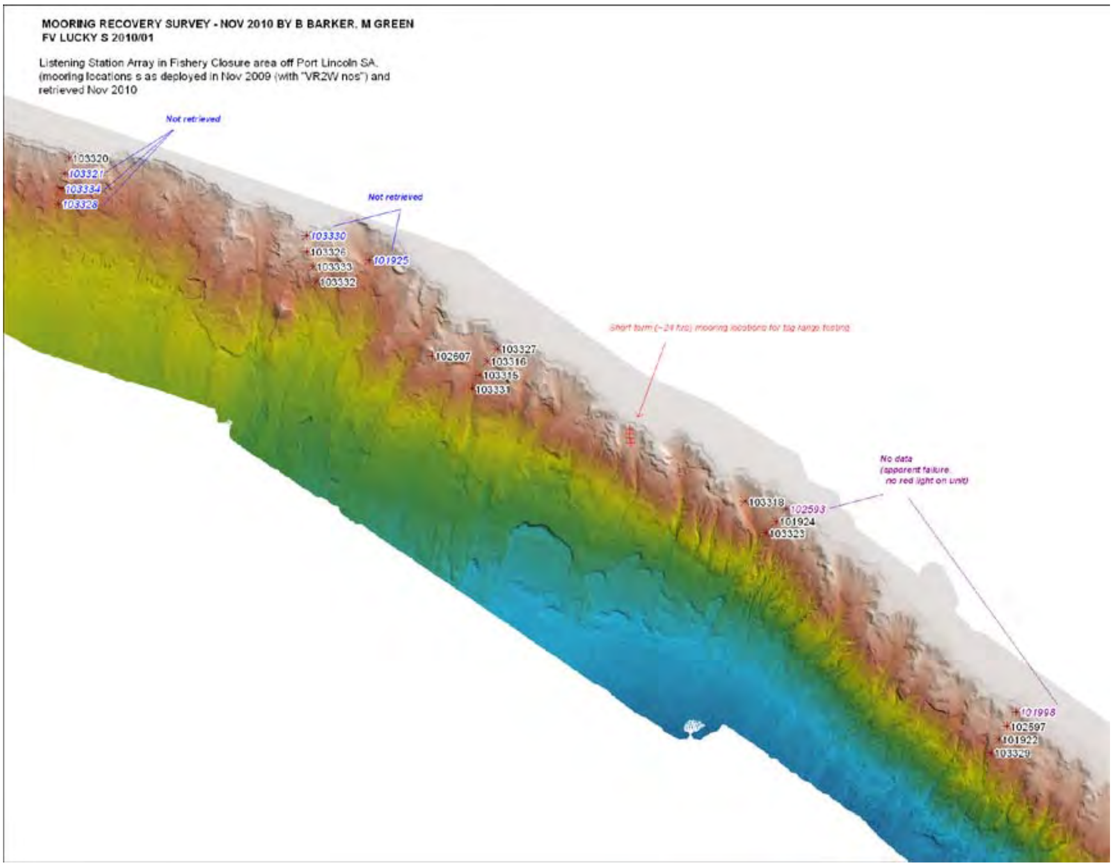


Figure 1. A map of the study area within the fishery closure area off Port Lincoln with locations of the moorings, receiver (VR2W) numbers and moorings for which we were unable to retrieve or get data from. The map shows sun-illuminated swath bathymetry for the area.

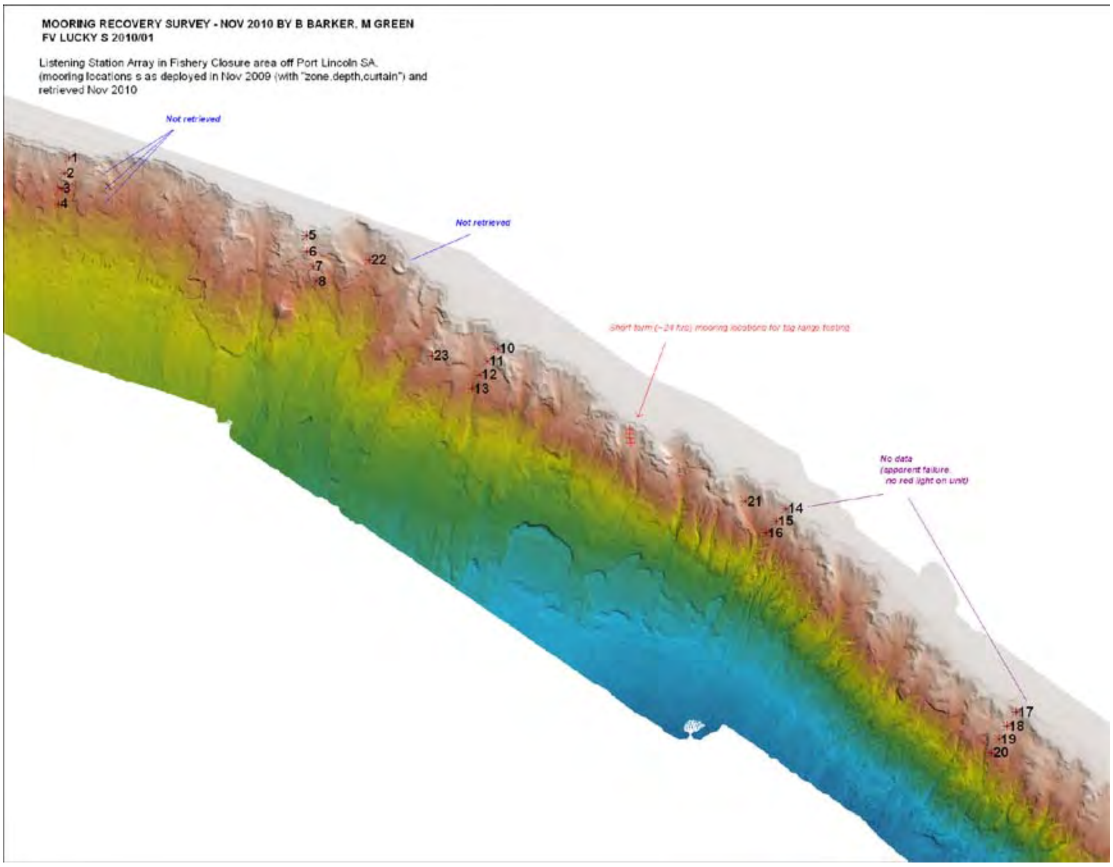


Figure 2. A map of the study area within the fishery closure area off Port Lincoln with locations of the moorings, mooring location numbers and the moorings for which we were unable to retrieve or get data from. The background image of the map is sun-illuminated swath bathymetry for the area.

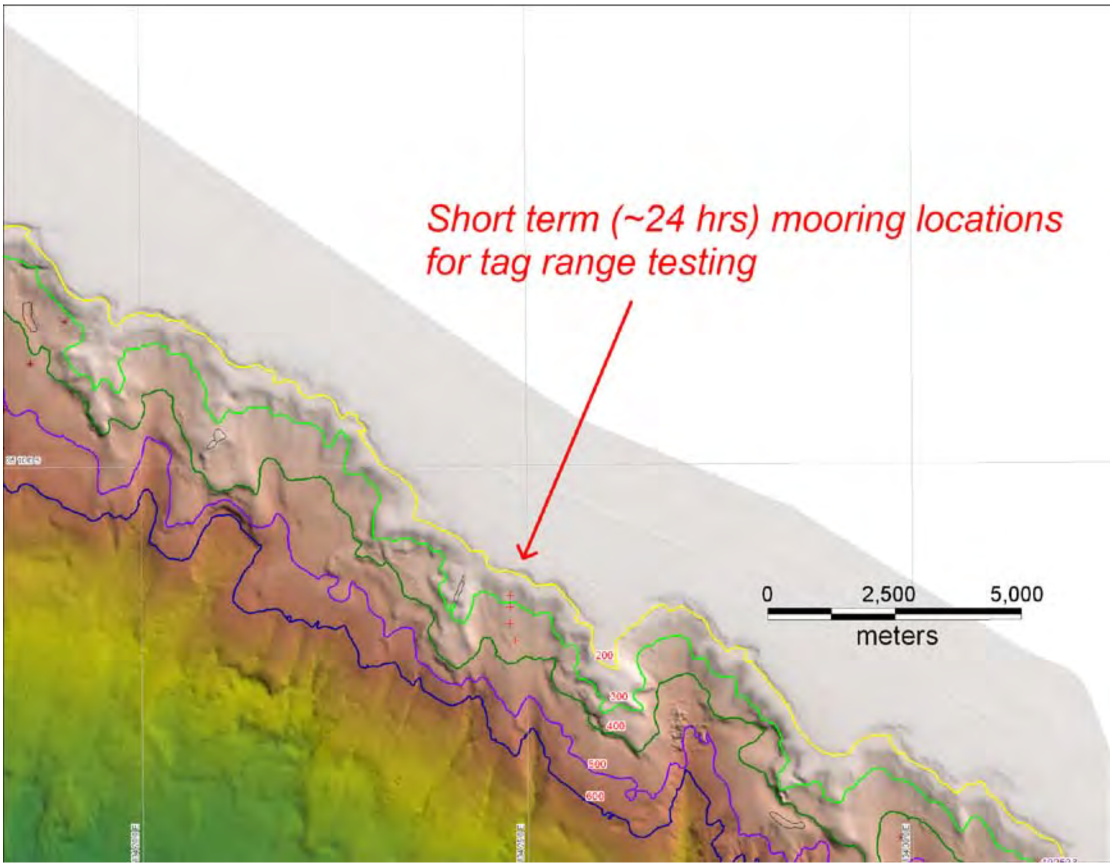


Figure 3. A map showing the locations of the short term tag range test moorings.

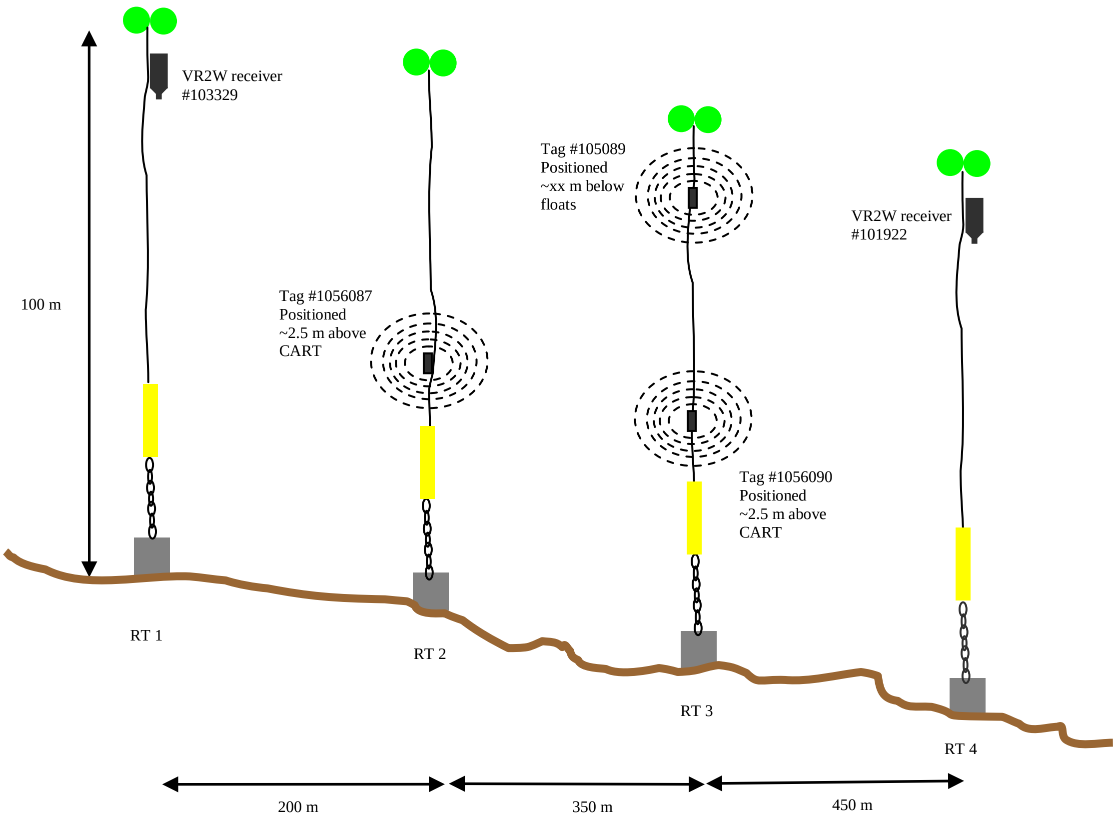


Figure 4. Schematic diagram of the tag range-test mooring arrangement as deployed and retrieved ~24 hours later during the survey.


Figure 5. The surface floats are brought on board following release and ascent from 100 meters off bottom.


Figure 6. The range-test tag enclosed in plastic mesh and attached to the mooring rope using cable ties.


Figure 7. Images showing damage, at varying levels of severity, to the mooring lines. It is most likely the damage is from shark and or fish i.e. leather jackets biting the rope. Not all ropes were damaged, probably only 20% had damage. In many cases the overall strength of the rope wasn't compromised significantly, whereas in one case we were probably fortunate to get the mooring back at all as it was attached by only by the inner core

Table 1. Details of listening station mooring retrievals and deployments for the tag range-testing experiment.

	Mooring Retrieval								**Time at download**		
Event	**Date (local)**	**Time (local)**	**Mooring location number**	**Depth (m)**	**VR2W #**	**CART #**	**Detections**	**Pings**	**VR2W time**	**Laptop time**	**Notes**
1	1st Nov	7:55:00	17	295	101998	33715					No red light on VR2
2	1st Nov	8:18:00	18	352	102597	33723	4918	57487	22:39:00	9:40	
3	1st Nov	8:40:00	19	440	101922	32891	5055	57243	22:44:54	9:45	
4	1st Nov	8:57:00	20	570	103329	33721	10450	109532	22:48:05	9:48	
5	1st Nov	10:45:00	16	580	103323	32852	61920	631127	1:39:50	12:40	
6	1st Nov	11:10:00	15	410	101924	32890	185955	1773685	1:47:15	12:47	
7	1st Nov	11:30:00	14	300	102593	32857					No red light on VR2
8	1st Nov	11:45:00	21	450	103318	33717	185328	1912128	2:01:00	13:01	
9	1st Nov	13:00:00	RT 1	280	103329	32891	na	na			Deployment of mooring for range test experiment
10	1st Nov	13:10:00	RT 2	320	na	33721	na	na			Deployment of mooring for range test experiment
11	1st Nov	13:16:00	RT 3	350	na	33723	na	na			Deployment of mooring for range test experiment
12	1st Nov	13:22:00	RT 4	380	101922	32852	na	na			Deployment of mooring for range test experiment
13	1st Nov	14:30:00	13	650	103331	33722	47203	466550	4:11:00	15:04	
14	1st Nov	14:50:00	12	500	103315	33713	44700	461889	4:26:10	15:26	
15	1st Nov	15:10:00	11	420	103316	32889	27691	291189	4:47:11	15:47	
16	1st Nov	15:27:00	10	330	103327	32892	26596	263303	5:16:14	16:16	
17	1st Nov		22	450	101925	32888	na	na			No release
18	1st Nov	16:40:00	23	385	102607	32850	59981	652073	6:24:36	17:24	
19	1st Nov	17:15:00	8	540	103332	32854	61186	695320	6:53:25	17:53	
20	1st Nov	17:35:00	7	400	103333	32884	58816	685619	7:11:00	18:11	
21	1st Nov	17:45:00	6	300	103326	32858	98286	1053602	7:29:00	18:29	
22	1st Nov		5	230	103330	32855	na	na			No release
23	2nd Nov	7:45:00	1	250	103320	32853	3340	33839	3:04:12	2:04	
24	2nd Nov		2	400	103332	32851	na	na			No release
25	2nd Nov		3	570	103334	32885	na	na			No signal from CART
26	2nd Nov		4	660	103328	32759	na	na			No release
27	2nd Nov	12:30:00	RT 1	280	103329	32891	16538	228769		13:00	Retrieval of range test moorings
28	2nd Nov	12:40:00	RT 2	320	na	33721	na	na		13:10	Retrieval of range test moorings
29	2nd Nov	13:00:00	RT 3	350	na	33723	na	na		13:16	Retrieval of range test moorings
30	2nd Nov	13:25:00	RT 4	380	101922	32852	11138	169199		13:22	Retrieval of range test moorings

Table 2. Table of information relating to the deployment of four moorings for the short term tag range test. The moorings were deployed on the 1st November 2010 and retrieved almost 24 hours later on the 2nd November 2010 Australian Central Daylight Time (ACDT) *UTC+10.5 hours*.

Code	Longitude	Latitude	Depth (m)	CART	VR2W	Tag nos.	Configuration
RT1	134.413	-35.19	280	32891	103329		VR2W 100 m off bottom
RT2	134.413	-35.192	320	33721	na	1056087	Tag 2.5 m above CART
RT3	134.413	-35.195	350	33723	na	1056089, 1056090	2 tags on this mooring (top and bottom of mooring respectively)
RT4	134.414	-35.198	380	32852	101922		VR2W 100 m off bottom

SUB-APPENDIX E11 – VOYAGE SUMMARY: AMC '*BLUEFIN*' 2010

SHIP **Name:** *Bluefin* **Call Sign:** **Type of ship:** Australian Maritime College training vessel
VOYAGE NO.: AMC BLUEFIN 2010-01 **VOYAGE NAME:** Training cruise of south eastern Bass Strait
VOYAGE PERIOD: 13/12/2010 to 17/12/2010 **PORT OF DEPARTURE:** Beauty Point **PORT OF RETURN:** Beauty Point
CHIEF SCIENTIST(S) Dave Maynard (AMC), Ross Daley (CSIRO)
OBJECTIVES AND ACHIEVEMENT Objective. If opportunity presents, sample areas off Cape Barron and Babel Island with longlines to attempt capture of Harrisson's Dogfish. **Achievements: One shot 500 hooks inside Cape Barron, no Harrisson's captured. One shot 500 hooks in the proposed Babel Closure, single juvenile Harrisson's Dogfish captured.**

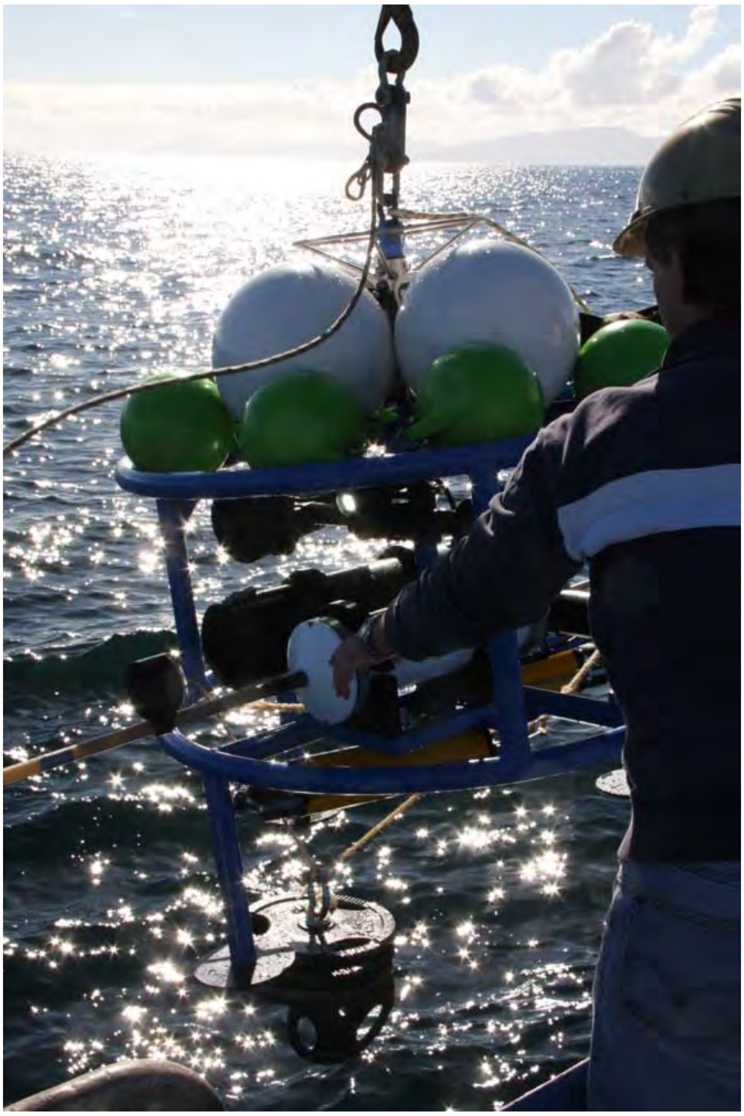
Voyage Summary AMC Bluefin 2010

From 13 – 17 December 2010 CSIRO participated in an Australian Maritime College training cruise off south eastern Bass Strait. Two demersal longline shots were deployed specifically with the intention of capturing Harrisson's Dogfish. Both shots consisted of 500 hooks deployed in 300–700 m during the day. The first shot inside the Cape Barron closure did not catch any Harrisson's Dogfish. The second shot was in the Babel Closure (see map 3 in Williams *et al.,* 2010) and caught a single Harrisson's Dogfish juvenile as well as a large sample of deepwater coral that was snagged in the gear at the same location. A number of elasmobranches were tagged and released. Details of tags are available from Dave Maynard at AMC.

SUB-APPENDIX E12 – VOYAGE REPORT: FV '*CHALLENGER'* 2010

SHIP **Name:** *Challenger* **Call Sign:** **Type of ship:** Charter vessel
VOYAGE NO.: FV CHALLENGER 2011-01 **VOYAGE NAME:** DeepBRUVS testing
VOYAGE PERIOD: 2/5/2011 to 13/5/2011 **PORT OF DEPARTURE:** Hobart **PORT OF RETURN:** Hobart
CHIEF SCIENTIST(S) Bruce Barker
OBJECTIVES AND ACHIEVEMENT Objective. Conduct first at-sea trial of the DeepBRUVS with full system testing. **Achievements: Two test deployments completed.**

Mapping Distribution and Movement of Gulper Sharks



Voyage Report

DeepBRUVS testing, RV Challenger, May 2011

National Research FLAGSHIPS Wealth from Oceans — CSIRO

Australian Government Fisheries Research & Development Corporation

Voyage Summary

DeepBRUVS testing

FV Challenger, Challenger Marine Services Pty Ltd

Departure: Hobart 2nd May 1030 hours
Arrival: Hobart 3rd May 1330 hours

Background

Areas of seabed in Commonwealth waters off temperate Australia are being closed to fishing as marine reserves are 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.

One of the key objectives for the gulper project was to evaluate non-extractive tools for monitoring gulper shark populations. Namely to, "design and implement a non-lethal monitoring program to identify trends in relative abundance as part of the conservation strategies for Harrisson's Dogfish and Southern Dogfish".

This survey aimed to conduct the first at-sea trial of the DeepBRUVS with full system testing in a water depth where we could evaluate the dynamics of the unit.

The vessel time was also used to assist the CMAR Acoustics Group by deployment of their multi-frequency acoustic water column profiler in 90 m water depth off Storm Bay.

Survey summary

CSIRO chartered the 20 m RV Challenger for the testing of the newly fabricated DeepBRUVS system. The DeepBRUVS is a deepwater (1000 m) capable, self-contained mooring that attracts fish through the timed released of bait, and records the activity on stereo video. The system is programmable and controlled through an electronics package to switch lights and cameras as well as controlling the release of the bait solution. The DeepBRUVS utilizes acoustic release units so doesn't require a surface line and buoys. For deployment the DeepBRUVS is free falling once released at the side of the vessel. For retrieval the acoustic release unit receives a coded command via a deck-unit hydrophone, activating a release mechanism to ascend to the surface, having jettisoned sacrificial weights, using it's inbuilt positive buoyancy.

Table 1. A list of the test schedule for the DeepBRUVS unit.

DeepBRUVS Test	Weights	Configuration	Programming schedule
Test 1	75kg	Without bait boom	(no camera recording)
Test 2	85kg	PVC boom	(no camera recording)
Test 3	85kg	Fibre-glass boom	(no camera recording)
Test 4	2 x 85kg	Fibre-glass boom	(no camera recording)
Test 5	85kg	Fibre-glass boom	Schedule (5 mins on 5 mins off) Deployed at 16:00 2 May 2011 ORE Cart Release activated at 17:00 2 May 2011
Test 6	85kg	Fibre-glass boom	Schedule (30 mins on 30 mins off) Deployed at approx 18:50 2 May 2011 ORE Cart Release activated at 10:00 3 May 2011
Test 7	85kg	Fibre-glass boom	Schedule (no recording – release test and ascent check only) Deployed morning approx 10:30 3 May 2011 ORE Cart Release approx 10:53 3 May 2011

Bait testing

The bait canister was loaded with a bait mix (Skretting fish meal mixed with seawater) but on-deck testing showed that the motor drive wasn't powerful enough to dispense the mix. We noted that there was settling of the particulates of this mix and that made it rather stiff in consistency. The particulates also made for a rather gritty paste which added to the friction in the dispensing unit. We chose to use the liquid portion of a wet mix after the particulates had time to settle to the bottom. This bait flavoured seawater solution was able to be dispensed and would have contained plenty of 'fish flavour'.

Bait release boom

The principal of the boom is that the bait is dispensed out in front of the cameras. Because the boom protrudes outside the protective frame of the other components there is potential for impact damage. A pvc tube is one option for the bait release boom.. A stout fibre-glass tube was sourced as a stronger and more resilient option. Most of the test deployments were with the fibre-glass tube fitted. It did what was required and provides a suitably robust boom that would withstand knocks and stresses and exhibits less flexing than the pvc option.

Deployments and retrievals from a vessel

The Challenger has a hydraulic articulated lifting device as used for both deployments and retrievals of the DeepBRUVS. The lifting hook was connected to the DeepBRUVS using our 'Sea Catch' release so once over the side and in the water the unit is easily disconnected for free-fall through the water column. The articulated lifting arm allows extension to a position well away from the side of the vessel during deployment. For retrieval it is necessary to come alongside the BRUVS at close quarters to attach the lifting hook. This was facilitated by a looped line a few meters long that is part of a buoy pick-up line. Again, once attached, the extendable lifting arm is able to keep the unit away from the side of the vessel for a clean lift and lowering onto the deck. Once tethered, the protruding bait boom tended to stream away from the vessel lessening chance of contact and damage.

Cameras and lighting
Cameras and the LED light were tested both with ambient light (daytime) at 50 m and during the overnight deployment. Light power settings were varied to gauge the effectiveness at various settings. The cameras were programmed to record for bursts during the deployment checking that the system worked as required.

Ascent and descent rates
Logging depth against time provided accurate data on the ascent and descent rates of the DeepBRUVS. With the 85 kg payload the descent rate was 35 meters per minute. Ascent, following release of the payload, was 60 meters per minute.

Stability during free fall
MRU data verified that the DeepBRUVS was adequately stable during both descent (free-fall) and ascent.

Video was downloaded from the cameras to computer hard-drive for later interpretation.

Voyage Narrative

Monday 2nd May
Once gear was loaded and secured on board we departed the CSIRO Hobart wharf at ~1030 hours and steamed to Storm Bay. Several deployments of the DeepBRUVS were conducted during the afternoon. A Motion Reference Unit (MRU) with data logging capability was mounted on the unit to obtain data re stability during freefall and speed of descent and ascent. As these were the first deployments of the DeepBRUVS in water, other than at the wharf, a tether-line and surface buoys were maintained. Our final deployment had the bait dispenser full and the unit programmed to run the system in different modes throughout the night. We steamed to Wedge Island where we anchored for the night.

Tuesday 3rd May
We departed the anchorage early in the morning and steamed to outer Storm Bay to a position to deploy the acoustics group's ASL in 90 meters water depth. Once this unit was deployed we steamed back to the DeepBRUVS mooring site. We triggered the acoustic release unit and retrieved the unit after the 12-14 hour overnight deployment. We redeployed the unit, again with the MRU attached, to obtain ascent rate data following the release of the anchor weights. Once retrieved and back on deck we steamed back to Hobart.

Bruce Barker CSIRO Marine and Atmospheric Research, Hobart Tasmania

Staff

Matt Francis (master)	Challenger Marine Services
Bruce Barker (voyage leader)	CSIRO
Matt Sherlock (electronics engineer)	CSIRO
Andreas Marouchos (design engineer)	CSIRO
Tim Green (deck and galley)	Challenger Marine Services

Acknowledgements

Thanks to Matthew Bransden of Skretting for the supply of bait product. Thanks to the CMAR workshop staff for the build of the DeepBRUVS units.

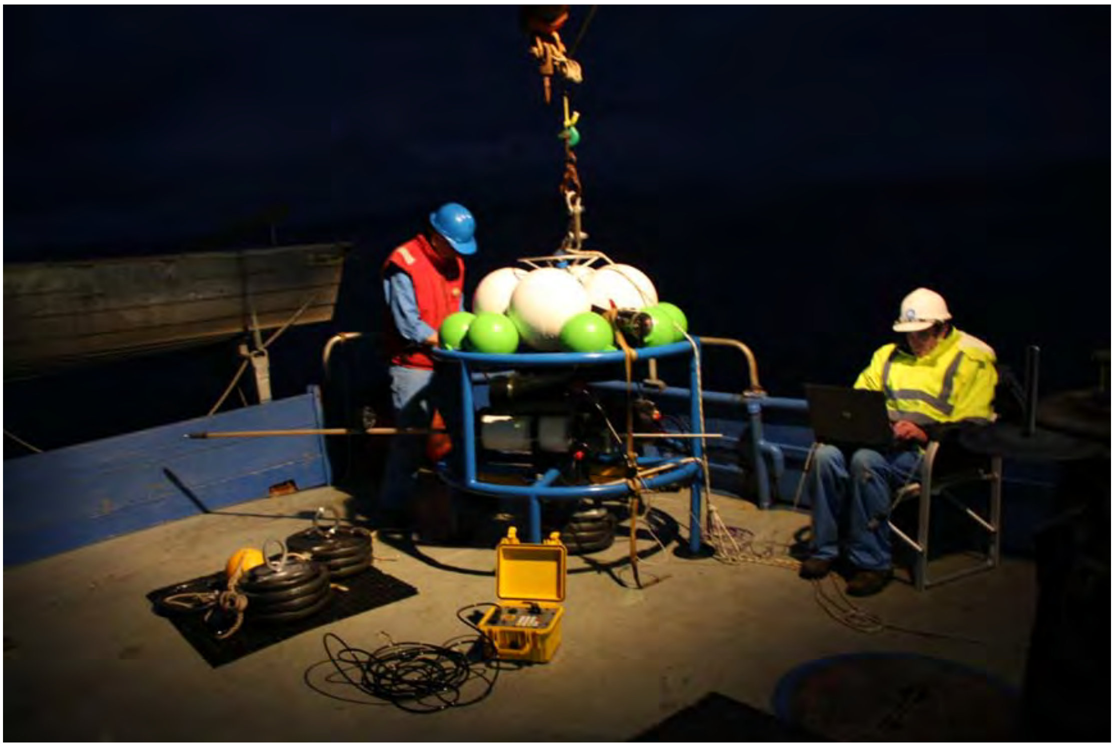


Figure 1. Preparing the DeepBRUVS for the overnight deployment.

Figure 2. The DeepBRUVS with sacrificial 85 kg weights alongside.

Figure 3. The DeepBRUVS at the surface following ascent from the bottom with release of the weights.

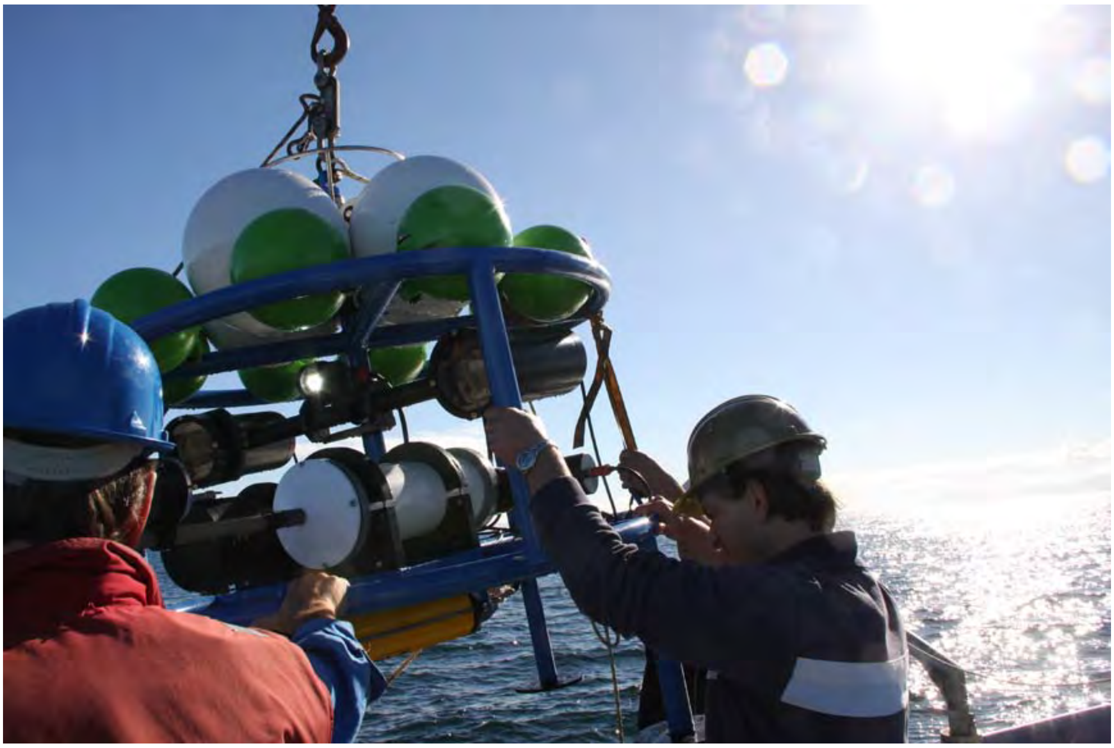


Figure 4. The DeepBRUVS being lifted over the side by the articulated lifting arm and showing the 'Sea Catch' release connected to the lifting hook.

Figure 5. The DeepBRUVS in the water at the side of the vessel just prior to detaching via the ‘Sea Catch’ release

SUB-APPENDIX E12

APPENDIX F – SPATIAL CLOSURES TO PROTECT GULPER SHARKS – OPTIONS FOR CONSIDERATION IN AFMA'S *UPPER-SLOPE DOGFISH MANAGEMENT STRATEGY*

Spatial closures to protect gulper sharks – options for consideration in AFMAs Upper-Slope Dogfish Management Strategy

Alan Williams[1], Ross Daley[1], Ian Knuckey[2], SETFIA[3] and the SESSF Longline sector, Fortuna Fishing[4]

[1] CSIRO Marine and Atmospheric Research, Castray Esplanade Hobart TAS 7000
[2] Fishwell Consulting, 22 Bridge St Queenscliff VIC 3225
[3] South East Trawl Fishing Industry Association
[4] Fortuna Fishing, Mooloolabah, Queensland

This discussion paper was an output of FRDC / CSIRO Project 2009/024:

"Mapping the distribution and movement of gulper sharks, and developing a non-extractive monitoring technique, to mitigate the risk to the species within a multi-sector fishery region off southern and eastern Australia"

Table of contents

Development and purpose of this document

This document forms part of the updated advice that CSIRO and relevant fishing industry sectors will provide to inform Stage 2 of AFMA's Upper Slope Dogfish Management Strategy. The discussion paper has been developed within FRDC project 2009/204 and evolved, following initial meetings with the SE fishing industry in May 2010, to now document all areas identified as potential options for spatial closures and summarise their role against criteria relevant to conserving gulper sharks. Other components of the science advice related to interpretation of tagging data and management strategy evaluation for key spatial closure options will be provided for a meeting involving CSIRO, AFMA and stakeholders on August 13, 2010. Details of the designs for some individual options remain under discussion.

This paper has been developed in four parts:

Part 1: examination of options from Everard Canyon (eastern Victoria) to Tasmania, and one off western Victoria, with SETFIA and the SESSF Longline sector in May/ June 2010.

Part 2: examination of options on offshore seamounts with AFMA and Fortuna Fishing in June 2010

Part 3: documentation of all marine reserves and fishery closures that may benefit gulper sharks, with details of closed area designs provided for consideration where relevant

Part 4: summary of options against conservations guidelines during August 2010 by CSIRO

Background to gulper shark conservation

Gulper sharks (*Centrophorus* species) are caught as a bycatch of commercial fishing by gillnet, line and trawl methods in the Southern and Eastern Scalefish and Shark Fishery (SESSF). Three species of these gulper sharks: Harrisson's Dogfish (*C. harrissoni*), Southern Dogfish (*C. zeehaani*) and Endeavour Dogfish (*C. moluccensis*) have been nominated for threatened species listing under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). AFMA's Ecological Risk Assessment (ERA) process identified Harrisson's Dogfish and Southern Dogfish as at high risk from the impact of fishing in the SESSF. In consultation with industry, scientific experts and the DEWHA, a Draft Upper-Slope Dogfish Management Strategy has been developed by AFMA to reduce the ecological impact of fishing on these species with the intent of maintaining the viability of populations in the wild. The Draft Strategy formed part of AFMA's submission to the Threatened Species Scientific Committee (TSSC) for their consideration during the listing process for gulper sharks.

Work presented in this paper focuses on the needs for Harrissons and Southern Dogfish; the third nominated species, Endeavour Dogfish, is a sub-tropical species of relatively much lower concern (CSIRO submission to TSSC). We note, however, that all closure options off the NSW coast, including offshore seamounts, will also have benefits for this species.

Fishery closures are highlighted as one of the key management tools to aid in the protection / recovery of gulper sharks. There are a number of closures already in place throughout the SESSF that offer protection to gulper sharks. Four have been specifically placed to protect gulper sharks:

1. The Commonwealth Scalefish Hook Sector Gulper Shark Closure – Southern Dogfish and Great Australian Bight Trawl Sector Gulper Shark Closure – Southern Dogfish (collectively known as 'GAB 60-mile closure' off Port Lincoln)

2. Gulper Shark Closure – Endeavour Dogfish (Sydney Endeavour Dogfish closure)

3. Gulper Shark Closure – Harrisson's Dogfish (Harrisson's Dogfish closure in eastern Bass Strait),

4. Barcoo and Taupo Seamounts Closure.

Other closures have been implemented for alternative reasons but may provide some level of benefit to gulper sharks (e.g. ling closures in eastern Bass Strait) (Map1). The Draft Strategy has a two stage process for the implementation of further closures to protect gulper sharks:

Stage 1 – Closures implemented by 30 June 2010.

In addition to existing closures, additional closures were implemented by 30 June 2010 as part of Stage 1. These new closures include:

- o Closure of all areas deeper than 183m to shark hook fishing,

- Complete closure of all waters deeper than 183m to gillnet methods,
- GAB Far west Gulper Shark Closure that essentially extends the existing GAB far western deepwater closure up to 200 m depth,
- Closure of the Barcoo and Taupo seamounts,
- Continuation of the Seiner's and Everard Horseshoe closures (until 17 December 2010).

An extension of the Endeavour dogfish closure off Sydney to include prohibition of all fishing is also proposed as a part of the Strategy however this is not under Commonwealth jurisdiction.

Stage 2 - proposed to be implemented on 17 December 2010.

Further spatial closures to protect upper-slope dogfish are to be implemented following analysis of all information currently available together with the extra information collected from surveys conducted as part of this CSIRO-FRDC funded research project. The exact location and size of area closures will be informed by these analyses.

Seagoing surveys

Much of the baseline survey work underpinning this project has now been conducted by CSIRO in collaboration with the fishing industry. A large part of this was the *FV Diana* longline survey along the east coast of Australia between Brisbane and Hobart, including the Taupo seamount (Map 2). The aim of the survey was to locate and map the distribution of populations of gulper sharks, including remnant populations in heavily fished areas, or populations that exist in lightly fished areas where historical fishing mortality has been low, including areas that are closed to some fishing methods, or where the bottom is too rough to fish with the permitted gear. Information used to design the survey included consultative planning with input from all stakeholders together with specific maps based on industry and science data to identify prospective sampling sites. The survey focussed on the preferred depth range of these gulper sharks (300–600 m) and an emphasis was placed south of 30º S where Harrisson's Dogfish were known to have been more abundant. It included habitats where gulper sharks have been previously recorded on both trawlable and un-trawlable grounds.

During the preparation of this paper, further targeted survey work was continued to validate the potential value of some prospective closure options off SE Australia. With the support of the fishing industry, CSIRO worked aboard the *FV SARDA* longline vessel in specific regions of eastern and western Bass Strait in June/ July 2010. The results from that work are reported at the end of Part 1.

Research Zone Closure concept

As part of an overall management strategy, a regional-scale network of closed areas is necessary to maximise the likelihood of meeting management objectives. Stakeholders recognise the need for the network includes significant areas that are fully-closed area to fishing for each of Harrissons Dogfish and Southern Dogfish to guarantee their protection. Significant full closures need to encompass a healthy population of each species in a large area of suitable habitat in a core area of the species' original range.   Prior to work done by the CSIRO-FRDC project,the recommended scale of major full closures was 60 n.m. alongslope. One major full closure is in place off Port Lincoln for Southern Dogfish. Recent analysis of project tagging data indicates that smaller closures may also be effective in certain circumstances and locations, for example off Port MacDonnell.

Additional closures are required for both species to meet the management objectives. These additional closures may be fully-closed or, following consultation with management and industry, managed as “Research Zone Closures”. Through a management strategy evaluation of selected key closure options, CSIRO will provide AFMA with tools to select the appropriate strategy that is consistent with the level of precaution they select. The concept of “Research Zone Closures” was developed in the Great Australian Bight Trawl Fishery to enable controlled fishing for orange roughy under a research permit in areas that would otherwise be closed to commercial fishing; they are considered to have some relevant application for gulper sharks. These individual area closures would be managed with a set of tailored regulations, and with boundaries that are ‘clinical’, i.e. designed to optimise effectiveness for the management goal, minimise the loss of fishing access, and be feasible and cost-effective to manage. Possibilities for regulation need to be based on consultation and formalised by AFMA. During meetings with the SE fishing industry it was noted that ‘research zones’ should be regarded as complementary to other large no-take closures within the network of closures established for each gulper shark species. Options within research closures could include full or high levels of observer coverage, a verified code of conduct, scientifically designed research program, effort caps, and other measures. With industry participation, these zones could cost-effectively and regularly provide quality assured data to measure performance, and substantially increase biological and ecological knowledge, e.g. from catch rates and tagging. Performance assessment includes recognising that further restrictions to fishing could be considered if conservation objectives are not being met, e.g. if fishing mortality rates could lead to further population declines within closures.

An example of how a “Research Zone Closure” might be applied to an area is provided for the Babel and Cape Barron Deep closure options (Map 3).

Part 1: Options from eastern Victoria to Tasmania

Part 1 of this paper is based on information provided during a series of meetings between the CSIRO project team, SETFIA and automatic longline operators in the SESSF in Hobart, Lakes Entrance and Melbourne during May and June 2010. These meetings were to discuss **options** for additional closures to protect gulper sharks for potential inclusion in the Upper-Slope Dogfish Management Strategy, and focussed on closure options either side of Bass Strait. Participants recognised that a full system of gulper shark closures would include areas off NSW and in the Great Australian Bight.

This part of the document:

1. Documents the knowledge held by the project team and fishing industry operators.

2. Provides maps and details of closure options in the region from Everard Canyon to Tasmania.

3. Provides catch data from several of the areas discussed, which were collected subsequently to the meeting.

The gulper shark closure options that were considered and evaluated are shown in Table 1 and Maps 3-8, and are described below.

1) "*Cape Barren Ground Deep*" (Maps 3,4 and 4a)
   This proposed closure option is 10 n.m. long from 40^{o} 03' S to 40.13 in an area adjacent to the Cape Barren fishing grounds (aka Gull Island to the closure, aka 40.11 canyon). Longline operators have reported significant localised populations at 40^{o} 11' and other smaller group at 40^{o}04'. The meeting resolved that clinical research closures in this area had high potential value. It was suggested that the high density area in the south be closed (perhaps in a series of closures) and the remaining area to the north (inside the proposed closure) be an autolongline (ALL) research permit fishery. There is some evidence of sexual disaggregation with more males residing to the north of Flinders (Map 3, area 2) and some females residing to the south of Flinders - off Cape Barren. Initial survey data at this site (Map 3, area 1) showed the population is dominated by females and is likely to be demographically dependant on males from the Babel area (Map 3, area 2) for breeding success

2) *"Babel Deepwater to Babel Horseshoe"* (Maps 3, 5 and 5a)
   Stretching from 39^{o} 36'53" to 39^{o} 25' 48", this proposed closure option is 11 n.m. long (aka *Sister's Canyon North*). Trawlers do currently work what they call the "Babel shot" which is a 8 n.m. tow in this area. An industry member with good knowledge of the area reported that there are no dogfish in the canyon part of this proposed closure. The meeting resolved that this area had strong potential for closure. Survey data at this site show the population is dominated by males and is likely to be dependant on the Cape Barren area for breeding success

3) *"Smithy's Corner Deep"* (Map 6)
   The area is a productive part of the ALL fishery but catch records that show only a 15 kg catch of gulper sharks has occurred over the previous 10 years. It was noted that there was very little appropriate depth in this area. This area was not considered a strong candidate for closure based on most recent catch data, but it

was noted that the area was large, had very rough bottom and had not had a large amount of historical effort. It was resolved that this area was worthy of future research but was a lower priority for closure at this stage.

4) Dooley's (Rigs) (no map)

This area was discussed, but recognised as being heavily used for both ALL and trawl fishing. It has been intensively fished over a long period of time, including through the depth zone of interest, while historical catches appeared low. For these reasons the meeting resolved it had low prospects for conserving gulpers.

5) *"Seiners Horseshoe ling closure"* (no full map, but see Maps 8, 9b)

This was an existing closure put in place some years ago to reduce ling catch and aid recovery. Although there is anecdotal evidence of very high historical catches of dogfish (not identified to species) were taken during the mid 1980's by a gill net operator along a single isolated ridge (Mackerel Spit in SW corner – see option 6 below), no gulper shark catches were recorded in this ling closure during the *FV Diana* survey.

6) *"Mackerel Spit"* (Map 7)

This area overlaps the SW corner of the Seiners Horseshoe closure. It was reported to have been an area of high historical catches in late 80's to early 90's. Based on the historical catches being indicative of suitable habitat, a potential small closure within Seiners extending slightly to the west of the existing closure, was mapped along the ridge. The proposed closure option is approximately 59km^2 – see option 6 below. Although this area was not considered a key one for addressing immediate needs of protecting remnant populations of gulper sharks, it has potential for longer term research to provide a better knowledge of recovery rate of a known gulper shark habitat with fishing under a research permit.

7) *"Middle Bight Canyon to Everard Canyon" (*no full map, but see Maps 8, 9c*)*

This area was not surveyed by *FV Diana*, but has had some observed catches of dogfish indicating there may have been significant populations in the past. The #2 trawl shot runs through this area. This was not considered a strong option because there was no recent evidence of gulper sharks and the area is a valuable and continually used trawl ground.

8) *"Everard ling closure" (*no full map, but see Maps 8, 9a*)*

This area was surveyed by *FV Diana* and the presence of Harrissons Dogfish confirmed by the capture of two individuals, and consistent with this information it was suggested by industry that there may be some dogfish in the S/E corner of this closure. This region is an important fishing ground but there are no observer records of gulper shark catches. CSIRO and industry suggested that if it was to remain it would provide some level of protection for gulper sharks but it was not considered a strong option as a gulper shark closure. A validation survey of the SE corner may be warranted, and if justified, this smaller area could be considered for a closure in the future.

9) *East of the Everard Canyon* (no map)

There are confirmed records of Harrissons Dogfish from this area, but none were caught during the *FV Diana* survey.

Updated information based on validation surveys in June/ July 2010

Further targeted survey work and consultation with industry to validate the potential role of prospective closures in eastern Bass Strait and refine their boundaries continued during the preparation of this paper between June and August2010. A summary of results from that work are reported below; the full Sarda survey report is available from the project team on request. The areas surveyed are shown in Map 8. Catches are summarised in Map 9 where fishing line sets (each of ~3000 hooks) are shown as purple lines in relation to the 300 and 600 m depth contours (blue lines). The boundaries of the ling closures at Everard and Seiners are shown by red lines. Boundary changes at Babel and Barren are shown in maps 4a and 5a.

Everard Canyon/ Everard ling closure (Map 9a)

Very low numbers of gulper sharks were caught in this area.

Seiners Horseshoe ling closure/ Mackerel spit (Map 9b)

Very low numbers of gulper sharks were caught in this area.

Middle Bight Canyon to Everard Canyon (Map 9c)

Low numbers of gulper sharks were caught in this area.

Smithy's Corner Deep (Map 9d)

Very low numbers of gulper sharks were caught in this area.

Babel Deepwater to Babel Horseshoe" (Maps 5a and 9e) = Babel closure option

Relatively large numbers of Harrissons Dogfish were caught in this area. It has the highest number of breeding female Harrissons Dogfish recorded during any recent survey. Large numbers of Harrissons Dogfish were also recorded by an observer during commercial fishing in July. These are shown in Map 5a (left hand panel). Industry suggested boundary changes are also shown – a contraction of the western boundary by ~0.5 to 1.25 n.m., and extension of part of the southern boundary. To evaluate the cost to industry of these modifications, estimates of total catch of commercial species for trawl and autolongline are shown from 3 sub-areas at this site: adjacent shelf (3), corridor formed by the industry proposed modification inside the closure box (4), and the upper slope within the closure box (5) – right hand panel in Map 5a.

Area between "Babel Deepwater" and "Cape Barren Ground Deep" (Map 9 f)

Survey data showed Harrissons Dogfish is present throughout this area at higher abundance than the 'background' level abundance observed in other parts of eastern Bass Strait. This information, together with the evidence of sexual disaggregation (males off Babel and females off Cape Barren), and electronic tagging data that shows regular gulper shark movements over scales of 10s of miles, identify that this intermediate area also needs to be managed, and suggests the need for a larger closure than considered in the initial meetings. Details for this option are provided in CSIRO's MSE paper (Paper 2).

"Cape Barren Ground Deep" (Maps 4a and 9g) = Barren closure option

Relatively large numbers of Harrissons Dogfish were caught in this area and these included a large number of mature females. These new data increase the certainty that the populations of Harrissons Dogfish in the Babel and Cape Barren areas are dependant on each other for breeding success. Thus, one management option is to mange the whole "Babel to Barren" area as two closures embedded in a larger managed area. The key uncertainties associated with this option are implementation success (managing mortality associated with catches between the areas) and future effort levels in the area. These issues are explored in CSIROs Management Strategy Evaluation paper (Paper 2).. Large numbers of Harrissons Dogfish were also recorded by an observer during commercial fishing in July. These are shown in Map 4a (left hand panel). Industry suggested boundary changes are also shown – a contraction of 1.5 n.m. at the northern boundary, and removal of the southwestern corner – together with estimates of total catch of commercial species for trawl and autolongline within the closure option (area 11).

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Table 1 List of closure options from eastern Victoria to Tasmania

Closure option details			Science criteria						Industry considerations
Name (and alternative names)	Size (n.m.)	**Map no.**	Species of greatest relevance	****Catch rate recent surveys (High/Med /Low/ None)*	Present in recent comm. catches (Y/N)	Scope for breeding (mature males & females present)	Suitable habitat (refuge & untrawled) (High/Med /Low)	Historic comm. gulper catch (High/Med/Low)	Commercial interest (notes from meeting - except where noted)
1. Cape Barren Ground - deep (Gull Island to the Flinders Closure; 40.11 Canyon)	9.8 n.m. long 80 km2	**4**	Harrissons	*High*	Y	F	Med	Med (291 kg), species mix unclear	Used for both ALL and trawl fishing; trawl poorly represented by Mapped effort - but effort and accessibility appears low for trawl. Northern area shallow; minimum exploitation of gulpers off Flinders; treacherous hard ledgy bottom between shelf edge and 700 m. Anecdotally 2 localised pops of gulper on spits - believed to be Harrisson's.
2. Babel Deepwater-Babel Horseshoe (Sisters Canyon)	11 n.m. long 127 km2	**5**	Harrissons	*High*	Y	M	Med	Med; species mix unclear	Used for both ALL and trawl fishing. Trawl effort restricted to shelf break. Steep edge - little bottom between 200 and 300m. Very narrow area (~2 nm).
3. Smithy's Corner - deep	10 n.m. 160 km2 (+23 km2 for poss. extension)	**6**	Harrissons	*Low/ none*	N	M	High	Low (**noting no trawl effort*); species mix unclear	Used for ALL fishing around the perimeter. No trawl fishing. A proposed closure with distinctly defined boundaries was proposed by trawl. Much rough bottom, no historical trawling and strong tides.
4. Dooley's (Rigs)	--		Harrissons	--	?	--	Low	Low; species mix unclear	Used for both ALL and trawl fishing. Intensively fished over a long period of time, including through the depth zone of interest.
5. Mackerel Spit	7.5 n.m. long 73 km2	**7**	Harrissons	*Low/ none*	N	--	Low	Low; species mix unclear	Overlaps SW corner of Seiners Horseshoe closure. Some apparent overlap of trawl effort, and some ALL fishing. Anecdotally an area of high historical catches in late 80's to early 90's .
6. Seiners Horseshoe (Little Horseshoe; Tuna Canyon)	256 km2		Harrissons	*Low/ none*	N	--	Low	Low- med; species mix unclear	Used for both ALL and trawl fishing, historically for meshnet fishing. Closed to protect ling seasonally, then year-round during last year.
7. Middle Bight to Everard Canyon	--		Harrissons	*Low*	N	--	Med	Med; confirmed records of both Southern and Harrissons	Used for both ALL and trawl fishing; the longstanding No.2 trawl shot goes thru middle of area.
8. Everard Canyon (Big Horseshoe)	149 km2		Harrissons	*Low/ none*	N	--	Med	Med; no confirmed ID of Harrissons	Used for both ALL and trawl fishing. The No.4 shot goes thru middle of area, and some ALL fishing.
9. East of the Everard Canyon			Harrissons	__	N	--	Low	High; confirmed records of Harrissons	Used for both ALL and trawl fishing

**** data updated to reflect FV Sarda survey catches (High >1gulper/100 hooks; Med >10 individuals; Low <10 individuals)*

Part 2: Options for offshore seamounts

10) Taupo Seamount (within Tasmantid AFA)
11) Barcoo Seamount (within Tasmantid AFA)
12) Fraser Seamount (with Coral Sea AFA)
13) Queensland Seamount (outside AFAs)
14) Brittania Seamount (outside AFAs)
15) Derwent Hunter Seamount (within Tasmantid AFA)

Closures on offshore seamounts were supported by survey capture of Harrisson's dogfish on Taupo Seamount during the FV *Diana* survey. This and the adjacent Barcoo Seamount were closed to all forms of fishing by AFMA at Stage 1 (See Map 10). Although the Barcoo seamount was not surveyed, the inference that similar habitat supporting gulper sharks would be present on this closely adjacent feature was confirmed by commercial line fishers.

The potential to enhance the conservation outcome under AFMAs Management Strategy was identified during meetings between AFMA, CSIRO and commercial line operators in Canberra, and then subsequently between CSIRO and industry in Mooloolaba, in May and June 2010:

(1) a hand line ('minor line') fishing method was reported to be highly selective, able to target blue-eye trevalla while avoiding capture and mortality of gulper, although this has yet to be verified;

(2) it was noted that a valuable data stream could be provided by minor line fishing if selective targeting of gulper sharks was verified by a scientifically directed survey; and,

(3) four additional adjacent seamounts (Brittania, Frazer, Queensland and Derwent Hunter) were reported to also support species of gulper shark and could be surveyed as part of the longer term monitoring plan.

The meetings concluded that to achieve this outcome, the spatial management arrangements for the offshore seamounts would need to be revised. Options included (1) allow fishing on the Taupo and Barcoo Seamounts under a research permit by managing seamounts in 'research zone closures' (precautionary); (2) relaxing the full closures of Taupo and Barcoo Seamounts by leaving some small areas open to forms of fishing that cause low mortality of gulper sharks and no damage to habitats (less precautionary). Option 1 was implemented at Stage 1, but the arrangement would be interim pending verification of the selectivity of the hand line method and the compliance of fishing operations to avoid gulper sharks - on these seamounts and potentially on others within the range of Harrissons Dogfish. [Note, check whether all under AFMA jurisdiction; 3 are within the Eastern Planning Region AFAs and potentially subject to DEWHA Fishery Risk Assessment.] It is intended that the evaluation needed to support a revised management strategy could be substantially advanced during 2010 through initial data collection during fishing operations and by establishing a research plan. This plan will be based on the needs of the overall conservation goal, framed in the context of the TSSC criteria, and be integrated with an overall monitoring strategy. A first draft will be developed by CSIRO in consultation with commercial operators in August 2010.

Due to the lack of detailed mapping data held by CSIRO, these seamount areas are shown on a composite map (Map 10).

Part 3: Detail of all other options/ implemented closures (provided by CSIRO)

This part of the discussion paper lists all other closure options that (1) have been listed in AFMAs Draft Management Strategy documents; (2) were identified on the basis of gulper shark catches; (3) are planned for other purposes but have a possible benefit for gulper sharks.

This list excludes the following areas listed in the original AFMA document: Trawl 700 m closure and St. Helens Hill (too deep for gulper sharks); Rough bottom Batemans Bay to Jervis Bay and Rough bottom Eden to Bermagui (the areas identified were on the shelf, <200 m depth, and therefore too shallow for gulper sharks); and the Tasmanian Seamounts Reserve (now part of the Huon Marine Reserve, and covered below).

Information is provided for Areas for Further Assessment (AFA) identified by the Department of the Environment, Heritage, Water and the Arts (DEWHA) for their Eastern and South-west Planning Regions. Information of the overlap of AFAs with distribution of selected gulper sharks was provided previously to AFMA and DEWHA by the project: formally on 30 March 2010, and informally at other times.

16) *Fraser AFA* (Map 11a)

There are no reports of gulper sharks from this AFA, but Harrissons Dogfish is known from one location to the north. A Commonwealth Marine Reserve that includes depth-parallel (along slope) habitat in relevant depth range has potential to assist in maintaining the extent of occurrence towards the northern limit of the range of Harrisons Dogfish. The management of this closure, however, is dependent on the outcomes of the Eastern Marine Bioregional Planning process currently being conducted by the Department of the Environment, Heritage, Water and the Arts (DEWHA). The project team is engaged in the Eastern Planning process and is willing to assist in the development of management arrangements by liaising with NSW Fisheries.

17) *Tweed AFA* (Map 11b)

No gulper sharks were observed during recent surveys and there are no other reliable reports, but this AFA includes suitable habitat (bathymetric range) within historic geographic range of Harrisons Dogfish and Endeavour Dogfish. AFA adjacent to observed population to the south. A Commonwealth Marine Reserve that includes depth-parallel (along slope) habitat in relevant depth range has potential to assist in maintaining the extent of occurrence of Harrisons Dogfish. The management of this closure, however, is dependent on the outcomes of the Eastern Marine Bioregional Planning process currently being conducted by the Department of the Environment, Heritage, Water and the Arts (DEWHA). The project team is engaged in the Eastern Planning process and is willing to assist in the development of management arrangements by liaising with NSW Fisheries.

18) *Clarence AFA* (Map 11c)

During the Diana survey, Endeavour Dogfish were observed at 6/6 sites and Harrissons Dogfish observed at 5/6 sites. The AFA includes observed populations at adjacent sites, and another close to southern boundary. A Commonwealth Marine Reserve that includes depth-parallel (along slope) habitat in the relevant depth range in the southern area of AFA has potential benefit for gulper sharks to assist in maintaining the extent of occurrence in an area characterised by several areas of occupancy where mature individuals of both sexes of Harrisons Dogfish are present. Based on the demographic composition of the population in the area, the likelihood of future breeding success at this site is medium whereas for most areas in the region the likelihood is low.

Discussion paper 2 considers three options for closures off northern NSW in the region of this AFA and Hunter (#19 below). NSW Industry has developed a gulper shark Management Process that includes a set of tasks and indicative timeframes. These were tabled at the AFMA workshop held on 13 August 2010. The management of this AFA, however, is dependent on the outcomes of the Eastern Marine Bioregional Planning process currently being conducted by the Department of the Environment, Heritage, Water and the Arts (DEWHA). The project team is engaged in the Eastern Planning process and is willing to assist in the development of management arrangements by liaising with NSW Fisheries.

19) Hunter AFA (Map 11d)

CSIRO considers that the Port Stephens area off northern NSW is a strong candidate area because breeding success for Harrisson's Dogfish has been demonstrated by the large number of juveniles that were present in recent survey catches. The likelihood of future breeding success is less certain because mature males and females were not present during the survey. The "Hunter" Area for Further Assessment in the regional planning process is suitably located.The management of this closure, however, is dependent on the outcomes of the Eastern Marine Bioregional Planning process currently being conducted by the Department of the Environment, Heritage, Water and the Arts (DEWHA). The project team is engaged in the Eastern Planning process and is willing to assist in the development of management arrangements by liaising with NSW Fisheries. See also, notes for Clarence AFA (#18) above.

*20) NSW (Sydney) Endeavour Dogfish closure (*Map 12)

This option was identified in the original draft of AFMA management strategy: "Expansion of the Endeavour Dogfish closure off Sydney out to the 700 m depth contour and make longer so that it measures around 60 nm in length. This area encompasses the 'dumping ground'." The plan noted that other considerations were: "Would require complementary arrangements from NSW as Commonwealth have jurisdiction over trawl only in this area. Commonwealth operators are supportive of this option as it is an expansion of an existing closure, there are records of Harrisson's Dogfish and other dogfish species within the area."

Diana survey catches confirmed that a high abundance population of southern dogfish occur in this closure; subsequent survey catches support the view that this is the only known remaining remnant population of Southern Dogfish on Australia's east coast. Males, females and juveniles are present at this site. This indicates that breeding has occurred here in the past and is likely to in the future. Increasing the size of the closure would increase the area of occupancy, and the habitat diversity (depth and the inclusion of hard ground areas to the south – e.g. "Ayres Rock"). Collaborative arrangements with NSW would reduce implementation uncertainty. The option to expand the closure to 700 m depth and to ~60 n.m. in length is to be considered at Stage 2 of the Strategy. Draft options for the design of this closure are provided here (Map 12).

The importance of extending the closure of the NSW Endeavour Dogfish closure to include NSW State vessels was emphasised at the CSIRO meeting with the SE fishing industry. For this closure to be effective it requires complementary arrangements between AFMA and NSW to regulate fishing by State licensed operators. The project team is available to help liaison between the relevant parties, including AFMA, NSW Fisheries and industry.

21) *Bateman's Bay AFA* (Map 11e)

No gulper sharks were observed during recent surveys, but this AFA includes suitable habitat (bathymetric range) that have supported high historic catches, probably of both Harrisons and Southern Dogfish. A Commonwealth Marine Reserve that includes depth-parallel (along slope) habitat in relevant depth range has potential to assist in maintaining the extent of occurrence of Harrissons Dogfish and Southern Dogfish. The management of this closure, however, is dependent on the outcomes of the Eastern Marine Bioregional Planning process currently being conducted by the Department of the Environment, Heritage, Water and the Arts (DEWHA). The project team is engaged in the Eastern Planning process and is willing to assist in the development of management arrangements by liaising with NSW Fisheries.

22) *East Gippsland Commonwealth Marine Reserve* (Map 13 and 14a)

The depth range of this CMR is too deep (>700 m depths) to be of appreciable benefit to Southern Dogfish or Harrissons Dogfish.

23) *Flinders (Banks Strait) Commonwealth Marine Reserve* (Map 13, 14b)

This area was not surveyed by Diana, but the AMC vessel and a previous auto-longline survey had done some work in the area and found some dogfish including one mature female Harrissons. The inner area of the reserve is open to the auto-longline sector under the bioregional marine planning but has been overlaid with a dogfish closure in recent years. In the meeting with SE industry, it was resolved that there should be further validation research in the closure, but this was not likely to happen before the closure network design was finalised or affect the Flinders CMR boundaries. *[Note: this is implemented.]*

24) *Freycinet Commonwealth Marine Reserve* (Map 13, 14c)

This reserve includes suitable habitat (bathymetric range), is within the historic geographic range of Southern Dogfish and at the southern limit of the historical range of Harrissons Dogfish. Recent CSIRO surveys did not extend this far south, and there are few reports of gulper sharks being caught this far south.

25) Huon *Commonwealth Marine Reserve* (Map 13, 14d)

This reserve includes suitable habitat (bathymetric range), is within the historic geographic range of Southern Dogfish and at the southern limit of the historical range of Harrissons Dogfish. Recent CSIRO surveys did not extend this far south, and there are no reliable reports of gulper sharks being caught in this area.

26) Tasman Fracture *Commonwealth Marine Reserve* (Map 13, 14d)

This reserve includes suitable habitat (bathymetric range), is within the historic geographic range of Southern Dogfish and at the southern limit of the historical range of Harrissons Dogfish. Recent CSIRO surveys did not extend this far south, and there are no reliable reports of gulper sharks being caught in this area.

27) Zeehan *Commonwealth Marine Reserve* (Map 13, 14e)

This reserve includes suitable habitat (bathymetric range), is within the historic geographic range of Southern Dogfish and beyond the southern limit of the historical range of Harrissons Dogfish. Recent CSIRO surveys did not extend this far south, and there are no reliable reports of gulper sharks being caught in this area.

28) *"Port MacDonnell"* (Maps15 and 15a)

A recent longline survey at Port MacDonnell by the FV *Sarda* showed the highest gulper shark (Southern Dogfish) catch rates of surveys to date. The area is 8 hours steam from Portland and is adjacent to one prominent trawl ground called "the South Drag" used by a number of Portland trawl vessels, and historically by Beachport trawl operators who provide these fishing ground names. Further, the area is an important ALL target area for 2 vessels steaming into and out of

Portland. There are observer records of high gulper shark catches at either end of the heavily fished trawl ground. It is difficult to reconcile whether these catches originate from fish dispersed across the ground or from “flowover” from the canyon habitat at either end of the trawl ground. It was suggested that given the intensity of the trawling, the latter may be more likely. The meeting resolved that, based on locations fished during the *FV Sarda* survey, the area outside the southeast end of the tow was likely to be the source of gulper shark catches in trawls and that it should be closed to all commercial fishing. The ALL sector noted that any longline effort in the area would result in significant catches of gulper sharks. 200 dogfish have been tagged in the area. It was proposed that this area was ideal as a “research closure” for a tagging program with a research permit requirement.

This region was discussed at the very end of the final CSIRO-SE industry meeting and no actual closure options boundaries were drawn. Subsequent discussions with industry in August, including during the stakeholder meeting, corroborated earlier information. This in conjunction with trawl effort mapped at 1 km grid resolution and (limited) swath habitat, enabled new boundaries to be detailed around an adequate area containing the remnant population whilst minimising the overlap on established fishing grounds (Map 15a).

29) Murray *Commonwealth Marine Reserve* (Map 13, 14f)

This reserve includes suitable habitat (bathymetric range) within the historic geographic range of Southern Dogfish but there are no authenticated reports of Southern Dogfish being caught here.

30) Western Eyre AFA (Map 16a, b)

This AFA includes suitable habitat (bathymetric range) within the historic geographic range of Southern Dogfish but there are no authenticated reports of Southern Dogfish being caught here. The implementation of this closure, however, is dependent on the outcomes of the South-west Marine Bioregional Planning process currently being conducted by the Department of the Environment, Heritage, Water and the Arts (DEWHA).

31) GAB 60-mile Closure (no map)

A westward extension by ~30 n.m. is an option to protect an aggregation of mature females of Southern Dogfish and promote the expansion of an area of high abundance of Southern Dogfish. The effect of expanding this closure would increase the likelihood of maintaining breeding females, and reduce decline in gulper shark numbers in and around the closure due to edge effects of fishing. However, the likelihood of breeding success in the current closure is already high because males, females and juveniles are present. This also indicates that successful breeding has occurred here in the past. This pattern has been observed over a number of years which further reduces uncertainty. Increasing the size of the closure would increase the area of occupancy but would not change habitat diversity.

32) GAB Benthic Protection Zone (Map 16a, c)

This reserve includes suitable habitat (bathymetric range) within the historic geographic range of Southern Dogfish but there are no measurements of relative abundance available for this area.

33) GAB Far West Gulper Shark Closure (map 16d)

Proposed by the Great Australian Bight trawl fishing industry, this is an expansion of an existing deepwater closure at its shallow margin to also cover the upper slope depth range of Southern Dogfish. It is in what appears to be suitable habitat (steep upper slope) but there are no are no measurements of relative abundance available for this area. It is within the Recherche AFA *[Note: implemented June 30, 2010]*

34) GAB Benthic Protection Zone, including extension (map 16c)

This reserve includes suitable habitat (bathymetric range) within the historic geographic range of Southern Dogfish but there are no are no measurements of relative abundance available for Southern Dogfish in this area. The implementation of this closure, however, is dependent on the outcomes of the South-west Marine Bioregional Planning process currently being conducted by the Department of the Environment, Heritage, Water and the Arts (DEWHA).

35) Recherche AFA (Map 16d)

This reserve includes suitable habitat (bathymetric range) within the historic geographic range of Southern Dogfish but there are no measurements of relative abundance of Southern Dogfish available for this area.. The implementation of this closure, however, is dependent on the outcomes of the South-west Marine Bioregional Planning process currently being conducted by the Department of the Environment, Heritage, Water and the Arts (DEWHA).

36) South West Corner AFA (Map 16e)

This reserve includes suitable habitat (bathymetric range) within the historic geographic range of Southern Dogfish but there are no authenticated reports of

Southern Dogfish being caught here. The implementation of this closure, however, is dependent on the outcomes of the South-west Marine Bioregional Planning process currently being conducted by the Department of the Environment, Heritage, Water and the Arts (DEWHA).

Part 4: Summary evaluation against conservation guidelines

The long list (36) of relevant closure options/ implemented closures is summarised here (Table 2) in a simple format to facilitate the process of screening and short-listing. This is intended to help focus discussions during the CSIRO-AFMA-stakeholder meeting in August 2010. This summary evaluation captures the elements of the guidelines for assessing conservation status contained in the EPBC Act as used by the TSSC. Additional information for discussion at the August meeting will expand this summary evaluation in a management strategy evaluation (MSE) format (Discussion paper 2) to aid decision-making about the composition of the closure network for Harrissons and Southern Dogfish.

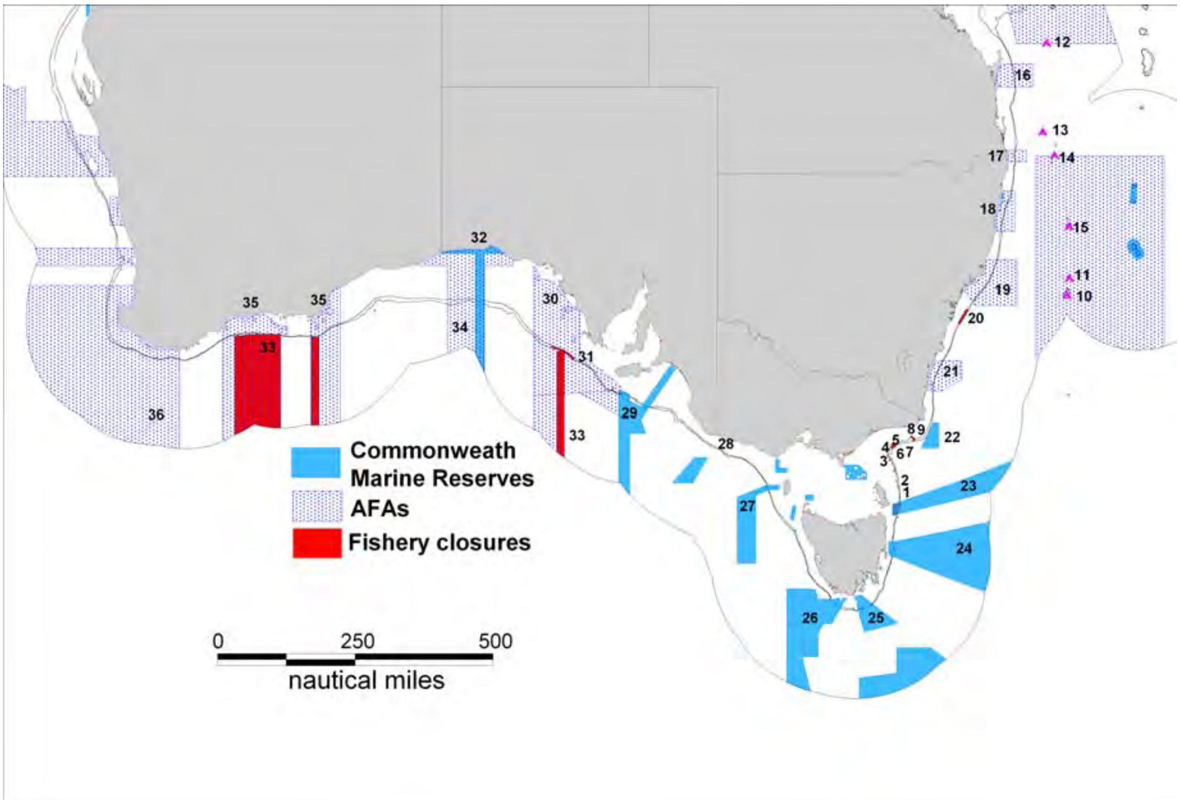
		Summary of conservation objectives for each closure option					
		Harrissons Dogfish			Southern Dogfish		
	Closure 'option'	Presence absence	Breeding potential	Habitat potential (variety, extent & condition)	Presence absence	Breeding potential	Habitat potential (variety, extent & condition)
1	Cape Barren Ground - deep	1	1?	1	1	0	1
2	Babel Deepwater-Babel Horseshoe	1	1?	1	1	0	1
3	Smithy's Corner - deep	1	0	1	1	0	1
4	Dooley's (Rigs)	0	0	0	1	0	0
5	Mackerel Spit	1	0	0	1	0	0
6	Seiners Ling Closure	1	0	0	1	0	0
7	Middle Bight to Everard Canyon	1	0	1	1	0	1
8	Everard Ling Closure	1	0	1	1	0	1
9	East of the Everard Canyon	1	0	0	1	0	0
10	Taupo Seamount (Tasmantid AFA)	1	1?	1	--	--	--
11	Barcoo Seamount (Tasmantid AFA)	?	?	?	--	--	--
12	Fraser Seamount (Coral Sea AFA)	?	?	?	--	--	--
13	Queensland Seamount	?	?	?	--	--	--
14	Brittania Seamount	?	?	?	--	--	--
15	Derwent Hunter Guyot (Tasmantid AFA)	?	?	?	--	--	--
16	Fraser AFA	?	?	?	--	--	--
17	Tweed AFA	?	?	?	--	--	--
18	Clarence AFA	1	0	1	--	--	--
19	Hunter AFA	1	1?	1	--	--	--
20	Endeavour (Sydney) closure	1	0	1	1	1?	1
21	Batemans AFA	0	0	0	0	0	0
22	East Gipplsand CMR	--	0	--	--	0	--
23	Flinders CMR	1	0	1	?	?	?
24	Freycinet CMR	1	0	1	?	?	?
25	Huon CMR	--	--	--	?	?	?
26	Tasman Fracture CMR	--	--	--	?	?	?
27	Zeehan CMR	--	--	--	?	?	?
28	Pt. MacDonnell	--	--	--	1	1?	1
29	Murray CMR	--	--	--	?	?	?
30	Western Eyre AFA	--	--	--	?	?	?
31	GAB 60-mile Closure	--	--	--	1	1?	1
32	GAB Benthic Protection Zone	--	--	--	?	?	?
33	GABIA Deepwater Closure	--	--	--	?	?	?
34	GAB extension AFA	--	--	--	?	?	?
35	Recherche AFA	--	--	--	?	?	?
36	South West Corner AFA	--	--	--	?	?	?

Pre-existing fishery closure
Commonwealth Marine Reserves and AFAs
Fishery area options

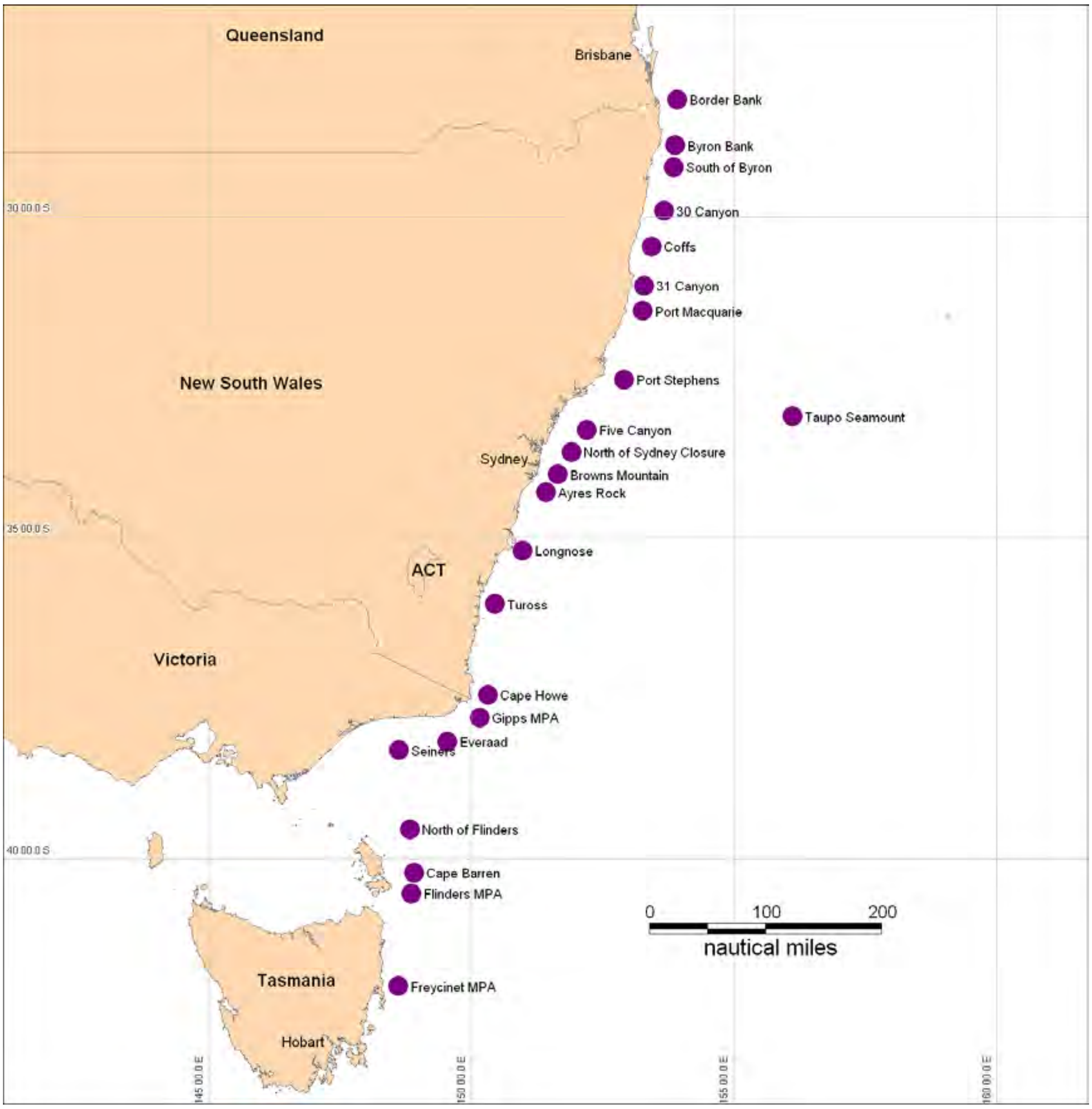
(orange) Confirmed high abundance
(yellow) Extensive suitable habitat
? Within species range but data absent
-- Not relevant (outside range)

Table 2 Full list of managed areas and closure options relevant to conserving Harrissons Dogfish and Southern Dogfish. The type of each area is shown together with a simple summary against factors relevant to management objectives.

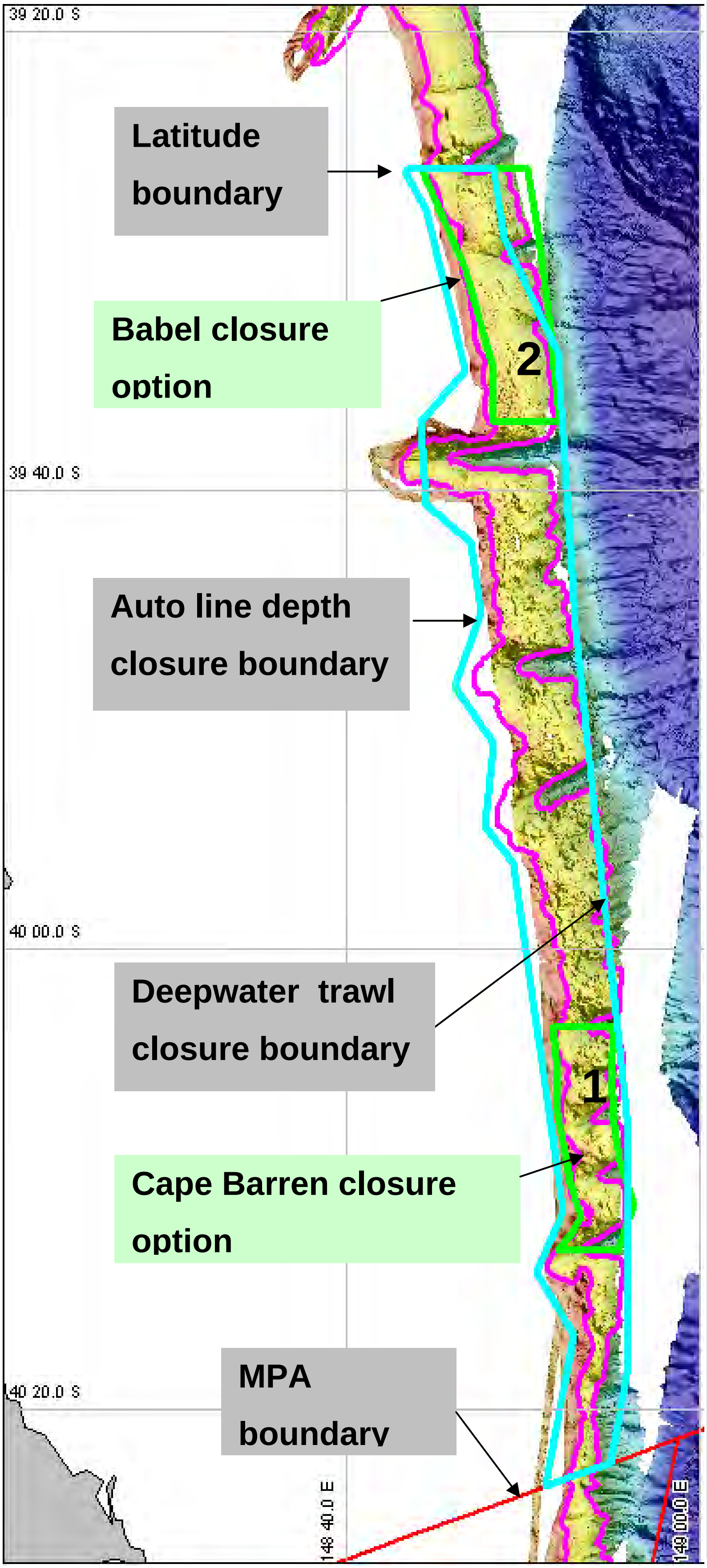
Note: any closure area implemented off the NSW coast, including offshore seamounts, will also have benefits for Endeavour Dogfish (*C. moluccensis*).



Map 1 The locations of spatially managed areas relevant to considering the conservation of gulper sharks (Harrissons Dogfish and Southern Dogfish). Individual areas can be identified by referring the numbers shown here to Table 2. Existing closures are located off Sydney (#20), Flinders Island (#23), Port Lincoln (#31) and the Taupo and Barcoo Seamounts (#10 and 11).



Map 2 Sampling sites completed during the CSIRO 2009 survey aboard the FV *Diana* auto-longline vessel.



Potential options for management regulations

RESEARCH ZONE

* no auto-dehooking

* zero take of gulper sharks - all live sharks tagged, all dead sharks retained as science specimens

* verification of code of conduct, inc. proven ability to identify gulper sharks, and inc. involvement by industry leaders to advocate buy-on*

* emphasis on observer coverage by ISMP

* pre-determined interval for review of arrangements

* structured research program with active industry participation which has reporting/ feedback to all stakeholders

CLOSURES

* sector specific access

* cap on effort

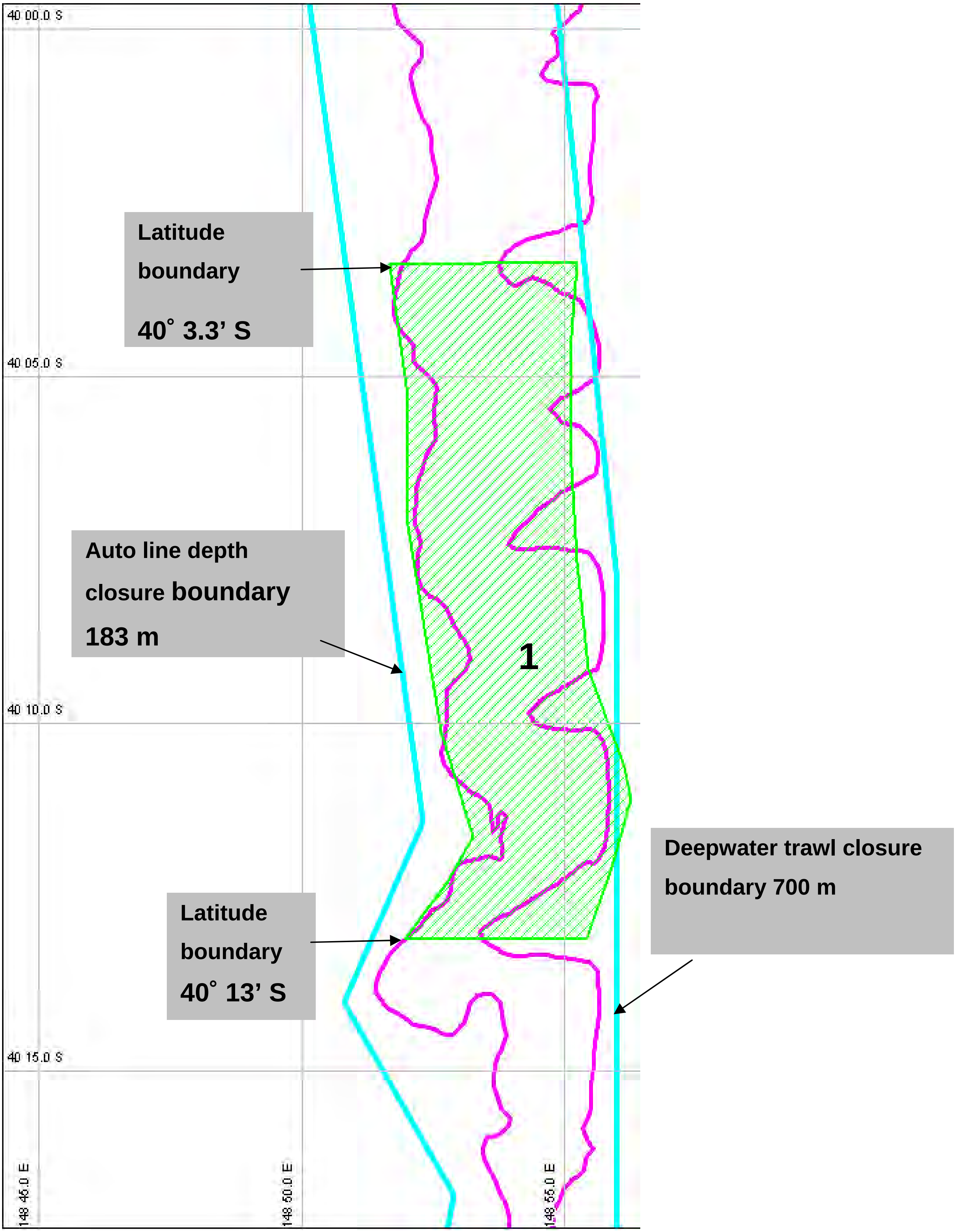
* performance assessed by monitoring program at sites within closures. Program is scientifically designed, involves industry, includes pre-determined frequency of sampling

* need for gear size to match fine spatial distributions of remnant gulper populations and small closures, e.g. shorter longlines

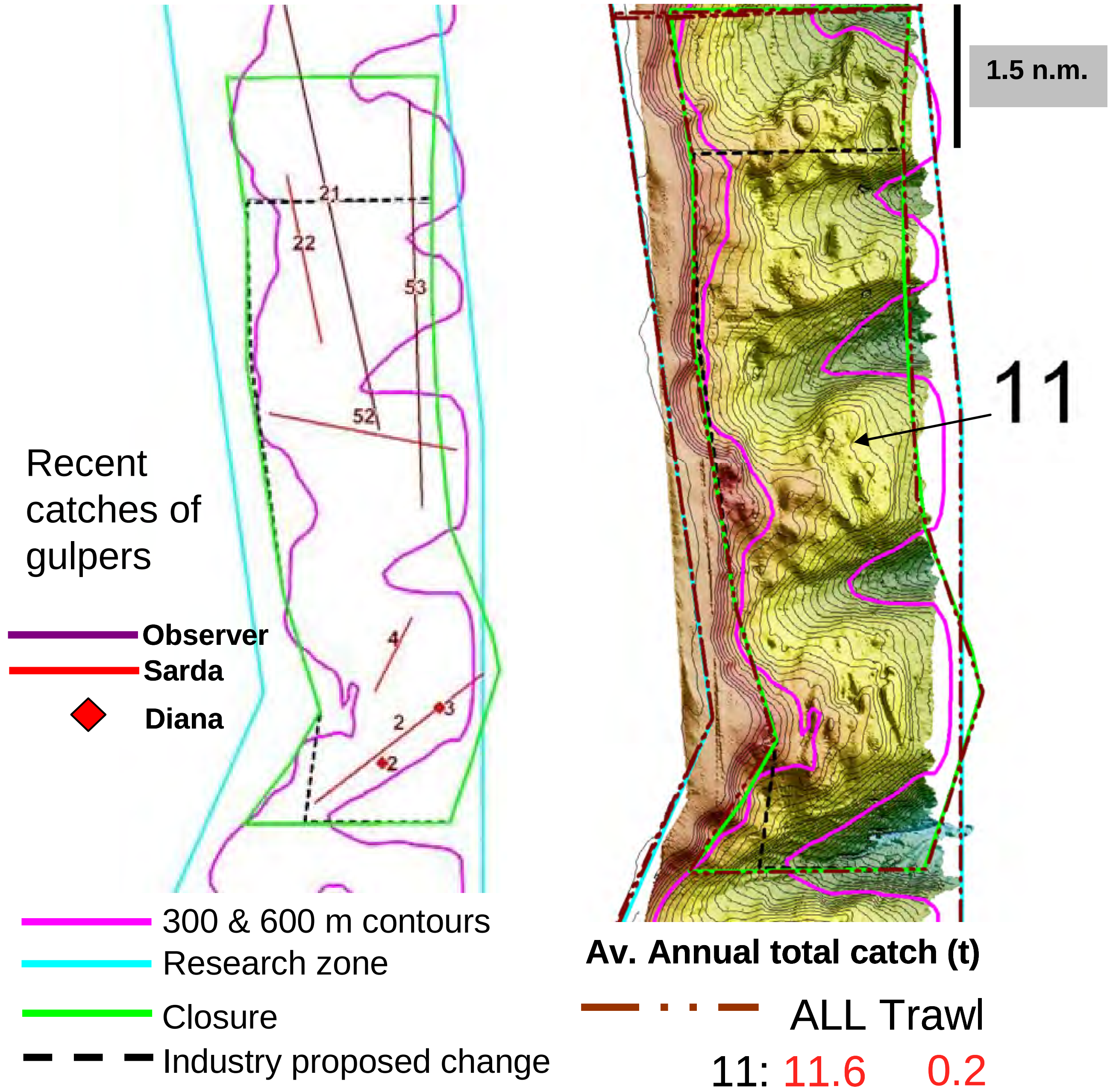
* data from industry vessels provides new research – e.g. genetic approaches to determine movements and stock size

Map 3 Illustration of research zone concept : research zone bounded by BLUE line containing 2 closure areas bounded by GREEN lines. **[58 n.m. long, 763 km^2]**

- Intuitive boundaries based on pre-existing lines, fishing grounds, depths and latitude.
- Potential options for management regulations in inset



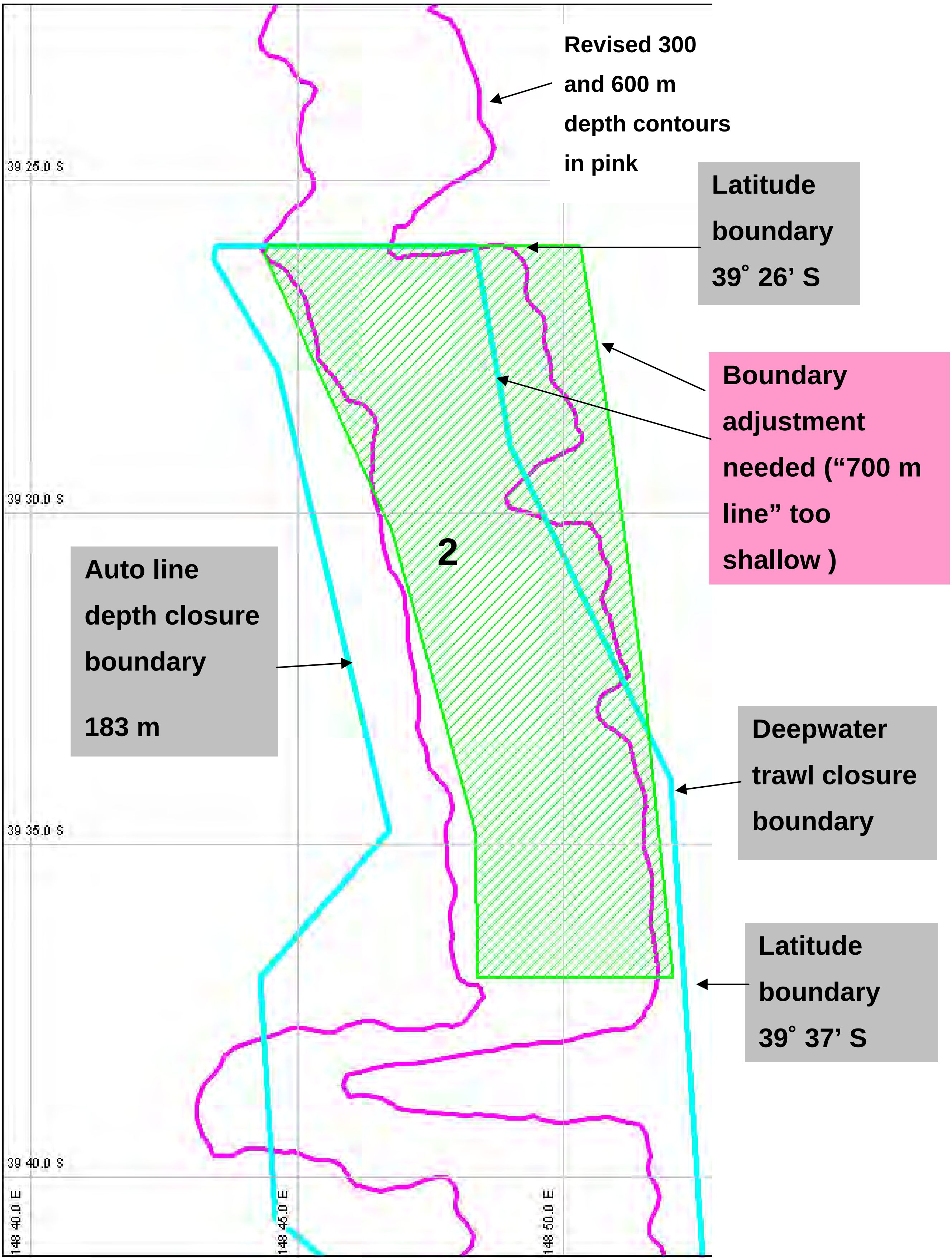
Map 4: Cape Barren Closure option [80 km^2, 9.8 n.m. long]



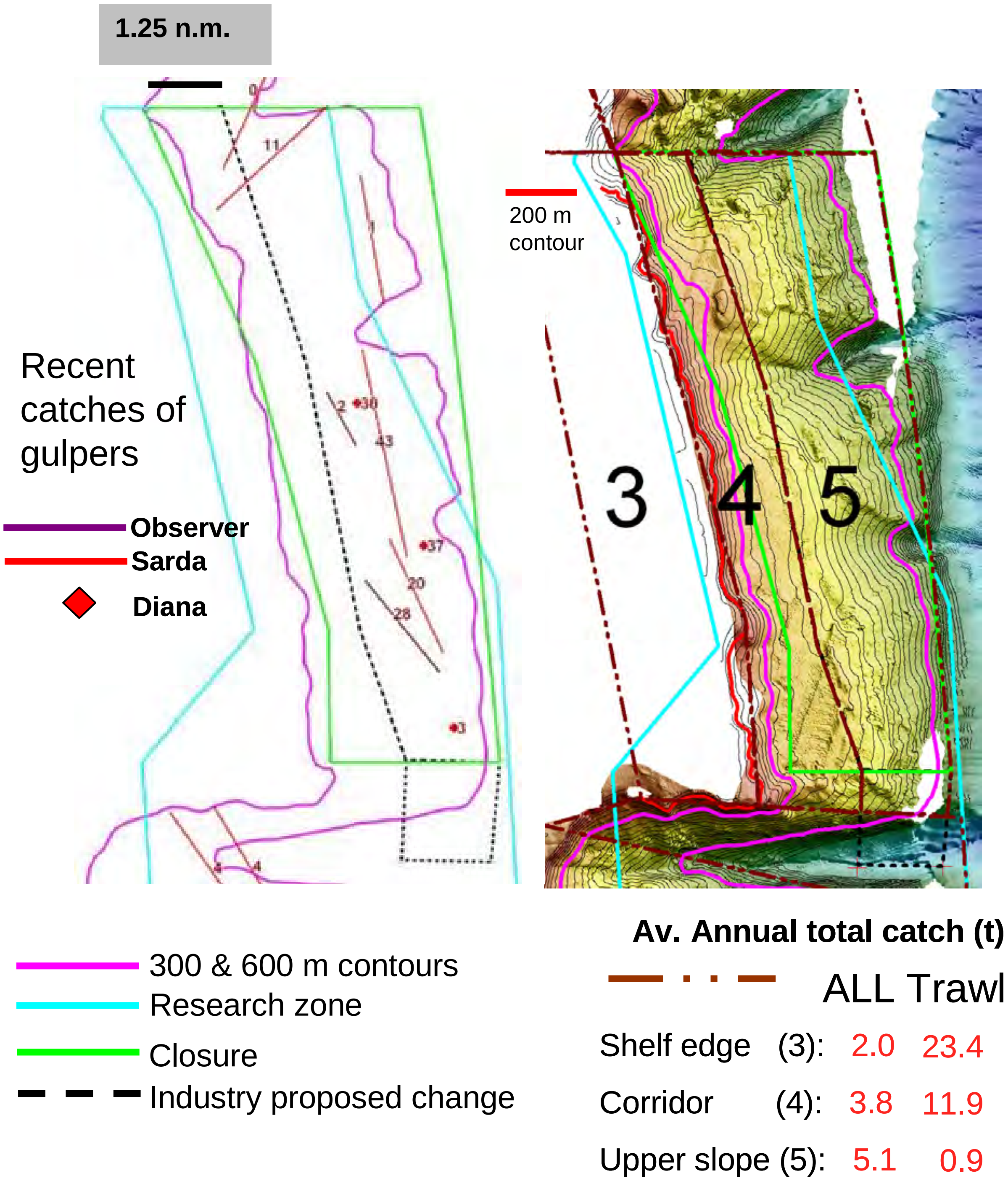
Map 4a Revised Cape Barren Closure option [80 km^2, 9.8 n.m. long]

Left hand panel: industry suggested modifications made during stakeholder and agencies meeting in August, and the recent catches of Harrissons Dogfish (no. individuals) during three surveys.

Right-hand panel: the total annual average (2006-2009) trawl and autolongline (ALL) catch of commercial species (tonnes) from the closure box (11)



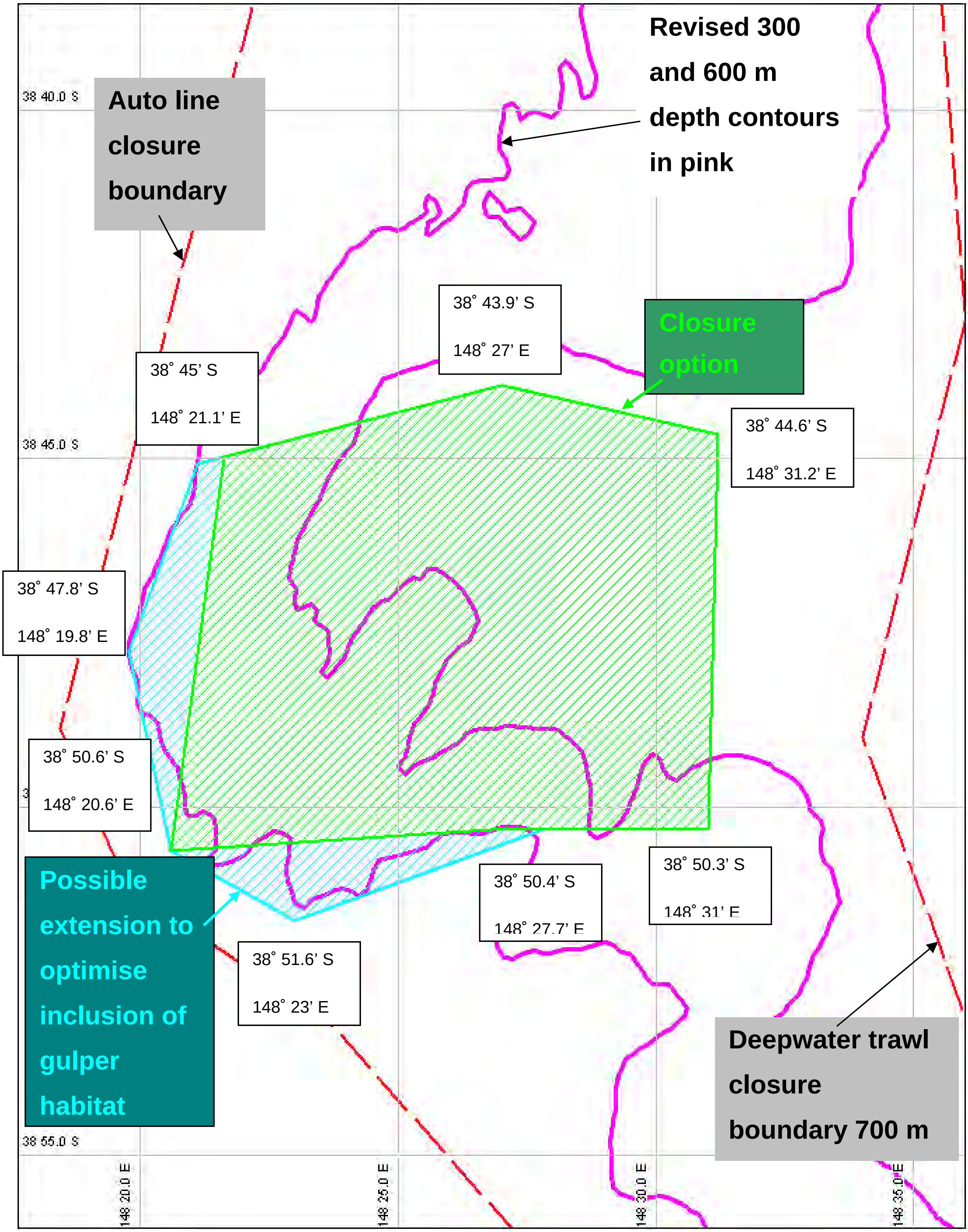
Map 5: Babel Closure option [127 km^2, 11 n.m. long] (Sister's Canyon north)



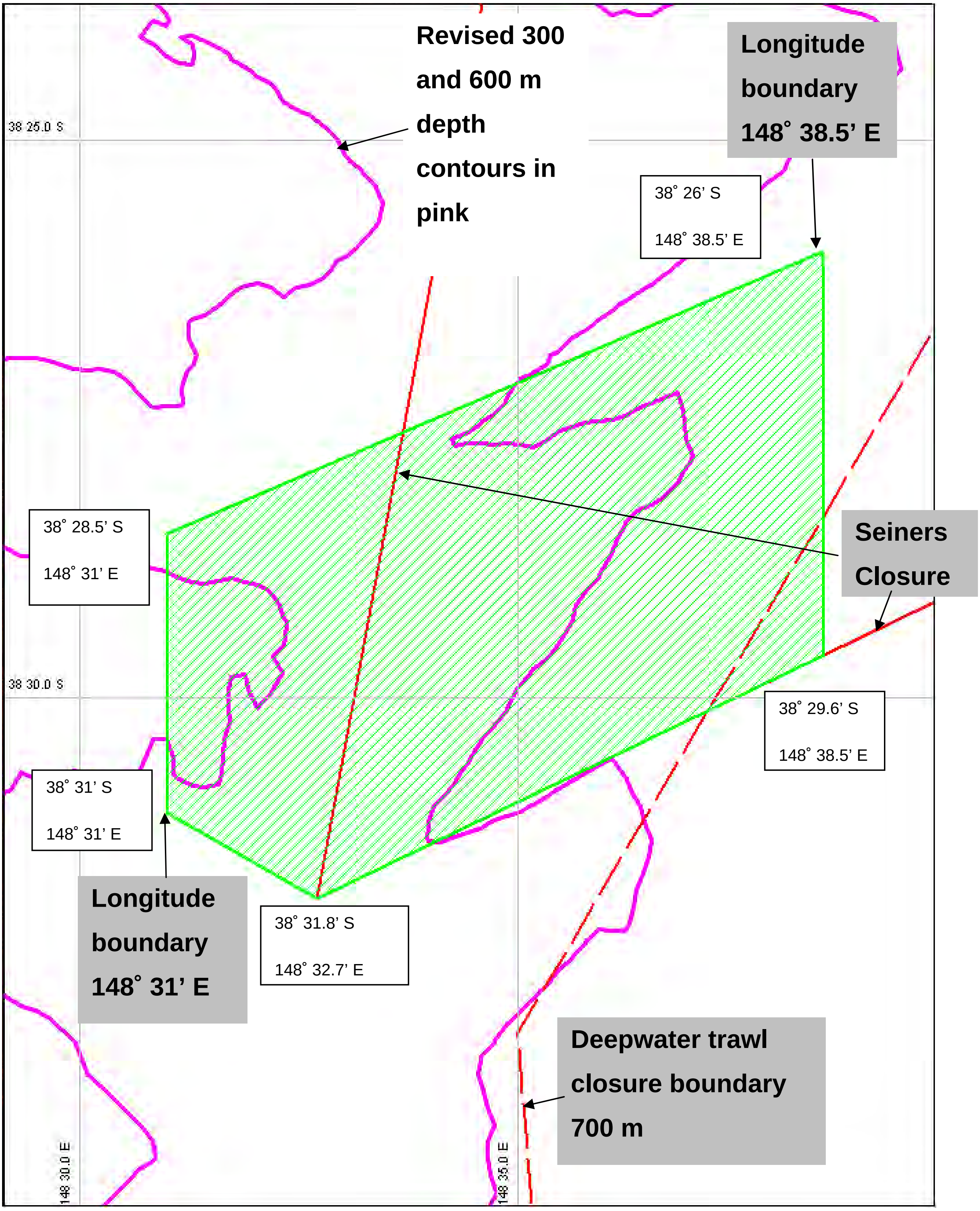
Map 5a Revised Babel Closure option [127 km^2, 11 n.m. long] (Sister's Canyon north)

Left hand panel: industry suggested modifications made during stakeholder and agencies meeting in August, and the recent catches of Harrissons Dogfish (no. individuals) during three surveys.

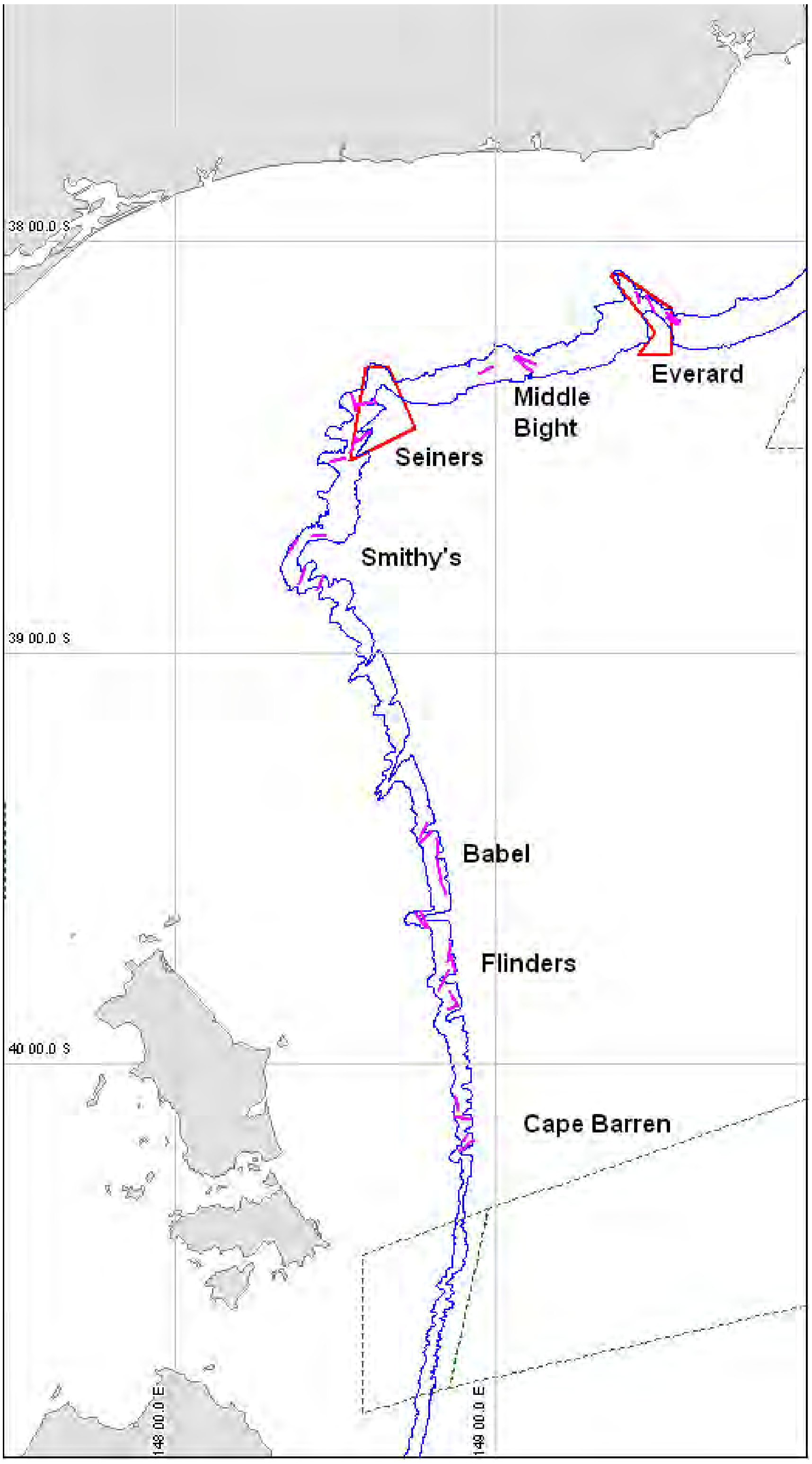
Right-hand panel: the total annual average (2006-2009)) trawl and autolongline (ALL) catch of commercial species (tonnes) from 3 sub-areas: adjacent shelf (3), corridor formed by the industry proposed modification inside the closure box (4), and the upper slope within the closure box (5)



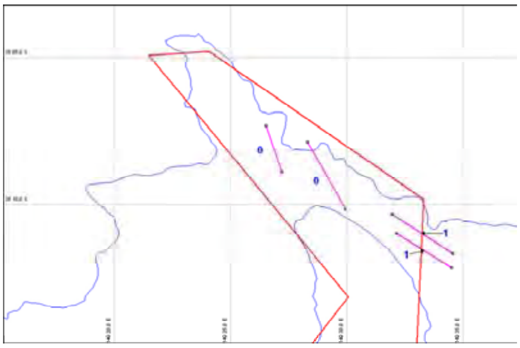
Map 6: Smithy's Corner – deep Closure option Proposed [160 km^2, ~10 n.m. long]
Total with possible extension [183 km^2, ~10 n.m. long]



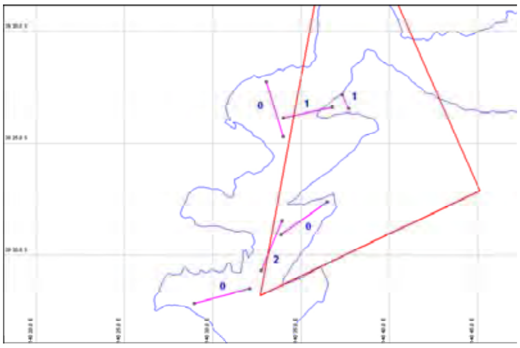
Map 7: Mackerel Spit Closure option [73 km^2 , 7.5 n.m. long]



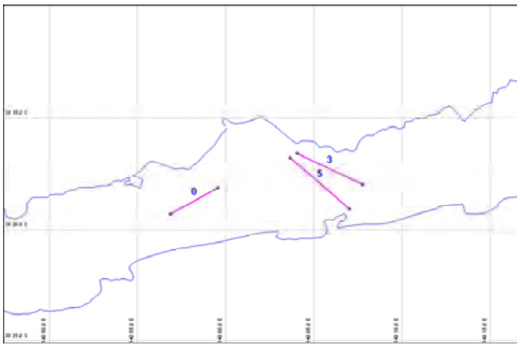
Map 8. Location of areas surveyed from FV *Sarda*, Leg 1 in waters of NE Bass Strait and Leg 2 from Smithy's to Cape Barren. Catches are summarised in Map 9. Fishing line sets are shown as purple lines in relation to the 300 and 600 m depth contours (blue lines). The boundaries of the ling closures at Everard and Seiners are shown by red lines existing reserves are indicated as dashed green lines.



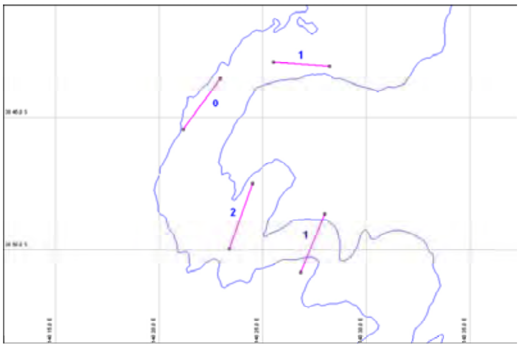
(a) Everard Canyon



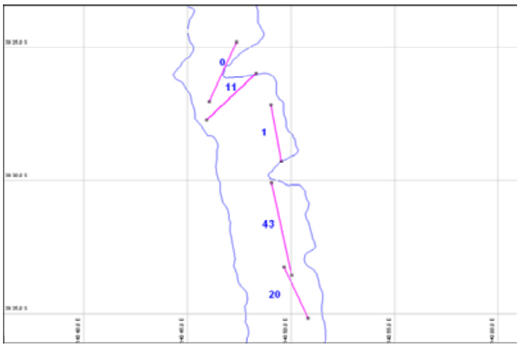
(b) Seiners Canyon



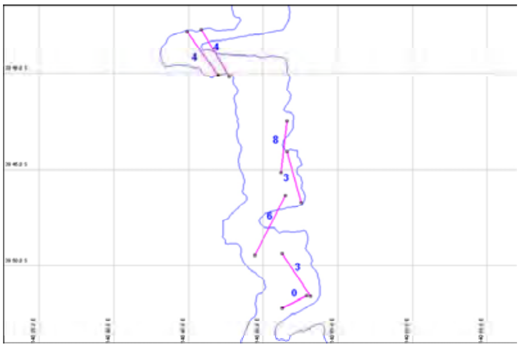
(c) Middle Bight



(d) Smithy's Corner



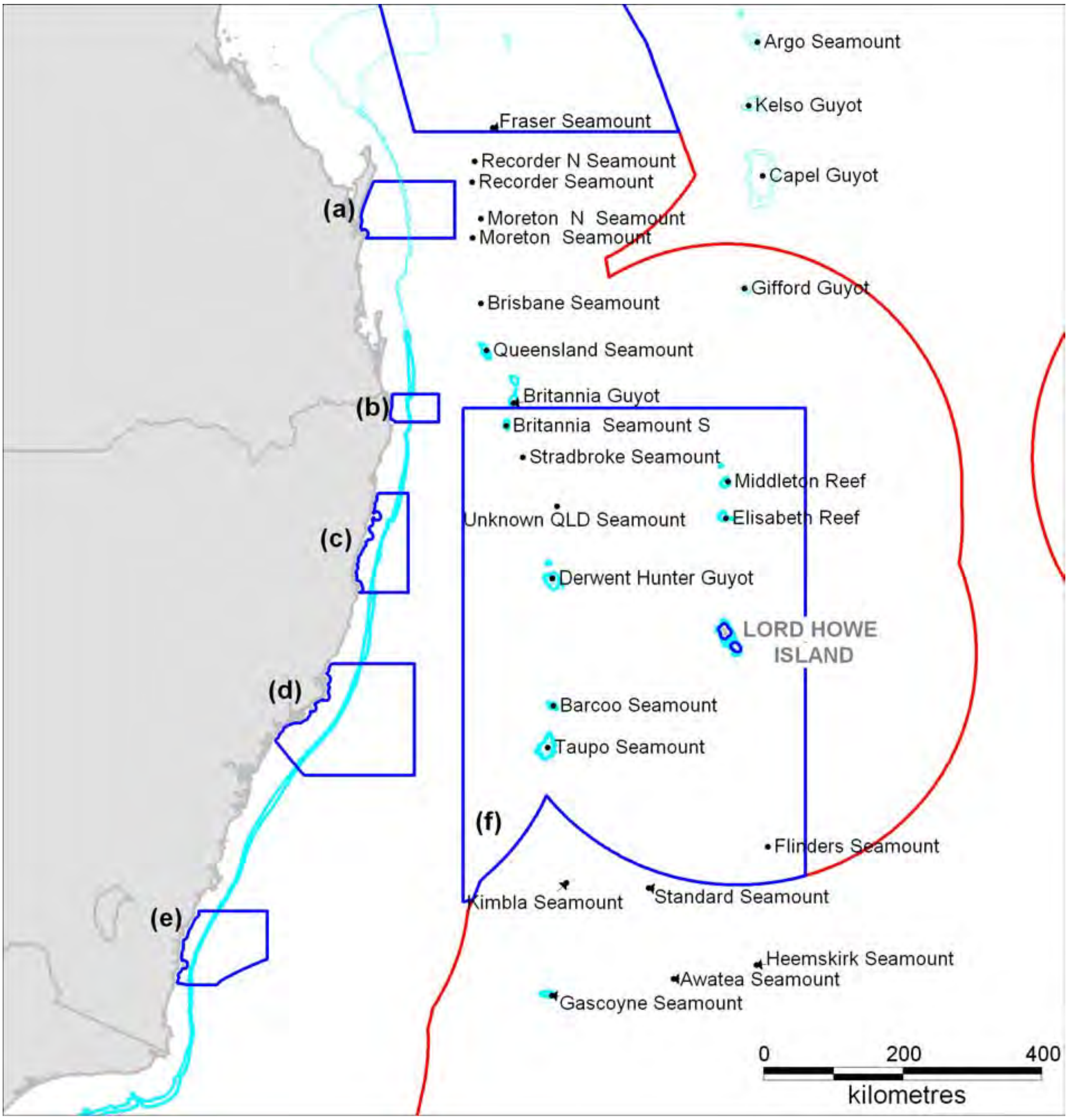
(e) Babel Deepwater to Horseshoe



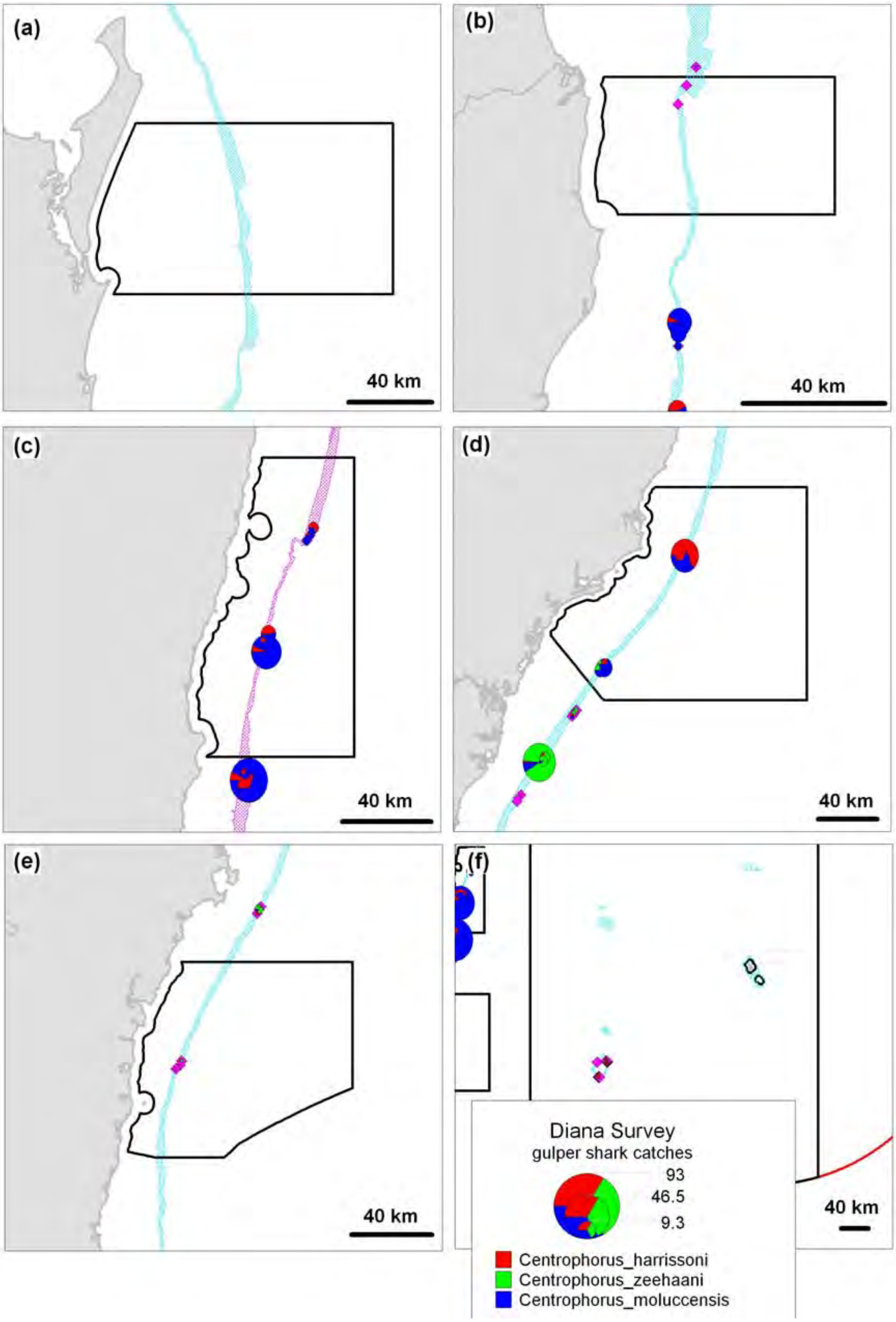
(f) Babel Horseshoe to Cape Barren Ground Deep

(g) Cape Barren Ground Deep

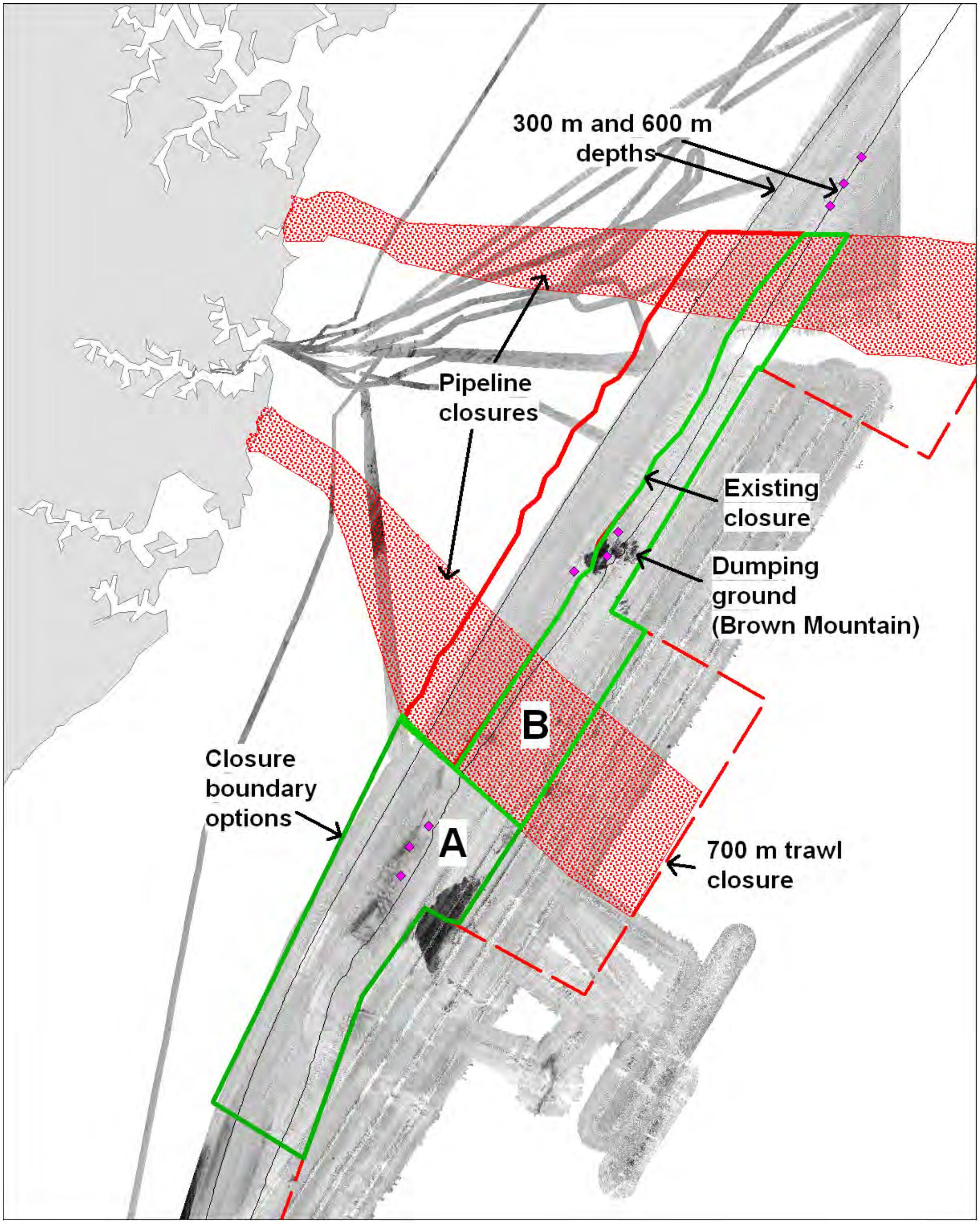
Map 9 (a–g) Catch and location of Harrissons Dogfish for FV *Sarda* operations. Fishing line sets (each of ~3000 hooks) are shown as purple lines in relation to the 300 and 600 m depth contours (blue lines) with the numbers of Harrissons Dogfish caught shown for each set. The boundaries of the ling closures at Everard and Seiners are shown by red lines existing reserves are indicated as dashed green lines.



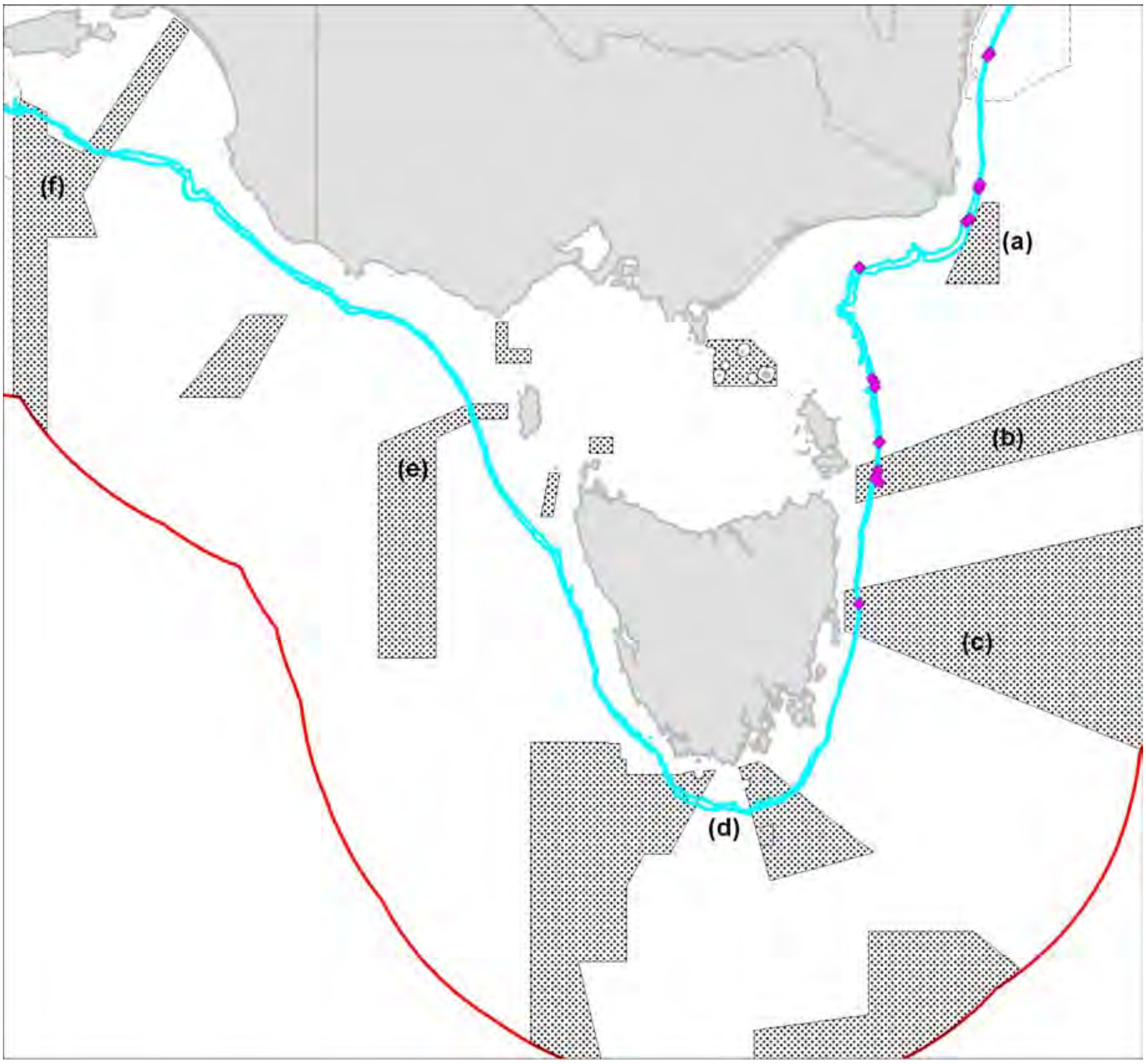
Map 10 The named seamounts off Australia's east coast in relation to the Eastern Region 'Areas for Further Assessment' (AFA) (Areas a-f shown in detail in Map 11; Coral Sea AFA unlabelled) and, including the 300-600 m depth zone (light blue).



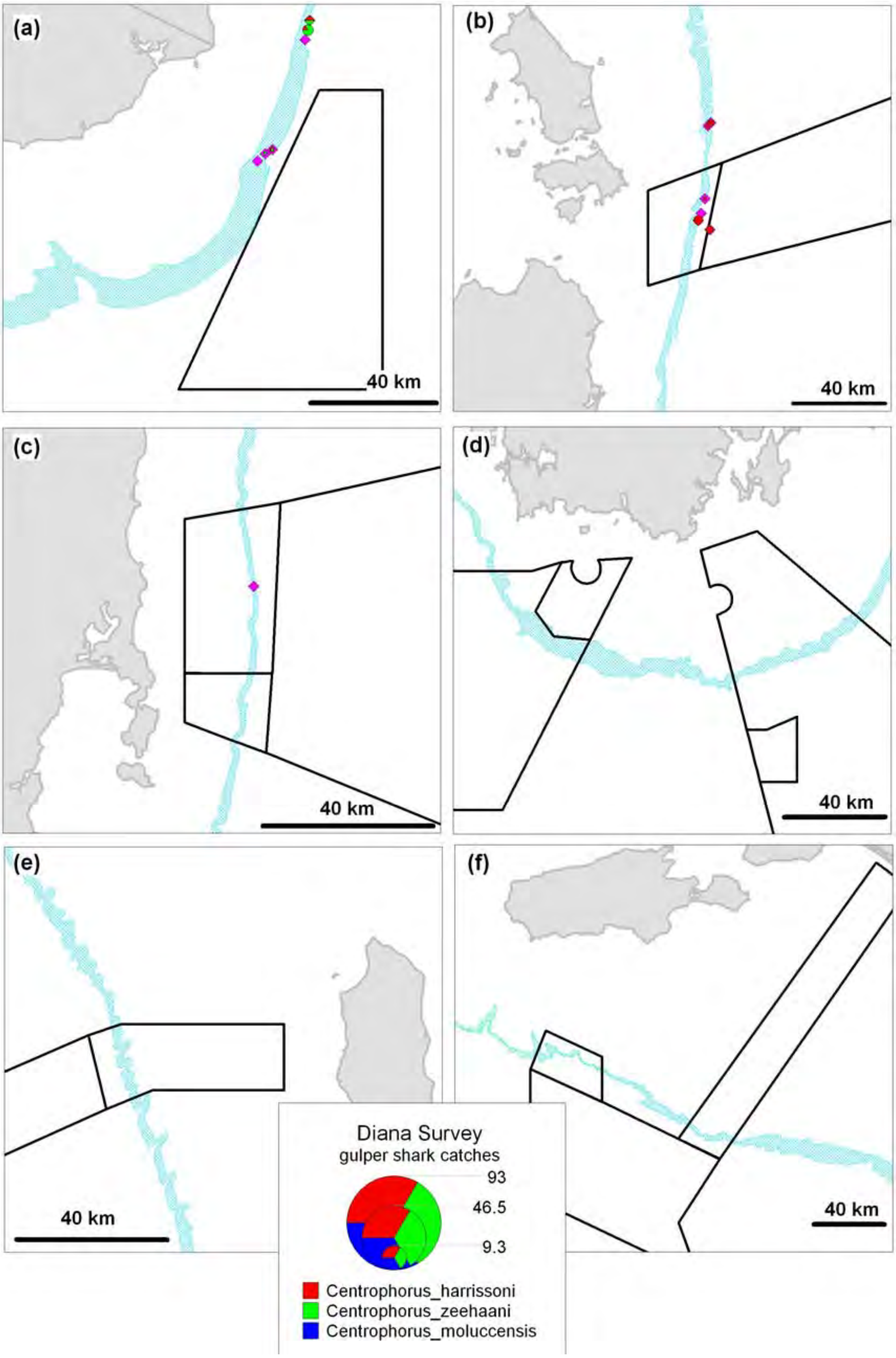
Map 11 The eastern AFAs with the 300-600 depth zone overlaid and showing the Diana survey sampling locations graded by gulper shark catches – pink diamonds where no gulpers were caught. (a) Fraser, (b) Tweed, (c) Clarence, (d) Hunter, (e) Batemans, (f) Tasmantid



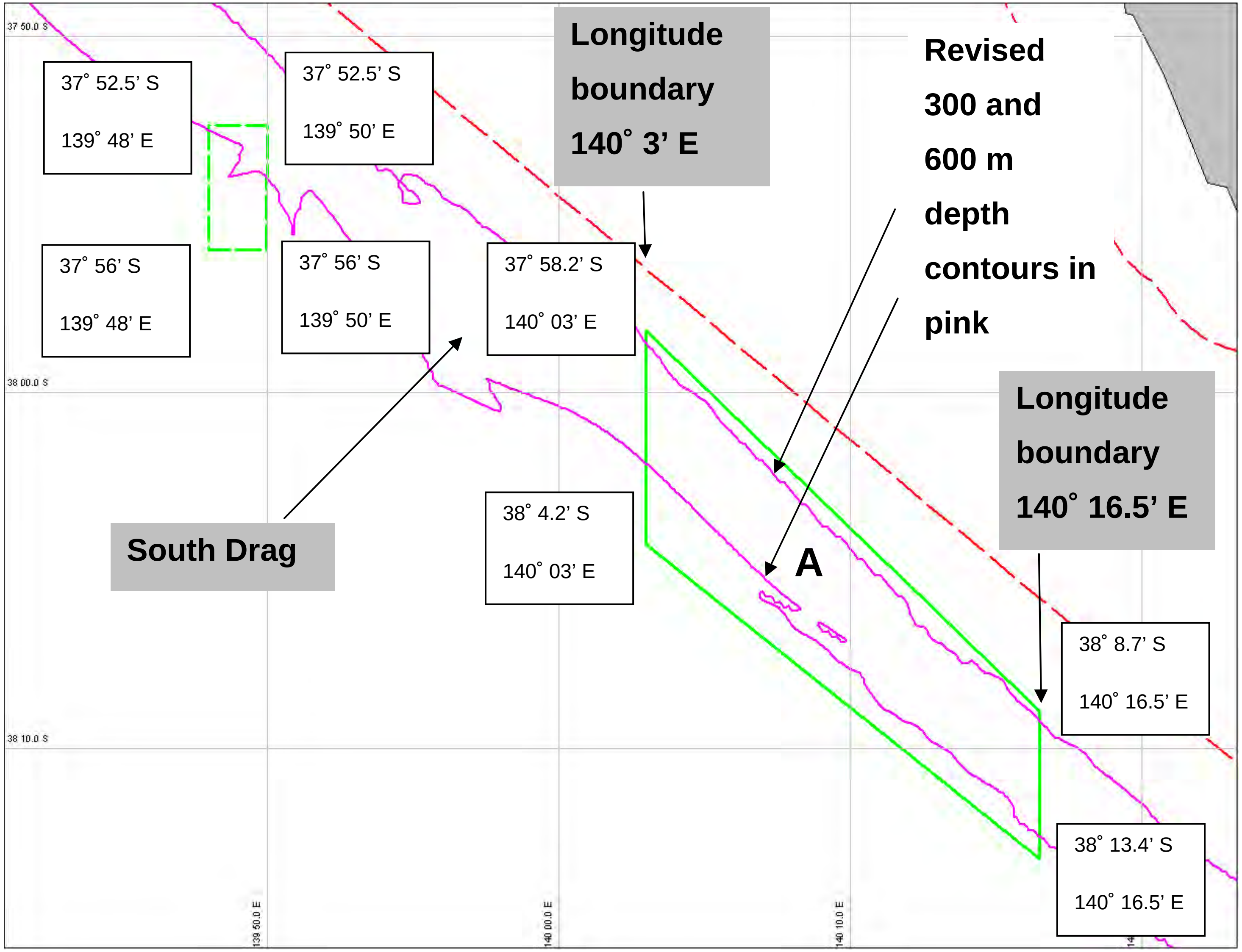
Map 12 DRAFT option for expansion of Sydney Endeavour Dogfish Closure (red box) for discussion. Expansion (green boxes): A+B = expansion to 60 nm and to 700 m depth; B= expansion only to 700 m depth



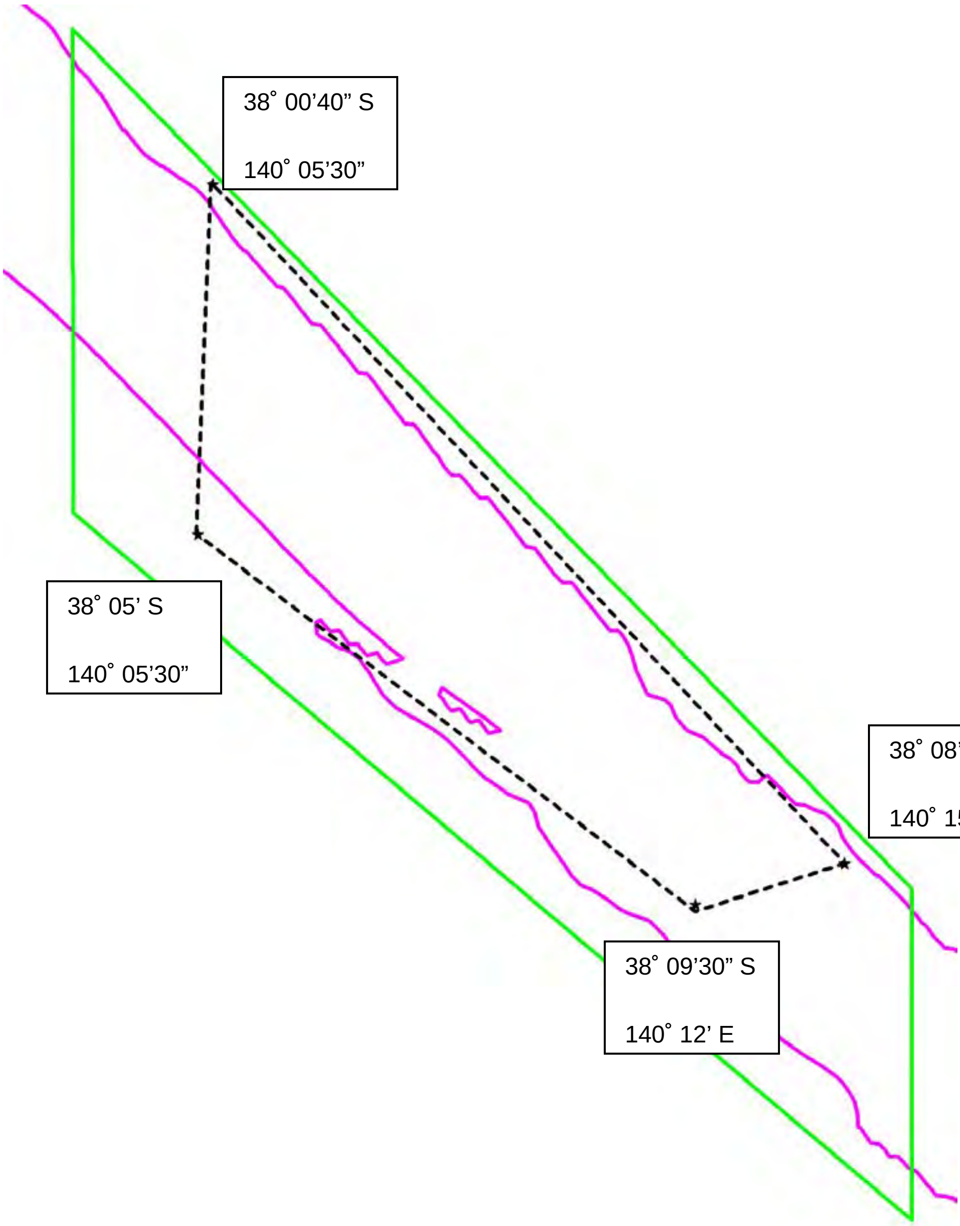
Map 13 Overview of the SE region Commonwealth Marine Reserves (CMR) showing the sampling stations from the RV *Diana* survey (pink diamonds) and the 300-600 m depth zone (in blue); (a-f) indicate the location of detailed maps shown in Map 14.



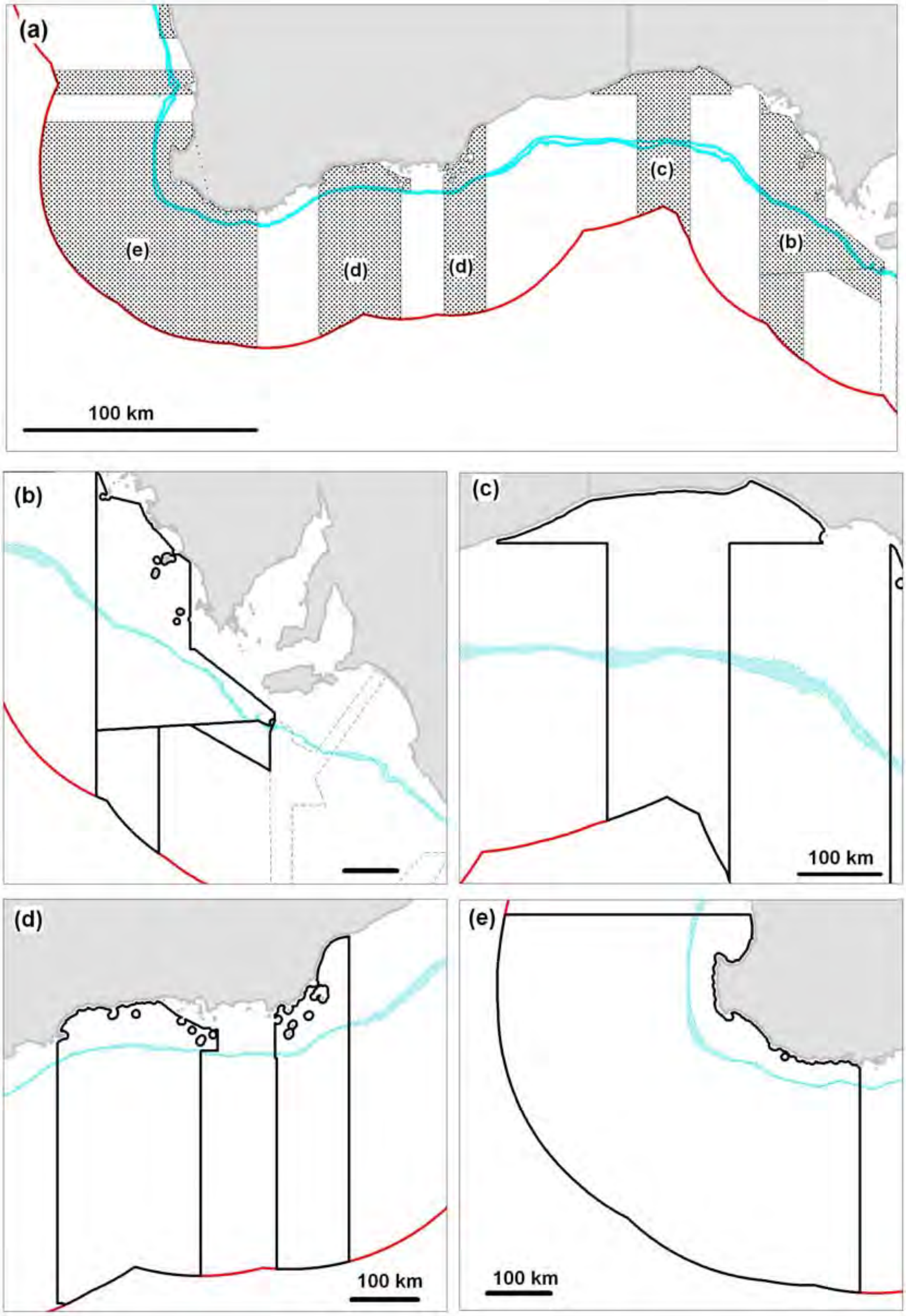
Map 14 Detailed maps of SE CMRs that cover the 300-600 m depth zone; (a) East Gippsland, (b) Flinders, (c) Freycinet, (d) Huon and Tasman Fracture, (e) Zeehan, (f) Murray. (a-c) also show FV *Diana* survey sampling locations graded by gulper shark catches – pink diamonds where no gulpers were caught.



Map 15: Port MacDonnell closure option Green area = potential closure option A: [185 km^2, 15 n.m. long]. Small box (dashed line) for possible consideration as a monitoring site. Note: inside boundary intended to track 100 fathom line.



Map 15a: Port MacDonnell closure option with industry suggested modification



Map 16 The south-western AFAs with the 300-600 depth zone (in blue) showing (a) an overview of the AFAs in the GAB and off SW WA, and details of: (b) Western Eyre, (c) Great Australian Bight Benthic Protection Zone, including extension, (d) Recherche (2 areas), and (e) SW Corner.

APPENDIX G – EVALUATION OF NETWORK CLOSURE OPTIONS FOR HARRISSON'S DOGFISH AND SOUTHERN DOGFISH

Evaluation of network closure options for Harrissons Dogfish and Southern Dogfish

For discussion at SEMAC on 14–15 September 2010

Ross Daley, Tony Smith, Alan Williams, Mark Green, Michael Fuller
CSIRO Marine and Atmospheric Research, Hobart

Overview

This document is intended to help stakeholders discuss and evaluate a selected set of options for closure strategies for two species of gulper sharks. It accompanies a document that screens a larger range of potential options, referred to in this paper as "Document A". Earlier drafts of both documents were presented and discussed at the Upper Slope Dogfish Management Workshop on August 13 2010. The information presented in this document is intended to help identify the tradeoffs between meeting conservation objectives and minimising the cost of closures to industry. This paper does not advocate any particular option.

Options are evaluated at three spatial scales with corresponding management options:

1. Regional scale – Options based on networks of closures across the range of the species leading to Network Closure Options (NCO)

2. Local scale – Options based on the characteristics of individual areas leading to Fishery Closure Options (FCO)

3. Fine scale – Fine scale adjustments to FCOs

A total of 8 criteria are used for the evaluation (Table 1). Criteria 1-5 are conservation criteria that apply at the regional and local scales and are designed to help judge whether each area is likely to contain a self sustaining population. Criterion 6 looks at the cost to industry of closing an area to fishing and applies at all scales. At the regional and local scales, criterion 6 uses estimates of the annual average (2006 – 2009) of recent catches of quota species. Quota species are closely linked to management objectives for target species. At the fine scale, total landed catch of all species is used. This provides greater insights into fishery practices including depth of shots. Criteria 7 and 8 are used to judge whether conservation criteria are met at the geographic scale of the full species range. Important considerations here are whether the range of the species is maintained, and whether several self sustaining populations are included in the network of closures. Scoring the criteria is based on information from a variety of sources (e.g. surveys, logbooks, habitat maps) and was undertaken by the authors of this paper (Appendix A).

Some additional data are presented for Endeavour Dogfish (Figure 6). However the distribution of this species lies mainly outside the range of recent survey data and specific management options have not yet been evaluated for this species. It is likely that the development of management arrangements for Harrissons Dogfish off northern NSW would also have benefits for Endeavour Dogfish. These are discussed briefly in section 2. The Greeneye Spurdog is also referred to in the Upper Slope Dogfish Management Strategy. However, preliminary analysis of tagging data indicates the home range for this species is likely to be too large for practical implementation of spatial management strategies.

Options are scored in a series of tables with colour coded cells:
Key for interpreting tables
Green: option provides the maximum likelihood of meeting an objective when measured against a particular criterion
Orange: option provides an intermediate likelihood of meeting an objective when measured against a particular criterion
Red: option provides a low likelihood of meeting an objective when measured against a particular criterion
Grey: uncertainty in scoring
Yellow: an existing closure
White: criterion has no resolving power for options in a particular table

Table 1: Scoring criteria and thresholds to evaluate gulper shark closures

Criterion number	Criterion	Metric	Thresholds		
			High	Med	Low
1	Relative abundance	Estimate of: % catch rate (numbers per hundred hooks)	1	0.1	<.1
2	Breeding success	Number of conditions met: Condition 1- mature males and mature females present. Condition 2 - juveniles present	2	1	0
3	Area of occupancy	Measurement of: plan area in square kilometres (fully quantitative)	NA	NA	NA
4	*Habitat diversity	Presence of types (count): (i) canyons and seamounts (ii) terraces (iii) rocky banks and reefs (iv) sediment plains	≥3	2	<2
5	Refuge potential	Dominated by: UnTrawled Hard bottom = UTH UnTrawled Soft bottom = UTS Trawled Soft bottom = TS	UTH	UTS	TS
6	Cost to industry	Estimate of annual average sum of weight of quota species/all species: Cost to trawl; Cost to non-trawl	Confidential	Confidential	Confidential
7*	Extent of occurrence	Existing latitudinal and longitudinal range as a proportion of pre-fishery range	Extensive latitudinal and longitudinal range	Restricted latitudinal or longitudinal range	Restricted latitudinal and longitudinal range
8*	Genetic diversity	Number of demographically independent groups (characterised by a combination of age/size and sex) that occur in geographic areas separated by barriers to dispersal** contained in the network as a proportion of the possible pre-fishery areas	>2/3	>1/3	<1/3

Criteria 7 – 8 are only applied at the regional scale
**Demographic groups identified using survey data (Figures 4–6). For example if three areas were identified for a species and two were included in the network then the score for criterion 8 would be medium.

1.0 Network Closure Options

At the regional scale, options consist of one or more areas for closure and are evaluated using criteria 6–8.

Of immediate concern for fishers is the cost to industry (criterion 6). This is expressed as a range of costs (lost yield measured by average catches of quota species/all species over the past four years in areas considered for closure) for both trawl (CTS) and non-trawl (ALL). No catch data have yet been analysed for either GAB trawl or NSW fisheries. The impacts on industry are scored as high, medium or low and can result in a range of values depending on finer scale closure choices. These are considered as Fishery Closure Options (Section 2 of this document). The thresholds for scoring criterion 6 are confidential due to application of the "5 boat rule".

Two criteria are used to examine the likelihood of various network options meeting the conservation objectives of the management plan: Extent of occurrence and genetic diversity. Extent of occurrence (criterion 7) is simplified from a corresponding TSSC criterion. Protection over a larger fraction of the known range provides insurance against the possibility that an impact on the species in part of its range will affect the species as a whole. Number of areas is used as a proxy for genetic diversity (criterion 8). To be considered a separate area, evidence of separation is required. Two types of data were examined to assess the likelihood that areas are genetically separated:

1. Demographic data (size and sex structure) (Figures 4–6, Appendix A)
2. Habitat data (Appendix A)

1.1 – Harrissons Dogfish

Areas for inclusion in the network include parts of northern NSW, the Taupo Seamount, and the area east of Flinders Island in Bass Strait. Each of these areas was identified at the screening stage as most likely to support viable local populations of this species.

In these network options, differences in cost to industry (criterion 6) between options can not be evaluated because catch data for two of the three regions (northern NSW and the Taupo Seamount) have not yet been obtained. The range of values for both sectors is particularly sensitive to finer scale consideration of the management arrangements for the Flinders area (see Section 2).

Three options were considered (Table 2 and Figure 2). Survey data from 2009 suggest at least two geographically separate demographically independent groups: Eastern Bass Strait and remaining areas. Habitat data show that the remaining areas off the eastern seaboard of NSW are separated from remote seamounts by large expanses of open ocean. These data suggest that separate populations are likely in these areas, although this has not been tested with genetic data.

<u>Evaluation of Network Closure Options for Harrissons Dogfish</u>
NCO1 (NSW only): When measured against either aspect of criterion 7 (latitude or longitude), this option results in a poor outcome for extent of occurrence. If the

population does not interbreed with Taupo or Flinders then this option is also unlikely to meet criterion 8.

NCO2 (NSW + Taupo Seamount): This option increases the extent of occurrence by increasing the longitudinal range. If the population does not interbreed with Taupo or Flinders then the likelihood of maintaining greater genetic diversity is increased.

NCO3 (NSW + Taupo Seamount + Flinders area): This option increases the extent of occurrence by more than doubling the latitudinal range and increasing the longitudinal range (relative to NCO1).

Table 2: Evaluation of Network Closure Options for Harrissons Dogfish

Criterion number	Criteria	Network Closure Option		
		1. NSW only	2. NSW + Taupo Seamount	3. NSW+ Taupo Seamount+ Flinders Area
6.1	Cost to Industry: Trawl		?	L-H
6.2	Cost to Industry: Non-trawl		?	L-HH
7	Extent of Occurrence	L	M	H
8	Genetic diversity*	L	M	H

* NCO1 offers some protection for 1/3 areas, NCO2 offers some protection for 2/3 areas, NCO3 offers some protection for 3/3 areas

1.2 Southern Dogfish

Areas for inclusion in the network for this species include existing or expanded closures off Sydney and the 60 mile GAB closure, as well as Port MacDonnell and a proposed area in WA. The first three of these areas meet prior screening criteria for likelihood of supporting viable local populations.

Three options were considered (Table 3 and Figure 3). Survey data from 2009 indicate at least three geographically separate demographically independent populations: Sydney Closure, GAB 60 mile Closure and Port MacDonnell (Figure 5). The species also occurs off WA but without survey data the likelihood that Southern Dogfish there are demographically independent from other populations can not be assessed. Upper slope habitat is continuous across the Great Australian Bight but extensive surveys by the Diana in 2005 found no southern Dogfish between the WA border and Ceduna, despite almost two weeks of fishing. This suggests that populations in the western part of the GAB may form separate populations. However, genetic data are lacking for Southern Dogfish and genetic structure is uncertain.

Evaluation of Network Closure Options for Southern Dogfish

NCO1 (Sydney + GAB 60 mile): When measured against extent of occurrence this option scored Medium. It extends across at least half of the pre-fishery longitudinal range (Figure 3). The extent to which the option extends through the latitudinal range of the species is unclear. The key uncertainty in this respect is the latitudinal range off WA where survey data are limited (grey area in Figure 3). Since this option includes two existing closed areas, the further costs to industry are low (unless extensions to existing areas are considered – see Section 2).

NCO2 (Sydney + GAB 60 mile + Port MacDonnell): This option increases the extent of occurrence to some extent by increasing the latitudinal range, although the overall classification is unchanged.

NCO3 (Sydney + GAB 60 mile + Port MacDonnell + WA): Potentially this option would significantly increase the longitudinal range if the species is still distributed across the south coast of WA. There are some liver sales figures that suggest fisheries have had an impact on the species in WA, but CSIRO data indicate the species is still present in that area.

Table 3: Evaluation of Network Closure Options for Southern Dogfish

Criterion number	Criteria	Network Closure Option		
		1. Sydney + 60 Mile	2. Sydney + 60 Mile + Port Mac	3. Sydney + 60 Mile + Port Mac + WA
6.1	Cost to Industry: Trawl	L-H	L - H	L - H
6.2	Cost to Industry: Non-trawl	L	L	L
7	Extent of Occurrence	M	M +	H?
8	Genetic diversity*	M	M	H

* NCO1 offers some protection for 2/4 areas, NCO2 offers some protection for potentially 3 areas (allowing for uncertainty off WA), similarly NCO3 offers some protection for potentially 4 areas.

2. Fishery Closure Options

At this scale, criteria 1–6 are applicable.

2.1. Fishery Closure Options for Southern Dogfish at Sydney Closure

The evaluation in this example considers three options (Map 12 in Document A). FCO1 consists of the existing closure. FCO2 incorporates an extension into deeper waters to reduce edge effects. FCO3 extends the area to the South. The evaluation results are described in Table 4 and Figure 3. FCO2 provides some useful benefit for low cost. FCO3 would provide limited benefit and only at high industry cost to the trawl sector.

Table 4: Evaluation of Fishery Closure Options for Sydney Closure

Criterion number	Criteria	Fishery Closure Options		
		1. Existing	2. Existing + Deeper, area B	3. Existing + Deeper and longer
1	Relative abundance	H	H	H
2	Breeding success	M	M+	M++
3	Area of occupancy			
4	Habitat diversity	M	M	H
5	Habitat condition	M	M	M
6	Cost to trawl	C	L	**HH**
6	Cost to non-trawl	C	0	**0**

2.2. Fishery Closure Options for Southern Dogfish at the GAB 60-mile Closure

The evaluation in this example considers two options (Table 5). FCO1 consists of the existing closure. FCO2 also incorporates an extension to the west. The overall breeding potential of the existing area has been demonstrated over a number of years. Westward extension would provide limited additional conservation benefit (a larger closed area so less "edge" effects) at higher cost to the ALL sector (and potentially to the GAB trawl sector).

Table 5: Evaluation of Fishery Closure Options for GAB 60-mile Closure

Criterion number	Criteria	Implementation strategy options	
		1. Existing	2. Expand to west
1	Relative abundance	H	H+
2	Breeding success	H	H+
3	Area of occupancy	1215	?
4	Habitat diversity	H	H
5	Habitat condition	M	M
6	Cost to trawl	C	*
6	Cost to non-trawl	C	H

* Data are available for GABT but have not been analysed

2.3. Fishery Closure Options for Harrisson's Dogfish off Northern NSW

The evaluation in this example considers three options (Table 6). FCO 1 considers a small closure around the Port Stephens Survey Site. Past breeding success has been demonstrated because juveniles are present (Figure 4). FCO2 adds an additional separate closure around the 31 Canyon, an area that contains breeding females to the north. FCO 3 includes the Port Stephens, 31 Canyon and the ground in between. The likelihood of breeding success is high because the migration path between areas is protected. The overall geographic scale of Option 3 (90 n.m.) is larger than options developed for other areas. If additional surveys could be undertaken north of Port Stephens then the resulting data could be used to evaluate additional options, potentially at smaller scales with lest cost to industry. At this point in time the levels of uncertainty associated with northern NSW options are the highest of any of the regions considered.

Table 6: Evaluation of Fishery Closure Options for Harrissons Dogfish off N NSW

Criterion number	Criteria	Implementation strategy options		
		1. Port Stephens	2. Port Stephens + 31 Canyon	2. Port Stephens 31 Canyon + Port Macquarie
1	Relative abundance	H	H	H++
2	Breeding success	M	M+	H
3	Area of occupancy	?	?	?
4	Habitat diversity	H	H	H
5	Habitat condition	H	H	H
6	Cost to industry	?	?	**?**

2.4. Fishery Closure Options for Harrissons Dogfish off Flinders Island

The evaluation in this challenging example considers four options (Table 7 and Map 3 in Document A).

FCO1 considers a small closure off Babel. Past breeding success is demonstrated by the presence of juveniles (Appendix A). The cost to industry is Medium for trawl and High for ALL. FCO2 considers an alternative smaller closure off Cape Barren where future breeding potential is indicated by the presence of mature females (Figure 6). This has a Low cost to trawl but a High cost to ALL. Options 1–2 do not maximise the likelihood of meeting the conservation objective because their limited scale is likely to leave sharks vulnerable to edge effects. Although there to date no electronic tagging data for Harrissons Dogfish, the likelihood of edge effects can be assessed by comparison to Southern Dogfish. For this species in the GAB, electronic tagging data indicates that 38 out of 50 tagged sharks would have some exposure outside an 11 mile area surrounding the release point within three months of release.

FCO3 includes both Babel and Cape Barren with some fishing allowed in the area in between. The costs to industry are potentially Medium for trawl and High for ALL. The likelihood of this option providing continued breeding success is dependent on the management and monitoring arrangements applied to the "middle ground" between Babel, where males and juveniles are dominant, and Cape Barren where females are dominant. Breeding requires successful movement through the middle ground where sharks will be exposed to some fishing. Capture survivorship would be dependent on consistent implementation of the Code of Practice and release survivorship is uncertain.

FCO4 considers the entire area between Babel and the Flinders CMR closed to fishing. Breeding success is likely to be maintained but the cost to industry would be very high, particularly for non- trawl. FCO 3 is evaluated further in section 3.

Table 7: Evaluation of Fishery Closure Options for Harrissons Dogfish in the area northeast of Flinders Island

Criterion number	Criteria	Fishery Closure Options			
		1. Babel	2. Cape Barren	3. Babel and Cape Barren closed, area between managed – some fishing allowed	4. Babel, Cape Barren closed and area in between managed – closed
1	Relative abundance	H	H	H	H
2	Breeding success	M	M	M-H?	H
3	Area of occupancy	80	127	207	764?
4	Habitat diversity	M+	M	M+	M+
5	Habitat condition	H	H	H	H
6	Cost to trawl	M	L	M	**H**
6	Cost to non-trawl	H	H	H?	**HH**

2.6. Fishery Closure Options for Harrissons Dogfish on Remote Seamounts

Presence of Harrissons Dogfish has been demonstrated for Taupo Seamounts. Anecdotally the species is reported from other proximal seamounts and this seems plausible given the type and extent of habitat. However, until data can be collected for additional seamounts alternative options can not be evaluated.

3. Fine scale considerations for Harrissons Dogfish in the area northeast of Flinders Island

In this section we discuss some information that may be relevant to consideration of FCO3 (Table 7). Maps showing catch summaries are presented in Document A. For practical consideration of monitoring, the minimum dimension of the closure option becomes a key consideration.

Babel closure option
Two alternatives have been proposed for this area – see Document A, Figs. 5 and 5a. The first is the initial option (Fig. 5a, areas 4+5). The second excises area 4 – a corridor of 0.5 to 1.25 n.m. using for trawling at the shelf edge.

Excising the trawl corridor is less precautionary because it increases the likelihood of capture of Harrissons Dogfish at the shallow extent of its bathymetric range. There are no depth profiles or electronic tagging data for Harrissons Dogfish but the likelihood of this 'edge effect' can be considered by comparison to Southern Dogfish. Electronic data for that species shows most individuals move into waters less than 300 m deep at night. If Harrisons Dogfish have similar profiles then we would expect most individuals to enter area 4 each night. The estimated additional cost to industry of closing the area 4 would be 3.8 t for ALL and 11.9 t for Trawl (per year, all species).

"Middle Ground" – between Babel and Barren
This area of upper slope habitat lies between the Babel and Barren closure options and is defined by areas (Map 3, Document A). The key uncertainty associated with allowing some fishing to continue here is whether fishing mortality can be reduced to low enough levels to allow continued breeding migrations (see section 2.5). Autolongline catch data of suitable quality to inform relative abundance of gulper sharks in Bass Strait is only available for 2006–2009 therefore no trend can be established and therefore whether current effort levels are sustainable is currently uncertain. It is known that sustainable harvest rates for gulper sharks are likely to be 1–5% but to date there are no estimates of absolute abundance. It is plausible that tag recaptures could provide the information required for assessment of sustainable fishing mortality, to gulper sharks, but the practical feasibility of this type of approach has not been assessed for these species.

A code of practice has been developed for careful handling and release of gulper sharks. Field trials indicate this can reduce capture mortality to less than 5% if applied consistently to all vessels. What is not as well understood is release mortality. Current estimates based on electronic tagging data for Southern Dogfish indicate this could be as high as 34%. The range of estimates is large because only 3 months tagging data is available. Approximately 30% of the sharks released have not been detected yet. If these sharks are detected in subsequent months then the range of estimates of release mortality will be narrower and lower.

Barren closure option

Two options have been proposed for this area (Document A). Because the second option is only 1.5 miles longer than the first, fishery and survey data lack sufficient spatial resolution to compare these options.

Future monitoring

In terms of future monitoring for the region, future management responses would be best informed by:

- Catch rates
- Length frequencies
- Sex ratios
- Compliance with Code of Practice (jaw marking)

Experience has shown that it is technically possible to assess new data within weeks but the feasibility of providing a management response within this time frame has not been assessed.

4. Conclusions

None of the tables above imply a unique solution to the tradeoffs between conservation objectives and industry impacts. However we hope that by being explicit about various criteria and how they are or are not met by various options, this will assist industry, managers and other stakeholders reach a scientifically supportable decision on a set of options for Stage 2 of the Upper slope Dogfish Management Strategy.

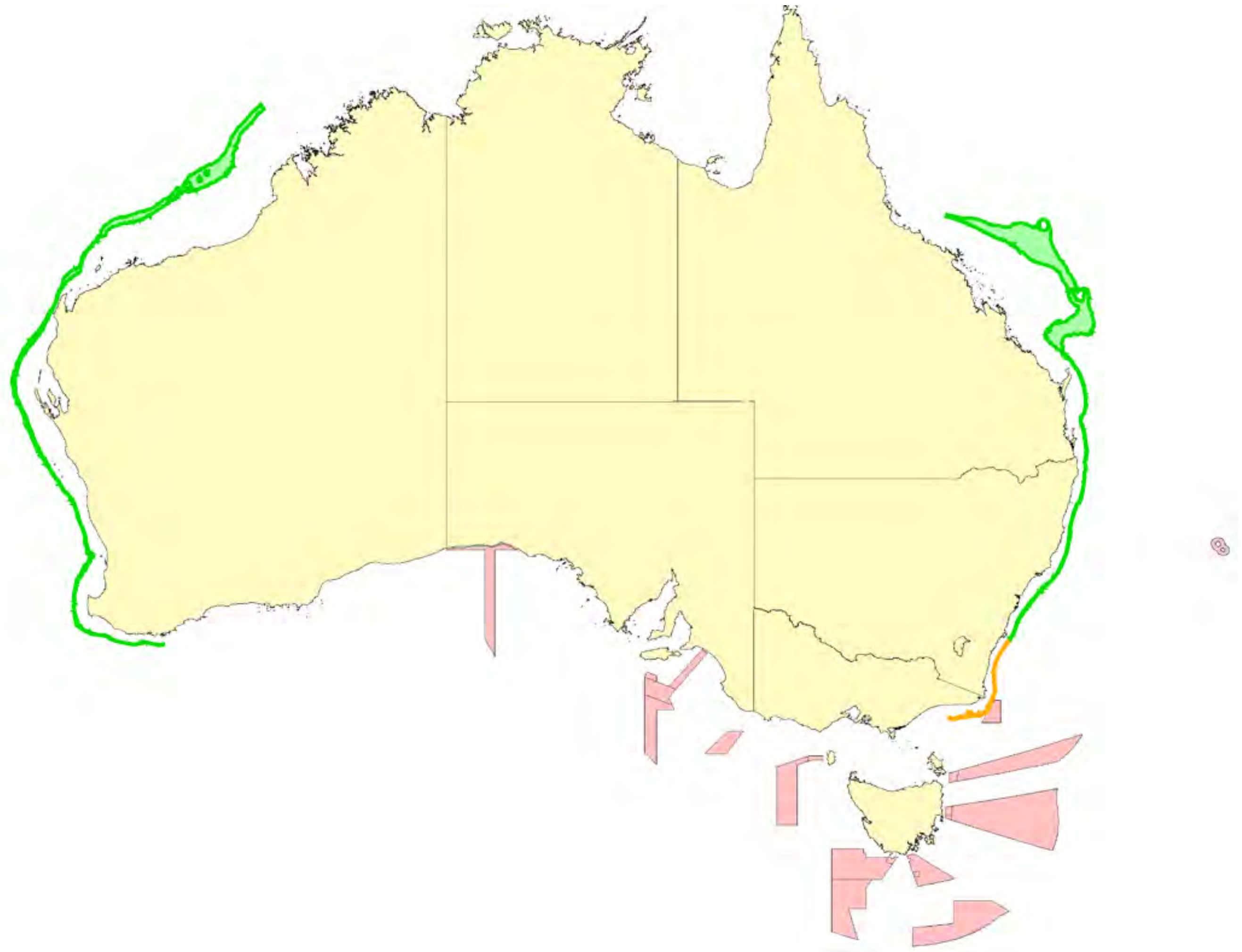


Figure 1: Historical (orange + green) and current (green) extent of occurrence of Endeavour Dogfish in the Australian EEZ showing Commonwealth Marine Reserves that currently do not support this species (pink)

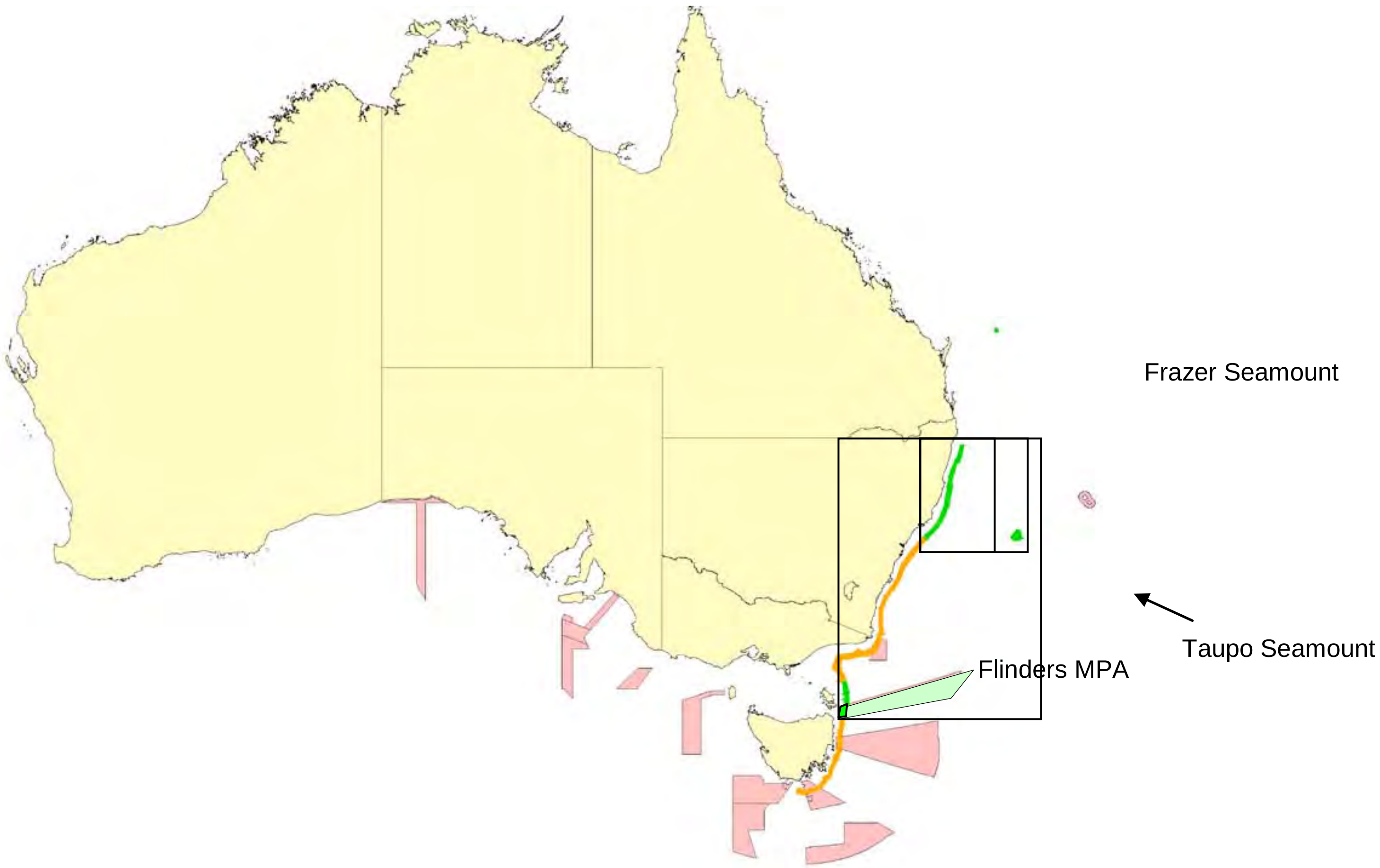


Figure 2: Historical (orange + green) and current (green) extent of occurrence of Harrissons Dogfish in the Australian EEZ showing Commonwealth Marine Reserves that currently do not support this species (pink) and one that does (green). Boxes indicative of extent of occurrence for different management options.

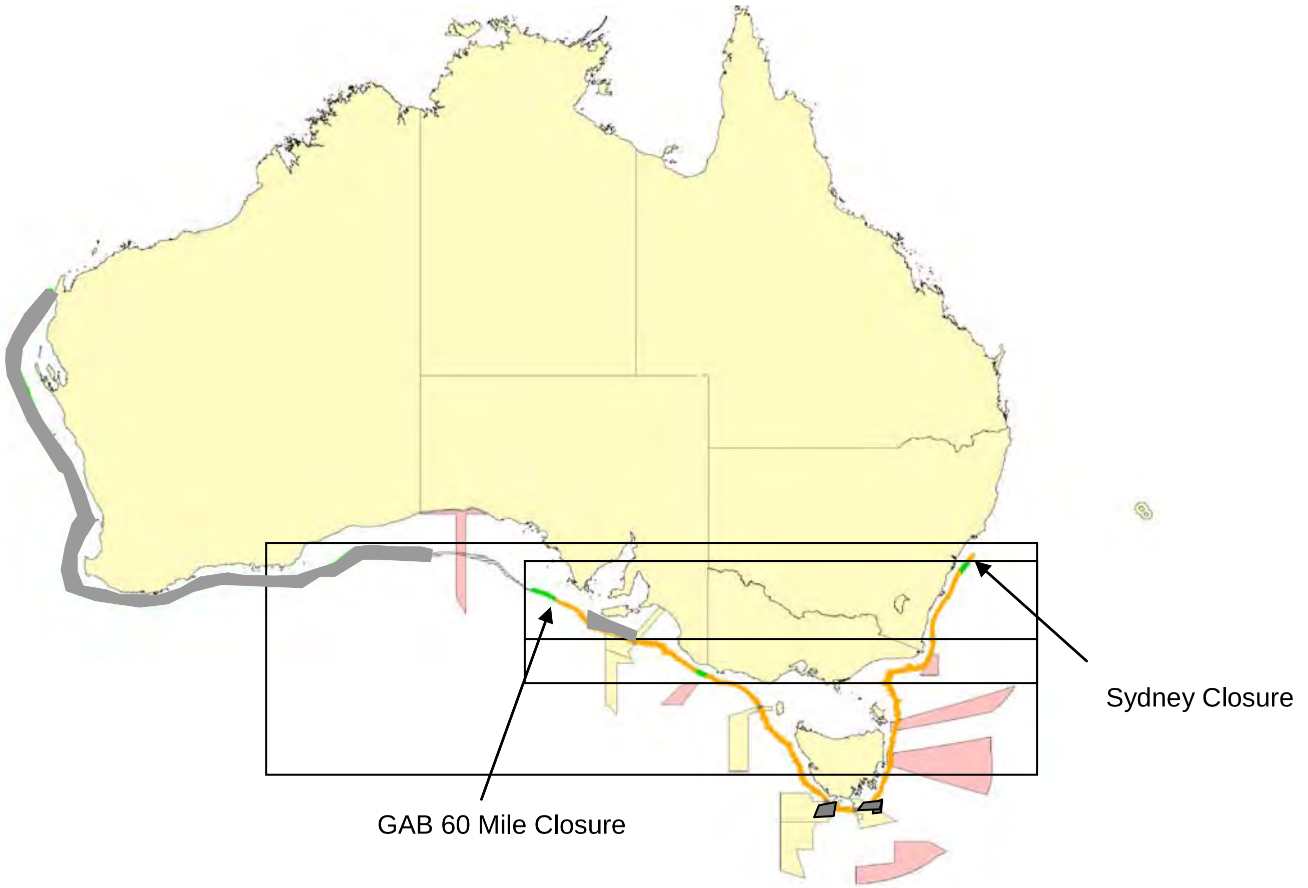


Figure 3: Historical (orange + green) and current (green) extent of occurrence of Southern Dogfish in the Australian EEZ showing Commonwealth Marine Reserves that do not currently support this species (pink) and other Commonwealth Marine Protected Areas (yellow) that contain a proportion that could support the species (dark grey) Boxes indicative of extent of occurrence for different management options.

Figure 4. Harrissons Dogfish – Length vs frequency vs spatial distribution

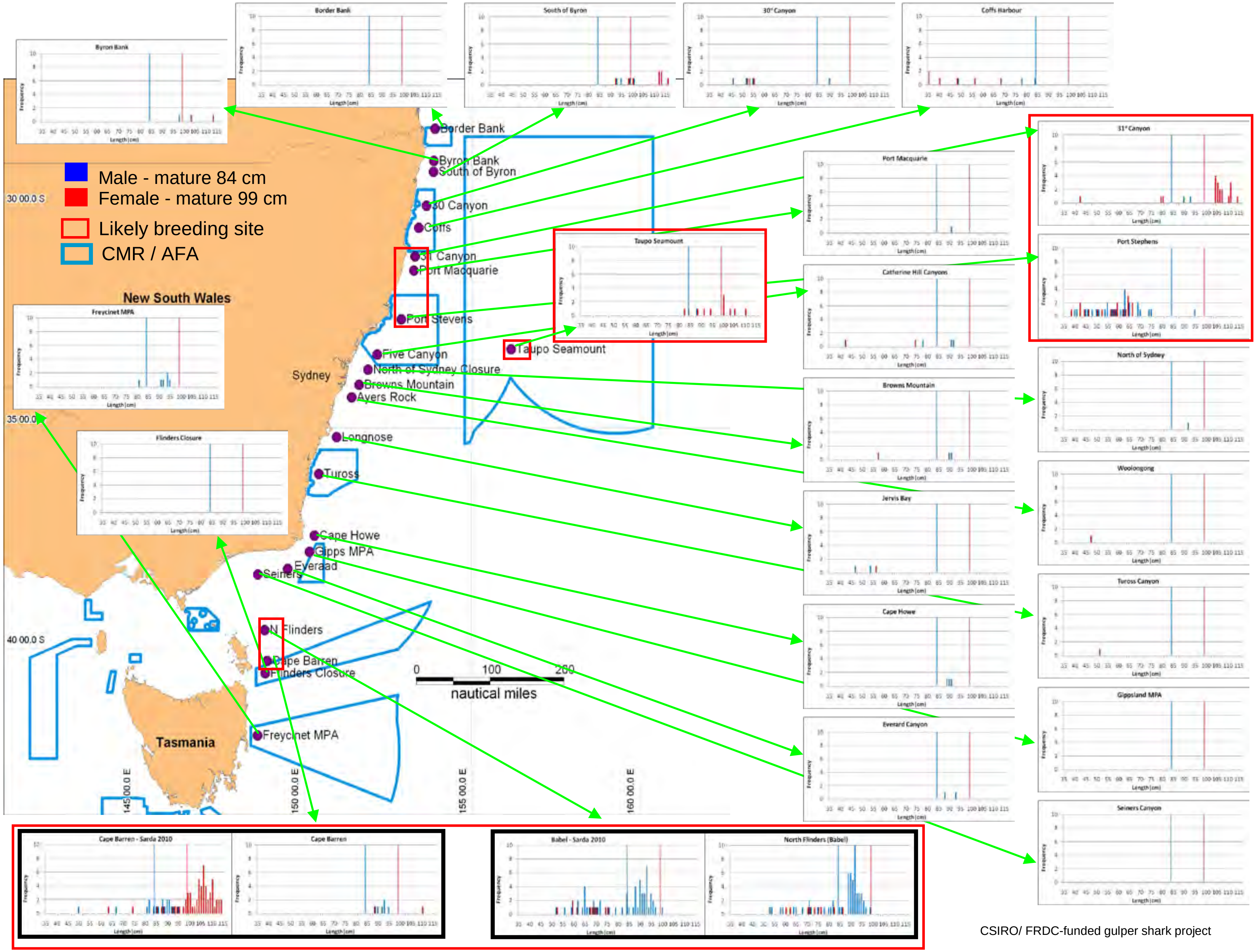


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Figure 5. Southern Dogfish – Length vs frequency vs spatial distribution

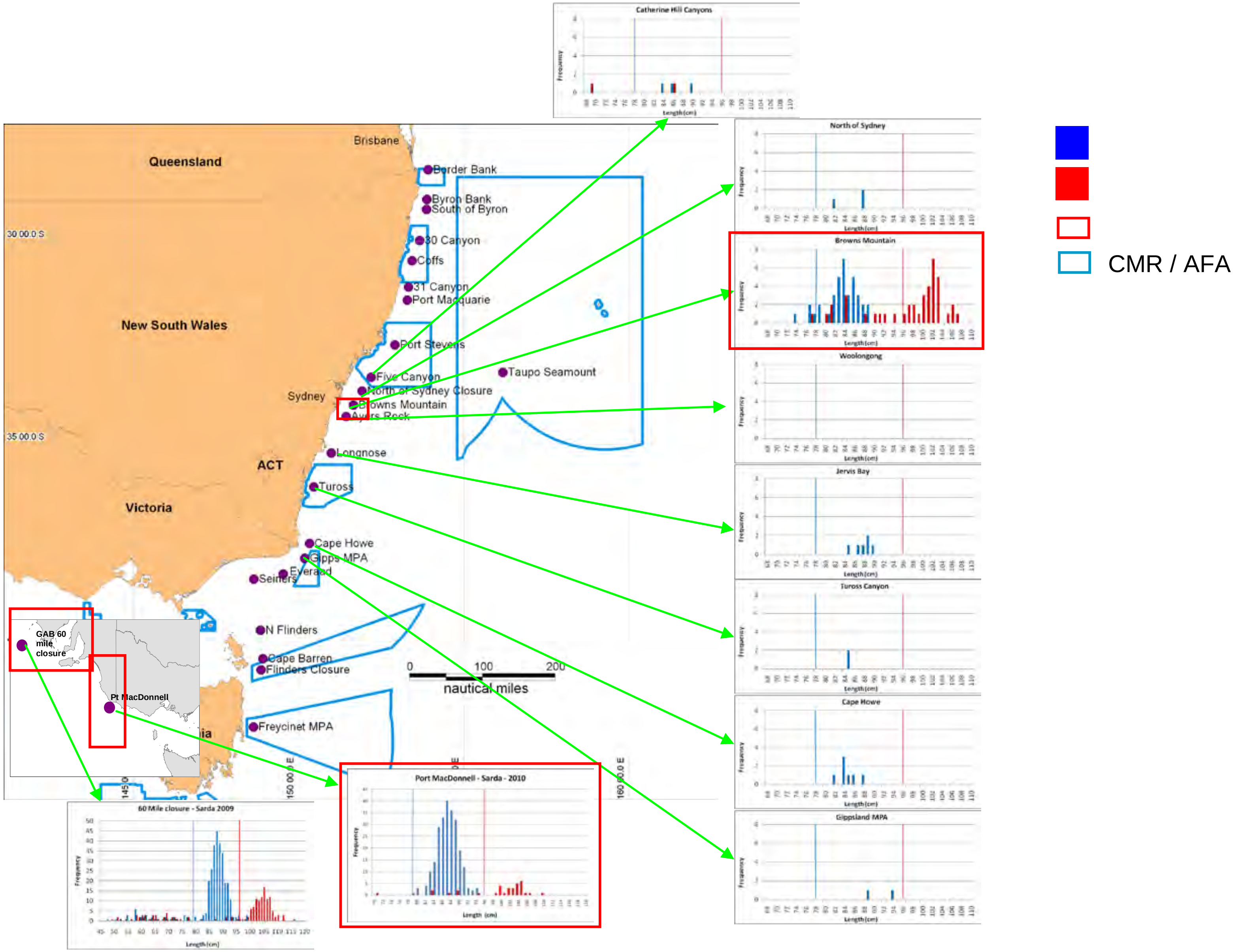
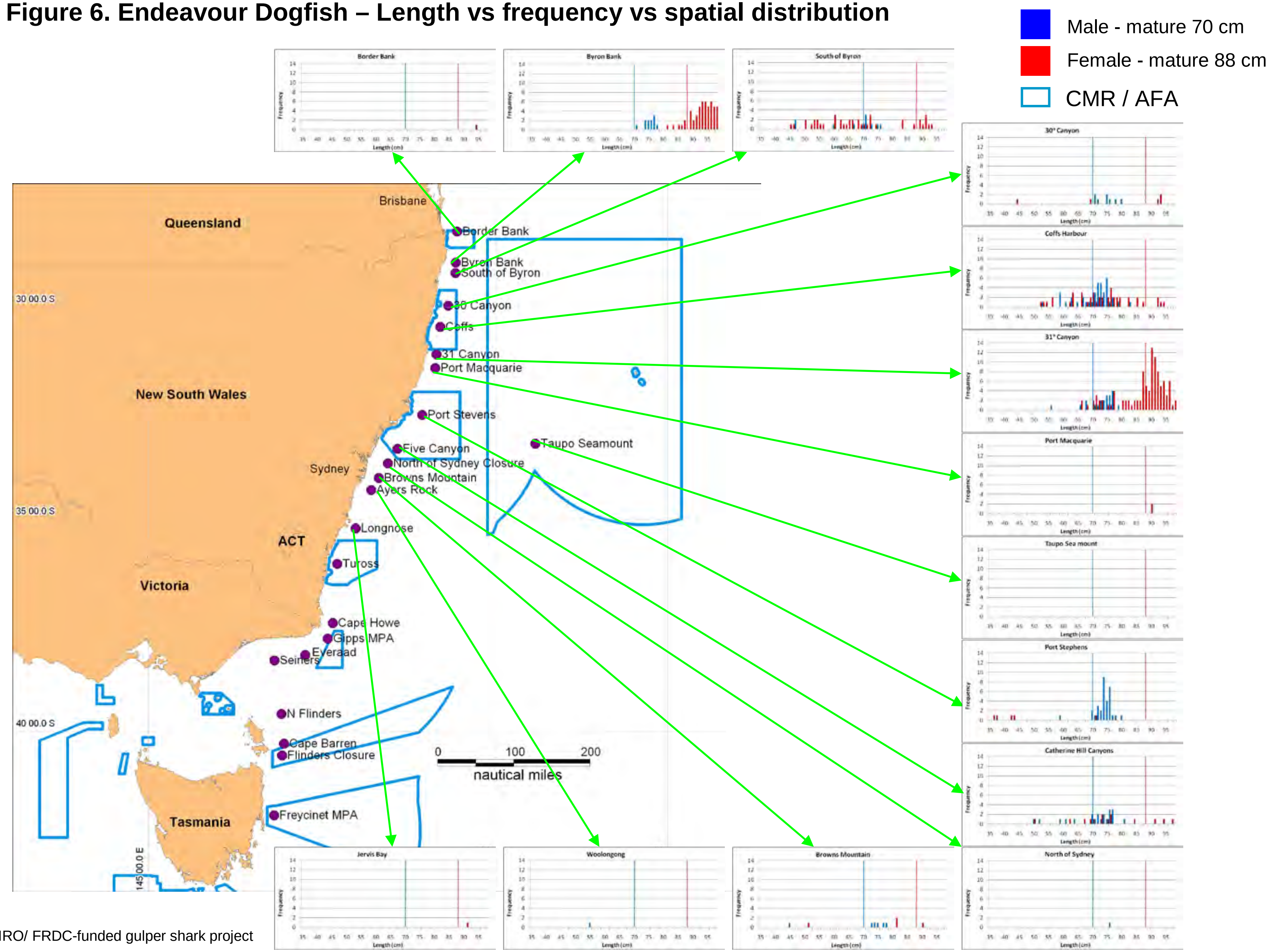


Figure 6. Endeavour Dogfish – Length vs frequency vs spatial distribution



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Appendix A: Scores against criteria for all areas considered

		Harrissons Dogfish		**Southern Dogfish**		**Habitat**	RESULTS		**Cost to Industry**	
Spatial Closure	**Map**	**1A Relative abundance Harrissons (number caught/100 hooks retrieved (n))**	**2A Breeding Potential**	**1B Relative abundance number caught/100 hooks retrieved (n))**	**2B Breeding Potential Southern**	**3. Area of occupancy**	**4. Habitat diversity**	**5. Refuge potential**	**6A CTS catch**	**6B ALL catch**
Cape Barren Ground - deep	4	D1_2009: 0.20 (3) S2_2010: 0.67 (4) A1_2010: 0.59 (2)	M	S2_2010: 0.02 (4) Al_2010: 0.00 (2)	L	80	M	H	L	H
Babel Deepwater-Babel Horseshoe	5	S2_2010: 0.60 (4) A1_2010: 0.80 (2)	M	S2_2010: 0.02 (4) Al_2010: 0.00 (2)	L	127	H	H	M	H
Flinders area middle ground		S2_2010: 0.09 (6) A1_2010: 0.10 (3)	L	S2_2010: 0.01 (6) Al_2010: 0.00 (3)	L					
Flinders research zone (CB, Babel, MG)	3	see above	H?	see above	L		H	H	H	HH
Finders shelf		no data	L	no data	L					
Smithy's Corner - deep	6	S2_2010: 0.03 (4)	L	S2_2010: 0.00 (4)		160	H	H	H?	L
Smithys +	6	see above		see above			H	H	H	L
Dooley's (Rigs)	none	no data		no data		-				
Mackerel Spit	7	S2_2010: 0.02 (3)	L	S2_2010: 0.01 (3)	L	73	M	M	L	L
Seiners Ling Closure		S2_2010: 0.00 (3)	L	S2_2010: 0.02 (3)	L	113	H	L	H	H
Middle Bight to Everard Canyon - WH	none	S2_2010: 0.07 (3)	L	S2_2010: 0.00 (3)			H	H	M	L
West Horseshoe Deep	"	see above		see above			M	H	M	L
West Little Horseshoe Can	"	see above		see above			H	H	M	M
Everard Ling Closure		D1_2009: 0.04 (3)	L	D1_2009: 0.00 (3)		65	H	H	M	M
East of the Everard Canyon		S2_2010: 0.02 (4)	L	S2_2010: 0.00 (4)						
Taupo Seamount (Tasmantid AFA)		D1_2009: 1.00 (8)	M	D1_2009: 0.00 (8)		201	M	H		
Barcoo Seamount (Tasmantid AFA)		no data		no data		99	M	H		
Fraser Seamount (Coral Sea AFA)		no data		no data		20				
Queensland Seamount		no data		no data		189				
Brittania Seamount		no data		no data		185				
Derwent Hunter Guyot (Tasmantid AFA)		no data		no data		429				

Appendix A continued: Scores against criteria for all areas considered

		Harrissons Dogfish		Southern Dogfish		Habitat	RESULTS		Cost to Industry	
Spatial Closure	**Map**	**1A Relative abundance Harrissons (number caught/100 hooks retrieved (n))**	**2A Breeding Potential Harrissons**	**1B Relative abundance (number caught/100 hooks retrieved (n))**	**2B Breeding Potential Southern**	**3. Area of occupancy**	**4. Habitat diversity**	**5. Refuge potential**	**6A CTS catch**	**6B ALL catch**
Fraser AFA		no data		no data		399	H	H		
Tweed AFA		D1_2009: 0.00 (2)		D1_2009: 0.00 (2)		93	H	H		
Clarence AFA (30 canyon, Coffs)		D1_2009: 0.29 (6)	L	D1_2009_0.00 (6)		494	H	H		
31 Canyon		D1_2009:0.47 (3)	M	D1_2009_0.00 (3)			H	H		
Port Macquarie		D1_2009: 0.02 (3)	L	D2_2009_0.00 (3)			H	H		
Hunter AFA (Port Stephens)		D1_2009: 2.54 (6)	M	D2_2009_0.00 (6)		687	H	H		
NSW area for further research		see above	H	see above						
Endeavour (Sydney) closure	12	D1_2009: 0.07 (3)	L	D1_2009: 1.96 (3)	H	341	M	M	C	
Endeavour (Sydney) closure + A (south)		D1_2009: 0.00 (3)		D1_2009: 0.00 (3)			H	L	HH	
Endeavour (Sydney) closure + B (deep)		no data		no data			M	M	L	
Batemans AFA		D1_2009: 0.00 (3)		D1_2009: 0.00 (3)		318	H	L		
East Gipplsand CMR		D1_2009: 0.00 (3)		D1_2009: 0.04 (3)	L	0	L	--		
Flinders CMR (five large males)		D1_2009: 0.13 (3)	L	D1_2009: 0.00 (3)		146	H	H		
Freycinet CMR		D1_2009: 0.00 (3)		D1_2009: 0.00 (3)		68	H	H		
Huon CMR		out of range		no data		211	H	H		
Tasman Fracture CMR		out of range		no data		267	H	H		
Zeehan CMR		out of range		no data		51	H	H		
Murray CMR		out of range		no data		158	H	H		
Pt. MacDonnell A (new)	15	out of range		S1_2010: 3.97 (4)	M+	185	M	H	L*	L
Pt. MacDonnell east	15	out of range		no data		19			H	L
Western Eyre AFA		out of range		no data		1749				
GAB 60-mile Closure		out of range		D1_2005:1.29 (14) N1_2008:2.06 (09) S1_2009:3.38 (06)	H	1215	H	M		C
GAB 60-mile Closure - w extension		no data		no data			H	M		H
GAB Benthic Protection Zone		no data		no data		359				
GABIA Deepwater Closure		no data		no data						
GAB extension AFA		no data		no data		1751				
Recherche AFA		no data		no data		1214				
South West Corner AFA		no data		no data		2149				

APPENDIX H – DEEPBRUVS PAPER

Development of a Stereo Deepwater Baited Remote Underwater Video System (DeepBRUVS) (2011), Marouchos A., M. Sherlock, B. Barker, A. Williams. Oceans Marine Technology Society (MTS) and the Oceanic Engineering Society of Electrical and Electronic Engineers (IEEE/OES) 2011 Conference, Kona Hawaii September 2011.

Development of a Stereo Deepwater Baited Remote Underwater Video System (DeepBRUVS)

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***Abstract*-Marine researchers aiming to acquire composition and size-frequency information on fish assesmblages have successfully used Baited Underwater Video Systems (BRUVS) as a non-extractive alternative to more traditional sampling methods using nets or traps. In a monitoring study of gulper shark populations on the eastern Australian upper continental slope (300-700 m depths), it was necessary to re-design the BRUVS lander to enhance its capabilities. The DeepBRUVS lander was designed to allow self contained and independent deep water operation (up to 1000m), with an extended deployment period of up to six months. DeepBRUVS is equipped with a stereo video system, lighting, and a bait release mechanism that permits multiple replicate video samples to be taken. The data will be used to provide relative abundance and size data as indicators of the viability of gulper shark populations protected within fishery closed areas. This paper discusses the design, prototyping and deployment of DeepBRUVS. The mechanical design of the bait piston, and camera assembly are reviewed in detail, along with a discussion of free fall and ascent dynamics. Bait types, bait release schedules, and camera recording sequences are also reviewed. The paper also discusses potential future additions and system improvements.**

I. INTRODUCTION

Baited Remote Underwater Video Systems (BRUVS) have a history of being successfully used to document the community composition and structure of fish assemblages in many shallow water applications [1-4]. BRUVS have some advantages over traditional net based sampling of fish assemblages including an ability to target a wide range of specific habitats (especially rocky reefs), and in being non-extractive.

Common net and trap-based sampling, are subject to selective sampling biases but these do not appear to compromise their utility to discriminate between assemblages or feeding types. For example, a comparison of BRUVS and prawn trawls [2] showed that while BRUVS recorded larger, mobile species from a much wider size range of families, both methods discriminated the same site groups. The use of bait raises questions about bias towards scavengers and predators, but a comparison of baited and unbaited BRUVS by Harvey et al. [3] showed that bait attracted greater numbers of predatory and scavenging species without decreasing the abundances of herbivorous or omnivorous fishes. That study concluded that a greater similarity between replicate samples from baited video within habitats implied the use of bait will provide better statistical power to detect spatial and temporal changes in the structure of fish assemblages and the relative abundances of individual species within them. BRUVS techniques have also been applied to study particular fish groups, and have provided good relative estimates of shark distribution and abundance. These methods have proven cost-effective for detecting rare species [5].

The successful use of baited cameras to study fishes in abyssal depths [6] has led BRUVS researchers to explore the potential of BRUVS configurations to work in deep continental shelf and continental slope depths off Australia and New Zealand. Within the last two years, deep water configurations with upgraded pressure casings have been used successfully in depths of at least 1,000 m [3].

BRUVS proven track record and its scope for deep water deployment led to the shallow water system being assessed for its ability to acquire monitoring data on demersal sharks in upper slope depths (300-700 m) off eastern Australia. The species of interest (gulper sharks from the genus Centrophorus) have been heavily depleted by fishing over much of their range and are being evaluated for threatened species listing [8]. The viability of remnant populations now protected in fishery closures will be monitored using relative abundance and distribution data. Non-lethal sampling is a pre-requisite for monitoring, while operationally the monitoring tool needs to be robust and deployable because costs-effective sampling will rely heavily on fishing vessels.

Initial trials with shallow BRUVS were promising, but they also revealed a number of necessary developments for the shark monitoring application. Principally, the need to collect data during commercial fishing operations will provide limited sampling time during infrequent survey opportunities. Acquiring sufficient sample numbers will therefore be dependent on multiple replicate video recordings at suitable intervals on long deployments, rather than numerous short deployments. Lights would be necessary to illuminate visiting sharks, and a mechanism was needed to generate bait plume to match interval recording. Lighting, video recording and the bait plume needed electronic control to synchronize the interval sampling. In addition, there were other ways to enhance the sampling program, including using a current meter to index bait plume dispersal, using acoustic releases to replace surface lines/floats, and deploying additional sensors to characterize the environment during long deployments. This paper describes these developments incorporated into the DeepBRUVS.

II. Conventional BRUVS

Traditionally, BRUVS systems consist of a simple frame to hold a camera, while a mesh bag with some fish bait would attract marine life in the surrounding area to the cameras field of view. These systems would typically be deployed in shallow water for short durations (on the order of hours or days) with a surface float for recovery. The cameras lacked external control and are enabled or disabled at the surface prior to deployment. As these systems are generally operated in shallow water, they would typically rely on natural lighting only. In some cases stereo camera systems have been deployed to enable measurement of fishes and have become increasingly popular. In order to attract marine life, fish bait (typically ground up pilchards) would be placed in a bag at the end of a boom in the line of sight of the cameras. This served to attract marine life in the surrounds until the bait was exhausted.

These simple systems have proven to be a reliable and cost effective way of collecting large amounts of video data of feeding marine life in shallow water. There are however some limitations owing to the simplicity of these systems. The lack of autonomous control over camera recording and bait release do not allow the system to operate for extended periods. In addition, the reliance on natural light combined with the lack of autonomous release mechanisms do not allow for use at depth. It was necessary to overcome these limitations in order to allow for the study of Gulper sharks in deep water.

Figure 1. Conventional 2D(L) and 3D(R) BRUVS systems.

III. System Design

A. System Requirements

The study of Gulper sharks imposed some challenging requirements in the design of the DeepBRUVS system. The system would have to operate autonomously in depths up to 1000m for deployment periods of up to six months. Owing to the depth and deployment duration the systems were required to be designed as independent landers with no surface signature. Stereo video recording in high definition was required for sizing of targets, along with artificial lighting. A minimum of 24 hours of record time was imposed to allow scientists to make the most of each deployment. In order to attract targets on a regular and controlled basis, a bait

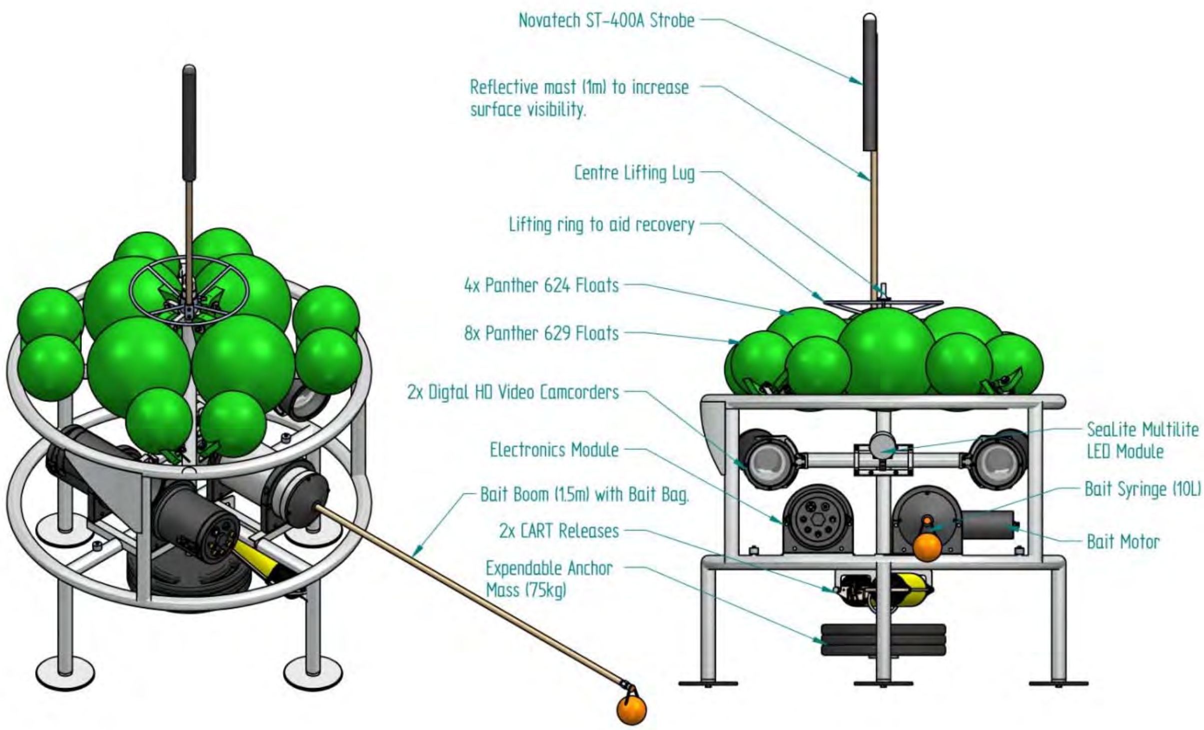

Figure 2. DeepBRUVS system concept.

Figure 3. Front view of DeepBRUVS electronics bay.

Figure 4. Completed DeepBRUVS ready to deploy.

dispensing system would be required that would allow for the controlled release of 10 liters of liquefied bait. Finally, the system should have a small enough footprint to be deployed from a small vessel and an in air mass of less than 250kg. Once on the surface, the systems should have a turnaround time of less than 12 hours, to facilitate near continuous monitoring of sites. Finally the design should incorporate payload flexibility, such that additional oceanographic instruments such as conductivity temperature and depth probes (CTDs) and acoustic doppler current profilers (ADCPs) can be added in the future. After extensive consultation with science staff, a final design was approved and can be seen in figure 2.

B. *System Overview*

The adopted deepwater BRUVS design consists of a cylindrical style lander with a 1.25m diameter standing 1.4m tall. The landers frame is made of aluminum tubing and divided into three sections; floatation, instrumentation, and releases. The frame not only provides structural support for the equipment, but acts as a protective cage during deployment and recovery. Extending beyond the frame is a demarcation and positioning mast, and a bait release boom. The system is equipped with stereo high definition video cameras, a bait release piston, and electronics housing. Floatation is provided through the use of cost effective and readily available deepwater trawl floats. In this case four Panther 624 and eight Panther 629 floats were used. A fully loaded system weights 250kg in air, but only 15kg in water, with a reserve buoyancy of 60kg. There is sufficient reserve buoyancy that the system will still surface in the event of multiple float failure.

Systems are deployed at the surface using a davit or A-frame with a quick release mechanism. The system is designed to free fall to the desired depth without the aid of a drogue. Given the systems low weight in water, it descends at a leisurely rate of 0.5m/s taking around 30min to reach its maximum operating depth of 1000m. Four landing legs with pads distribute the system mass as it lands on the bottom. With a pad diameter of 0.2m the pressure on each pad is around 0.01 kg/cm^2 (or 0.16 psi). The hope is that the slow descent rate of the landers, combined with its minimal mass in water will reduce the probability of landers getting stuck in soft, muddy substrates.

Each system is equipped with a pair of ORE Offshore CART acoustic releases, which are connected to an expendable mass of steel weighing 75kg in air. Dumbbell weights have proven to be a convenient and cost effective anchoring solution for packages of this size. Once the mass is released the system returns to the surface at a more rapid rate of around 1m/s. A 1.5m reflective mast is used to increase the surface signature and aid in recovery. Systems are also equipped with a NovaTech strobe and radio range finder. A steel recovery ring allows the systems to be lassoed shipside for recovery. In order to provide good replication for gulper shark stock assessment, three identical landers were constructed.

C. *Camera System*

The BRUVS systems are each equipped with a pair of high definition video cameras. It was decided that commercial handheld cameras would be used as they are cost effective, and come complete with storage media. In addition, the cameras could easily be replaced as the technology improves. The systems are equipped with a pair of Panasonic HDC-HS700 cameras which have good low light performance, and high resolution 1080/50p recording capability. A 240GB storage capacity also allows for 21 hours of record time. Each camera is equipped with a wide angle Raynox DCR-6600Pro2 lens with an approximate magnification of 0.66x.

The cameras are housed in acetal housings with acrylic view ports. As the systems are being deployed for extended periods of up to 6 months, acetal was used to reduce corrosion on the housings. It was however necessary to pay close attention to creep and temperature affects in the design of the acetal housings. Internally, each camera is rigidly located and bolted in place with a locating ring which sits on the internal diameter of the housings. This is critical to maintaining stereo calibration stability throughout deployments. All camera control signals including USB are accessible via external

Figure 5. Stereo video camera assembly.

connectors on each housing such that housings do not need to be opened during the survey. Data from both the video cameras and built in sensors can be downloaded through the external USB and serial ports respectively.

Pairs of camera housings are rigidly connected with an armature that fixes the cameras relative positions. This allows for easy separation of the camera assembly from the main DeepBRUVS landers for calibration and other general servicing. The aluminum armature is also sealed at both ends to add buoyancy. As a result, the camera assembly is neutrally buoyant at depth. On the armature, the cameras are spaced 0.6m apart at an angle of 8 degrees relative to centre. The focal point of each cameras field of view lies 2.8m from the camera lens, but owing to the use of wide angle lens adapters the cameras are able to have nearly full frame overlap a mere 1.5m from the housings. Once installed on the frame, cameras are trimmed to allow viewing of the sea floor at the 1.5m target distance. Lighting is provided by a single color balanced LED Multi-SeaLite Matrix lighting source by Deep Sea Power and Light. The Matrix lights have a maximum output of 2600 lumens, but also allow for power dimming, which can be adjusted to reduce target washout if needed.

Once assembled, cameras are calibrated both in air and in water to allow for target size measurement. Calibration is performed by recording motions of a calibration cube with reflective targets in two planes. Paired images are then processed in the computer and the cameras are paired. Typically, calibrations are performed before and after surveys to evaluate any calibration drift. As a result it is critical to ensure that the camera assembly is sufficiently rigid during normal use that the cameras are able to hold their calibration throughout a deployment.

Although cameras are calibrated, they are operated asynchronously, and so it is necessary to synchronize recorded frames during processing. This is accomplished using a simple array of LED's and digital counter, which is placed on the boom in the cameras field of view. Each frame will see a unique LED pattern and allow for frames to be synched during post processing.

D. Bait Release System

Extended BRUVS deployments require a bait dispensing system that will allow for the controlled release of bait, and hence controlled bait signal in the surrounding water. It was felt that the use of liquefied bait would provide the greatest flexibility in dispensing varying amounts of bait, and provide efficient dispersal of the bait plume. A large syringe with an internal diameter of 180mm and a volume of 10 liters was designed. The syringe is driven by a highly geared electric motor via a simple rack and pinion gear box. A boom at the end of the syringe releases the bait in the cameras field of view at a distance of 1.5m. A one way flow valve prevents the release of bait, and seals the piston between release periods. This allows for the removal of the bait signal, such that independent observations can be made over time. Fine motor control allows for bait to be released in 20cm^3 (0.68oz) increments.

Due to the nature of the piston and boom orifice size, only liquefied bait can be used. Non-perishable baits were required so that bait effectiveness would not decay during deployment. It was also vital to find bait that would disperse effectively in the surrounding water, maximizing its attractiveness. During the initial trials a mixture of fish oil and fish meals was used to assess system effectiveness.

E. Power, Electronics and Sensors

Each BRUVS system is powered by a single 53Ah rechargeable nickel metal hydride battery pack located in the electronics housing. The batteries are connected in seven strings and run at a nominal voltage of 16.8V. During operation all strings operate in parallel, but are charged independently to reduce heat build-up. Each pack is designed to provide a full 24 hours of stereo video recording, lighting and bait release.

A centrally located microprocessor controls all system components. Missions consisting of recording, lighting and bait release intervals can be pre-programmed externally using

Figure 6. Bait release piston.

Figure 7. (L) Electronics housing connectors and interface. (R) Complete electronics housing with battery pack showing.

a laptop computer over an RS232 serial link. An external power switch allows for the system to be armed just prior to deployment, while an LED provides system status and health information. In addition to system control, the microprocessor records water temperature and depth. Camera video data however is stored locally on each camera and can be downloaded directly via externally accessible USB ports.

Initially, the systems have been configured to record the system descent and landing. Once on the bottom, the pre-scheduled science program will begin. The basic program releases bait and begins recording with lights on at various intervals. It is still unclear if this recording regime is the most effective at capturing targets, and the team is actively exploring additional configurations that may result in better target acquisition rates. Once the system has completed its pre-set instructions, or runs out of battery it shuts down. Throughout the mission, the system monitors its depth, and in the event of a premature system release will stop any current actions and power the system down for recovery.

IV. System Evaluation and Testing

Individual system components (cameras, electronics, bait release) systems were each tested on the bench to verify functionality. Following bench testing, a fully instrumented system was run in a controlled environment on land to assure proper system operation. A test from the CSIRO wharf in 10m of water was then conducted to trim system buoyancy and check the integrity of the video stream, and bait release mechanisms in water.

Once base functionality of the system was confirmed open water tests were conducted. These consisted of tethered and free deployments in around 100m of water to verify hydrodynamic stability of the DeepBRUVS platforms while descending and ascending. A three-axis self-logging accelerometer was installed to evaluate stability of the platform during deployment. Very short programmed test scenarios were also conducted to further test the video and electronics systems, as well as to replicate real world turnaround scenarios.

V. Conclusion and Future Work

The DeepBRUVS systems which were developed provide enhanced capabilities for monitoring gulper shark populations. Principally, they allow for deep water (up to 1000m) observations over extended periods (up to 6 months). The equipped stereo video system records high resolution stereo video of targets, allowing scientists to collect crucial size frequency information. The addition of a bait release system, allows for controlled bait signal and attraction of targets throughout the deployment period. Flexibility in the lander design allows for the addition of other instruments such as conductivity, temperature and depth sensors (CTDs) in the future. This will allow for the collection of a wide range of oceanographic data in situ with target size frequency information.

Future system improvements are currently being considered and tested in an attempt to improve performance. The current bait formula remains untested and further evaluation is needed to find a mixture that is most suited to attracting gulper sharks. The timing of video recording and bait release is being explored in hopes of increasing the footage time in which targets are in view. Active triggering mechanisms are also being considered to limit recording to times when targets are in view. This will allow for optimal use of battery power during extended deployments. Finally, it is envisioned that shark tag listening stations can be incorporated into the landers such that specific sharks can be identified in the video footage.

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APPENDIX I – FLINDERS RESEARCH ZONE MANAGEMENT POLICY

Managing the Flinders gulper shark Research Zone: discussion paper

Purpose of this paper

This paper provides background information and suggestions from the CSIRO-led gulper shark project for the first review of management arrangements for the Flinders Gulper Shark Research Zone (FRZ).

Background

Harrisson's and Southern Dogfish (gulper sharks) will be provided with additional protection from fishery interactions by new regulations in AFMAs 'Upper Slope Dogfish Management Strategy' (USDMS). The strategy adds four upper slope areas to a regional-scale network of fishery closures. Thirty six candidate closed areas were evaluated during extensive consultation between scientists, the fishing industry and AFMA (Williams *et al.* 2010). A management strategy evaluation (MSE) of selected key candidate areas (Daley *et al.* 2010) provided tools to select a network of closures consistent with an identified level of precaution and socio-economic trade-offs. Options for closures and the MSE were discussed formally at a 2-day stakeholder workshop and subsequently endorsed by SEMAC. The final result was the recommended closure of a highly targeted and substantially smaller area of upper slope than was originally anticipated to be necessary to protect gulper sharks (Wilson *et al.* 2009).

Flinders Gulper Shark Research Zone

The closure network includes a large Research Zone closure off Flinders Island to protect the only known viable population of Harrisson's Dogfish south of Sydney. The FRZ is designed to balance the competing management considerations of resource use, and gulper shark sustainability. The Research Zone contains two fully closed areas: 'Barren' that contains mainly mature females, and 'Babel' that contains mainly mature males and juveniles; the remaining area is to be managed with a set of regulations tailored to achieve the conservation goals while being feasible and cost-effective to manage, and providing a source of scientific information to fill key knowledge gaps.

Fig. 1 The Flinders Gulper Shark Research Zone (blue line) is 58 n.m. long and defined (originally) by a latitudinal boundary at 39˚ 26' and three pre-existing boundaries: AFMA's '183 m' and '700 m' lines and the northern boundary of the Flinders Commonwealth Marine Reserve. The Research Zone spans the core 300-600 m depth range of Harrisson's Dogfish (pink lines) and contains 2 fully closed areas (in green) – Babel in the north, Barren in the south – separated by the Middle Ground. The Trawl Corridor is adjacent to the Babel closure; South Barren Ground lies between the Barren closures and the Flinders Commonwealth Marine Reserve

Establishing the Flinders Research Zone instead of a large full-closure was a trade-off between protecting the gulper shark population and reducing the economic cost to commercial fishers; the economic cost of full closure would have been high for trawl fishers and very high for auto-longline fishers (Daley *et al.* 2010). The key needs from the USDMS are to mitigate fishing impacts on gulper sharks by preventing capture and mortality of individuals, and to provide opportunities for longer-term population expansion. A critical part of the USDMS, however, is to continue to gain a better understanding of gulper shark population dynamics, and this is enabled through the structure of the Research Zone. Thus, establishing the conservation effectiveness of the USDMS is immediately contingent on minimising fishing mortality within the Research Zone but still being able to collect important information on the gulper shark population it protects. Within the FRZ, there is a relatively high probability of catching gulpers sharks in the 'Trawl Corridor' closely adjacent to the shark population in the Babel closure, and in the 'Middle Ground' where continued breeding success is assumed to require successful movement of sharks between the Babel and Barren closures.

Post-capture survival and post-release survival will depend on sound education and consistent implementation of industry Codes of Practice. The degree of post-release survival remains unknown at this point, but is likely to be negligible for trawl-caught sharks (i.e. virtually all are dead when landed), but considerably higher for hook-caught sharks. An initial estimate based on electronic tag data indicate survival of properly handled hook-caught sharks is within the range of 65-95%.

Research and monitoring undertaken within the Research Zone will be a key part of assessing the performance of management measures, and will potentially provide a cost-effective and regular source of quality-assured data to measure performance and to substantially increase biological and ecological knowledge that will assist in long term recovery, e.g. catch rate data and survival estimates. Stakeholders recognise that further restrictions to fishing could be considered if conservation objectives are not being met, e.g. if fishing mortality rates lead to further population declines within closures.

Regulation of fishing within the Flinders Research Zone

Regulation and monitoring within the FRZ is a key element of assessing the effectiveness of the USDMS, but, thus far, there has been incomplete consideration of how to regulate fishing in the FRZ. The fishing industry have expressed strong commitment to demonstrating that codes of conduct were being implemented, and that low levels of interaction are possible: a very low catch rate by trawl, and high capture and post-release survivorship from autoline fishing.

Finalising the fishing regulations is now a high priority. There is also a consensus view (e.g. at Slope RAG) that there is also a need to identify specific times at which review of data and management arrangements would occur.

Observations / risks with regard to regulation of the Flinders Research Zone

1. Inner depth boundary

We have concern that the industry proposed boundary erodes the ability of the FRZ to conserve Harrissons Dogfish by permitting un-observed access to the shallow margin of the shelf edge area previously mapped as being inside the FRZ (Fig. 1). It is considered the new proposed boundary will increase the likelihood of incidental bycatch of Harrissons Dogfish at their upper depth range compared to the originally proposed boundary (the pre-existing AFMA 183 m line), and that this bycatch will remain undetected. <u>There is currently limited protection afforded to dogfish in waters shallower than 250 m and based on work on Southern Dogfish, it is likely that Harrisson's Dogfish moves into waters as shallow as 150 m. A shallower boundary such as the pre-existing AFMA 183 m line is an option that could address this issue.</u>

Justification:

- AFMA's pre-existing 183 m boundary was proposed as the inner boundary on May 18 2010 in a science industry meeting. Justification for this boundary was detailed, validated and transparent, and undertaken as part of the development of the USDMS. That boundary remained in all subsequent science-industry-AFMA meetings and at SEMAC over the following 7 months. The new boundary was incorporated at SETFIA's request without the same level of scrutiny and/or quality checking.
- This change is a significant and less precautionary departure from the original MSE option 3 provided by the CSIRO-led project. While boundary changes have not been evaluated in detail, it is clear that there is higher risk of impacting the shark populations at the FRZ margins because gulper sharks movements extend to depths around 200 m (Fig. 2), and a higher uncertainty about the effectiveness of the FRZ results from this change.
- Electronic tagging data shows that 70% of Southern Dogfish have a home range larger than ten miles along slope. The along slope boundaries are longer than the across slope boundaries therefore we expect the greatest edge effects to be on the shallow boundary of the fishery. Gulpers move into 150–450 m at night (Fig. 2). Assuming Harrissons Dogfish behaves as Southern Dogfish, then 50% of individuals will be exposed to fishing between 150 – 300 m at night.
- Initial scrutiny raises several technical concerns:

- Node 22 is within the Barren Closure; the new boundary provides access to the closure in two areas;
  - Many boundary nodes (e.g. 8,9,11,12,13,15,17,20,22,25) are deeper than 250 m.;
  - The proposed boundary reaches depths well into the core depth range of Harrissons Dogfish (>300 m) in many locations;
  - Depths up to 520 m inside the FRZ can be trawled using the new boundary; and,
  - The new boundary provides access to 3 canyon heads in the FRZ that are likely to hold structured habitat for Harrissons Dogfish.
- There appears to be weak justification for trawl access as there is little evidence of historical trawl fishing effort within the area defined by the new boundary – although we acknowledge that some fine-scale detail may have remained undetected by the effort mapping methods used.
- Moving the 183 m line to deeper waters has implications for other sectors working the shelf and presently constrained by this boundary, e.g. shark gillnetting. Any precedent that served to increase fishing in this area by other methods has the potential to increase mortality at the margins of the FRZ. All fishing in deep waters along the inner western boundary increases uncertainty about the effectiveness of the USDMS.

2. Mechanisms to limit fishing mortality

It is estimated that sustainable harvest rates of gulper sharks (numbers caught as a proportion of numbers in the population) are likely to be <5%, perhaps as low as 1% (Forrest and Waters 2009). Although there is no estimate of absolute abundance of Harrisson's Dogfish in the Research Zone, or estimate of post-release survivorship, to enable a sustainable harvest rate to be estimated, <u>mechanisms to limit mortality from the capture process and mortality following release, that are currently absent, could be implemented to address this gap. Measures could include such things as annual catch thresholds and move on provisions.</u>

In the absence of precise data, the plausible upper and lower limits of the population size of Harrissons Dogfish in the FRZ will be estimated from density estimates of lightly fished populations elsewhere and an extrapolation into the areal extent of habitat in the FRZ. These estimates could be used to provide options for limits on acceptable across-sector mortality and catch in the first-year. There is potential for uncertainty in the estimates to be reduced as additional catch rate and tagging data become available.

A move-on rule would prevent mortality if a concentration of gulper sharks is encountered. The threshold should be lower for trawling because survival is lower. Rapid turnaround of reporting will be essential for monitoring, especially if a catch trigger is implemented.

Justification: Of ~100 Harrison's Dogfish caught during 2 autoline fishing operations in July 2010, a capture mortality of 17 Harrisson's Dogfish was observed (AFMA, unpublished data) in the area proposed for the FRZ. Without precautionary catch and mortality triggers a population decline may occur within the FRZ. High observer coverage is important to increase certainty about the total catch and mortality will maintain uncertain. Without fishing and monitoring, population changes will remain undetected.

3. Improving post release survival

Survival is likely to be reduced by sharks spending a long period on hooks, or if handling practices decline when a large volume of gear is being retrieved, and/ or if the catch rate of gulper sharks is high. Industry reported at Slope RAG that shortened trawl duration could have similar positive consequences, and a maximum trawl duration has been implemented. <u>It is therefore suggested that mechanisms to ensure a high release survival of gulper sharks are considered such as reducing the hook numbers per set (i.e. <10,000 hooks) or reducing soak times in the FRZ .</u>

Justification: The reasons need to be better understood, but a contributing factor to the high capture mortality in July 2010 of 17 of 57 Harrisson's Dogfish caught in 2 standard autoline operations may have been that the total catch or catch rate exceeded the capacity of the vessel to release sharks alive.

4. Maintain habitat quality

Inside the Research Zone, irrespective of catch triggers and caps on total fishing effort, <u>mechanisms to maintain habitat quality should be considered. For example, the area of fishing should not change (expand or shift) from the historical fishing area (the 'footprint'), especially in the narrow Trawl Corridor, the Middle Ground and the South Barren Ground, and that fishing is permitted only inside the identified footprint.</u> The footprint could be defined using mapped logbook records, and any additional fine-scale information industry can supply to meet inadequacies of logbook data mapping.

Justification: Preventing the expansion of fishing effort will prevent degradation of habitat by removing or damaging seabed structures including structural fauna such as corals and sponges, and decrease the interaction with gulper sharks. Both are necessary for an area being managed to conserve gulper sharks in suitable habitat. The 'Trawl Corridor', 'Middle Ground' and South Barren Ground represent the highest risk areas for fishery interaction in the existing closure network because they are immediately adjacent to the remaining identified shark populations and/ or where movements are assumed to be required for continued breeding success. This consideration is relevant to both trawling (impacts on habitats are well established), and auto-longlining – based on recent evidence of removals of long-lived, slow growing corals from within the FRZ (Fig. 3). Coral removals are from hard bottom areas used by juvenile gulper sharks.

5. Ensuring adequate data quality and availability

For the reasons outlined, and to ensure the correct identification and life-state of any captured gulper sharks, <u>there is a risk that data quality and availability will be compromised if coverage inside the FRZ is less than 100%.</u> As noted previously, 100% coverage may be needed for an extended length of fishing time that is sufficient to determine that incidental mortality is within acceptable limits. It is suggested that criteria for this purpose are developed during further discussion, including through the independent review of the USDMS, and that the results of the 100% observer coverage are reviewed – together with catch data in areas adjacent to the FRZ - before any change in either observer coverage or fishing practices is allowed.

Suggested criteria and possible threshold for line vessels:

1. Capture survivorship is high: e.g. > 95% of Harrissons Dogfish are returned to the water alive.
2. The Code of Practice is implemented consistently: e.g. on 95% of shots where Harrissons Dogfish are caught, the code is implemented and the number of Harrissons dogfish released alive is not lower than the number of Harrissons Dogfish caught alive.
3. Abundance, as indicated by relative catch rates, remains high: e.g. average catch rate > threshold set by SlopeRAG.

Suggested criteria and threshold for trawl vessels:

1. A Code of Practice, in line with SETFIA's skipper training and certification, is implemented consistently

Justification: The FRZ is a vital part of the closure network required to conserve Harrisson's Dogfish but parts of it remain open to give industry access to economically valuable fishing grounds. Because this arrangement represents a lower level of precaution than a full closure (Daley et al. 2010), it is necessary to have certainty about total catch, catch rates and fishing mortality of Harrisson's Dogfish in the early phase of the USDMS to assess the effectiveness of the FRZ. The 'Trawl Corridor' and 'Middle Ground' represent the highest risk areas for fishery interaction in the entire closure network because they are immediately adjacent to the remaining identified shark populations. Based on movement data for Southern Dogfish, a closely related species to Harrissons Dogfish, it is also possible that 70% of individuals in the small closures would have some exposure outside the closure at the north and south boundaries. Most individuals would have some exposure inshore of the shallow boundary during the night and outside the deep boundary during the day.

It is also necessary to verify that industry codes of conduct are implemented – including that trawl skipper training and certification has provided the necessary skills and buy-on to justify reducing observer coverage in the future.

Conclusions

1. The CSIRO-led project has identified five gaps or risks to the management arrangements of the FRZ and suggested options for how they might be addressed, with justification.

2. In the context of the FRZ, the CSIRO-led project also draws attention to the need to recognise that the level of precaution needed to meet the management goals for Harrissons Dogfish is accentuated by a substantial gap in the closure network (MSE network option "NCO3", Daley et al. 2010) that results from the lack of a large full closure for this species (a consistent and repeated recommendation of the CSIRO-led project). The endorsed closure network (NCO3) requires closures off Flinders and off northern NSW – the latter being the only known location supporting an apparently lightly fished population in a relatively large area of mostly un-impacted habitat on the continental margin. The area adjacent to Port Stephens, and in the vicinity of the Hunter AFA, a candidate MPA area for DSEWPaC's Eastern Planning Region, is the preferred candidate area based on demographics and habitat characteristics (Williams et al. 2010).

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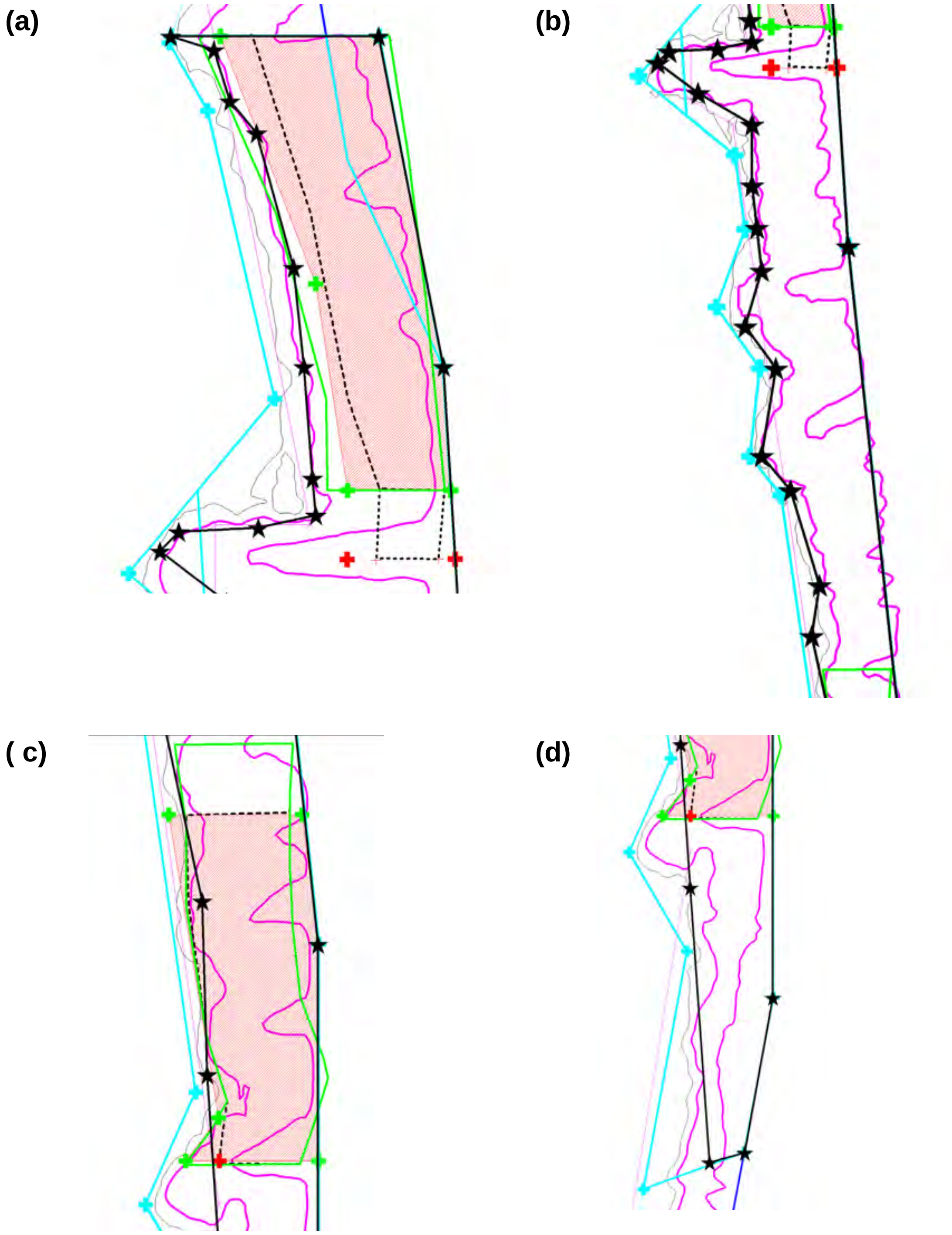

Fig. 1 The Flinders research zone split into 4 overlapping segments: (a) the Babel Closure; (b) the Middle Ground; (c) the Cape Barren Closure and (d) the South Barren Ground. Pink lines -core gulper depth zone between 300 and 600 m; black line + stars - industry proposed boundary; blue line - original FRZ proposed boundary; green line/pink hatching - closed areas; dashed black line – previous industry requested adjustments.

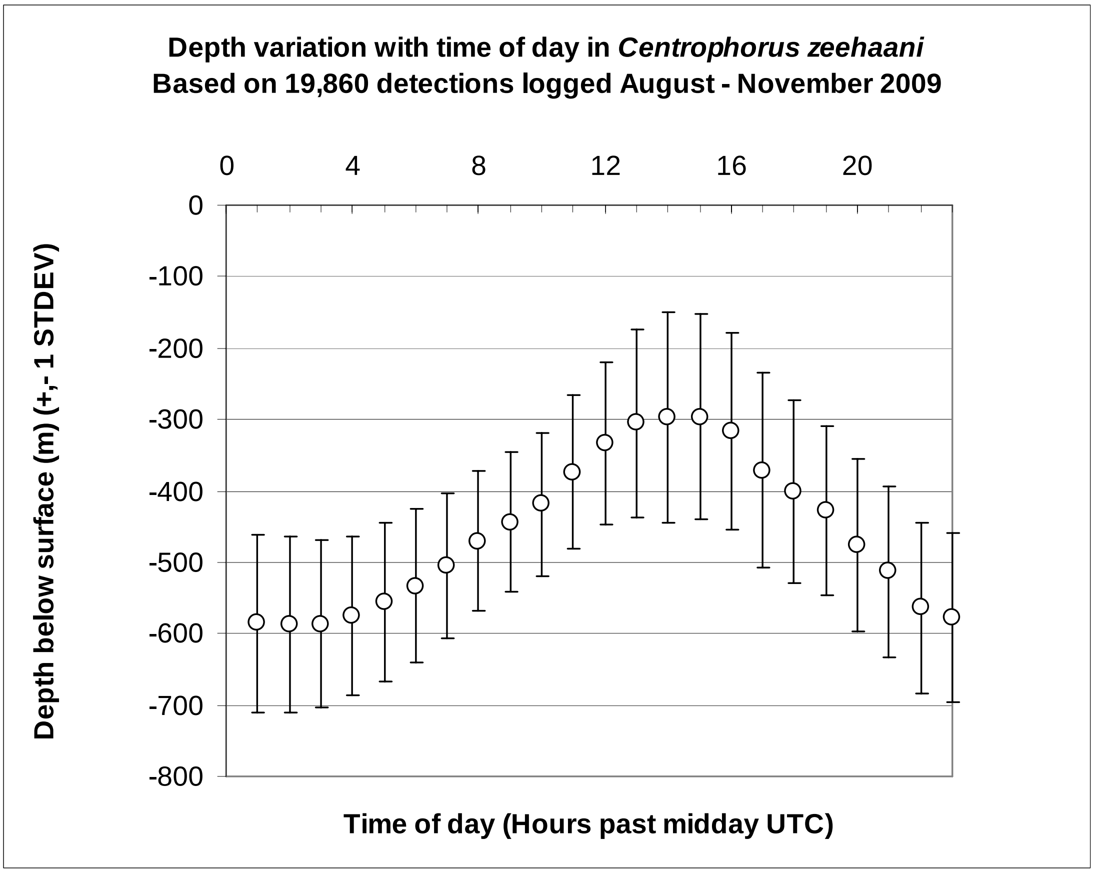

Fig. 2 Daily vertical migration pattern of Southern Dogfish, a closely related species to Harrissons Dogfish, in the “60-mile gulper closure”, indicating the importance of protecting the shallow upper slope and shelf edge (200-300 m depths) of the FRZ.

(a) very large black coral

(b) large bamboo coral

(c) large hard octocoral

(d) large black and octocoral

Fig. 3. Large corals removed by 2 auto-longline shots in the FRZ in 2010.

APPENDIX I

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