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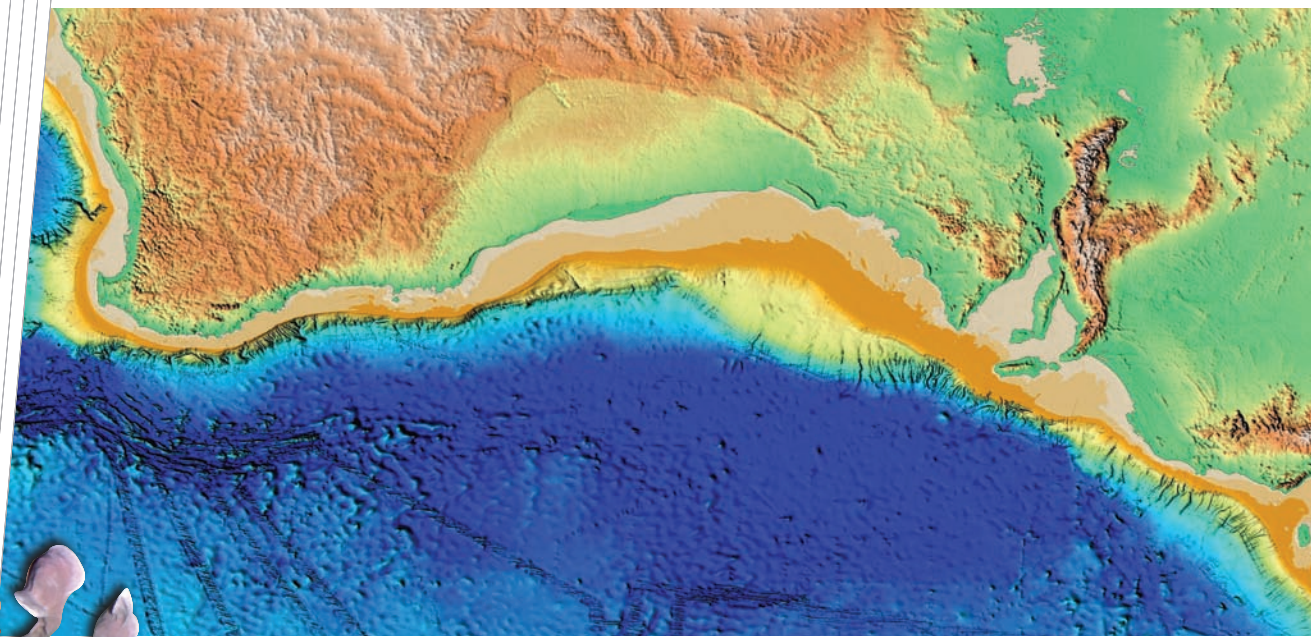

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Supporting sustainable fishery development in the GAB with interpreted multi-scale seabed maps based on fishing industry knowledge and scientific survey data

FRDC Final Report • Project Number 2006/036

Alan Williams, Ross Daley, Mike Fuller and Ian Knuckey

GABIA

Australian Government
Fisheries Research and Development Corporation

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Non-Technical Summary

2006/036 Supporting sustainable fishery development in the GAB with interpreted multi-scale seabed maps based on fishing industry knowledge and scientific survey data.

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Objectives:

1 Acquire, collate and map information on the spatial extent and use of the GAB seabed habitats from multi-sector fishing industry and scientific sources.

2 Validate and complement industry information gathered for Objective 1 by ground-truth sampling with cameras from a chartered industry vessel.

3 Integrate information from Objectives 1 and 2 to generate interpreted seabed maps at scales relevant to management needs: fishing grounds, features, terrains and bottom types.

4 Quantify habitat vulnerability using the ERA methodology and upload a representative set of video and photographic images into the CSIRO seabed image database.

5 Interpret and summarise this information to permit informed area management (spatial and temporal) of the GAB.

6 Evaluate and summarise this information in relation the recommendations of the strategic assessment of the fishery and for stock assessments.

OUTCOMES ACHIEVED

Scientists and the GAB fishing industry collaborated successfully to produce a credible, quality controlled, map-linked database of spatial information that covers the entire Great Australian Bight fishery in depths from the shoreline to 1,300 m – an area of some 360,000 km^2. Mapping was at the resolution of 484 ‘fishing ground polygons’ with an average size of 745 km^2. Skippers provided their personal knowledge and plotter information which was added to a database of spatial information that also includes logbook data, and scientific data on habitats and species. The project highlights the advantages that come from an active collaboration between the fishing industry and the research community, and demonstrates the commitment of commercial operators to the long-term sustainability of the GAB fishery.

Uptake and impact of the project was enhanced by a focus on 5 key issues identified by the Steering Committee (1) species listed under the EPBC Act; (2) key non-target species; (3) important fishery habitats; (4) vulnerable benthic habitats; and (5) the Commonwealth Regional Marine Planning process. Based on a literature review, examination of catch data, and knowledge of habitats, metrics were developed to describe the distributions of species and habitats and then map them into the template of fishing grounds. A diagnostic “Polygon Analysis Tool” (PAT) was also developed to extract summaries of catch and effort from logbooks to inform ‘trade-off’ spatial management scenarios.

The preliminary metrics developed in this project show how the GAB fishery could be evaluated against management goals for protecting species and habitats, although to assess performance it is necessary, (1) to define relative or absolute targets, and (2) further develop mappable metrics that provide finer spatial scale mapping and/ or compound metrics for *multiple* habitats or species. The structure and flexibility of the existing database will enable refinements of this legacy dataset.

Analyses completed during the project have already had uptake by supporting:

- implementation of a network of closures to replace a blanket deepwater closure under a co-management arrangement between AFMA and GABIA;
- submissions by industry to the DEWHA in relation to (1) gulper sharks, (2) Southwest bioregional marine planning, and (3) trawling as a key threatening process.

The projects achievements

1. Acquire, collate and map information on the spatial extent and use of the GAB seabed habitats from multi-sector fishing industry and scientific sources.

In this project, a successful collaboration between scientists and the fishing industry enabled seabed habitats to be mapped across the entire offshore Great Australian Bight (GAB) fishery area – an area of some 360,000 km^2 in depths from the shoreline to 1,300 m. Fishing knowledge was contributed primarily by working skippers – many of whom had more than a decade of experience at sea in GAB waters.

Skippers provided their personal electronic trackplotter data, and worked with the scientists in a step-wise fashion to ensure that their data were accurately represented in maps produced for the project. The combined map of 484 fishing grounds is linked in a database to knowledge provided by fishers using a questionnaire, and a variety of spatial information including logbook data and scientific data on habitats. The incorporation and integration of fishers’ information and knowledge was based on the philosophy that integrated mapping can be superior to either industry or science data in isolation because it combines the strengths of industry knowledge – mapping, naming and repeated sampling of large areas over long periods – with detailed scientific observation of relatively small areas during infrequent surveys using novel samplers such as swath mapping and cameras. This was borne out in the GAB, where a credible spatial data product has been produced.

Agreements were put in place to preserve data confidentiality and security during and after the project; these were strictly observed, and no unauthorised release of industry information occurred. Measures have been put in place to ensure this same security of data remains for future users of the database.

Important context for this work is the finding that, despite the long history of sampling (dating back to the early 1900's), and the geographical scope of recent mapping with multibeam (swath) acoustics, much of the massive GAB fishery area (depths <1,300 m) had remained very poorly known in terms of habitat and species distributions. Mapping for ecosystem based management (EBM) of fisheries not only requires maps of habitats, but also knowledge of the associations between habitat and fishery-relevant species. Similarly, species mapping requires data for areas where catches may never have been taken or recorded at sufficient (species-level) resolution, for example much of the western half of the GAB, and the continental slope (depths > 300 m).

2. Validate and complement industry information gathered for Objective 1 by ground-truth sampling with cameras from a chartered industry vessel.

The survey design, developed in conjunction with the steering committee, and with direct input from trawl and non-trawl fishers, identified an ambitious list of sampling sites (Appendix D). The voyage was implemented very successfully with 39 operations at 35 sites completed along the ~1,200 nautical miles vessel track. In total, 13.6 hours of seabed video and ~ 2,500 high-resolution digital still images were taken in depths between 18 and 415 m. The data acquired from imagery contributed to the mapping and validation of benthic habitat types in the database, and to analytical results. The success of this survey illustrated the effectiveness of the science-industry collaboration – for both planning and implementing the field survey, and for interpreting the results.

3. Integrate information from Objectives 1 and 2 to generate interpreted seabed maps at scales relevant to management needs: fishing grounds, features, terrains and bottom types.

The project output is a credible, quality controlled, map-linked database that covers the entire offshore GAB region of the SESSF fishery. It summarises information at scales relevant to fishing operations and spatial planning for conservation and fisheries management needs. Proven methods were employed from a similar study in the SEF, but there were also several important methodological developments. Data collection methods were adapted to suit the extensive GAB region (larger than the SEF but with fewer operators). Fishery observers also contributed their knowledge and there was a higher reliance on non-fishery data to define the boundary and bottom types of areas in the western GAB where there is minimal fishing activity. In this project, the knowledge of fishers from all three sectors was integrated into the final map set.

One of the key outputs, a mapping of terrain types into fishing ground polygons illustrates the distribution of terrain types (Figure 5.1.1) and their composition within the total GAB fishery area as:

Type 1: heavy contiguous reef – 1.5% of total GAB area
Type 2: sediments with many reef patches – 24.9%
Type 3: sediments with few reef patches – 39.8%
Type 4: clear sediments – 27.0%
Type 5: unknown - 6.8%

A more sophisticated GIS database and mapping capability enabled more complex map products to be produced. This included some 'within ground' feature level mapping (although this remains confidential), more flexibility in dealing with logbook data summaries of catch and effort, and the development of the Polygon Analysis Tool – PAT. This tool automates a process of determining some measure of trade offs to industry of potential area closures by aggregating total catch (a linear proxy for dollar value) within any chosen closure area at various degrees of resolution by species and time period. This will enable rapid scenario development, for example during the process of defining boundaries and zoning plans for Commonwealth Marine Reserves.

Further data on species were explicitly included in data acquisition and analysis to provide data products for individual species and groups of species. Importantly, this enabled the mapping of habitats to be extended to mapping of habitats classified by their importance to the fishery based on species-habitat associations. Several compound metrics to describe the distributions and importance of habitats were developed and explored; their utility is discussed further in the following sections.

4. Quantify habitat vulnerability using the ERA methodology and upload a representative set of video and photographic images into the CSIRO seabed image database

The ERA methodology was used to determine the distribution of vulnerable habitats at polygon resolution across the GAB. A scoring system was developed to extrapolate fine scale spatial data so it could be applied across the entire GAB. Data from the photographic survey contributed to this process, and the photographic images are archived in the CSIRO Data Warehouse.

5. Interpret and summarise this information to permit informed area management (spatial and temporal) of the GAB

To increase the likelihood of uptake and impact of the project, and at the suggestion of the Steering Committee, we focussed on a number of specific issues related to spatial management of fisheries, rather than the more generic mapping and product development approach specified in the project's objectives and methods. Five key issues provided this focus: (1) species listed under the EPBC Act; (2) key non-target (bycatch and by-product) species; (3) important fishery habitats; (4) vulnerable habitats; and (5) the Commonwealth Regional Marine Planning process. The processes contributing to the lists of species and habitats considered included the

Strategic Assessment of the SESSF (2006 WTO), the Ministerial Direction, the Bycatch Action Plan for the SESSF, the ERA for the fisheries operating in the GAB, and the development of the SW Commonwealth MPA network by DEWHA.

Information is summarised in the form of spatially derived metrics, and interpreted against the five key issues. Metrics show how the GAB fishery could be evaluated against management goals for protecting species and habitats. Performance evaluation could be relative to other fisheries, or against spatial targets for species or habitat, or groups of either species or habitats. These developments would represent an evolution of the Ecological Risk Assessment for the Effects of Fishing (ERAEF) process by a spatially explicit evaluation of risk (e.g. incorporating the areal extents of vulnerable and important habitats).

However, two further developments are needed to accomplish fishery evaluation against species and habitat metrics: (1) relative or absolute targets are needed against which the effectiveness of spatial management can be assessed, and (2) further development is needed of mappable metrics to describe the finer distributional scale of species and habitats below fishing ground polygon level, and of compound metrics to represent the distributions of *multiple* habitats or *multiple* species. Both needs can be addressed by future research that will require no additional collection of data.

6. Evaluate and summarise this information in relation the recommendations of the strategic assessment of the fishery and for stock assessments

Summaries of information have been briefly evaluated for their utility in regard to strategic assessment and stock assessments, but exploratory scenario mapping and analysis has been deliberately kept to a minimum because the near-term implementation of the Commonwealth Marine Reserve (CMR) network in the Southwest Region will profoundly change all results. Project outputs can assist with zoning, off-reserve management (e.g. the benefits for, and remaining needs from, fishery closures), and in *assessing* the fishery and conservation values of candidate areas. In particular, the PAT tool will enable ‘trade-off’ scenarios to be generated rapidly and flexibly as CMRs are developed, by automating the process of determining by aggregating total catch at various degrees of resolution by species and time period.

The structure and flexibility of the existing database will enable refinement or development of what is a legacy dataset which can be used into the future to assist with sustainable fishery planning in the GAB.

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The success of this project was facilitated by input from a large and diverse group of experts and stakeholders. Important direction was provided by the Steering Committee: Sandy Morison – Chair (Morison Aquatic Sciences, formally BRS), Ian Knuckey (Fishwell Consulting), Steve Auld (AFMA), Semi Skoljarev (trawl), Peter Kenny (non-trawl), and Crispian Ashby (FRDC), Alan Williams and Ross Daley (CSIRO). Many skippers contributed mapping data and expertise including Tim Parsons, Peter Woods, Jeff Blackman, Murray Stevenson, Stuart Bell, Russel Bradshaw, John Collinson, Anton Blass, Kyriakos Toumazis, Grahame Tapley, Mathew Larson and Peter Reisley. Jeff Moore (Executive Officer, GABIA) made a major contribution to co-ordinating trawl sector input, identifying key issues and reviewing the final report. ISMP observers Lauren Brown, Paul McCoy, Justin Bell, Fabian Trinnie, Matias Braccini contributed habitat data and assisted with interpretation of species habitat associations. Staff at SARDI, Tim Ward, Anthony Fowler and Adrian Linnane, kindly provided State fishery data and benthic survey data from South Australia. Rory McAuley compiled State fishery data from Western Australia. CSIRO staff Neil Klaer, Franzis Althaus, Bruce Barker, Mark Green and Ruth Sharples compiled, translated and mapped components of the fishery and science data. Darci Wallis (AFMA) provided details of fishery closures and ERA species lists. Jeremy Prince, Terry Walker and Lofty Atterton assisted with interpretation of catch data and distribution of school shark. We thank the skipper and crew of the *FV Lucky S* and Semi Skoljarev from Sekol Fishing for the success of the field survey together with the CSIRO scientific crew: Bruce Barker, Mark Green, and Jeff Cordell. Phil Alderslade (CSIRO) identified the shallow water stony corals. Janine Baker made a substantial contribution to the species synopses and literature review. Funding was provided by CSIRO Wealth from Oceans Flagship. We also thank Debbie Vince (CSIRO) for administrative work, and Carolyn Stewardson and other FRDC staff for their ongoing support, input and advice.

1 Background

The Southern and Eastern Scalefish and Shark Fishery (SESSF) is a vast fishery that covers nearly half of the waters within the Australian Fishing Zone (AFZ) from the coast off Fraser Island in Queensland, south around Tasmania and west to Cape Leeuwin in Western Australia (Figure1.1.1.1). It is managed by the Australian Fisheries Management Authority (AFMA) and has a GVP of $86.7 million (Morison et al. 2009) the SESSF is a complex multi-sector, multi-gear and multi-species fishery comprising the Commonwealth Trawl Sector (CTS: otter board trawl, Danish seine) Great Australian Bight Trawl Sector (GABTS: otter board trawl) East Coast Deepwater Sector (ECDW: otter board trawl) and the Gillnet, Hook and Trap Sector (GHAT: auto-longline, dropline, demersal gillnet and trap).

The current study focuses on the area of the SESSF in southern Australia known as the Great Australian Bight (GAB). The GABTS operates over the entire region of the GAB and the GHAT sector operates in the GAB to the east of the Western Australian border. A number of Western Australian and South Australian state fisheries (gillnet trap and line) also operate in the inshore regions of the GAB.

Compared to the highly-populated eastern region of the SESSF, which has been trawled constantly for almost a century, the GABTS is relatively under-exploited. The remote location of the GAB away from major population centres has dictated that only a few short-term commercial ventures have historically operated in the region, hindered by inadequate vessels, poor cold storage and the distance of the fishing grounds from the eastern markets (Tilzey and Wise 2003). Significant commercial trawling did not really begin until the mid 1980s, prompted by the discovery of Orange Roughy. Recognising some of the failures of over-exploitation and over-capitalisation in the eastern SESSF, the GABTS became the first fishery to be managed under the Commonwealth *Fisheries Management Act* (1991) and, based on previous levels of involvement in the fishery, only 10 Statutory Fishing Rights (SFRs) were issued. Although low levels of Orange Roughy fishing have continued subsequent to the mid 1990s, most GABTS effort has focussed on the outer shelf resources, particularly Deepwater Flathead (*Neoplatycephalus conatus*) and Bight Redfish (*Centroberyx gerrardi*).

In the GHAT sector, there has been a long history of first longline, then gillnet fishing for School Shark and Gummy Shark in the eastern region of the GAB. Although the School Shark fishery has been over-exploited and is now in a recovery phase, the use of gillnets to target gummy sharks remains an important and viable part of the SESSF in the eastern GAB. The last decade, has seen the increased use of automatically baited demersal longlines (auto-longlines) targeting upper-slope scalefish species such as ling and hapuka.

Since 1986, the SESSF has been managed primarily through Total Allowable Catches (TACs) allocated as individual transferable quotas (ITQs) which applied to over 80% of the landed catch but also had input controls including limited entry, gear restrictions and some fishery closures. Nevertheless, the fishery was generally recognised to be in a poor economic and ecological situation by the early 2000s, although less so in the GAB region due to lower effort levels. A review of SESSF management during 2004 (Smith et al. 2009) emphasised the need for a suite of "integrated" management strategies to meet the needs of all the sectors across the full range of management objectives, and particularly to meet ecosystem requirements. Spatial management and the need for fishery closures were recognised as critically important components of future management of the SESSF.

Introduced during 1999, the Environmental Protection and Biodiversity Conservation Act (EPBC Act) was a strong driver for a change in fisheries management. It focused attention on the ecological impacts of fishing and provided strong external scrutiny on fisheries from an environmental perspective. In its move towards ecosystem-based fisheries management (EBFM), AFMA is now incorporating greater levels of spatial management into all sectors of the SESSF to meet a wide variety of management objectives: global TACs now have spatially managed trigger points in different regions to guard against overfishing; fishery closures are in place to protect nursery grounds and prevent targeted fishing of some spawning stocks; closures are also used to manage levels of bycatch; regional closures are utilised to minimise some cross-sectoral conflicts; and, spatial closures are also being implemented to protect vulnerable species and habitats. In addition, to the increased push for spatial fisheries management, a system of Marine Protected Areas (MPAs) to protect biodiversity was being rolled out around Australia as part of the Marine Bioregional Planning process, starting in the south east region of the SESSF.

It was under these circumstances that the need for the current project developed. The same factors that had lead to the generally controlled and low-level development of commercial fishing in the GAB also made this region a prime candidate to embrace the use of spatial management as an integral tool to address a number of current fishery management issues in the pursuit of economically viable and ecologically sustainable fisheries.

At the beginning of this project there were numerous issues in the GAB region of the SESSF that were potentially amenable to a spatial management solution. These are outlined below.

GAB operators recognised that the benthic impact of trawling on bycatch and marine habitats and communities is of particular concern to the community and the need to have appropriately determined areas that are protected from these impacts was recognised. Demersal trawling in the SESSF had been nominated as a "Key Threatening Process" under the EPBC Act – a case that will be considered during 2010. Despite the intense scrutiny on the effects of trawling, the Great Australian Bight Industry Association (GABIA) is endeavouring to implement a worlds-best-practice trawl fishery in the GAB and fully recognise the need for spatial management and spatial closures to achieve this goal, especially to protect vulnerable upper slope and deepwater habitats.

The long-lived Orange Roughy (*Hoplostethus atlanticus*) had been listed as "Conservation Dependent" under the EPBC Act – mainly because of the depletion levels in the east of the SESSF – and required development of a Conservation Plan to ensure its recovery. Orange Roughy stocks in the GAB have appeared to have been fished down during the early 1990s, but there was considerable uncertainty in the level of depletion due to the wide geographic extent over which this fish had historically been taken across the GAB.

School shark had also been listed as “Conservation Dependent” under the EPBC Act – a critical issue for the demersal gillnet fishery of the GHAT sector. This long-lived species is vulnerable to capture by both gillnets and auto-longlines and is often taken as a bycatch of these fishing methods. Different spatial and temporal characteristics of School Shark distribution enable spatial management as a possible method to reduce the bycatch of School Shark with minimal loss of target species.

A number of gulper shark (*Centrophorus* spp) species have also been nominated as “Threatened” under the EPBC Act, one of which – the Southern Dogfish (*Centrophorus zeehaani*) – is distributed across the GAB region. The decision on this nomination is due in 2010. Again this is a long-lived species with low productivity and is vulnerable to both gillnet fishing and trawling in the GAB and, more recently, to auto-longline as effort expands westwards into the GAB from the historical grounds around Tasmania. Early tagging data suggests that these species are territorial, which makes spatial management an appropriate option for their protection from fishing. It is hoped that by characterising gulper shark habitat in the GAB, it will be possible to verify that current management arrangements including closures are adequate, or that additional measures need to be considered.

AFMA and CSIRO have completed the risk-based assessments of the ecological impacts of SESSF fishing across the GAB (Daley et al. 2007a, Daley et al 2007b, Walker et al. 2007) Although the results of these Ecological Risk Assessments (ERAs) indicated there were no “high-risk” species in the GABTS, there were a number of bycatch/byproduct species which could be of concern given the multiple fishing methods used across the GABTS. Although these species cover a wide range of depths and habitats within the GAB, there was an obvious opportunity to investigate whether, instead of managing each species individually, some form of spatial management could reduce fishing impacts of multiple species.

Finally, a network of reserves is being developed for the SW Marine Planning region that covers all of the GAB fishery area. Although some reserves exist, the GAB Benthic Protection Zone at the head of the Bight and the Murray CMR in the east as part of the SE planning region, these will be overlayed with additional CMRs as the SW Region Management Plan is finalised.

Given all of the above drivers, the proposed project aims to take the unique opportunity that exists in the GAB to explore the potential for integrated spatial management that achieves a wide range of management objectives across different fisheries. The ideal starting point for planning spatial closures is access to mapping information on species/stocks, fishing activity and habitats at the scale of the regional fishery. This project will provide that information.

2 Need

Spatial management is now an integral part of the overall management of the SESSF, particularly in the large area of the GABTS. To ensure that spatial management can meet the needs and expectations of all stakeholders across the full range of management objectives, it is critical to have a sound understanding of the underlying marine habitats and their vulnerability and availability to different fishing methods. Apart from the broad bioregions categorised under the Integrated Marine and Coastal Regionalisation of Australia (IMCRA), the GAB remains mostly unmapped at the scales relevant to the needs of managers, industry members and scientists when evaluating options for ecosystem based management (EBM). The relevant scales are: fishing grounds (areas with characteristic patterns of bottom types, fish communities and use); features (including submarine canyons and large rocky banks); and, terrains (sediments, rocky bottom and broken bottom that form the seabed). Maps alone will not usefully inform management decisions. There is also a need to interpret the structure and functions of their component parts, e.g. individual fishing grounds or certain habitat types. This will enable stakeholders to understand their role for fishery production, their value to the fishery, and their natural values – including for threatened species and unique/vulnerable habitats. A wide range of data and knowledge can be collated from industry and scientific surveys. The project will provide the mechanism needed to acquire, collate and map all of the available information, then evaluate and summarise it for management purposes while preserving the confidential nature of industry data. The project is based on a model used successfully for a similar study in the SESSF. The methodology – including data security measures - and infrastructure (spatial database, portable camera system) is largely in place. This project will differ from the previous project by including all relevant fishing sectors (not just trawl and non-trawl) and by further developing the written agreements governing the security and use of industry-derived data.

3 Objectives

1 Acquire, collate and map information on the spatial extent and use of the GAB seabed habitats from multi-sector fishing industry and scientific sources.

2 Validate and complement industry information gathered for Objective 1 by ground-truth sampling with cameras from a chartered industry vessel.

3 Integrate information from Objectives 1 and 2 to generate interpreted seabed maps at scales relevant to management needs: fishing grounds, features, terrains and bottom types.

4 Quantify habitat vulnerability using the ERA methodology and upload a representative set of video and photographic images into the CSIRO seabed image database

5 Interpret and summarise this information to permit informed area management (spatial and temporal) of the GAB

6 Evaluate and summarise this information in relation the recommendations of the strategic assessment of the fishery and for stock assessments

4 Methods

Many data sets are used in this project, and the analyses are complex and inter-linked. In this section we outline the area mapped (section 4.1), then the data sets compiled and the mapping methods which integrate fishers' knowledge, catch data and science data to form the fishing ground maps (Sections 4.2–4.4).

We then describe the key issues highlighted by the Steering Committee (Section 4.5.0) and how we applied mapping information to species issues (section 4.5.1–4.5.2) and to two classes of habitats (Sections 4.5.3–4.5.4). The two classes of habitat referred to are

- Vulnerable Benthic Habitats (VBH) – seabed habitat types most likely to be damaged by direct contact with fishing gears
- Important Fishery Habitats (IFH) – seabed habitat features that have recognisable and consistent associations with either target and/or non-target fish species.

The final section (4.6) describes the mathematical approaches and the units used in the species and habitat analyses.

4.1 Jurisdictional and management boundaries

4.1.1 Area mapped

The Great Australian Bight (GAB) is an extensive latitude-parallel marine area encompassing the warm temperate waters off Australia's south coast between 115ºE and138 º E. The area spans a range of biogeographical provinces (defined by the Integrated Marine and Coastal Regionalisation for Australia version 4.0 (IMCRA v4.0) and the National Marine Bioregionalisation) and forms the major part of Australia's 'Southwest Planning Region' that extends from Shark Bay to Kangaroo Island. In a review of the physical and biological characteristics of the SW Region, McClatchie et al. (2006) note that while many aspects of the physical environment are well known, the region's ecology is relatively poorly understood.

The scope of this project was primarily to map the GAB seafloor where Commonwealth fisheries operate. The offshore areas (continental shelf and slope) of the GAB support commercial fishing by several sectors of the Commonwealth's Southern and Eastern Shark and Scalefish Fishery (SESSF), including the GAB Trawl Sector (GABTS) as well as the automatic longline and gillnet sectors of the Gillnet Hook and Trap (GHAT).

To simplify the data analysis we mapped almost all waters between 115º–138º longitude; from the 1,300 m line to the shore (Figure 4.1.1.1) including most large embayments. The only two specific exclusions were parts of the Spencer Gulf and Gulf of St Vincent because they are large internal waters with different ecological characteristics to the GAB. It was not possible to draw simple boundaries that separate Commonwealth from State waters because jurisdictional boundaries are complex and overlap and in some cases jurisdiction is shared (see 4.1.2). In addition a number of the species and habitats interacting with Commonwealth fisheries also occur in State waters, particularly for early life history stages.

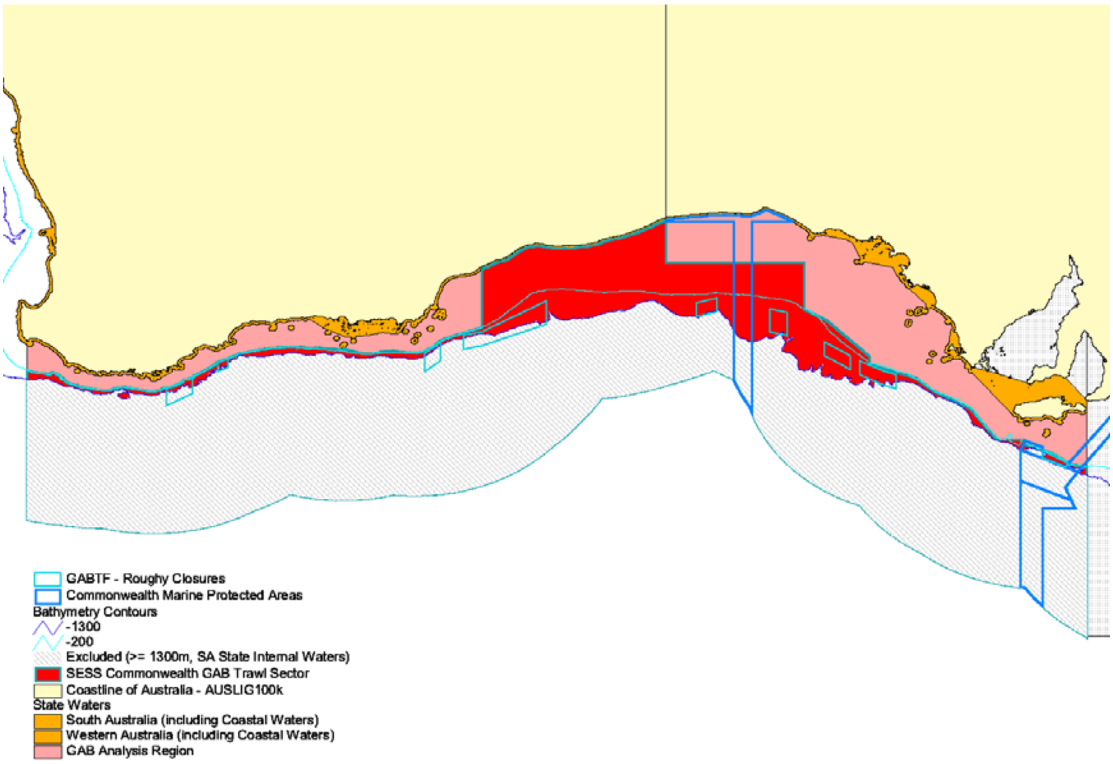


Figure 4.1.1.1: Area Mapped showing excluded waters (stippled areas)

4.1.2 State waters and internal waters

Off South Australia, waters within 3 nautical miles of the shoreline are managed by the South Australian Government. Commonwealth licenses do not permit fishing in SA state waters. However South Australian State Scalefish permit holders are permitted to take a limited number of School Shark and Gummy Shark from state waters on a daily basis for most of the year (Government of South Australia 2001) (Figure 4.1.1.1). Therefore inshore habitats in state waters need to be considered for effective management of these species. Within SA state waters, gillnetting is further restricted and closed in some internal waters (Figure 4.1.2.1). The SA State managed rocklobster fishery extends into Commonwealth waters.

Off Western Australia, the State generally has jurisdiction over shelf waters from the shoreline to the 200 m contour west of 125º including inshore trawl fisheries (Figure 4.1.1.1). From 125–129º Commonwealth trawlers have access to waters outside 3 n.m from the shoreline. Responsibility for managing gillnet fisheries in all depths off Western Australia is shared between the Commonwealth and State but currently administered by the State.

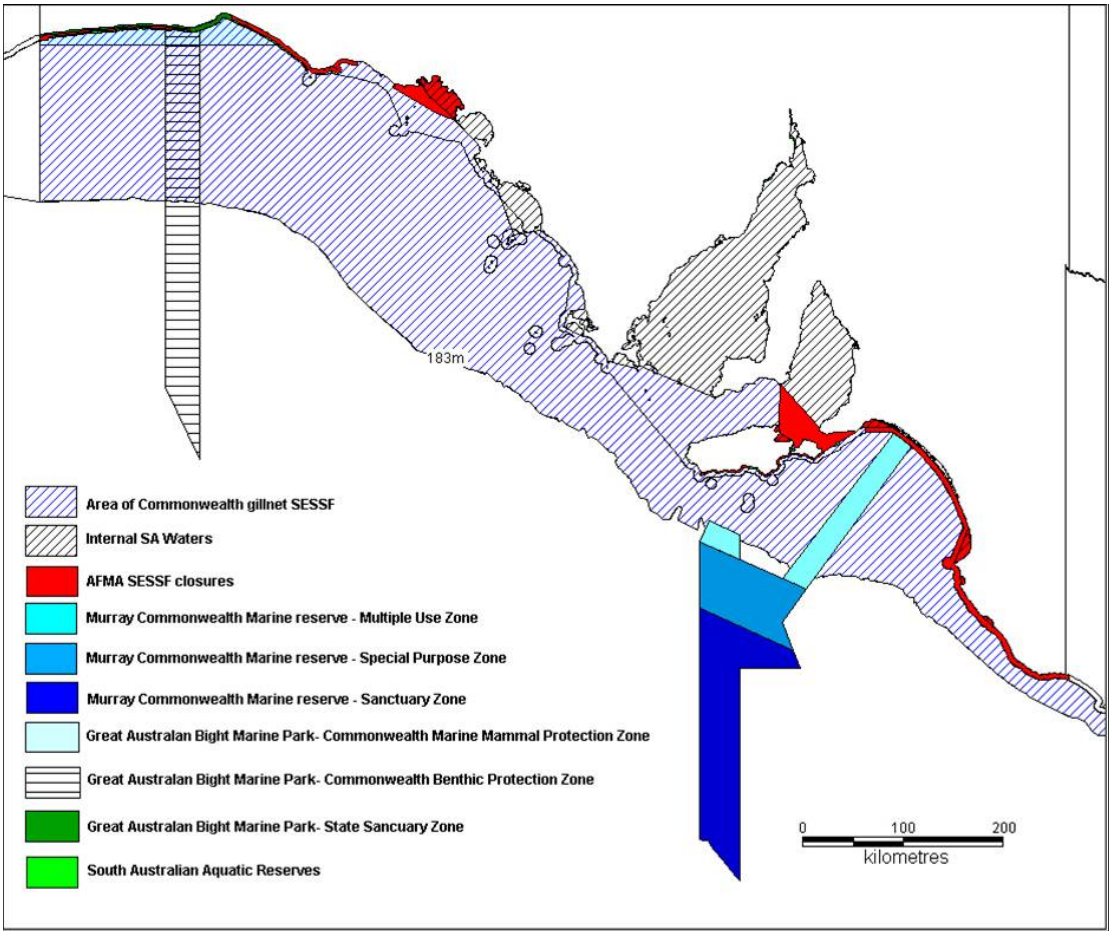


Figure 4.1.2.1 South Australia State and internal waters, AFMA closures and Marine Reserves

4.1.3 Commonwealth Fishery Area Closures: shelf and upper slope

Most inner shelf waters of the GAB are closed to trawling with the exception of part of eastern Western Australia (Figure 4.1.1.1, Table 4.1.3.1)

Seven areas have been closed by the Australian Fisheries Management Authority (AFMA) in Commonwealth and South Australian waters to mitigate fishery impacts on particular high risk species highlighted by ecological risk assessments and/or protected under the EPBC Act (Table 4.1.3.2).

Table 4.1.3.1 Areas closed to trawling in the Great Australian Bight (and see additional Deepwater Management closures in following section)

Schedule	Area	Species/Habitat and aim	Methods excluded
22	Eastern SA	juvenile scalefish – reduce catch; structured benthic habitat - protect	Trawl

Table 4.1.3.2 Summary of the Commonwealth Fishery Area Closures implemented to mitigate fishery impacts on high risk species on the shelf and upper slope

Schedule	Area	Species	Aim	Methods excluded	Figure
1	Murat Bay	Bronze Whaler, (Snapper, Mulloway)	Protect stocks	Gillnet	A
6	Seal Bay	**Australian Sea Lions**	Protect Breeding Grounds	All	B
7	Pages Island	**Australian Sea Lions, White sharks**	Protect	All	C
8	Head of the GAB	**School Shark**	Protect	All	D
10	Backstairs Passage	**School Shark**	28	Gillnet	E
11	Kangaroo Island	**School Shark**	Protect Breeding Stock	Gillnet	F
16	60 Mile Area	Southern Dogfish	Protect	Hook	G
17	60 Mile Area	Southern Dogfish	Protect	Trawl	H

* Species in parentheses not highlighted by ERA or EPBC
* EPBC listed species in **Bold**
* Priority nominated species underlined

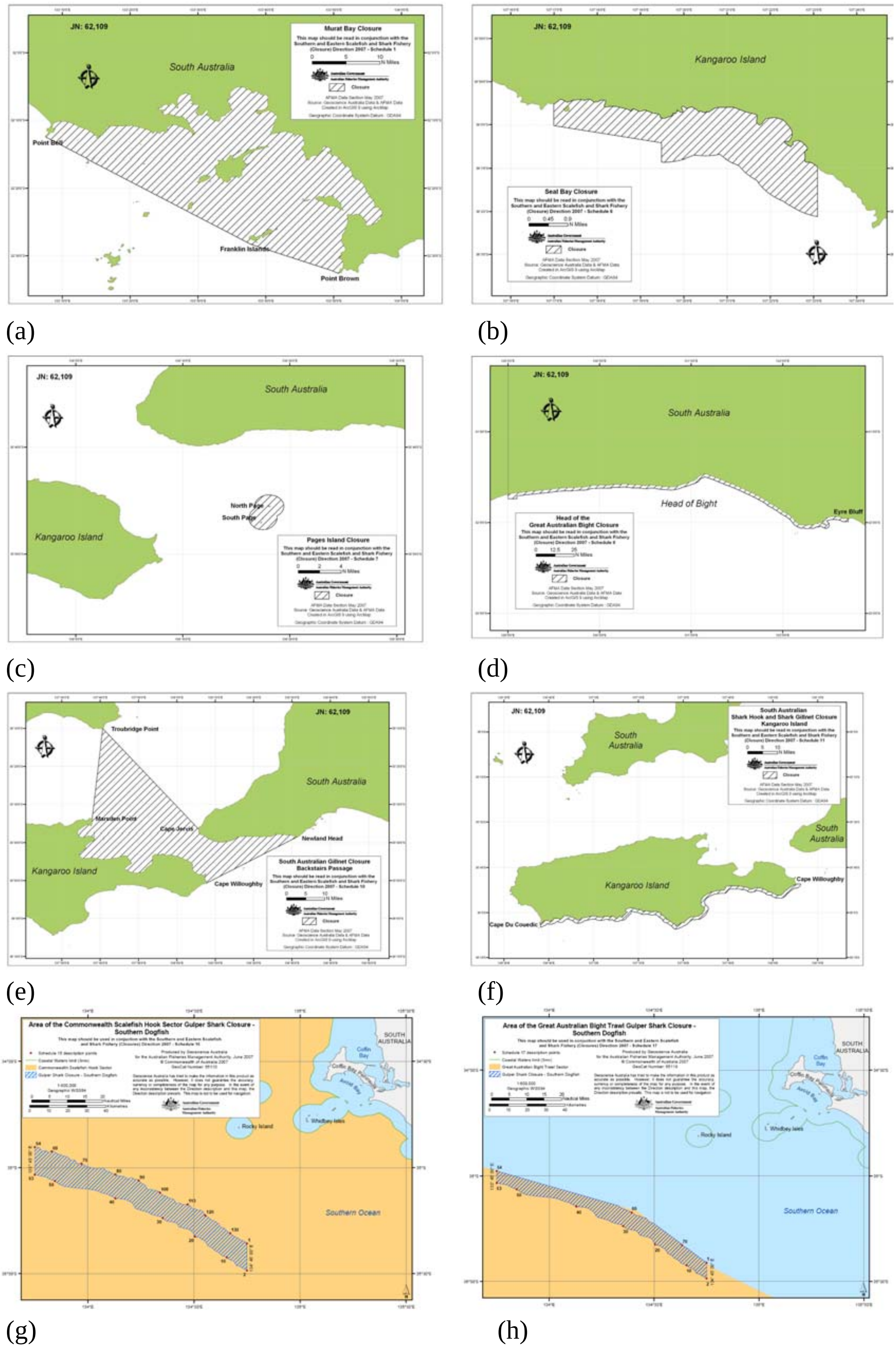


Figure 4.1.3.1 Commonwealth Fishery Area Closures implemented to mitigate fishery impacts on high risk species on the shelf and upper slope

4.1.4 Commonwealth Fishery depth closures

Two key depth closures are in place in the Gillnet Hook and Trap (GHAT) sector of the Commonwealth SESS fishery (Table 4.1.4.1). Gillnetting is restricted to waters shallower than 183 m (Figure 4.1.4.1) to limit impacts on School Shark in deep water, particularly) but also eliminates interactions with Southern Dogfish and Greeneye Spurdog. Conversely auto-longline vessels are restricted to waters deeper than 183 m (Figure 4.1.4.2) to reduce impacts on School Shark and Gummy Shark and eliminate gear overlap between these two sectors.

Table 4.1.4.1 Summary of the Commonwealth Fishery Depth Closures implemented to mitigate fishery impacts on high risk species on the shelf and upper slope

Schedule	Area	Species and aim	Methods excluded	Figure
13	Deeper than 183 m	**School shark** – protect large adults; Deepwater sharks including Southern Dogfish– prevent targeting	Gillnet	A
14	Shallower than 183 m	**School shark** and gummy shark – prevent targeting	Auto-longline	B

* EPBC listed species in **Bold**
* Priority nominated species underlined

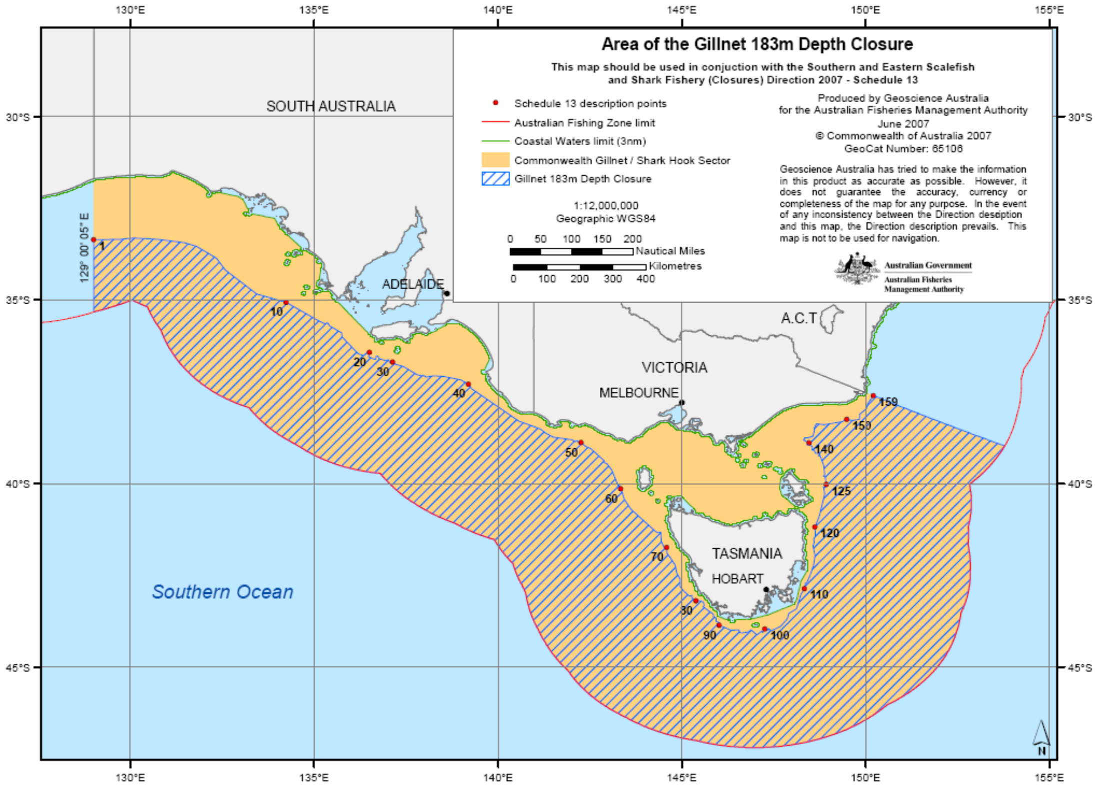


Figure 4.1.4.1 Area of the gillnet 183 m depth closure

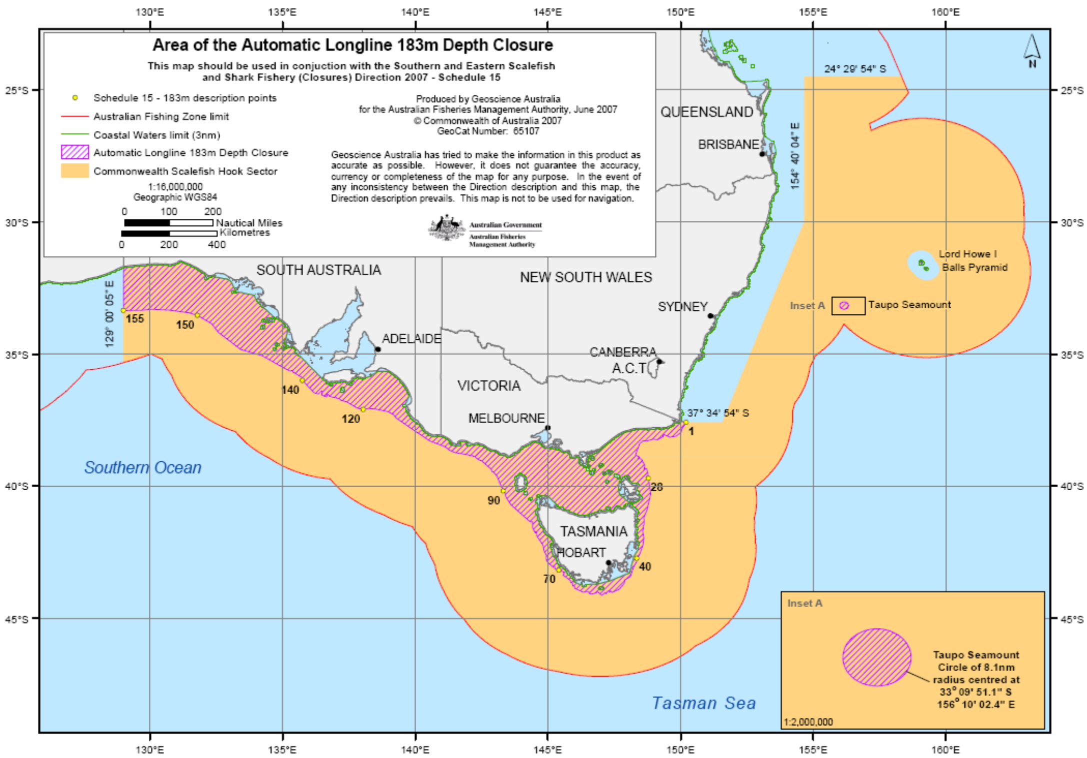


Figure 4.1.4.2 Area of the Automatic Longline 183 m depth closure

4.1.5 Deepwater management strategy

In addition to the GAB Marine Park, gulper shark closure and Murray MPA, GABIA implemented a network of fisheries spatial closures to demersal trawling to mitigate fishery impacts on Orange Roughy and vulnerable deepwater benthic habitats. This strategy was developed through the project in conjunction with GABIA and is combined with other measures designed to mitigate impacts on high risk bycatch species, such as deepwater sharks.

As a result of a GABIA recommendation, the deepwater fishery (outside 700m) in the GABTS has been divided into 5 management zones as follows:

- · Eastern Zone – 138° 08’ to 136° 00’ E (already exists)
- · Central East Zone – 136° 00’ to 133° 00’ E
- · Central West Zone – 133° 00’ to 129° 00’ E
- · Western Zone – 129° 00’ to 121° 00’ E
- · Far West Zone 121° 00’ to 115° 08’ E

Demersal trawling is now excluded from defined areas across the fishery in each of these deepwater management zones, on the following basis:

- Eastern Zone – Murray MPA, capturing known Orange Roughy “hills” and canyon systems
- Central East Zone – Southern Dogfish closure, 300 – 600m, from 133°45’ to 134°45’
- Central East Zone – GABIA deepwater fishery closure from 134°00’ to 134°20’adjacent to the Southern Dogfish closure
- Central West Zone - GAB Marine Park Benthic Protection Zone between 130° 51' 58" E and 130° 28' 02"

- Western Zone – GABIA deepwater fishery closure outside 700m to demersal
- trawling (over Salisbury Canyon to EEZ) from 123° 18‘ to 123° 40’ E
- Western Zone – GABIA deepwater fishery closure outside 700m to demersal
- trawling from 121° 00’ to 122° 00’ E
- Far West Zone – GABIA deepwater fishery closure outside 700m to demersal trawling from 120° 00’ to 121° 00’ E

Consistent with the Ministerial Direction, the GABIA deepwater closures have been implemented as fisheries closures and may be amended in the future if necessary for effective integration with the MPAs implemented under the SouthWest Bioregional planning process.

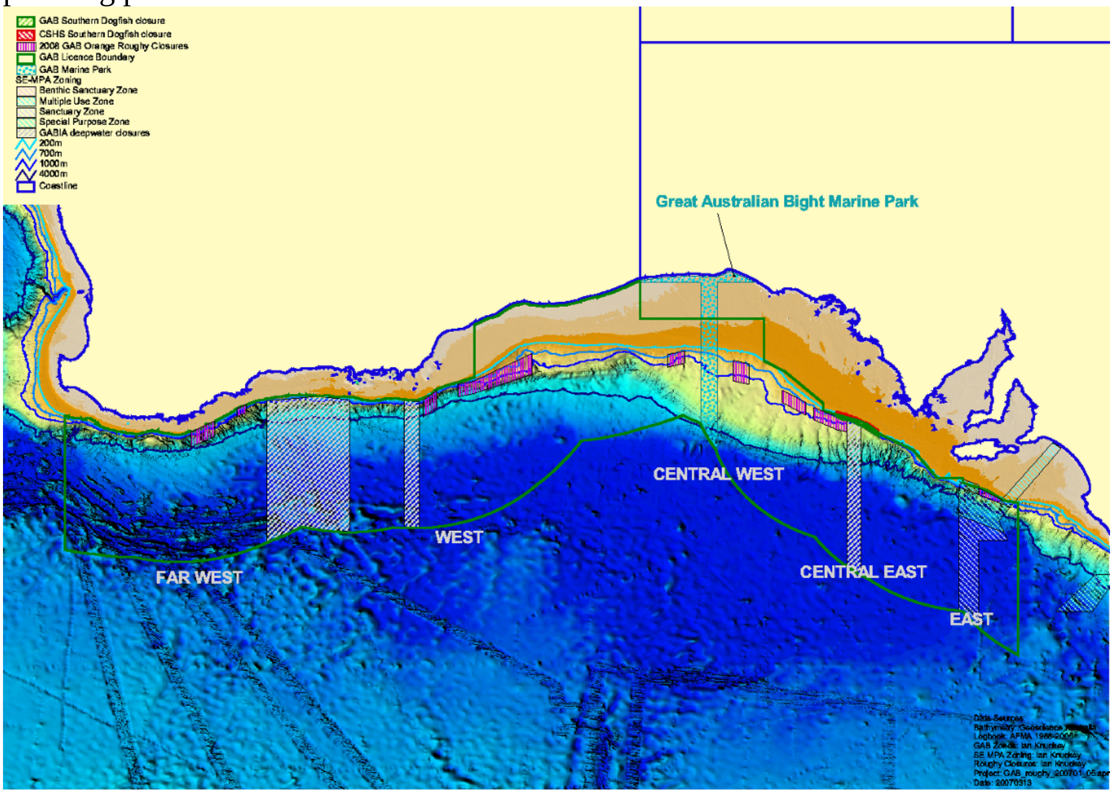


Figure 4.1.5.1 Locations of managed areas contributing to management of Orange Roughy, vulnerable deepwater benthic habitats and high risk species such as deepwater sharks.

Table 4.1.5.1 Summary of managed areas contributing to the deepwater management implemented to mitigate fishery impacts on vulnerable habitats, Orange Roughy and other high risk species including deepwater shark

Schedule	Area	Species	Aim	Methods excluded
24–26	GAB deepwater closures	Deepwater species and **Orange Roughy**	Protect deepwater species	Trawling
27–30	GAB Orange Roughy zones (west)	**Orange Roughy**	Protect stocks	Trawling
31–35	GAB Orange Roughy zones (west)	**Orange Roughy**	Protect stocks	Trawling

* EPBC listed species in **Bold**

4.1.6 Commonwealth Marine Reserves

Two extensive areas are enclosed within Commonwealth Marine Reserves (CMR). The first is the GAB Marine Park at the head of the Bight (Figure 4.1.6.1). comprised of the Benthic Protection Zone, Marine Mammal Protection Zone and the adjacent State Marine National Park and Whale Sanctuary.

The second is the Murray CMR, declared in 2007, adjacent to Kangaroo Island, which forms part of the network of CMRs within Australia's Southeast Region (Figure 4.1.6.2).. The zoning includes a Sanctuary zone (IUCN Ia), a special purpose zone and a multiple use zone (both IUCN IV). In sanctuary zones only scientific research and vessel transit are allowed. The special purpose zone excludes all commercial fishing activities but recreational fishing, charter fishing (under special permits) and mining activities are permitted. In multiple use zones, selected commercial fishing activities are allowed under special permit; demersal trawl, Danish seine, gill netting (below 183m) and scallop dredge are excluded (DEWHA – http://www.environment.gov.au/coasts/mpa/southeast/activity.html).

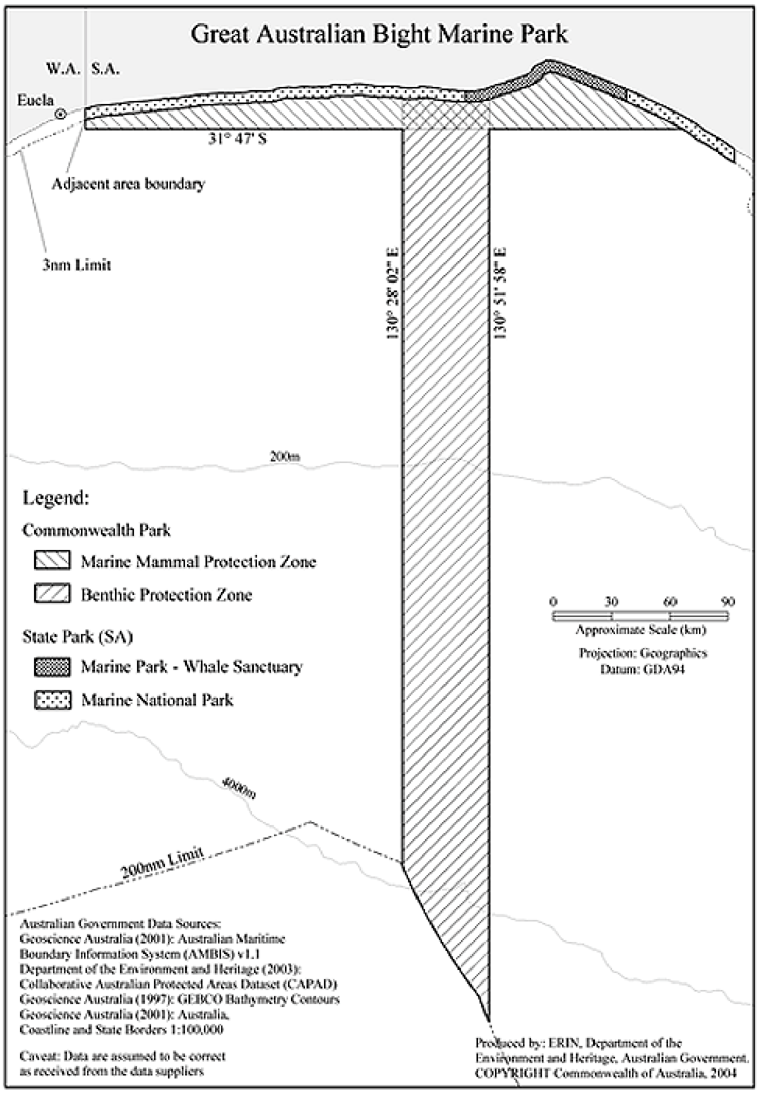


Fig. 4.1.6.1 The GAB Marine Park at the head of the Bight.

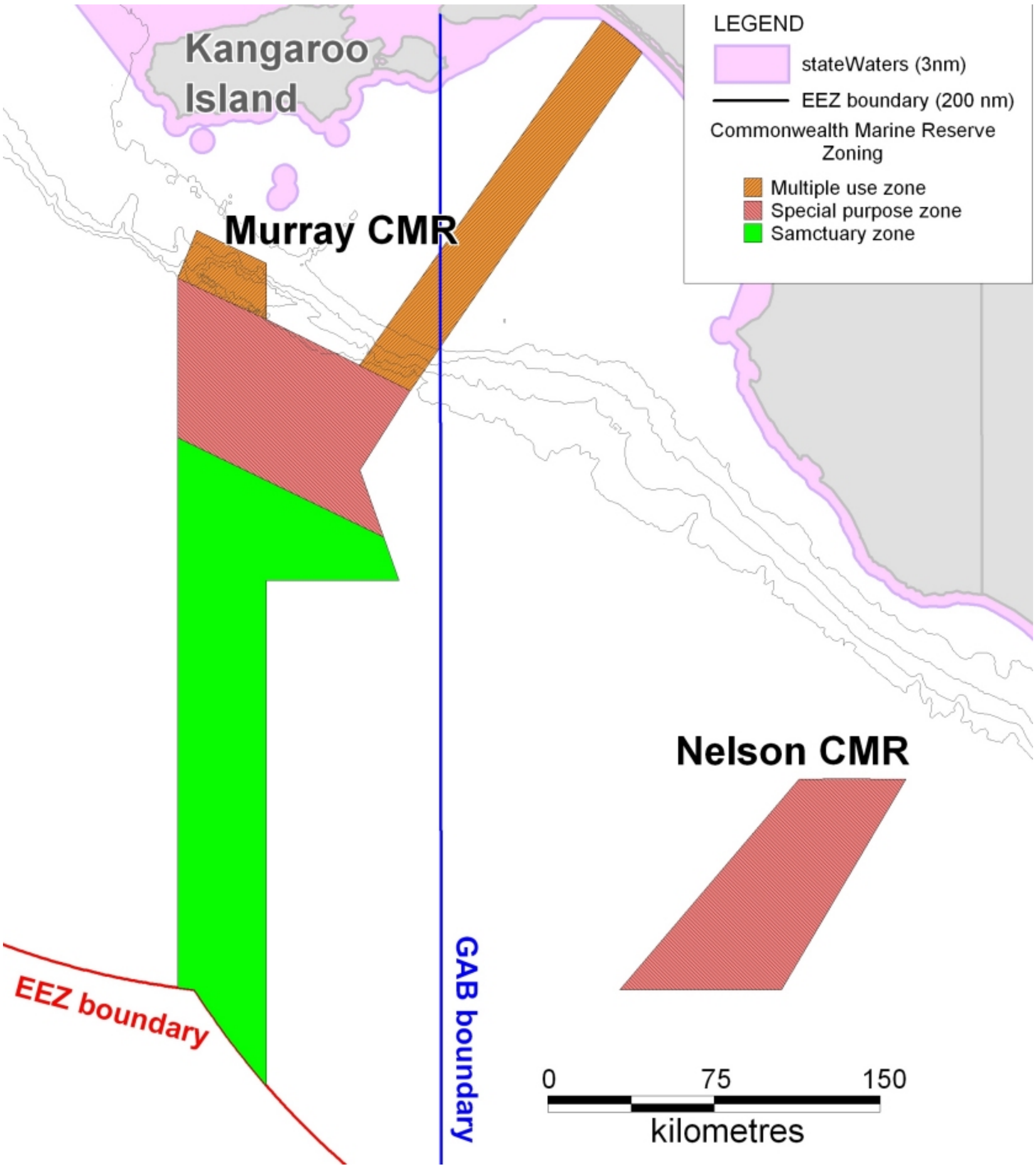


Figure 4.1.6.2 Location of the Murray Commonwealth Marine Reserve, in relation to the GAB boundary. Grey contour lines: 100 m, 20 m, 700 m, 1300 m

4.2 Fishing industry data

4.2.1 Data acquisition and communication with industry

In contrast to the “South East Fishery” (SEF) area of the SESSF mapped in a previous project (Williams et al. 2006), there are fewer stakeholders involved in the GAB region and all key participants are known to the Steering Committee. Therefore, a more focussed approach could be taken to making contact with fishing operators. A total of 15 operators with experience of fishing in the GAB from three fishery sectors were contacted directly and agreed to contribute data. Most fishers’ knowledge was provided during formal ‘one-on-one’ interviews in ports when mapping information was provided and reviewed.

Fishers making direct contributions of data were each visited to collect, review and refine maps, and to provide interpretation via a questionnaire (Appendix A). Fishery observers also provided notes and data on habitat observations and catch distribution of species with known habitat associations. Additional feedback was provided following planning meetings and presentation of results at meetings (Table 4.2.1.1) or during informal meetings in ports.

Good communication with stakeholders was key to the success of the project planning and uptake. Project updates were presented at Steering Committee meetings, MAC and RAG meetings, phone-hook-ups and reports circulated by email (Table 4.2.1.1).

Table 4.2.1.1 Communication with stakeholders including contacts for project planning and communicating results.

Year	Month	Forum	Location	Outcomes
2007	3	GAB SC 1/MAC	Canberra	Focus project approach on key issues
2007	3	GABIA	Canberra	Describe aims and methods of project
2007	3	GHATMAC	Canberra	Describe aims and methods of project
2007	6	GABRAG	Adelaide	Identify key contributors
2007	8	GABIA	Adelaide	Gain support from key contributors, identify additional contributors
2007	8	GAB SC 2	Melbourne	Consider Modelling approach, short-list key issues, support field survey
2008	5	Port Visit	Port Lincoln	Obtain data sets, discuss key issues, identify candidate survey vessels
2008	7	GAB SC 3	Adelaide	Discuss key issues, SW Marine planning, plan field survey
2008	9	Co-ordinator update	e-mail	Port visits, State fishery data, camera survey plans
2008	9	Co-ordinator update	e-mail	Mapping, science data, State fishery data
2008	9	Port Visit	Adelaide	Review non-trawl maps with gillnet operators, fill gaps on upper slope with additional trawl data
2008	10	Co-ordinator update	e-mail	Review progress on science data, follow up on action items
2008	11	Co-ordinator update	e-mail	First results from field survey
2008	11	SharkRag, AFMA bycatch meetings	Melbourne, Queenscliffe	present results to SharkRag, obtain input from observers, attend bycatch meetings to inform key issues, meet with skippers
2008	12	Port Visit	Streaky Bay, Ceduna	Complete non-trawl mapping
2008	12	GAB SC 4	Phone Hookup	Review report on field survey
2009	7	GAB SC 5	Hobart	Review analysis and draft report, obtain feedback
2009	12	Co-ordinator update	e-mail	Circulate revised draft report and plan final project meeting
2010	2	GAB SC 6	Melbourne	Review and approve revised analysis and updated final report

4.2.2 Formal arrangements

This project employed the same system that had successfully guided the integration, release and confidentiality of data in the previous SEF Mapping Project.

A Memorandum of Understanding (MOU - Appendix B) set out the ground-rules for exchange and release of data so that all parties had a common understanding of the intentions of the project. Specifically, the MOU detailed how CSIRO would inform the peak bodies and individual fishers about results from the project, how industry would be incorporated into the project and provide support for it, and how project results would be released to a broader audience. It also specified how industry would contribute to the project. Industry's knowledge and data was differentiated from project data through an annex (Appendix C) to the MOU in order to protect data from unintended distribution and use during the project, and to identify the fate of the project data beyond the 2-year life of the project.

The wording of the IP clause in the contract with FRDC was also changed to reflect the ownership by industry of industry data, as distinct from pre-existing scientific and derived project data.

An external Steering Committee was formed to aid communication and consultation and made up of representatives of GABIA and GHATMAC, SharkRAG, the DEWHA and AFMA; in addition, industry representatives attended some meetings.

4.2.3 Fishing industry mapping data and processing

Data types

Trawl fishery data were provided in electronic form from navigational trackplotters in Furuno GD88, C-Plot or SeaPlot format. Supplementary data was provided as Olex printouts and on paper charts. Auto-longline and dropline data were provided electronically in Seaplot and MaxSea format and supplemented with Piscatus printouts and paper charts. Gillnet data were only made available in paper format.

Way-point data that showed the existence and boundaries of different seabed types were most useful in defining ground boundaries. Only C-plot electronic data were converted directly to GIS (MapInfo and ArcView) data. Most of the grounds data were translated via paper printouts and entered manually into GIS, because data from modern sophisticated plotter packages could not be interchanged.

Defining fishing grounds

The spatial units of analysis in this study are fishing grounds. We defined 'fishing grounds' as seabed areas recognized by commercial fishers for fishing or not fishing (avoiding), or areas where the distributions and abundances of commercial fishes are distinct. Typically, grounds are related to natural geological features – substratum type and geomorphology – and mostly distinguish sediment plains (which can be trawled), patches of consolidated substrata such as rocky banks (which can be fished by static non-trawl gears but are generally not able to be trawled), and prominent features such as canyons and seamounts (targeted by a variety of fishing methods). Fishing grounds may have the same type of seabed throughout, or be highly variable in terms of both the structure and distribution of bottom types and what they look like (geomorphology). These attributes were recorded separately for each ground using the questionnaire.

Boundaries of grounds may be based on distinct or indistinct physical features, on distinct or indistinct depth contours, on jurisdictional lines (e.g. State-Commonwealth and State-State borders), aligned with adjacent seabed features (typically prominent reefs or canyons) or historical landmarks (such as mountains), measured by distance from port or shore, or they may be arbitrary. As such, fishing ground boundaries have two important properties: type and distinctness. Boundary type is unlikely to be similar for the entire perimeter of a ground, and its distinctness is likely to be variable – ranging from highly distinct (such as the edge of a prominent rocky bank) to fuzzy (such as depth-related boundaries over extensive sediment plains). To enable these attributes to be recorded with the data, each ground (polygon) boundary was treated as being composed of four segments – typically these were relatively well defined inner and outer segments together with two 'ends'. To achieve a consistent approach to recording information for all grounds, the segments were normally classed as being north, south, east and west segments.

Many fishing grounds are named by fishers, and provide insights into their bottom types, locations, features, or landmarks used to find them before the advent of GPS navigation, e.g. those from the eastern Bass Strait region (Williams and Bax, 2003). Names are fundamental components of maps and, as well as providing a common reference for fishers, are also very useful for scientists to visualize and navigate around the unseen working landscape of the offshore fleets. Slightly fewer grounds are named in the GAB (484) compared to the SEF (517) and the GAB grounds were generally larger. This is mainly due to the sheer scale of the region (some 360,000 km^2) coupled with the extent of unexplored areas, but also due partly to simpler geology in the fishery region of the GAB (Li et al. 2008), and difficulty meeting with fishers in remote areas across the central and western south coast where ground polygons were based mainly on scientific data.

Additional data on grounds from questionnaire

Descriptive and semi-quantitative attributes of the seabed were collected systematically for each fishing ground using a simple questionnaire developed with industry help. These data were subsequently linked to maps via a spatial database.

Terrain type and habitat attributes

At the coarsest scale of resolution, fishing grounds were classified into one of five 'terrain type' classes based on their estimated proportions of sediment plains and rocky reefs. In concept, this classification was a first step towards defining fishery habitats and was designed to assist in the delineation of grounds during the process of map making. It provided a simple thematic map product that could be returned to contributors as part of the quality assurance process, and could be used for error checking by the project team. It took no account of the different types of sediment and rocky bottoms at different depths, and the sediment: reef ratios were initial estimates. The five terrain types were:

1 - 'heavy reef'(contiguous rocky banks or densely scattered reef patches)
2 - 'sediments with many reef patches' (reef making up ~30-70% of total ground area)
3 - 'sediments with few reef patches' (~5-30% reef)

4 - ‘clear sediments’ (reef less than 5%)
5 - ‘unknown’

Subsequently, fishers provided their descriptions of geomorphology (‘what the bottom looks like’) and their best estimates of the proportions of bottom types (‘what the bottom is made of’) for each ground. The responses were recorded using a set of tick boxes linked to a set of terms commonly used and understood by fishers. Comment boxes were used to record other notes about habitats and other features of fishing grounds, such as patterns of use, seasonality of species, and any other relevant information.
Geomorphology (‘what the bottom looks like’) was recorded as presence or absence of the following features or characteristics:

1 - Flat 2 - Sloping 3 - Steep 4 - Undulating 5 - Rugged	6 - Bank 7 - Valley 8 - Canyon 9 - Hill 10 - Seamount

Bottom type (‘what the bottom is made of’) was recorded as the estimated percentage cover of 10 classes, or as unknown:

1 - Mud - soft & boggy 2 - Mud - compact 3 - Sand 4 - Gravel 5 - Rubble	6 - Sandstone 7 - Mud boulders 8 - Slabby 9 - Heavy low reef 10 - Heavy high reef

Map data processing

A customised relational database was designed in the database software "Access" to store the project data; all habitat attribute data were linked to geo-referenced maps of fishing grounds in the GIS.

The quality of the mapping and attribute data provided by fishers was estimated by CSIRO, both for reporting purposes and because the quality was variable. This variation in quality was due to a number of factors, including the detail of bottom type and spatial resolution of a boundary that was, or could be, provided. Most commonly, variable quality stemmed from a limited knowledge of particular areas and bottom types, e.g. rugged and complex areas that are only fished by static (non-trawl) gears which provide little in the way of physical material to back up a fisher's impression of bottom type. This resulted in some distinct sector-specific differences, with trawl skippers generally having the best impression of bottom types in areas that they fish as a result of seeing the wear on gear and material caught in trawl nets. They also provided more specific area boundaries because the limits of trawl areas are marked in plotter data to minimise damage to their gear. For shelf waters off Western Australia there was little contact with fishers and fishery data is not recorded with accurate locations. For western WA, scientific and chart data as well as some trawl records provided insights but for eastern WA and the western Eucla province in particular many of the grounds had low confidence.

We classified our confidence in the raw information provided by fishers with respect to bottom types and boundaries using the following criteria, and the scoring system shown in Table 4.2.3.1.

Table 4.2.3.1 Definitions and confidence scores for boundary types and bottom types attributed to 'fishing ground' polygons

	Boundary types definitions
Distinct	Defined physical feature (usually a reef or canyon)
	Depth (distinct surrogate for broad faunal boundary; inc 1300m line)
Moderately distinct	Poorly defined physical feature (eg, mosaic of patchy reefs)
	Depth (less distinct boundary)
	Arbitrary (but unimportant) - ground based on tow time/ boundary in line with other feature or landmark
	Political (State boundary; limits of GAB region)
Indistinct	Unknown (estimated) (eg, gaps, no information provided)
	Confidence levels and criteria
1: Boundary known with certainty	All known + distinct + corroborated
2. High confidence	All known + distinct/ moderately distinct + corroborated
3. Good confidence	All known + [most distinct + uncorroborated OR moderately distinct + corroborated]
4. Moderate confidence	All known + moderately distinct + uncorroborated
5. Low confidence	One or more indistinct (unknown) and/ or disagreement
	General bottom types definitions
Distinct	Homogeneous substratum (eg, 1, rocky reef to 4, sediment plain)
	Homogeneous geomorphology (as above)
Moderately distinct	Heterogeneous substratum (mixed types, eg, canyon)
	Heterogeneous geomorphology (mixed types, eg, canyon)
Indistinct	Unknown (only partly sounded/ unsampled) or terminology confused
	Confidence levels and criteria
1: Bottom type known with certainty	Distinct + corroborated + validated
2. High confidence	Distinct/ mod. distinct + corroborated + validated
3. Good confidence	Distinct/ mod. distinct + [corroborated OR uncorroborated but validated]
4. Moderate confidence	Distinct/ mod. distinct + uncorroborated + unvalidated
5. Low confidence	Indistinct (unknown) and/ or disagreement and/ or terminology confused

Confidence levels for fishing ground boundaries

Confidence was defined as: “CSIROs confidence that the lines used to define a polygon map object are valid'. The frame of reference is: "defined seabed areas (as polygons) are identifiable or natural areas for commercial fishes (distribution and abundance), or commercial fishing, or a major geomorphological unit where fishing doesn't occur".

General guidelines for scoring confidence:

• Corroborated is defined as a generally good (unquantified) agreement on a boundary in two or more maps. Agreement is not an exact match but the coincidence of polygons with generally similar boundaries. Often, two or more contributors contribute to, and agree on, features in one map. This is not counted as corroboration for these criteria unless both operators have a strong working knowledge of the areas as skippers.

• Validation is not included in this score because very few boundaries are validated (and then only in part) or can be validated (e.g. boundaries based on the depth distributions of fish assemblages). Verification of distinct boundaries would require swath maps and these exist for only a few areas.
• No distinction is made between original media types - electronic track plotter data, lat/ long coordinates or paper charts - because positional errors can not be estimated or compared between each. Any medium can be highly accurate.
• No account is taken of transcription errors for similar reasons; CSIRO was assumed to be consistent; fisher error (between boundaries and between fishers) is unknown.
• Fisher ability is not factored in because only experienced skippers contributed information for grounds they know well (experience is documented in questionnaire)
• Only very distinct physical features have natural boundaries; most boundaries are indistinct in nature

Confidence levels for fishing ground terrain type

Confidence level is defined as: “CSIRO confidence that the general description of terrain type within a polygon map object is valid”. The frame of reference is: "terrain type is the impression formed by fishers based on soundings, material caught, and wear on gear – including gear damage. Terrain type is generalised because it is assessed for areas ranging in size from a few square nautical miles to 100's of square nautical miles"

General guidelines for scoring confidence (and see Table 4.2.3.1):

• Corroborated is defined as a generally good (unquantified) agreement on a terrain type in two or more maps. Agreement is not an exact match but the coincidence of generally similar terrain types within matching polygons. Often, two or more contributors contribute to, and agree on, features in one map. This isn't counted as corroboration for these criteria.
• ‘Validation’ is included only in the terrain type score because many terrain types are validated with scientific soundings, photographs or sediment samples.
• Terminology has been standardized to the extent possible through extensive discussions with fishers and the use of a standard list of terms in the questionnaire.

• Fisher ability is not factored in because only experienced skippers contributed information for grounds they know well (experience is documented in the questionnaire).

We also applied quality assurance procedures to the other data used, especially logbook data – see relevant section below.

4.3 Fishery logbook and observer mapping data and processing

4.3.1 Commonwealth logbook data

Data used for analysis were annual downloads provided to CMAR by AFMA, processed using standard protocols. The last five years of or trawl logbook data were used because it most accurately reflects current fishery practices and the current distribution of effort. Data are provided for four statistical reporting zones (Figure 4.3.1.1).

Trawl Commonwealth logbook data

Coverage: Most current trawl effort is along the edge of the shelf at around 120–220 m. This logbook data covers less than 10% of the entire GAB.
Mapping Characteristics: Trawl data provide a detailed picture of the main shelf fishing grounds. The current five boat rule however impedes distribution of map products. For slope fishing grounds, much of the information is sensitive and confidential.
Quality: the last five years of data are of high quality. Early data is problematic with some (1%) shot locations that are clearly erroneous: e.g. on the abyssal plain, on land etc.
Utility to addressing key issues: the data has high utility for target and byproduct species and allows examination of spatial and temporal trends. Retained byproduct species are recorded but bycatch species are generally not recorded.

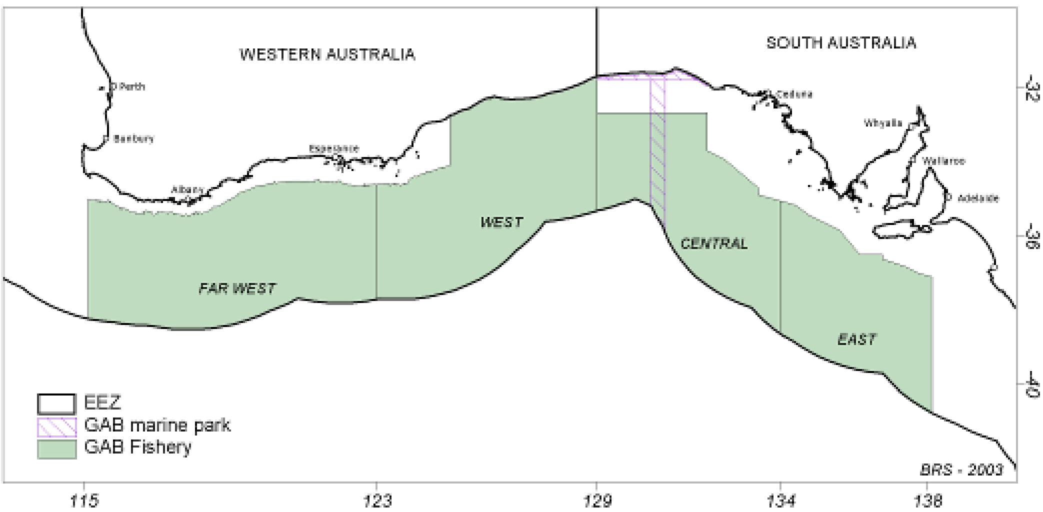


Figure 4.3.1.1 GAB showing four statistical reporting zones used for Commonwealth trawl logbook data

Commonwealth gillnet and auto-longline (GHAT) logbook data

Coverage: Auto-longline data is restricted to the narrow upper slope from the WA border to Kangaroo Island. Commonwealth gillnet data covers a greater area of the GAB than any of the other data sets considered.
Mapping Characteristics: Gear deployment is generally not restricted by bottom type therefore effort was not an indicator of particular bottom types. For gillnet data this could be inferred using whiskery sharks and a few other species as indicators of particular bottom types.
Quality: Only recent data, resolved to lat/ long resolution, were used for auto-longline and gillnet effort: 2004–2008 for auto-longline and 1997–2008 for gillnet. There are a number of identification problems where species are only recorded to the family level e.g. skates, gulper sharks and whaler sharks.
Utility to addressing key issues: The gillnet data were useful for examining movement patterns of byproduct shark species, particularly where concentrations could be seen seasonally at the head of the GAB and at the entrances to embayments e.g. hammerheads. Discarded bycatch species are not always recorded.

4.3.2 Commonwealth observer data

Data recorded by scientific observers on trawl and auto-longline vessels were used primarily to examine catches of key issue discard species that are not recorded in logbooks. The gillnet sector has only recently introduced observer programs and this data are not yet available, apart from bottom type and topography data. Bottom type data consists of the weight of different categories of benthos retained per gillnet shot (sponge, bryozoan, rock). Topography scored as either flat, sloping or undulating

Interviews with observers were valuable for interpreting the gillnet survey data and for the trawl sector, for checking locations and information about rare species and/or high risk species. Many fishing ground boundaries and bottom types were refined or corroborated during observer interviews using the same criteria and scoring as fishing industry data (see 4.2.3).

Coverage: Most observations are recent, starting in 2000 for the trawl and 2004 for the auto-longline sector. Observations are spatially and temporally patchy, largely reflecting the distribution of effort.
Mapping characteristics: The available observer data for the auto-longline sector is limited to <50 shots and potentially there is additional data to be collated.
Quality: Overall the data is of high quality. There are possible problems with the identification of some species e.g. dusky sharks, gulper sharks and boarfish
Utility to addressing key issues: The data has high utility in examining key issues, particularly for bycatch species. The 5-boat rule makes presentation of the data difficult and some of the fishing locations are confidential and sensitive. Not all areas are represented in the data sets and care is needed when using this information to interpret the bathymetric/geographic ranges or habitat preferences of species.

4.3.3 State fisheries data

Data from the South Australian Northern-Zone Rock lobster were used to verify coastal fishing grounds and heavy reef, particularly around the west of the Eyre

Peninsula. The data corroborated information from interviews with rock lobster fishers and published reports on rock lobster habitat in SA coastal waters.

Data from three fisheries operating in waters off Western Australia was also requested. South Coast Crustacean, South Coast Trawl and Temperate Gillnet. Only the gillnet data had sufficient spatial resolution to be informative and only at 60 mile scales therefore utility was low.

4.4 Scientific mapping data and processing

4.4.1 Historical bottom trawl data (1909 – 1989)

Endeavour (1909)
These data were mappable (Figure 4.4.1.1) after location conversions were made by Neil Klaer of CSIRO: positions recorded as line-of-sight references to landmarks, estimated distances offshore, and depth records, were converted to estimated lat/longs. Data collected between Aug and Sept 1909 and used here are 64 catch records of 20 species/species groups from 8 stations (see below).

Coverage: surveys only cover the eastern part of GAB (east of 132º longitude)
Mapping characteristics: position accuracy low – only estimates available
Quality: fish identified by common name only (interpreted as family groups)
Utility to addressing key issues: very limited scope, but the historical aspect of catch composition is potentially useful for considering temporal trends in latchet and leatherjacket. For other groups, utility is limited by species resolution in the data.

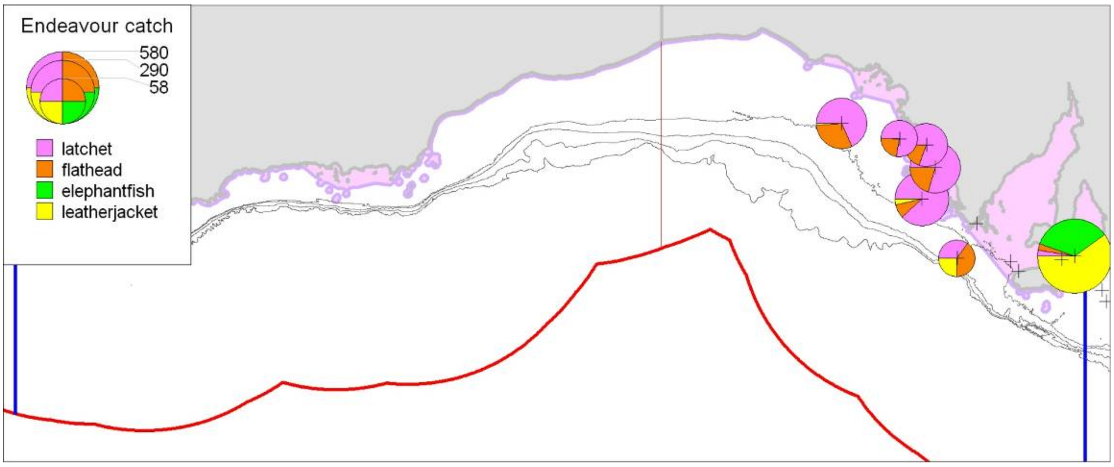


Figure 4.4.1.1 Location of Endeavour bottom trawl samples, coded and graded by catch numbers of four major fish groups. Red line: EEZ boundary, blue lines: GAB boundaries; pink: state waters; grey contour lines: 100 m, 20 m, 700 m, 1300 m

Ben Dearg and Commiles (1949-52)
Data could not be sourced.

Southern Endeavour (1960-61)
Data could not be sourced.

British United (Saxon) Trawlers (1975-79)
Data could not be sourced.

Soviet bottom trawl data (1965-1973)
Surveys conducted by Soviet vessels in the GAB were between April 1965 and October 1973; data are from16 surveys by 11 vessels, accounting for 2735 deployments (34,189 catch records) (Table 4.4.1.1). Station locations were recorded as latitude/ longitudes. The data were obtained by exchange with Soviet scientists in the mid 1990s and has had CSIRO species codes incorporated. See Koslow et al. (1999) for details of the data and quality assurance methods.

Table 4.4.1.1 Summary of the Soviet data downloaded from CSIRO Trawler, the Marlin ID refers to the metadata record number in CSIROs Information Network MarLIN.

SURVEY NAME	MARLIN ID	# deployments	Date first deployment	Date last deployment
BERG196503	5923	106	11/04/1965	2/05/1965
BERG196601	5924	468	10/01/1966	18/06/1966
SESK196601	5925	265	18/01/1966	17/06/1966
RADU196608	5926	381	15/09/1966	5/03/1967
LIRA196702	5927	556	21/03/1967	2/08/1967
KORI196802	5929	179	26/02/1968	21/05/1968
SUTC196807	5931	126	15/08/1968	5/01/1969
SRTM196903	5934	36	29/03/1969	13/04/1969
ALBA197009	5937	25	8/09/1970	20/09/1970
ALBA197103	5938	78	11/03/1971	2/04/1971
POSE197107	5939	25	22/07/1971	5/08/1971
EQUA197109	5940	46	18/09/1971	2/10/1971
RADU197206	5941	257	5/07/1972	13/10/1972
P-DER197210	5942	1	22/03/1973	22/03/1973
LIRA197304	5943	170	31/07/1973	4/10/1973
ALBA197310	5944	16	17/10/1973	22/10/1973

On 8 of the Russian surveys, the bottom type for the start and/or end of deployments were recorded – in total 915 records. We interpreted these records into 4 sediment types (1: sediments, 2: shelly sediments, 3: coral sediments, 4: rocky sediments) and used them for mapping (Figure 4.4.1.2).

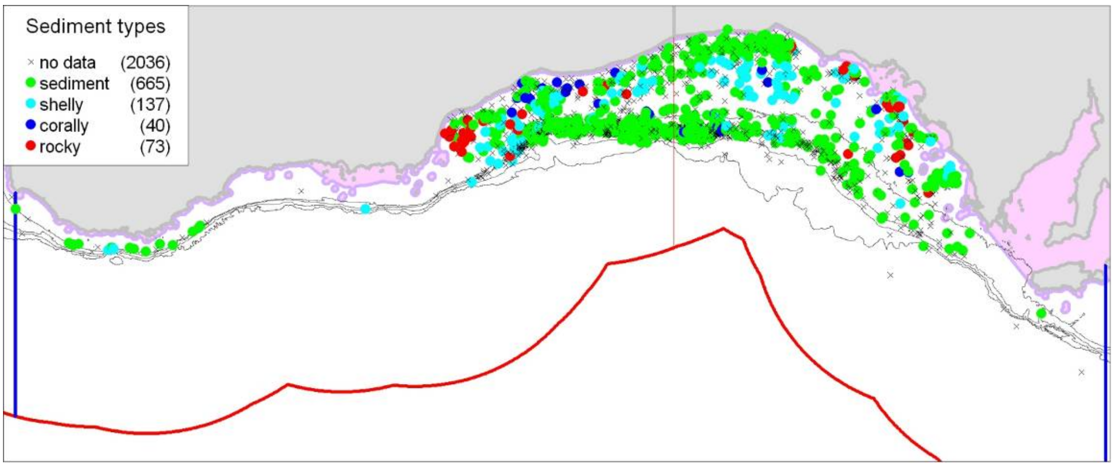


Figure 4.4.1.2: Location of Soviet bottom trawl samples coded by sediment types (see legend, # records in brackets); red line: EEZ boundary, blue lines: GAB boundaries; pink: state waters; grey contour lines: 100 m, 20 m, 700 m, 1300 m

Coverage: complete coverage of the GB region with most intense coverage in the central GAB (125ºE-136ºE)
Mapping characteristics: position accuracy reasonable; broad sediment types recorded in places
Quality: fish identifications are to species, but catch records may not be consistent across all surveys; position estimates could be out by 10 – 15 miles
Utility to addressing key issues: only presence/absence data used for quantitative analyses, while a relatively large number of species (61) were deemed to have consistent taxonomy and were available to assess distributions.
Notes: Underestimated the amount of sponge and coral when compared to the gillnet survey data, although presumably the trawls avoided the roughest patches. Good for delineating sandy and shelly sediments.

CSIRO bottom trawl surveys (1978-1989)
Australian fisheries surveys were conducted on the research vessels RV *Courageous* (6 surveys between February 1978 to April 1979) and RV *Soela* (7 surveys between January 1980 and January 1989). These data account for 382 deployments and 6574 catch records. Station locations were recorded as latitude/ longitudes (Table 4.4.1.2; Figure 4.4.1.3). These data are stored on the CSIRO database 'CSIRO Trawler' and are generally available through the MarLIN information network.

Table 4.4.1.2 Summary of the CSIRO bottom survey data downloaded from CSIRO 'Trawler' database. The Marlin ID refers to the metadata record number in CSIROs Information Network MarLIN.

Project	SURVEY NAME	MARLIN ID	# deployments	Date first deployment	Date last deployment
Courageous fish surveys 1978-1979	COUR197831	5113	18	14/02/1978	19/02/1978
	COUR197832	5114	31	1/03/1978	17/03/1978
	COUR197833	5115	34	31/03/1978	10/04/1978
	COUR197945	5126	44	26/01/1979	10/02/1979
	COUR197946	5127	28	24/02/1979	11/03/1979
	COUR197947	5129	53	23/03/1979	8/04/1979
Soela fish surveys 1980s	SO198001	4982	17	16/01/1980	23/01/1980
	SO198003	4986	6	7/05/1980	13/05/1980
	SO198006	5001	8	5/09/1980	20/09/1980
	SO198103	5011	42	25/07/1981	18/08/1981
	SO198103	5011	2	29/07/1981	
	SO198103	5011	17	30/07/1981	
	SO198105	4983	62	28/11/1981	14/12/1981
Orange Roughy Project	SO198801	5091	8	23/01/1988	25/01/1988
	SO198801	5091	1	24/01/1988	
	SO198901	4977	11	25/01/1989	27/01/1989

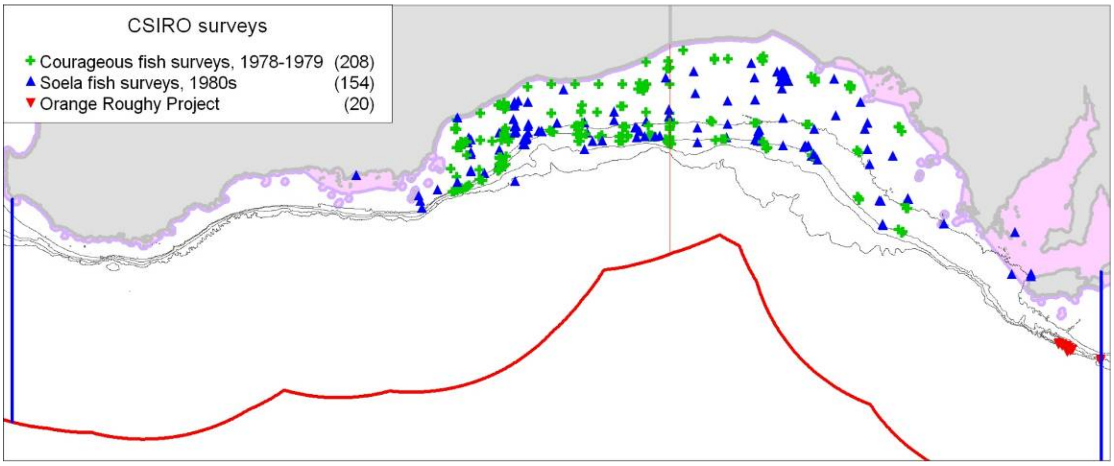


Figure 4.4.1.3 Location of CSIRO bottom trawl samples coded by project; red line: EEZ boundary, blue lines: GAB boundaries; pink: state waters; grey contour lines: 100 m, 200 m, 700 m, 1300 m

<u>Coverage</u>: mostly central GAB
<u>Mapping characteristics</u>: position accuracy good
<u>Quality</u>: fish identifications to species; catch records generally reliable
<u>Utility to addressing key issues</u>: good potential source of catch composition data, but see notes below. There is scope to map up species-habitat associations.
<u>Notes</u>: Catchability may be affected by differences between the survey gear and current commercial gear.

4.4.2 SARDI benthic survey data

Summaries of megabenthos (large benthic animals) biomass at phylum-level from a survey of undertaken by SARDI were kindly provided by Dr Tim Ward. The distribution of sample sites is shown in Figure 4.4.2.1 and examples of mapped data in Figure 4.4.2.2); a full account of the survey and results are given in (Ward et al. 2006).

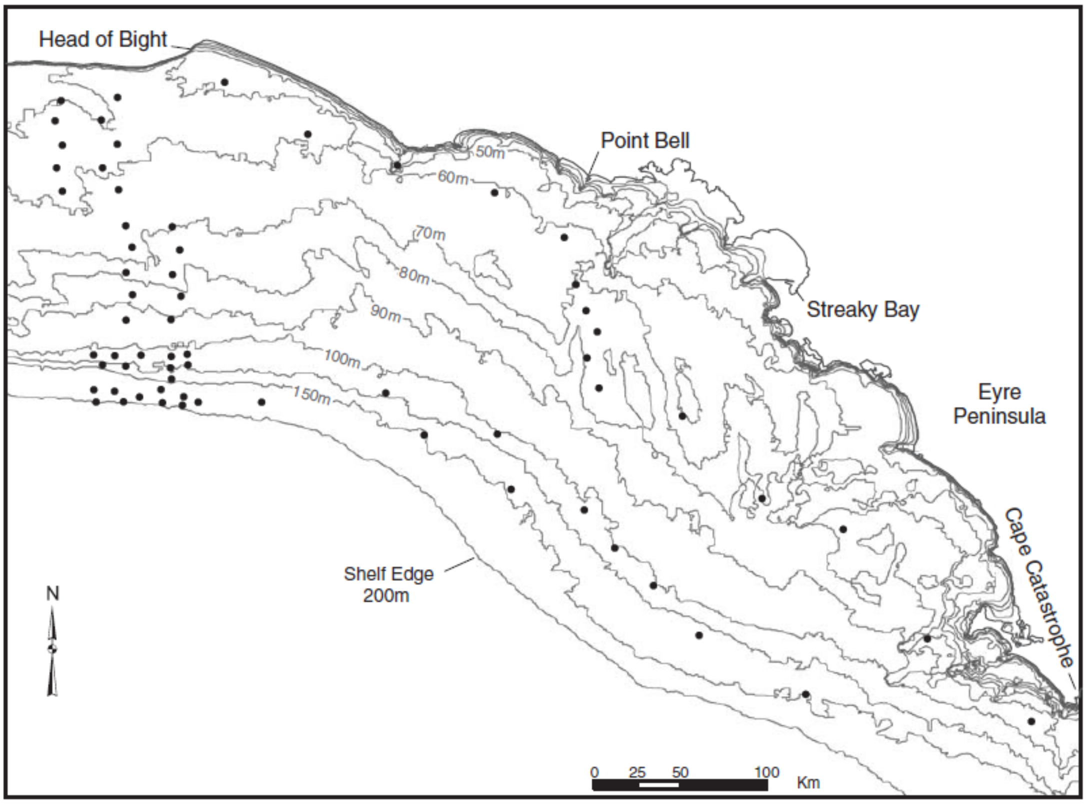
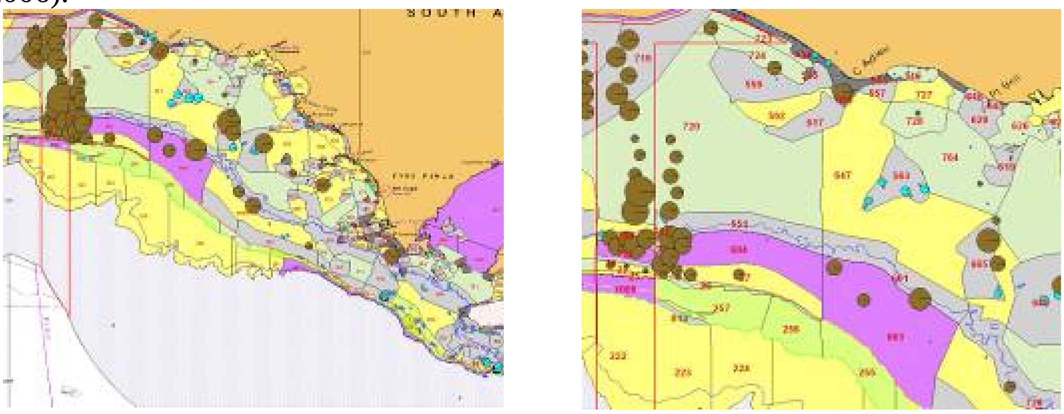


Figure 4.4.2.1 Distribution of SARDI sampling sites for megabenthos (from Ward et al., 2006).



(a) (b)

Figure 4.4.2.2 Distribution of bryozoans in SARDI megabenthos samples and from gillnet survey; (a) all sample locations shown, with symbols scaled to proportion of bryozoans: brown – SARDI samples, blue – gillnet survey samples. (b), zoom-in to central area.

Coverage: cross-shelf, eastern GAB
Mapping characteristics: faunal composition mappable at coarse taxonomic resolution
Quality: high
Utility to addressing key issues: key supporting data set
Notes: Sponges, bryozoans and cnidarians (corals) are good indicators of fishery habitats because they are frequently associated with ‘hard’ bottoms (rocky banks, consolidated or coarse gravelly sediments) and are ‘ecosystem engineers’ providing biogenic habitat - erect structural habitat for fishes and the key components of

sediments. The distributional results are consistent with the gillnet survey data (see section below) for sponge and bryozoan (recorded as 'coral'). Benthic community structure shows strong depth-related grouping on the inner and outer shelf (~80 m and ~110 m) and shelf edge at ~170 m. Among these three groups, the shelf edge group had the highest degree of endemism and has the greatest overlap with trawling. These distributions have important correlations with important fishery habitats, for example, (1) at 110 m the presence of an ancient (paleo-) coastline used by School Shark, Whiskery Shark and Gummy Shark, and (2) shelf edge grounds – principal habitat for Deepwater Flathead and one of the preferred habitat types used by Bight Redfish. Physical factors linked to community distribution and fishery habitats include temperature, salinity, oxygen and chlorophyll. The influence of temperature on productivity is frequently reported by fishers, e.g. warm water on Gummy Shark grounds near the head of the Bight.

4.4.3 Bathymetry and sediment data

The 250 m grid resolution bathymetry data set complied by Geoscience Australia (GA) was used in all mapping underlays. Reference was made to other GA seabed topographic classifications – especially the geomorphic feature mapping used for bioregionalisation (Harris et al. 2005; Heap et al., 2005; Heap and Harris 2008). (Figure 4.4.3.1).

Other sources of high resolution bathymetric mapping were available in some areas, for example the western GAB (see section 4.4.8). Figure 4.4.3.2 provides an example from the shelf and slope adjacent to Albany.

These high resolution data were amalgamated in overlays (Figure 4.4.3.3) for the purposes of informing some of the fishing ground polygons (bottom type, boundary definitions) where fishers' data were lacking or uncertain.

<u>Coverage</u>: variable: gridded bathymetry and geomorphic features for entire Australian EEZ, but local multibeam coverage.
<u>Mapping characteristics</u>: most bathymetry interpolated grid to 250 m cells based on relatively sparse data in the GAB
<u>Quality</u>: interpolated grid to 250 m cells based on accurate point data – data spread in the GAB is relatively sparse
<u>Utility to addressing key issues</u>: bathymetry data were highly useful for many mapping applications. Geomorphic features were useful, but frequently incomplete (where there were no multibeam data) and lacking detail on the continental shelf.
<u>Notes</u>: most of the GAB remains unmapped at fine scale.

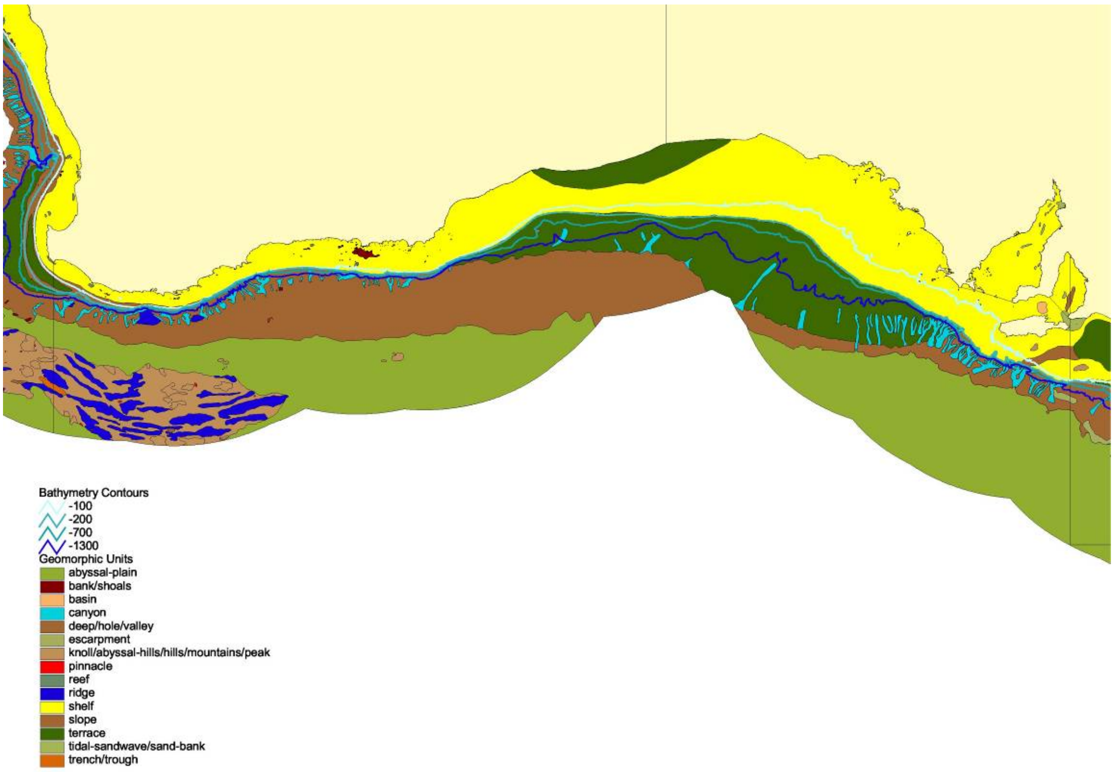


Figure 4.4.3.1 Seabed topographic classifications “Geomorphic features” by Harris et al. 2005. Red line: EEZ boundary, blue lines: GAB boundaries; pink: state waters; coloured contour lines: 100 m, 200 m, 700 m, 1300 m

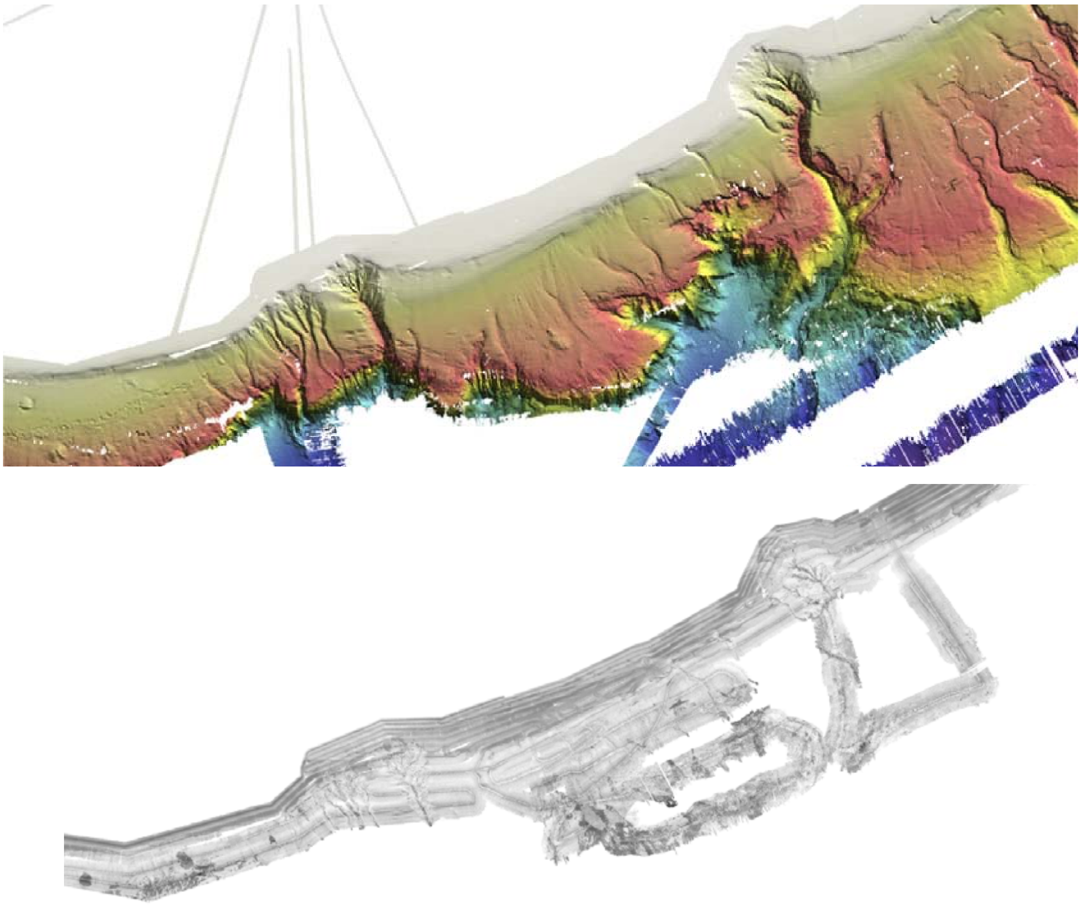


Figure 4.4.3.2 High resolution bathymetry data from outer shelf and slope adjacent to Albany (from 2005 CSIRO survey, WA VoD); top panel, high shaded bathymetry; lower panel, backscatter showing bottom hardness.

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Figure 4.4.3.3 Multi-beam backscatter data from the Western GAB coloured in three substrate hardness categories: green - soft, yellow- mixed, red – hard. Blue line: GAB western boundary; pink: state waters; pink contour lines: 100 m, 20 m, 700 m, 1300 m

4.4.4 Diana gulper shark survey data (2005)

In winter 2005, an industry survey was undertaken in upper slope waters off South Australia. The survey was successful in locating a lightly fished population of Southern Dogfish southwest of Port Lincoln (unpublished field survey data CSIRO 2005). Part of the areas was closed to all fishing methods, assisting with the conservation and management of this species. Data was collected on two vessels: the Riba 2 and the Diana.

Coverage: Upper slope waters (200–700 m) from the SA/WA border to kangaroo Island.
Mapping characteristics: Catch rates for a range of shark and scalefish species can be linked to particular depth and bottom types. The data is complemented by other observer data from the auto-longline sector.
Quality: The data from the Diana are reliable and suitable for quantitative analysis of catch rates. Catch rates for line surveys are expressed as the number of individuals caught per 100 hooks, or % catch rate. Data from the Riba 2 has reliable species identifications but can not be used for determining catch rates. These data were used to supplement records by identifying additional localities where Southern Dogfish occur.
Utility to addressing key issues: This data has high utility for high risk deepwater sharks including Southern Dogfish and Greeneye Spurdog. It is the only data set available for some species of sharks and rays that are new to science and only recently described.

4.4.5 CSIRO survey of ’60-mile’ gulper shark closure

During survey work in March 2008 in the 60-mile closure, which is located at the shelf edge in ~200-1000 m depths SSW of Pt Lincoln), the entire gulper shark closure was mapped with an EM300 multibeam sonar, and a variety of high quality maps were produced. Camera tows in the 60-mile closure (Figure 4.4.5.1) provided 13.5 hours of high quality: calibrated stereo video along 19 transects and 5600 high resolution digital still images. These data have been processed, and enable quantified mapping and description of habitats and fauna in a depth zone not surveyed in detail elsewhere in the GAB. Data are concentrated on the key depth zone of interest to gulper sharks (300-600 m), but some extended from the shelf edge (<200 m), or deeper than 600 m. The steepest and roughest seabed in the closure was surveyed successfully. Some additional data were also taken from the DeCoudec Canyon (Figure 4.4.5.1). Data have contributed to the risk assessment component of this project.

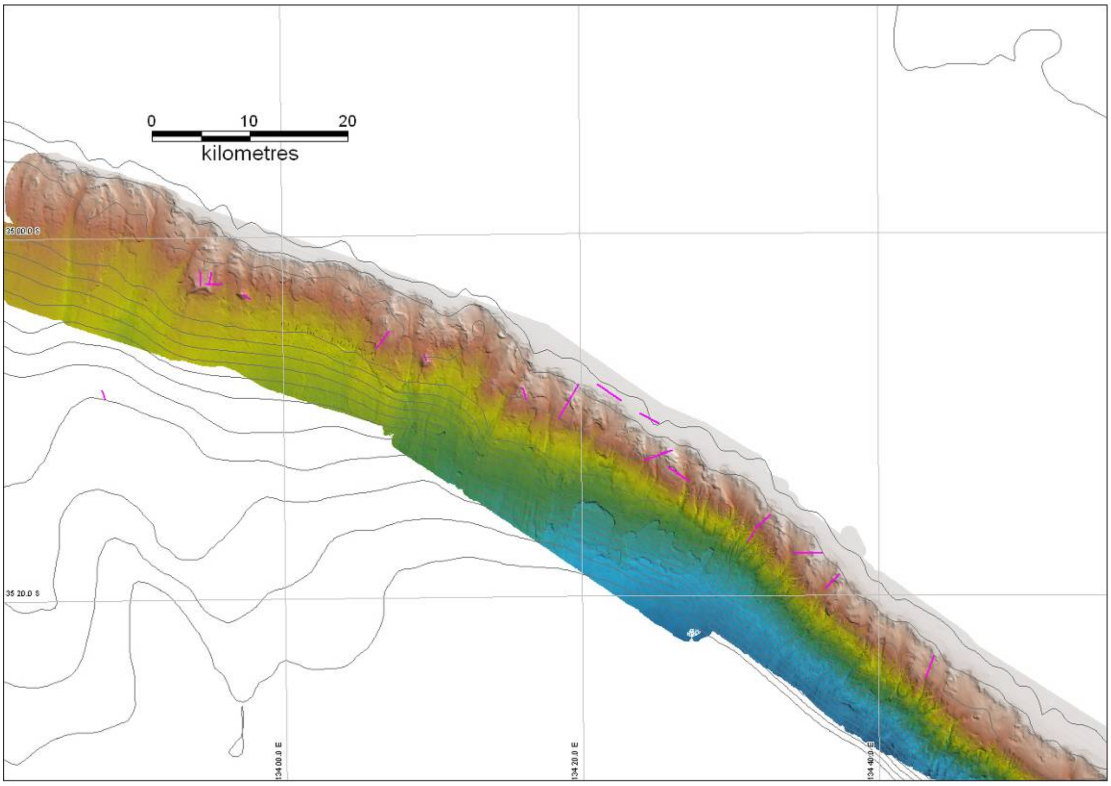


Figure 4.4.5.1 Sun-illuminated swath bathymetry of the fishery closure area off Port Lincoln showing camera transect positions (pink lines) completed during the National Facility survey (SS2008/03).

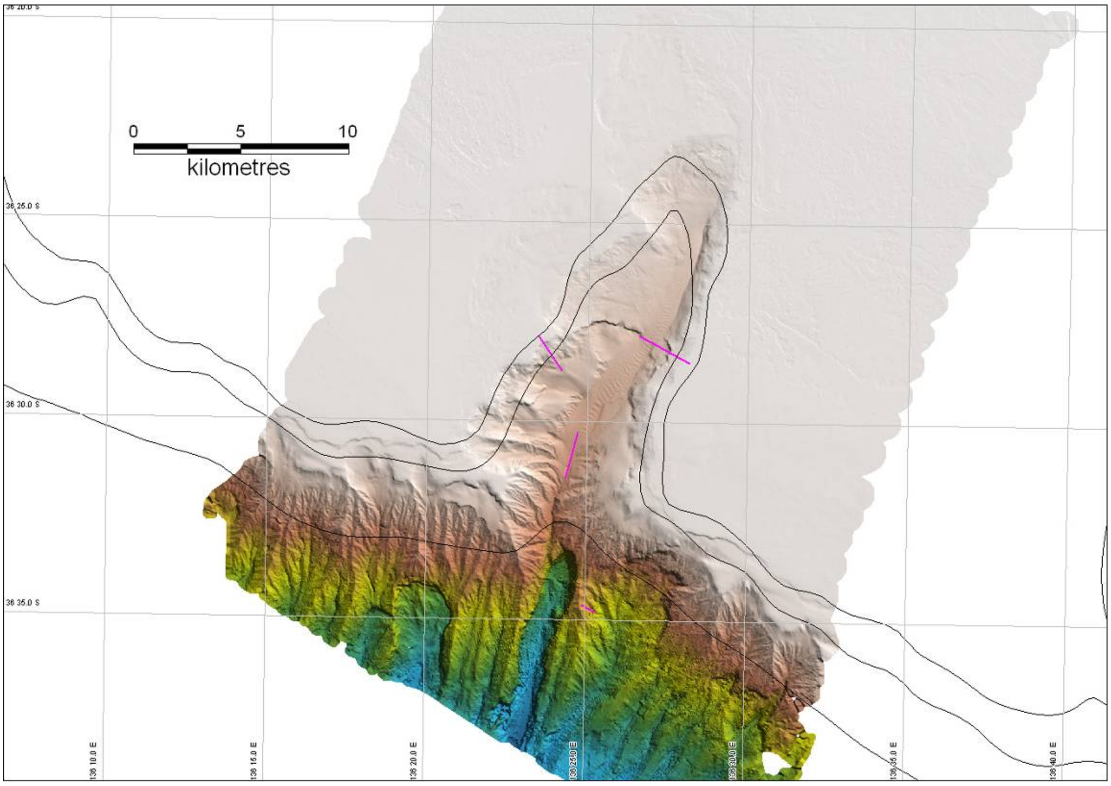


Figure 4.4.5.2 Sun-illuminated swath bathymetry of the DuCouedic Canyon off Kangaroo Island showing camera transect positions (pink lines) completed during the National Facility survey (SS2008/03).

Coverage: limited to closure area, with some coverage of DeCouedic Canyon to the east.
Mapping characteristics: excellent high resolution bathymetry and photography
Quality: high
Utility to addressing key issues: good insights into habitat requirements of gulper sharks and associated upper slope species. Quantitative data on habitat distributions at scales equating to the substructure (reef patches, gullies, canyons, sediment terraces) of fishing grounds.

4.4.6 Gillnet survey benthos and topography data

In 2008 the GHAT fishery undertook extensive gillnet surveys to establish baseline data for an index of abundance to measure recovery of School Shark stocks. A total of 187 sites were surveyed during 21 Voyages. Of these, 81 stations were completed off South Australia during eight voyages. The main data collected were catch rates for species. These data are currently under analysis by MAFRI and will be reported separately. Ancillary data collected during the voyage (when time permitted) included substrate, topography, the weight of three categories of benthos in the net (coral rock and sponge, as well as notes on any damage to the nets. These data were kindly provided by MAFRI and interpreted with the help of their observer staff.

Coverage: Limited to waters off South Australia but extending from the shoreline to the edge of the shelf.
Mapping characteristics: Because this information was not recorded for every shot, most analysis was qualitative.
Quality: The number of stations sampled was higher than the project's camera survey but the benthos are only characterised to broad categories. It is not clear how much of the 'coral' data represents bryozoans, although it was possible to verify that a number of types of hard coral were retained in the net by examining specimens retained by fishers (Figure 4.4.6.1).
Utility to addressing key issues: High utility for understanding the characteristics of School Shark habitats and other important habitats to the west of the Eyre Peninsula and at the Head of the GAB.
Note 1: For the purposes of future surveys it would be worth reporting this data with greater consistency if resources were adequate. It is noted that, depending on weather and schedules, this may not be possible for a single observer.

(a) *Euplexaura?* (b)Unknown 'tree-forming' coral

(c) Unknown stony coral

Figure 4.4.6.1: Examples of hard corals collected by fishers off South Australia

4.4.7 Bioregionalisation data

The benthic bioregionalisation of the Australian continental slope presented by Last et al. 2005 identified the GAB region as the Southern Province (Figure 4.4.7.1). The shelf area of the GAB encompasses seven meso-scale regions within the South Western and the Gulf demersal provinces and the GAB Biotone (IMCRA 1998). IMCRA 1998 is currently under review; however, changes to the regions identified in IMCRA 1998 are expected to be minor. The updated version is not yet available (W.White pers. comment).

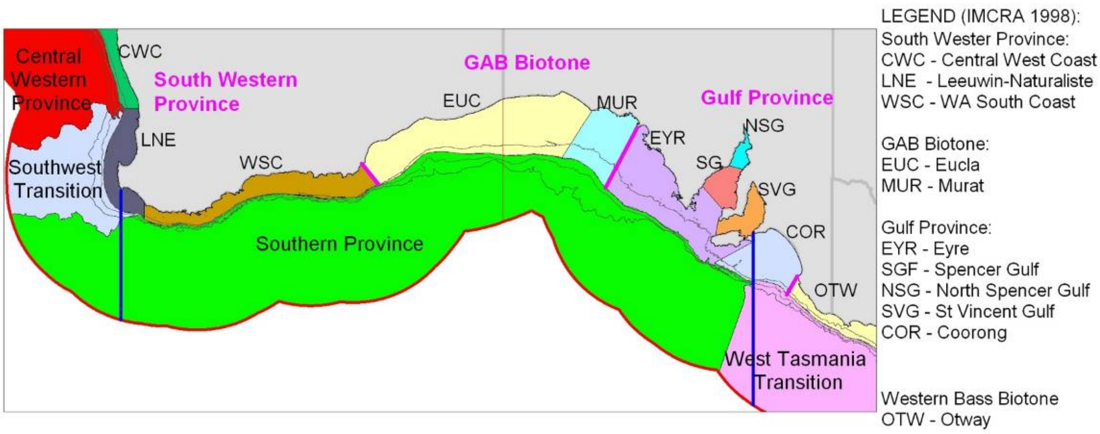


Figure 4.4.7.1 Bioregionalisation of the GAB: Coastal shelf bioregionalisation meso-scale regions by IMCRA 1998 (see legend) and slope bioregionalisation by Heap et al (2005). Red line: EEZ boundary, blue lines: GAB boundaries; pink: state waters; grey contour lines: 100 m, 20 m, 700 m, 1300 m

<u>Coverage</u>: covers entire region
<u>Mapping characteristics</u>: sources variable in type and quality, but broad structure strongly influenced by the distributions of fish communities which are the most comprehensive and reliable biological data set.
<u>Quality</u>: as above.
<u>Utility to addressing key issues</u>: this information provides a fundamental template for assessing ‘representativeness’ – the large sub-areas of the GAB which need to be considered separately when establishing a network of closed areas for habitat and

species protection. These are the upper slope and midslope, provincial structure of slope and shelf, and meso-scale structure of the shelf (Figure 4.4.7.1).

4.4.8 Seabed photographic survey undertaken by this project

CSIRO chartered the 29 m FV *Lucky S* for the photographic survey component of the GAB mapping project. An experienced GAB trawl skipper (Tim Parsons) was available to run the vessel and contribute to the finer details of the sampling design based on extensive detailed fishing ground knowledge.

The CSIRO ‘shallow’ camera system was successfully deployed from this vessel. Setup included deck mounting the electric hydraulic winch (with 1,000 m fibre-optic cabling), mounting a gantry at the stern of the vessel and setting up the camera control console and associated electronics on the bridge of the vessel. Typically the camera was towed near-bottom for 20 minutes at about 1.5-2 knots. The video was recorded to digital DV Cam tapes. High resolution digital still images were taken at 15 second intervals for the duration of the tows.

A camera survey was planned as a core element of the project to complement the information available to describe the habitat types of GAB fishing grounds (Objective 1). It was also designed to validate (at point locations) some of the habitat information provided by industry (Objective 2). The intention was to involve industry in the survey design and implement it from an industry vessel. The data acquired would then feed into the process of map making, and an assessment of habitat vulnerability to fishing (Objectives 3 and 4). The voyage report for the project is included as Appendix D. The survey design was developed in conjunction with the project’s steering committee, and with direct input from trawl and non-trawl fishers. An ambitious list of sampling sites was developed, and a rationale for each was provided (Appendix 1 in report). Overall the voyage was implemented very successfully and in accordance with the survey plan. There were 39 operations at 35 sites completed along the ~1,200 nautical miles vessel track (see survey report). In total, 13.6 hours of seabed video and ~ 2,500 high-resolution digital still images were taken in depths between 18 and 415 m.

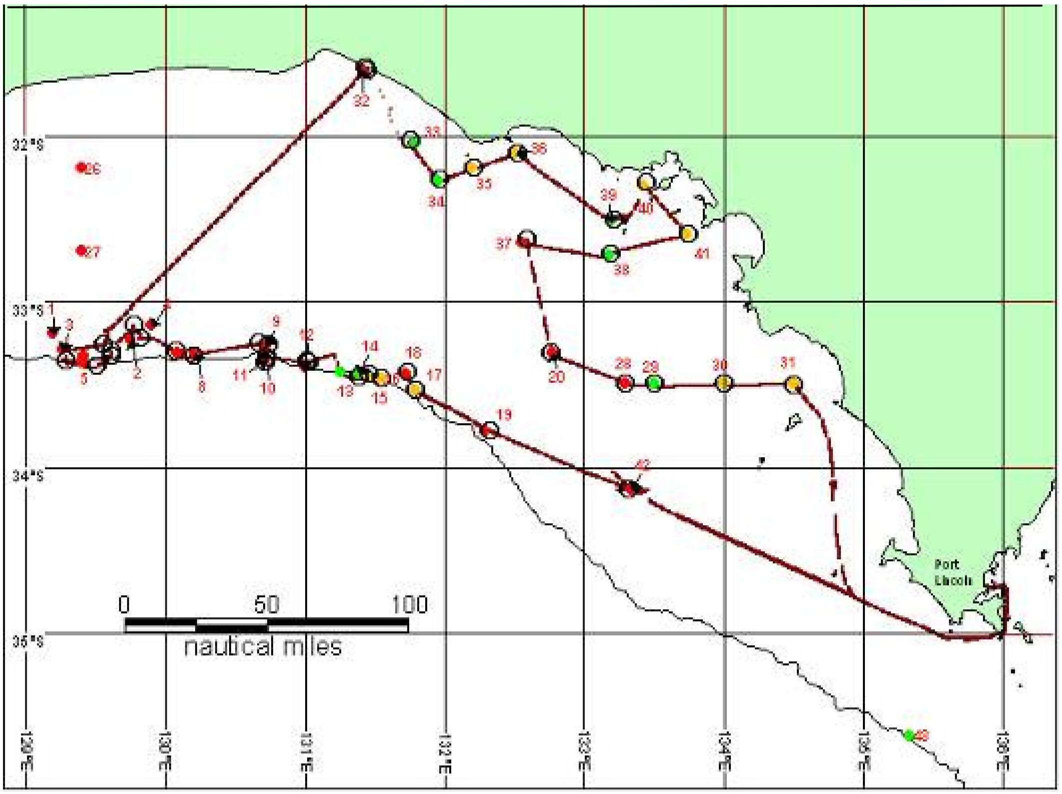


Figure 4.4.8.1. Map showing all potential photographic sampling sites for the GAB mapping camera survey, with those completed joined by the vessel track.

<u>Coverage</u>: short transect samples over a wide depth range in the eastern GAB
<u>Mapping characteristics</u>: limited to photographs
<u>Quality</u>: high quality, georeferenced images
<u>Utility to addressing key issues</u>: validate (at point locations) some of the habitat information provided by industry, and adds to the assessment of habitat vulnerability to fishing.
<u>Notes</u>: see report (Appendix D)

4.4.9 Historical seabed photographic surveys

Western GAB (as part of western Australian margin survey) (2005)
During 2005 two surveys of the Western Australian coast were conducted by CSIRO Wealth from oceans Flagship. On the first survey (SS200507) the habitats of the continental slope were mapped using multi-beam acoustics and towed video. Four of the survey sites were situated in western part of the GAB: D'Entrecasteaux, Pt Hillier, Albany and Bald Island (Table 4.4.9.1; Figure 4.4.9.1).

Table 4.4.9.1 Video transects from the western GAB collected on the western Australian margin survey SS200507.

Site	Target depth	Video transect numbers
Pt D'Entrecasteaux	400	163
Pt Hillier	100	210, 211
Pt Hillier	400	164, 165

Albany	100	175, 193
Albany	200	176, 209
Albany	400	177, 208
Albany	700	178, 192
Albany	1000	191
Bald Island	400	207
Bald Island	1000	206
Bald Island	100-750 (across depth)	205

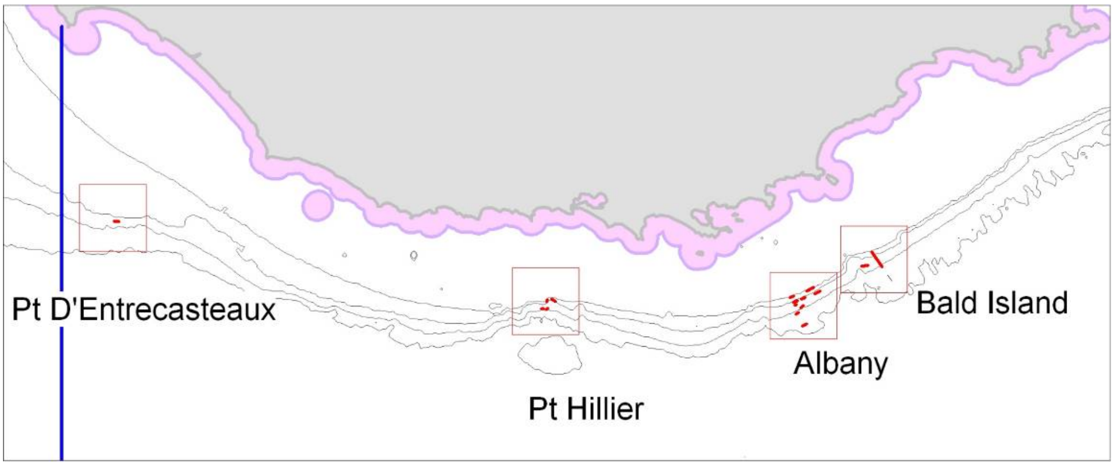


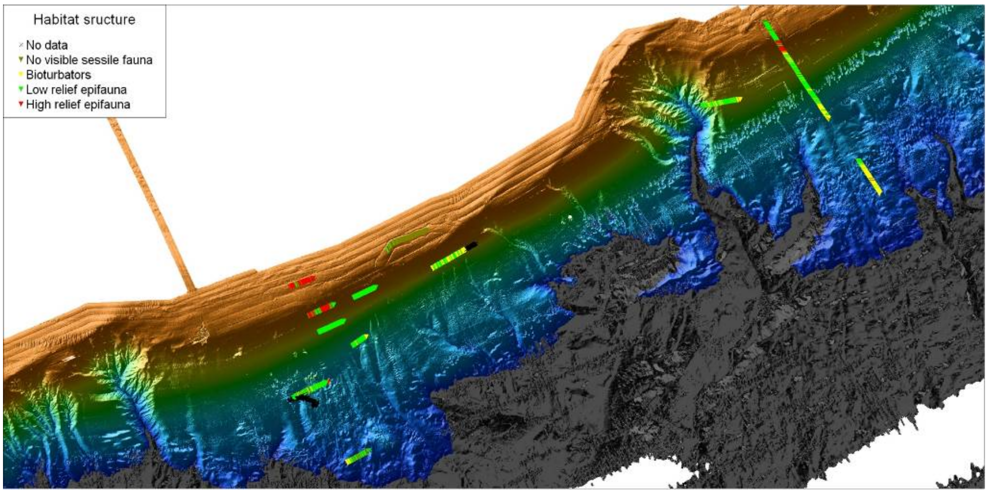
Figure 4.4.9.1 Location of the four sampling sites where video was collected on the SS200507 survey. Red line: EEZ boundary, blue lines: GAB boundary; pink: state waters; grey contour lines: 100 m, 20 m, 700 m, 1300 m

Description of the habitat types from the combined Albany and Bald Island sites: Habitat structure was described from video and can be visualised in Figure 4.4.9.2. The outer shelf (80-150 m) was dominated by consolidated, hard substrates that are covered by a veneer of fine to muddy sediments; but some areas of soft, rippled substrates were also observed to the west. The fauna formed sparse to moderately densely distributed, small patches of octocorals, hydroids, bryozoans, ascidians and small to medium sized sponges.

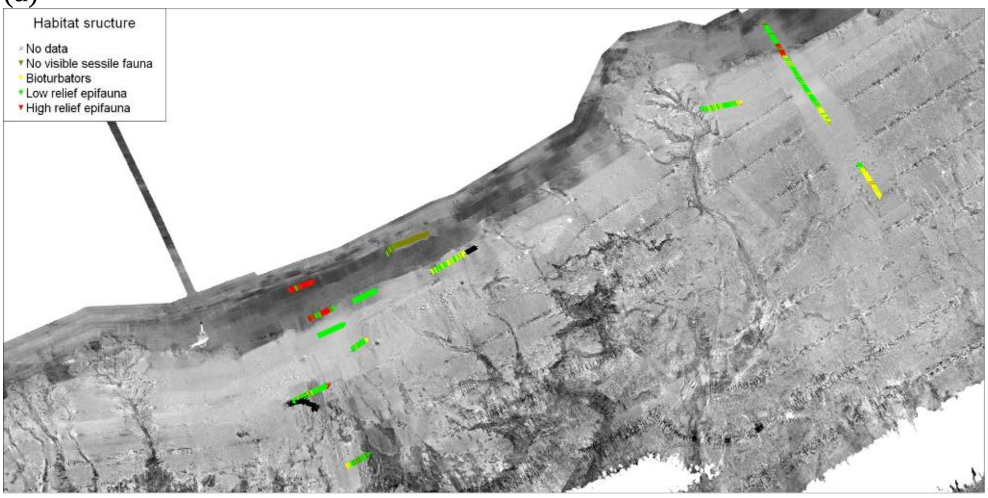
The shelf-break (150–250 m) was dominated by consolidated, hard substrates that were covered by a veneer of fine to muddy sediments with the occasional rocky outcrop in the east. The fauna formed moderate to densely distributed patches of larger sponges, octocorals, hydroids, bryozoans and ascidians.

The upper slope (250–800 m) was dominated by soft substrates pock-marked with feeding pits and burrows; the deeper part of the upper slope appeared to be covered in detrital matter. A small canyon head on the deep upper slope in the western part sported a few rocky outcrops. Emergent fauna was sparse – only occasional anemones and mall sponges were observed.

The mid-slope (800–1100 m) of the Albany site was covered in patches of old dead coral fragments, followed by weathered rocky outcrops dusted with muddy sediments in the deeper part of our transect. The coral substrate sported a moderately dense cover of low encrusting anemones, some life coral and sponges. The rocky outcrops were relatively devoid of sessile fauna, except for the occasional soft coral (anthomastus). Where sediments were observed they were bioturbated, and some urchins and ophiuroids were seen in our footage. The mid-slope of the Bald Island site still showed soft substrates pock-marked with feeding pits and burrows; however, there was evidence of currents winnowing detrital matter and coarser sediments into waves. We also observed an outcrop of large, rocky boulders. Emergent fauna was sparse – only occasional seapens or bryozoans and some sea urchins were observed.



(a)



(b)

Figure 4.4.9.2 Example of the combined Albany and Bald Island sites with video transects coded by dominant structural habitat type at 1s intervals (at m scale), underlaid with (a) swath bathymetry and (b) backscatter

Benthic Protection Zone (2000)

Several small areas of the BPZ were mapped during a survey in 2000 to evaluate an acoustic multibeam (swath) mapping instrument. An overview of results was provided by Kloser et al. (2001).

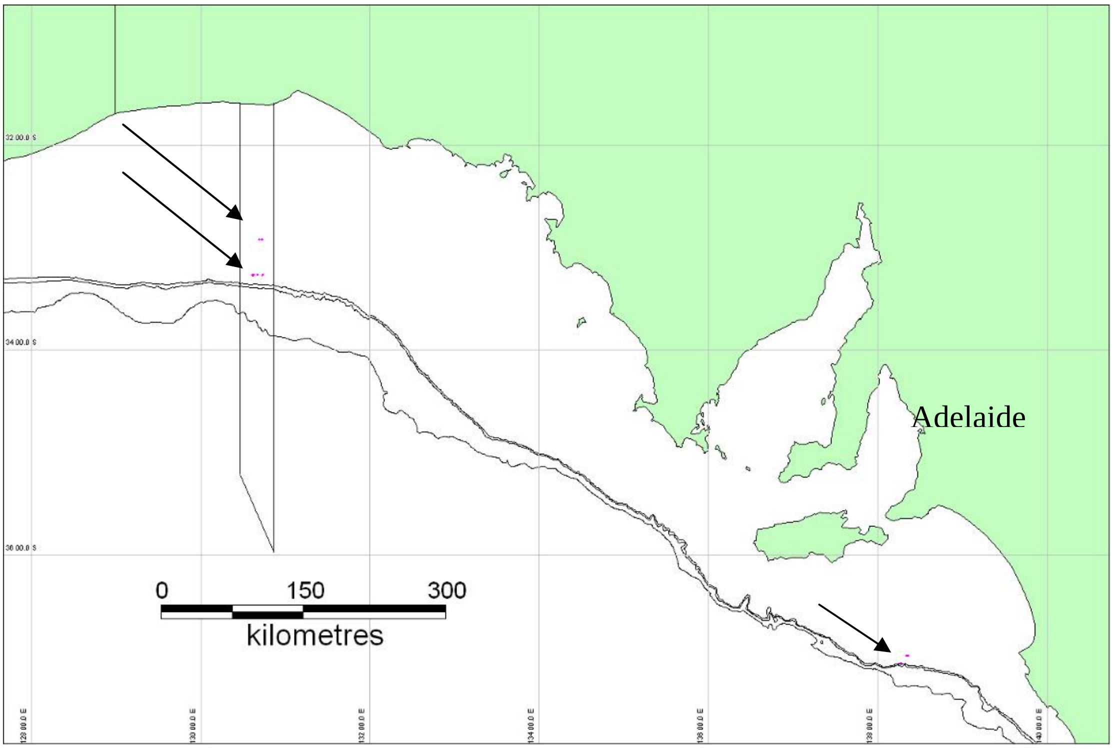


Figure 4.4.9.3 A map showing the GAB Benthic Protection Zone, 1000, 300 and 200 m depth contours, and the locations of camera transects (see arrows) both within the BPZ and on the Lacepede Shelf conducted during the survey conducted from FRV Southern Surveyor in the year 2000.

'60-mile' Southern Dogfish closure & DuCouedic Canyon (2008)
See Section 4.4.5.

4.4.10 Fishery Independent Surveys

Coverage: These independent data focus on fish caught using trawl gear. The survey area extends from 126º–132º 30' but is restricted to outer shelf waters: 120–200 m. Final survey reports are available for four annual surveys. The most recent report that has been widely circulated is for the 2008 survey (Knuckey et al. 2008). A draft report for the 2009 survey is completed and the next survey will be conducted in 2011.
Mapping characteristics: The data are recorded at the scale of individual trawl shots. There is some loss of precision because the exact point where a species enters the net can not be resolved. The uncertainty associated with this method of measurement is in the order of + - 1 mile.
Quality: These data are of high quality in terms of statistical design and quality control. The scale of reporting is more precise than most data sets with the exception of cray fishers marks.
Utility to addressing key issues: These data are used as a fishery-independent index of abundance for the major quota and non-quota species caught in the GAB shelf fishery. From 2005 – 2008 there were declines in five non-target species: Common Sawshark, Gummy Shark, Latchet, Ornate Angelshark and Spikey Dogfish. When the highest levels of risk assessment available for each sector are considered, none of these species are considered high risk and therefore not included in mapping analyses. However the Ornate Angelshark was included in mapping analyses in this project

because it is identified in the Chondrichthyan Guide for Managers and in the Ecological Risk Management plan for the GABT (see Section 4.5.0).

Although there has been limited use of the FIS data set in this project, these data are highly valued for identifying any issues as they emerge in the future.

4.5 Key issues for spatial management of the GAB

4.5.0 Process to identify the key issues

At the first Steering Committee meeting (26 March 2007) it was proposed that the uptake and impact of the project was likely to be higher if it focussed on a number of specific issues related to spatial management of fisheries, rather than the more generic mapping and product development approach specified in the projects objectives and methods. Further, any project-generated scenarios or evaluations would ideally consider the range of relevant issues together, i.e. an integrated series of closures would take account of species and habitat needs from conservation programs (e.g. Orange Roughy), risk assessments (ERA), development of the SW Commonwealth MPA network by DEWHA, and fishery initiatives including bycatch reduction. FRDC emphasized their interest in a high level of uptake of results from their projects. It was noted that there was a risk of being overly ambitious (e.g. in regard to MPA engagement) since the ‘key issues approach’ implied a considerable extension of the work required. However, because the end result would be considerably enhanced, it was agreed to follow this approach.

A draft table of key issues was developed and distributed to the SC, and discussed and refined at the two following SC meetings (August 2, 2007 and May 3, 2008). The final form of the list, endorsed by the SC, is shown below (Table 4.5.0.1).

The processes contributing to the lists of species and habitats to be considered included the Strategic Assessment of the SESSF (2006 WTO), the Ministerial Direction, the Bycatch Action Plan for the SESSF, and the ERA for the fisheries operating in the GAB. The process of developing the SW Commonwealth MPA network by DEWHA was an overarching influence.

Table 4.5.0.1 Key issues for GAB fisheries (relevant to spatial management)

Issue	*Sector(s)/ species*	*Need*	*Pathway*	*Fishery goal*	*Knowledge gaps/ key uncertainties*	*Existing measures*	*Other factors*
1. Key species Species listed, nominated, or singled out for urgent action due to overfishing	**Orange Roughy** **GABT**	1. Determine where Orange Roughy are concentrated and regulate fishing in these areas.	1. Map core Orange Roughy habitats from catch data and define managed research zones	Assess status of GAB stock as part of rebuild temperate Australian stock of Orange Roughy	1. Proportion of the likely core habitat within the research zones	1. GABIA plan Supported by AFMA Board in March 2007 2. Recovery plan under development 3. Orange Roughy Conservation Programme	Existing effort is focussed on the target species not the habitat (issue 3)
	Southern Dogfish (*C. zeehaani*) **GABT Auto-longline**	1. Determine where populations still exist and regulate fishing in these areas	1. Map habitats from catch, observer data and survey data 2. Determine habitat associations 3. Identify adequacy of exiting closures	Avoid listing	1. Existing closed areas offer some level of protection but its not clear how effective they are for the Southern Dogfish, or for a relatively large number of associated species	1. 60-mile closure in GAB 2. Other fishery closures and CMRs in CTS of SESSF	Largely addressed through other projects based on Industry survey and CSIRO project Base line abundance measurements needed. Possible monitoring through FRDC project.
	School Shark **Gillnet**	1. Ensure the new closures in inshore waters mitigate fishery impacts. See notes under bycatch	As for Important Fishery Habitat	Allow rebuilding of the School Shark stock	1. Locations of breeding females	1. Seasonal closure off Kangaroo Island. 2. Nursery areas in State waters off SA and WA. 3. Other closures that were implemented for other purposes may offer protection by good fortune	If listed will require a recovery plan
2. Byproduct and bycatch species: A variety of by-product and bycatch species exist in GAB	**GABT** **Auto-longline** **Gillnet**	1. List the important species and relevant sectors. List from GABRAG (GABT) GHAT – ERA species Gillnet – ERA species 2. Determine habitat associations of high	1. Quality assure and produce distribution maps of byproduct and bycatch species 2. Overlay with observer data for validation 3. Identify the species-habitat associations from mapping overlays (and any pre-existing	Understand spatial distribution of species to inform management options aimed at bycatch reduction.	1. Distributions of some species poorly known 2. Taxonomic resolution poor for some data	1. Trigger points for scale fish. 2. Catch limits on target species limit effort and effects on sharks and rays 3. Some relevant spatial closures exist	See Historical survey data

		risk by-product and bycatch species (for KEY ISSUE 3 – IFH)	data and literature) 4. Describe the preferred habitat of the species. 5. Determine the relevant areas unfished in the GAB.				
3. Important fishery habitats (IFH): Habitat dependencies of some GAB fishery species are linked to fishery production	**GABT** **Auto-longline** **Gillnet** ***Bight Redfish Deepwater Flathead Latchet Morwong Ornate Angelshark boarfishes Gemfish deepwater shark group***	1. List the species and relevant sectors 2. Define/ identify the types and characteristics of important fishery habitats (inc. species associations as proxies for ecological roles). To the resolution possible, determine how much of each and where they exist 3. Review literature on IFH conservation needs	1. Map science data (biodiversity surveys, seabed mapping, historical catch data) and GABT polygons. 2. Acquire and interpret fishers' knowledge 3. Review catch data/ and literature 4. Describe the preferred habitat of the species at scale relevant to regional mapping 5. Determine the relevant areas unfished in the GAB.	EBM includes measures to ensure IFH types are not compromised.	1. Ecological services and habitat associations not fully known 2. Mapping data may not provide sufficient temporal or spatial resolution to ID small areas	1. Commonwealth & State MPAs; (existing and planned).	Large untrawlable and untrawled areas exist in certain depth ranges
4. Vulnerable benthic habitats: ERA reports vulnerable habitat types exist in GAB	**GABT** **Auto-longline** **Gillnet** Habitat depth ranges and vulnerable types different for each sector	1. Determine which vulnerable habitats exist, and to the extent possible, how much of each and where they exist	1. Map science data (biodiversity surveys, seabed mapping) and GABTF polygons. (Note, coarse-scale definitions of habitat, may be surrogates for fine scale habiats, e.g. seamounts for deep corals, rocky banks for shelf sponges beds etc.)	EBM includes measures to ensure VBH types are not compromised.	1. Distributions/ amounts of vulnerable habitats may be known only at coarse scales 2. Incomplete mapping	1. Commonwealth & State MPAs; (existing and planned). 2. Orange Roughy managed areas. 3. GABIA closures 4. Permanent, year-round fishery closures necessary for habitat protection	Large untrawlable and untrawled areas exist in certain depth ranges. Sponge beds may be cleared if effort pushes into new grounds – relevant to trawl effort distribution

4.5.1. Key species (EPBC assessed)

Special consideration was given to two fish species listed under by Australia's Environment Protection and Biodiversity (EPBC) Act and known to interact with fisheries in the study area: Orange Roughy and School Shark. Both are listed as conservation dependent and are the subject of Conservation Plans that aim to halt further population decline and promote a level of population rebuild (AFMA 2006, AFMA 2008A). Although not currently listed, the Southern Dogfish has been nominated for listing and was also given special consideration to assist in preparing submissions to the Threatened Species Scientific Committee to inform their decision on the nomination. These species were analysed on a species by species basis because recovery plans call for species specific responses.

For the three EPBC species and all bycatch/ byproduct species (following section), we synthesised information relevant to determining species' habitat associations (Appendix E).

Orange Roughy

AFMAs initial management response under the conservation plan for this species was a blanket closure in waters >750 m depth across the GAB. The key research need for Orange Roughy highlighted by the Steering Committee was to determine where Orange Roughy are concentrated and regulate fishing in these areas (Table 4.5.0.1). This species is widespread on the mid-slope (~700-1300 m depths) off temperate Australia but concentrated within this bathome in relatively small areas where aggregations form around seabed topographic features such as seamounts (e.g. Koslow et al. 2001). These features are identified both as Important Fishery Habitat for this species and as vulnerable habitat, and treated below (Sections 4.5.2, 4.5.3).

In this project we identified and mapped Orange Roughy distribution based on historical catch data to provide the basis for a GABT Deepwater Management Plan (Moore and Knuckey 2007) as an alternative to the blanket deepwater closure. This identified a network of areas that encompass 95% of historical distribution of catches within which catches of Orange Roughy are closely regulated.

Southern Dogfish (gulper shark)

The key research need for this species highlighted by the Steering Committee was to determine where populations exist, and where suitable habitat occurs, as the basis to regulate fishing in these areas (Table 4.5.0.1). The Southern Dogfish is restricted to the upper slope bathome, mainly in 300–600 m depths, and appears most abundant around canyon heads and on the terraces that run between canyons on the upper slope. These features are separately identified as Important Fishery Habitats for this species (sections below). Within this bathome, abundance appears to vary between regions. Catch data for this species is limited and it has been misidentified in many fishery and scientific catch records. Consequently literature and fishery data sources do not provide robust understanding of the characteristics or distribution of preferred habitat. In this project we examine the distribution of a population examined between the SA/WA border and Port Lincoln, using industry survey data (Diana and Riba 2, 2005) and evaluate a scenario developed by GABIA for expanding spatial management of this species.

Catch data were first standardised between the Riba 2 and the Diana. On board Diana every hook of every shot was observed (with the exception of two shots when tagging took place. On board the Riba 2, approximately on third of hooks on each shot were observed. For Riba 2 the catch of gulper shark was estimated by multiplying the number of gulpers recorded by three. Because there were problems with standardising the number of hooks on the Riba, catches are represented as number per shot and are not standardised for effort.

School Shark

There is concern that the bycatch of School Shark in the gillnet sector is still a higher than acceptable to enable recovery of the species in the timeframe set out by the Conservation Plan. School Shark are known to be associated with hard bottom on the mid-outer shelf and a primary strategy for avoiding them is to 'fish shallow', away from deeper habitats with reef patches – particularly avoiding the ancient coastline and shelf edge IFHs (see Section 4.5.3).

A secondary avoidance strategy considers habitat variation on the inner shelf. When considering School Shark habitat association, the Important Fishery Habitat type 1 (see Section 4.5.3 below) - structured inner shelf habitats – can be sub-divided into: 1-a rocky shoreline with diverse attached epifauna, 1-b: sandy areas with low algae, 1-c areas with reef patches and attached bryozoans and sponges. The second of these (1-b) can be targeted by gillnet fishers aiming to avoid School Shark which are more commonly associated with the harder inner shelf substrates.

In this study we evaluated the primary strategy by reviewing archival tagging data (West and Stevens 2001) in light of information on the habitat preferences provided from fishers and the IFH classification for School Shark (See Section 4.5.3, Appendix E). It may be possible to evaluate the secondary strategy but this was not attempted at this stage because it would require more input from the gillnet sector and a finer scale examination of inshore habitats.

Important habitats for School Shark were further considered using field data from the Gillnet Survey and the Camera Survey together with catch data and fishing ground descriptions provided by fishers. This analysis was restricted to commonwealth waters east of the SA/WA border. It was not possible to analyse the area west of the SA/WA border because few School Shark occur in this area and further the lack of spatial resolution in WA gillnet data precludes such analysis

4.5.2. Bycatch and byproduct species, and habitat associations

While managing the catch levels of target or EPBC species is based on species-specific evaluation, such as through stock assessments, options for regulating catch of the broad range of non-target species (i.e. reducing bycatch) provides a separate challenge in the context of spatial closures. In this project we examined the options for mapping the distributions of bycatch and byproduct species groups, and reviewed knowledge of their habitat associations, to identify options for management actions aimed at bycatch reduction (Table 4.5.0.1).

Species selection

An initial set of 57 bycatch and byproduct species was selected and divided into four groups by the Steering Committee. The groups were based on Ecological Risk Assessment and risk management planning processes:

- the auto-longline Species Group (ASG) (6 species) and Gillnet Species Group (GSG) (7 species) were based on ERA rapid level 3 results and only contained chondrichthyans (Zhou et al. 2007).
- For the trawl sector no species were considered at risk at ERA level 3, therefore the Commercial Species Policy and the Chondrichthyan Guide for Managers (AFMA 2008B, AFMA 2009) were used to define two groups: Trawl Chondrichthyan Species Group (TCSG) (22 species) and Trawl Scalefish Species Group (TSSG) (12 species).

For each of the 57 bycatch/ byproduct and EPBC species considered, the quality of 7 different fishery and research catch data sets were evaluated on a species by species basis and scored according to set criteria (Table 4.5.2.1). To be included in analysis, the minimum data quality score was 3. Species that did not score 3 or higher for any data set were excluded: Bronze Whaler, Dusky Shark, Scalloped Hammerhead, Shortfinned Mako, Rough Flutemouth, Melbourne Skate and Silver Warehou. These species occur largely outside the fishery (out of range), entirely outside the range of the fishery (likely misidentifications), or have identification problems. Some species were duplicated in different groups and in each of these cases the species was considered in the sector where it was encountered most frequently. One species, the Southern Dogfish, was considered separately with key species (see Section 4.5.1). Chondrichthyan names were checked against the latest textbook and updated where appropriate following recent updates (Last and Stevens 2009). Species data were then analysed at the polygon level in groups (Section 4.6.2).

Units

For species, the catches referred to are generally the number of observations. Catch rates for gulper sharks is the number of individuals per 100 hooks. Catch rates for quota species generally refer to CPUE in kg/hr unless other sources are cited.

Metric selection

The groups of short-listed species were included in two analyses at the *species group* level. (Section 4.6.2).

- Bioregionalisation data analysis: A small number of high quality observations but with a high level of interpolation across broad scales and distributions are not scaled for intensity as affected by habitat distribution
- Integrated analysis of fishery and research catch data: No interpolation and potentially distributions can be scaled for intensity but the quality of the output is highly dependent on the spatial spread of the data

Table 4.5.2.1 Data quality scores for 57 species of interest to Commonwealth fisheries management in the Great Australian Bight. Species in red type were eliminated from further consideration; data sets with red highlight were considered duplicate data and excluded from some analyses.. Short listed species in black text. Data quality scores:1=potentially misleading, 0=nil value, 1=low, 2=medium, 3=high, 4=very high; definitions of quality scores expanded in Table 4.5.2.2 below.

Common Name	Trawl Log	Trawl ISMP	Trawl Survey	Line Log	Line ISMP	GN Log	Notes on Data quality
Auto-longline Species Group							
Blackbelly Lanternshark	NA	**3**	**3**	NA	3	NA	
Greeneye Spurdog	NA	3	-1	1	3	2	
Hapuku	1	3	3	3	3	1	
Skate (Bight)	2	3	NA	NA	3	NA	
Skate (Grey)	NA	3	NA	NA	3	NA	
Southern Dogfish							Considered in EPBC group
Gillnet Species Group							
Broadnose Sevengill Shark	1	3	3	0	NA	3	
Hammerhead (smooth)	1	3	3	1	NA	3	
Whiskery Shark	2	3	3	NA	NA	3	
Bronze Whaler							Confused ID
Dusky Shark							Confused ID
Scalloped Hammerhead							Out of range
Shortfinned Mako							Mainly in Bass St.
Trawl Scalefish Species Group							
Bigscale Rubyfish	1	3	3	1	1	NA	
Blacktip Cucumberfish	2	3	2	0	1	NA	
Deepsea (Spiny) Flathead	NA	4	3	NA	NA	NA	
Deepwater Stargazer	2	3	3	1	NA	1	
Gulf Gurnard Perch	2	3	3	NA	NA	NA	
King Dory	4	3	3	NA	NA	NA	
Swallowtail	2	3	3	NA	NA	NA	
Thetis Fish	NA	3	3	NA	NA	NA	
Tusk	4	3	3	3	3	NA	
Yelloweye Redfish	NA	3	NA	NA	NA	NA	
Rough Flutemouth							Essentially out of range
Silver Warehou							Limited catch data, spatially restricted
Trawl Chondrichthyan Species Group							
Black Shark		3	1	NA	3	NA	
Brier Shark	2	3	3	1	3	NA	
Golden Dogfish	2	3	3	1	NA	NA	
Gulf Catshark	NA	4	NA	NA	NA	NA	
Ornate Angelshark	3	3	3	NA	NA	-1	
Owston's Dogfish	2	3	3	1	1	NA	
Peacock Skate	1	3	3	0	NA	NA	
Platypus Shark	0	0	0	2	1	NA	

Portuguese Dogfish	2	NA	3	1	NA	NA	
Sawtail Catshark	NA	3	3	NA	3	NA	
Sharpnose Sevengill Shark	NA	3	3	1	3	NA	
Short-tail Torpedo Ray	No records	4	3	NA	NA	NA	
Smooth Stingray	NA	3	3	NA	NA	NA	
Southern Fidler Ray	2	4	3	NA	NA	NA	
Spikey Dogfish	2	3	2	2	4	NA	
Wide Stingaree	NA	4	3	NA	NA	NA	
Wobbegong (Gulf)	NA	2	2	NA	NA	2	
Wobbegong (Spotted)	1	2	2	NA	NA	2	
Southern Chimaera	2	3	2	2	4	NA	
Southern Dogfish							Considered in EPBC group
Melbourne Skate							ID problems

Table 4.5.2.2 Data quality classification for spatial analysis of species groups

Score	Category	Description
4	**Very high**	**Accurate ID, locations precise high spatial coverage, time series.**
3	**High**	**Accurate ID, precise location, limited spatial or temporal coverage**
2	**Medium**	**Mostly reliable ID, grid location, limited spatial or temporal coverage**
1	**Low**	**ID to genus or family level, position estimated, one or two locations only, no time series**
0	**Nil**	**No useful data**
-1	**Potentially misleading**	**ID incorrectly inferred from genus or family level, data outside known species range**

Description and classification of species-habitat associations

For each of the bycatch and byproduct species, as well as the three EPBC species, habitat associations were summarised using two approaches (Appendix E). The first approach was to summarise literature information. The second approach combined catch and habitat data.

To the extent possible, the literature review focussed on habitat dependencies with particular ecological roles (e.g. spawning area, shelter, food sources, etc.). While many of the species are poorly known and detailed information was very limited, species accounts were attempted for 48 species (3 EPBC species, 5 Auto-Longline Species Group, 7 Gillnet Species Group, 13 Trawl Scalefish Species Group, and 20 Trawl Chondrichthyan Species Group). This included some extra species that were not included in the species group analyses (Sections 5.5.1–5.5.3).

In the combined approach, catch data sets were mapped and overlaid on fishing ground polygons as well as habitat indicator data sets (gillnet survey data, SARDI benthic data, camera survey data, and CSIRO gulper shark data). Some 500 catch habitat maps were generated (a sub-set of 49 species x 6 catch data sets x 4 habitat data sets). For each map, the species–habitat associations were described in notes. The notes focused on maps derived from high quality catch data (Tables 4.5.2.1 and 4.5.2.1) although all available catch data were mapped and considered. These map notes were the basis for compiling a catch-habitat summary (C-HS) for each species. For each of the 48 species, the literature based summary and the C-HS are presented as species summaries (Appendix E). The individual maps and associated notes are not published here to maintain confidentiality requirements.

The catch-habitat summaries contributed to identifying Important Fishery Habitats (see following section). Most species (37) were more likely to occur on one or more IFH than in areas with no IFH. Two species were clearly not linked to particular IFHs: Broadnose Sevengill Shark, and Blacktip Cucumberfish. One species, the Rough Flutemouth, could not be linked to GAB habitats because it is sub-tropical. For five species (King Dory, Deepsea (Spiny) Flathead, Peacock Skate, Wide Stingaree) were only weakly linked to IFHs, although potentially they could be linked with further analysis or additional data.

4.5.3 Important Fishery Habitats (IFH)

The rationale for defining IFH in the GAB

The concept of "important fishery habitats" in the context of this study is used to define habitat areas that appear to provide ecological services linked to production of the fishery. The detail of the ecological linkage may remain unknown, and 'importance' is most often inferred simply from the fact that particular habitats support commercial species of marketable size and in sufficient abundance to support commercial catches. The previous section notes that spatial overlays of catch on maps of habitat, in conjunction with fishers' knowledge, provide an effective way to determine spatial relationships at coarse scale over a large fishery area. In the context of this project, the interest of the Steering Committee was in defining and better understanding distributions of IFHs to assist with the long term sustainability and spatial management of the GAB fishery.

It is worth noting that the comparable concept of 'Essential fish habitat' is defined under the primary United States fisheries legislation as: "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" (U.S. Magnuson-Stevens Act, 16 U.S.C. 1801 et seq). However, this definition is so general that it is unlikely to assist managers in making decisions on marine resource management. It also continues an overly species-centric approach to conservation that is increasingly seen as less valuable in comparison to the conservation of spaces or landscapes (Simberloff 1998, Roff and Taylor 2000).

Because the GAB is vast and the data available to map habitats is patchy and sparse, proxies are needed to extrapolate from mapped areas to those that remain unmapped. Integrating fishers' knowledge with science data is an effective way to do this at regional scale for the depth range that is fished (depths to ~1300 m) (e.g. in the SEF, Williams et al. 2006). Alternative methods to map habitats or species at fishery scale are not generally available, even for relatively intensely used areas, and there is no other alternative for the GAB. Geomorphology is a proxy that has had widespread use in marine resource planning in Australia (Harris 2007; Heap and Harris 2008) but typically does not classify and map habitat at fine-enough scales to be relevant to the distributions of fishery habitats or their use during fishing (Williams et al. 2009a).

In the integration of data during this project, fishers knowledge was used to refine maps of bathymetry and geomorphology, primarily by mapping finer scale features – albeit mostly at a rather coarse resolution for bottom type and with a need to define many different types of boundaries around and between habitat types (Section 4.2.3). However, mapping at this scale and resolution is highly suited to defining productive ('important') areas for the fishery. There were a number of habitats that were repeatedly and independently identified by different fishers and observers during our mapping process. Based on this, and from a considerable amount of other science data from the temperate Australian seabed used for fishing (e.g. Williams et al. 2006; Williams et al. 2000b), we defined six important fishery habitat types (IFH) represented in the fishery.

It is important to understand that IFH types are generalised descriptions, and while some of these are mappable at fine spatial scales, the mapping completed by this project was limited to the resolution of fishing ground polygons that have an average size of 745 km^2. Thus, IFHs were not individually mapped into the fishing grounds even where finer scale data were available. Rather, the distribution of IFHs was assessed using qualitative spatial analysis that scored each polygon based on whether each IFH was present or abundant there, and the confidence we had in that assessment. The polygon score for IFH was the sum of the scores for each individual IFH (Section 4.6.3)

IFH summary

'Important Fishery Habitats' (IFH) are descriptions of six classes of habitat important for fishery production that are:

- defined by integrating the knowledge of fishers, scientific observers and scientists on species-habitat associations and habitat distributions;
- represented at a spatial scale that is coarse relative to the real distributions of habitat types by using polygons with an average area of some 745 km^2;
- located spatially by using expert judgement to combine empirical evidence and inference about the presence and abundance of each IFH within fishing ground polygons; and,
- mapped by developing a simple metric that sums IFH scores within each polygon.

List and descriptions of six IFHs within the GAB

IFH type 1. Structured inner shelf habitats.

Structured habitats on the inner shelf (~<80 m depths) are provided by seabed communities (mainly sponges and bryozoan) which are often associated with hard bottom – variously coarse or cemented sediments; low relief rocky pavement – often with sediment veneers; and outcrops of rocky reef. These habitats are different to 'equivalent' structured habitats at the shelf edge where they support a different mix of fishes, life history stages, and community structure. They provide structural refuges, and probably higher prey densities, for a variety of key issue species:

- Typical inner shelf species, and other species that may have a shallow life history stage before adults migrate to deeper waters ('bigger-deeper'): Broadnose Sevengill Shark, School Shark, Dusky Shark, Rough Flutemouth, Latchet
- Highly mobile species that traverse the inner shelf and greater depths as adults: School Shark, Whiskery shark, Shortfin Mako, whaler sharks, hammerhead sharks, Grey Nurse Shark, White Shark

Additional comments:
Of the six IFH types described, structured inner shelf habitat is the most simplistic because it generalises over a variety of habitat types characterised by many different fauna and flora, and to some extent masks the importance of structured habitats associated with sediment bottom types.

Although no subdivision of the IFH 1 was attempted in the analysis, it is important to note that several distinct areas or general locations important for fishery productivity were identified, and these are referred to elsewhere, e.g. School Shark (Section 5.4.3).

1. Areas of prominent reefs or areas of reef patches ('cray weed') and adjacent sediment plains in coastal waters (<25 m depth) at the Head of the Bight where fishers' believe warm water from 'springs' enhances productivity

2. Areas of sand or few reef patches with low epifauna off the Venus – Streaky Bay area where enhanced chlorophyll appears to improve benthic productivity

3. Areas of prominent reefs or areas of reef patches on the deep inner shelf (~80 m depth), particularly those west of the Eyre Peninsula.

None of these habitats are identified as vulnerable by the ERA. This is for a variety of reasons including that the inner shelf is large and large areas are not fished, e.g. because there is low availability of rocky bottoms to trawl gear, and because shallow fauna are more resilient than deep fauna. However, the habitats are impacted in places by gillnets and trawls that remove sponge and bryozoans (mostly in the eastern GAB). Large areas of inner shelf closed to trawling may provide refuges for species that are trawled on the outer shelf but distributed across the entire shelf. However, while this is a commonly cited connection, it is yet to be substantiated by data on connectivity and abundances (biomass) of particular species such as Bight redfish.

Inner shelf IFH needs to be considered in the context of providing continuity (corridors) across the shelf for species with bigger-deeper patterns of distribution, and in terms of 'comprehensiveness' – providing protection across the GAB, i.e. within each of the major bioregions, especially where species exploited offshore may rely on connections to the inner shelf. This is likely to be important where the shelf is wide leading to inner and outer shelf habitats being further apart. However, fishers believe strong currents enhance food supply and produce productive fishing grounds in narrow areas of shelf, e.g. adjacent to the Eyre Peninsula and Kangaroo Island. These areas provide opportunities to protect connected cross-shelf habitats in relatively small closures. Where currents favourable for fish production occur on the shelf, productive (important) fishery habitats are likely to occur across all shelf depths, and on the adjacent slope, e.g. where deflected shelf currents and upwelling occur in the eastern GAB (~Port Lincoln to Kangaroo Island).

IFH type 2. Paleo-coastline.
This is roughly mapped by the 100 m contour, and is a persistent, although not continuous, feature around much of Australia associated with historical sea-level low stands. It is often a subtle feature, but frequently characterised by many reef patches. Fishers describe areas of ledges and drop-offs which are important for a variety of sharks and scalefish – consistent with fishers' knowledge and scientific mapping of the same feature off SE and NW Australia.

- Morwong, Melbourne Skate, short-tailed torpedo ray, Whiskery Shark, School Shark

<u>Additional comments:</u> this important fishery feature does not appear on maps of GAB geological features because the scale of mapping is too coarse.

IFH type 3. Structured shelf edge habitats (deep shelf - shelf break in 150– 300 m).
Similar to structured habitats on the inner shelf (~<80 m depths), IFH at the shelf edge is provided by seabed communities (mainly sponges and bryozoans, but also seapens and crinoids), which are often associated with hard bottom. They provide aggregations points – probably linked to higher prey densities – and structural refuges for a variety of key issue species:

- Species characteristic of the shelf edge, and shelf species that extend to the shelf edge, possibly in their adult life history stage: deepwater flathead, Bight redfish, morwong, Spotted Wobbegong, Gulf Catshark, Juvenile Mako shark, Smooth Hammerhead, Spikey Dogfish, Greeneye Dogfish, Ornate angel shark, southern fiddler ray, swallowtail, Yelloweye Redfish, Gulf Gurnard Perch, Thetis Fish, Latchet, Hapuka, (Boarfish)
- Highly mobile species that traverse the inner shelf and greater depths as adults: School Shark, Whiskery shark, Shortfin Mako, whaler sharks, hammerhead sharks

<u>Additional comments:</u> the ERA identified these habitats as vulnerable (e.g. *VBH types 1-6*) with habitats and fauna altered by trawling in some heavily used areas – despite consistent catch rates of key species such as deepwater flathead. There is a potential impact from multiple gear types, but the effects of cumulative impacts, and the distribution of impacts at the scale of the fishery, needs to be better understood.

IFH type 4. Heads of large canyons cutting the upper slope and shelf edge.
These occur at the shelf edge and on the slope where relatively high catches indicate they provide areas of elevated productivity and fishery production. The size and extent of canyons appears to be important, with large features that extend from deep waters beyond the slope up to the shelf edge being most important to fishery production (and likely to have the greatest degrees of structural fauna). They provide aggregations points – probably linked to higher prey densities – and structural refuges for a variety of key issue species:

- Ling, Hapuka, Greneye Shark, Blueye, Sevengill Shark, Sawtail Catshark, Shortfin Mako, School Shark, Southern Dogfish, Platypus Shark, Lantern Shark, Greeneye Spurdog, Bight Skate, Grey Skate, Southern Chimaera, Tusk

Additional comments: some large canyon heads remained un-mapped (e.g. by the geomorphic feature mapping for regional marine planning by DEWHA), and there is no between-feature differentiation that identifies valuable from non-valuable canyons in a fishery perspective. Their structural fauna is identified by the ERA as vulnerable (e.g. *VBH types 4, 5 & 6*).

IFH type 5. Upper slope terraces.
Where the upper slope is particularly narrow and steep, and between large canyons, it is typically more structured and provides IFH for several key issue species:

- Gemfish, Blue Grenadier, Southern Dogfish, Greeneye Spurdog, Bight Skate, Grey Skate, Sawtail Catshark, Lantern Shark, Southern Dogfish, Tusk, Hapuka, Blueye,

Additional comments: These productive fishery areas are limited in areal extent. Their structural fauna is identified by the ERA as vulnerable (e.g. *VBH types 4, 5 & 7*). The narrow upper slope (~300-700 m depths) resembles an escarpment, and off SE Australia provides a disproportionately high amount of the total offshore fishery catch by trawl and non-trawl sectors. The level of effort and catch is at a much lower level in the GAB.

IFH type 6. Seamounts (hill-like features) on the mid-slope (~700-1500 m depths)
Many, probably all, of these features have been recorded and mapped, but they make up tiny fractions of the mid-slope seabed at individual fishing ground scale. Fishers report that muddy bottom makes up the vast majority of mid-slope grounds, estimated to be often 95% or more, with seamount features making up the remaining small percentages of seabed area. However, several fishes including the conservation dependent Orange Roughy, preferentially aggregate around seamount features.

- Orange Roughy, Black Shark, Brier Shark, Platypus Shark

Additional comments: a considerable body of evidence shows that seamounts are among the most vulnerable benthic habitats (*VBH types 7 & 8*) because their structural fauna is fragile, long-lived and completely removable by trawling. There are relatively few seamounts in the GAB and it is not yet known whether they are important stepping stones to maintain connectivity between the biological communities, such as deep sea corals, that make up the structural habitat on them.

4.5.4 Vulnerable benthic habitats (VBH)

The rationale for defining VBH in the GAB

The concept of “vulnerable benthic habitats” in the context of this study follows the methodology of the Ecological Risk Analysis for the Effects of Fishing (Hobday et al. 2007). This process was used to define habitat types that are at risk from activities linked to fishing. In most cases, risk to habitat means damage, degradation or removal, and the relevant fishing activity is the direct impact of the gear on the seabed. In the context of this project, the interest of the Steering Committee was in defining and better understanding distributions of VBHs to assist with the long term sustainability and spatial management of the GAB fishery.

Initially, habitat types were identified using photographic data using the ERA methodology. Classification of habitats was based on substratum (what the seabed is made of), geomorphology (what the seabed looks like), and the dominant faunal type associated with the seabed. The detailed lists of habitat types generated by this process are subsequently rationalised into a smaller set of types that are relevant to the scales and context of the fishery.

As was stated in the previous section for IFH, it is important to understand that VBH types are generalised descriptions, and while some of these are mappable at fine spatial scales, the mapping completed by this project was mostly limited to the resolution of fishing ground polygons that have an average size of 745 km^2. Thus, while finer scale mapping data on habitat types were often available (either from scientific mapping or fishers data) VBH were not individually mapped into the fishing grounds. Rather, the distribution of VBHs was assessed using qualitative spatial analysis that scored each polygon based on whether each VBH was present or abundant there, and the confidence we had in that assessment. The polygon score for VBH was the sum of the scores for each individual IFH (Section 4.6.3)

Summary outcomes of the ERAEF in the GAB

A key issue to emerge from the Ecological Risk Assessment for the Effects of Fishing (ERAEF) analysis (Hobday et al. 2007) was the direct impact of the trawl, auto-longline (Auto-longline) and gillnet sub-fisheries on certain vulnerable benthic habitats (Table 4.5.4.1).

Habitats at potential risk from trawling occur across a range of depths, mainly on the outer shelf and the upper slope. Most trawling currently occurs on the outer shelf but there is increasing exploration of the upper slope and mid slope waters of this developing fishery.

Habitats at potential risk from gillnet fishing occur on the outer shelf, but because most gillnet fishing is now at less than 80-m depth (i.e. on the inner shelf) the threat to habitats from this method is reducing.

Habitats at potential risk from auto-longline fishing occur mostly on the upper-slope. Auto-longline fishing can target bottom types not fishable by trawling, but there is no empirical data that shows the effect of movement of the main line on large, erect and fragile epifauna.

The ERAEF report concluded that some form of spatial management (specific spatial closures) may be an appropriate way to protect vulnerable habitats from the impacts of all gear types. In many instances, informed placement of closed areas for habitats would also mitigate the impacts on high risk by-product and by-catch species, e.g. closures on the upper slope should be effective both for habitats and for species such as gulper sharks at risk from auto-longline fishing

Table 4.5.4.1 Summary outcomes from the ERAEF analysis for Trawl, Autoline and Gillnet sub-fisheries in the GAB in relation to habitats; no. of potentially high risk habitat types in each major depth zone shaded pink.

Trawl	Inner-shelf	Outer-shelf	Upper-slope	Mid-slope	Total
High	0	8	5	8	21
Medium	5	17	5	5	32
Low	6	16	1	1	24
Total	11	41	11	14	77
Autoline					
High	0	2	15	0	17
Medium	0	21	13	0	34
Low	0	50	11	37	98
Total	0	73	39	37	149
Gillnet					
High	0	22	0	0	22
Medium	10	8	0	0	18
Low	19	43	0	0	62
Total	29	73	0	0	102

Trawl

Of the 77 habitat types encountered by trawl, 21 were assessed to be at high risk, 32 medium, and 24 low. Of the high risk habitats, none were found on the inner shelf (0-100m), 8 were on the outer shelf (100-200m), 5 were on the upper slope (200-700m), and 8 were on the mid slope (700-1500m).

High risk mid-slope habitats include several categories of hard bottom (but still accessible to trawl gear) with large, erect or delicate epifauna consisting of octocorals, and sedentary animals. There are also three types of soft bottom habitat that support large, erect or delicate epifauna. Habitats of seamounts occur at this depth zone.

High risk habitats on the upper slope include types of low-relief hard bottom, in this case dominated by large sponges not seen on the mid slope, and also several soft bottom habitats characterized by octocorals and sedentary animals, as well as an additional soft seabed type based on bryozoan communities which are restricted to a narrow zone near the shelf break. Habitats of canyon features occur at this depth zone.

High risk habitats on the outer shelf are mainly soft sediment seabed types characteristically dominated by large sponges and mixed epifauna, with bryozoan communities at the shelf break. Sedimentary, sub-cropping rock with communities of large sponges also scored at high risk.

Gillnet

Of the 102 habitat types encountered by the gillnet subfishery, 22 were assessed to be at high risk, 18 medium, and 64 low. All high risk habitats occur on the outer shelf; these were 13 hard bottom types (low relief, gravels or outcrops) covered with large, erect or delicate epifauna and 9 soft bottom habitat types covered with large, erect or delicate epifauna. The epifauna consists of sponges, crinoids, octocorals, sedimentary animals, or communities of mixed fauna.

Auto-longline
Of the 149 habitat types, 17 were assessed to be at high risk, 98 medium, and 34 low. Of the high risk habitats, 2 were on the outer shelf (100-200m) and 15 on the upper slope (200-700m).

High risk upper slope habitats include several categories of hard bottom (but still accessible to trawl gear) with large, erect or delicate epifauna consisting of octocorals, crinoids, large sponges, and mixed epifaunal communities. Also ranked high are sediment veneers over hard bottom and sediment bottoms characterized by large sponges and sedentary epifauna. Habitats of the shelf break, and canyon features occur at this depth zone.

High risk habitats on the outer shelf include soft sediment seabed types over hard bottom characterized by sediment veneers interspersed with sub-cropping, friable sedimentary rocks or cobbles characterized by large sponges.

List and description of the eight VBHs in the GAB
It is possible to summarise the habitat types at potentially high risk to all the offshore gear methods by aggregating similar types. The relatively large number of habitat types defined by details of substratum, geomorphology, and the dominant faunal type can be summarised for each major depth zone as follows:

Outer continental shelf (100-200 m)

VBH type 1. Fine or muddy sediments, unrippled, wave rippled or forming veneers over sub-cropping rock, supporting large sponges or mixed epifaunal communities including gold corals or sedentary animals such as seapens. Occur across shelf, including at shelf-edge (>160 m depth).

VBH type 2. Gravel sediments, often wave or current rippled, supporting bryozoan-based communities or large sponges. Typically at shelf-edge (>160 m depth).

VBH type 3. Rocky bottom, existing as outcrop or subcrop, supporting large sponges and mixed faunal communities including crinoids. Occur across shelf, including at shelf-edge (>160 m depth).

Upper-continental slope (200-700 m)

VBH type 4. Fine or muddy sediments, unrippled or forming veneers over sub-cropping rock, supporting large sponges or sedentary animals such as seapens. Associated with gentle slopes, terraces and canyons.

VBH type 5. Coarse sediments, unrippled, supporting sedentary animals such as seapens. Typically near shelf-edge (200-300 m depths).

VBH type 6. Rocky bottom, existing as outcrop or subcrop, and supporting communities of gold corals, and other large erect fauna such as sponges. Typically associated with steep slopes, e.g. in canyons.

Mid-continental slope (700-1500 m)

VBH type 7. Coarse sediments, current rippled or irregular or scoured, supporting mixed faunal communities including sponges, seawhips, ascidians or encrusting or small erect forms such as bryozoans or sedentary animals such as seapens. Typically associated with current-exposed slopes and narrow terraces.

VBH type 8. Cobble or boulder bottom forming debris flows or rubble banks supporting sedentary fauna such as seapens. Rocky bottom existing as low outcrop or subcrop and supporting communities of stony and gold corals, and other large erect and sedentary fauna. Typically associated with steep slopes, e.g. in canyons, and seamount-like features.

4.6 Analytical methods

4.6.1 Outline of analytical approach

Data for each Key Issue species and habitat was quantified and added to each fishing ground polygon so that spatial closure scenarios could be developed. The approach to doing this is summarised in diagrammatic form (Figure 4.6.1.1).

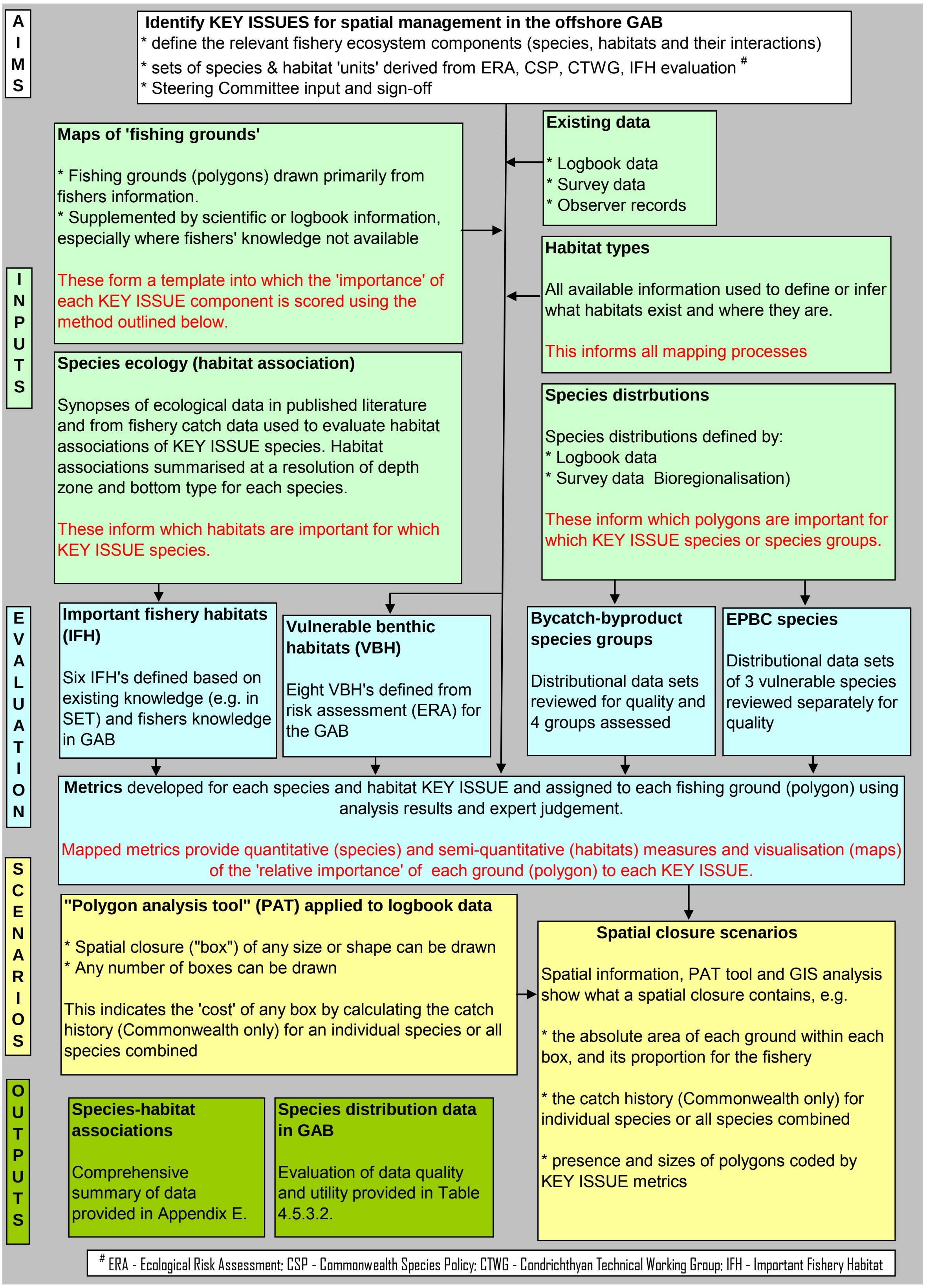


Figure 4.6.1.1 Diagram showing concept and approach to spatial analysis

4.6.2 Assigning species values to fishing ground polygons

Bioregionalisation data analysis

Bioregionalisation data are interpolated distributional maps of individual species based on a relatively small number of high quality historical distribution records (Last et al. 2005). Distributions are interpolated within the species' range simply using range end-points (latitude and longitude) and depth (minimum and maximum).

Integrated analysis of fishery and research catch data

The species group score for a polygon is based on the number of unique observations it contained, generally summed across species, fishery sectors and research methods. However, in polygons where high quality fishery logbook and observer data were available for the same species in the same fishery sector, only one data set or the other was chosen, so that catches were not included twice. In each of these cases, (Hapuku, King Dory, Tusk and Ornate Angel Shark) logbook data was chosen the identifications were reliable and the number of observations was larger. Species group scores were then mapped thematically. Two methods of standardising the data were explored firstly standardising the number of observations by area, and secondly by dividing the scores into quartiles. However, following advice from the Steering Committee it was decided that the unstandardised forms of the results were more informative.

4.6.3 Assigning habitat values to fishing ground polygons

Scoring system for habitat values

The importance of a fishing ground polygon to each important fishery habitat (IFH) and vulnerable habitat (VBH) was scored by assessing whether the habitat was present or abundant in each polygon. This assessment used all relevant sources of information and was integrated by applying the authors' expert judgement and modulated using a set of decision rules (Table 4.6.3.1). The relevant information was:

- bottom types and geomorphology scored in the fishers questionnaire (Appendix A)
- observations of fishers recorded in the questionnaire (Appendix A)
- other sources of habitat mapping (e.g. Sections 4.4.2, 4.4.3, 4.4.6, 4.4.8, 4.4.9)
- by inference from what is known about the distribution of fishery habitats and vulnerability in the better known and adjacent SEF fishery (Williams et al. 2006; Wayte et al. 2006; Daley et al. 2006).

It was not possible to generate quantitative metrics for habitats, e.g. area (km^2) of each habitat in each polygon because these detailed data were lacking for the vast majority of the GAB. Also, as previously emphasised, the spatial resolution of mapping is at polygon scale.

Table 4.6.3.1 Values and decision rules used to assign habitat values to fishing ground polygons.

Value and decision rules
4 - Habitat abundant + validated or strongly inferred
3 - Habitat abundant + weakly inferred
2 - Habitat present + validated or strongly inferred
1 - Habitat present + weakly inferred
0 - Habitat not present

The definitions applied to the decision rules are shown in Table 4.6.3.2.

Table 4.6.3.2 Definitions of decision rules used to assign habitat values to fishing ground polygons.

Decision rule definitions
Abundance: Habitat type occupies a large area within polygon, or represented by a relatively large fraction of its total distribution
Presence: Habitat type known to exist within polygon, or represented by a relatively small fraction of its total distribution
Not present: Habitat not known to exist within polygon, and no expection of presence based on proxies
Validation or strong inference: Habitat identification and abundance supported by conclusive survey data (e.g. photos, mapping or catches) <u>or</u> fishers' confidence of bottom type = good or better (1, 2 or 3) <u>or</u> proxies well-established and mappable (e.g. depth range + feature type + bottom type).
No validation or weak inference: Habitat identification and abundance supported by inconclusive survey data (e.g. historical records imprecisely describe type or location of habitat) <u>or</u> fishers' confidence of bottom type = moderate or low (4 or 5); <u>or</u> proxies not well established (e.g. similarity of overlying water masses).

Each IFH or VBH score for each polygon was recorded in the database and a sum of scores produced (Figure 4.6.3.1). These summed scores were used to thematically map the 'relative importance' of each polygon. Although the data products are not included in this report, it would be a simple matter to thematically plot individual or groups of IFH and VBH scores at some future time.

		IFH						VBH									
		1	2	3	4	5	6	1	2	3	4	5	6	7	8		
								Outer shelf (100-200)			Upper slope (200-700)			Mid-slope (>700)			
AREA_ Code	AREA_Name	Inner shelf	Paleo coast	Shelf edge	Canyon heads	U slope terraces	Sea mounts	muds >160	gravels >160	Rocky	fine slope/terr/ canyons	coarse 200-300	Rocky steep/ canyons	Coarse currents/ terraces	Debris steep/ canyons/ seamount	EFH sum	VBH sum
1	125 Inshore		1	2				2	2	2						3	6
2	126 Inshore		1	2				2	2	2						3	6
3	Heartbreak ridge			4						4						4	4
7	Gemfish 1					3				4	4	3	4			3	15
8	Quiet zone upper slope					2				2	2		2			2	6
9	Upper slope gemfish ground 2					2				2	2		2			2	6
10	Skinny patch									2						0	2
11	Boarfish								2	2						0	4
12	Dead patch								2	2						0	4
13	128 - 129 degrees			1				2	2	1						1	5
14	129 inshore W									2						0	2
15	129 inshore E									2						0	2
18	129 edge				4	4			2	4	2	2	2			8	12

Figure 4.6.3.1 Example of IFH and VBH scores assigned to each fishing ground polygon in database

4.6.4 Polygon Analysis Tool (PAT)

The polygon analysis tool (PAT) was developed as a means of summarising information within an existing or hypothetical spatial closure. The PAT allows a user to draw the boundary of a candidate closure and assess its importance to fisheries so that the potential trade-offs associated with candidate closures, particularly those developed as part of the Regional Marine Planning process, can be assessed

The polygon analysis tool (PAT) was developed in the GIS package ArcView and allows a user to draw the boundary of a candidate closure and generate catch and effort statistics from Commonwealth Fisheries logbook data.

Layers can be displayed thematically (in fishery dependent units) by 1 km grid as: Catch (kg); Shots; Hours; Kilometres; Sum of the proportions of shots (based on the proportion of the total length of each shot in a given cell); Total hooks set; Total Line Length; Kg/Hr; Kg/Shot and Kg/km.

Users provide a boundary for analysis by drawing on-screen. Statistics can be generated for any number of regions, and for a single year, or all years available for the theme. Statistics can be generated for totals including: catch; hours; kilometres; hooks and line length.

Display and analysis results can be filtered to include the 5 vessel rule (only show details where > 5 vessels occur in a cell). Themes can include all species in the fishery, or subsetted to individual species.

4.6.5 GAB demonstration area for data products

In consultation with the Steering Committee, a demonstration area was chosen in which details of the grounds underlying mapped data products are provided (Figure 4.6.5.1). This shows how fishing ground polygons are mapped, and shows the scale at which bottom type and all species and habitat metrics are attributed and subsequently mapped. Tabulated summary statistics within this area are generated for a hypothetical closure (red box); these show how areas can be calculated for bottom type, individual IFH or VBH (Tables 4.6.5.1 and 2). Summed scores provide an index of overall ‘importance’ of individual fishing ground polygons for either IFH or VBH.

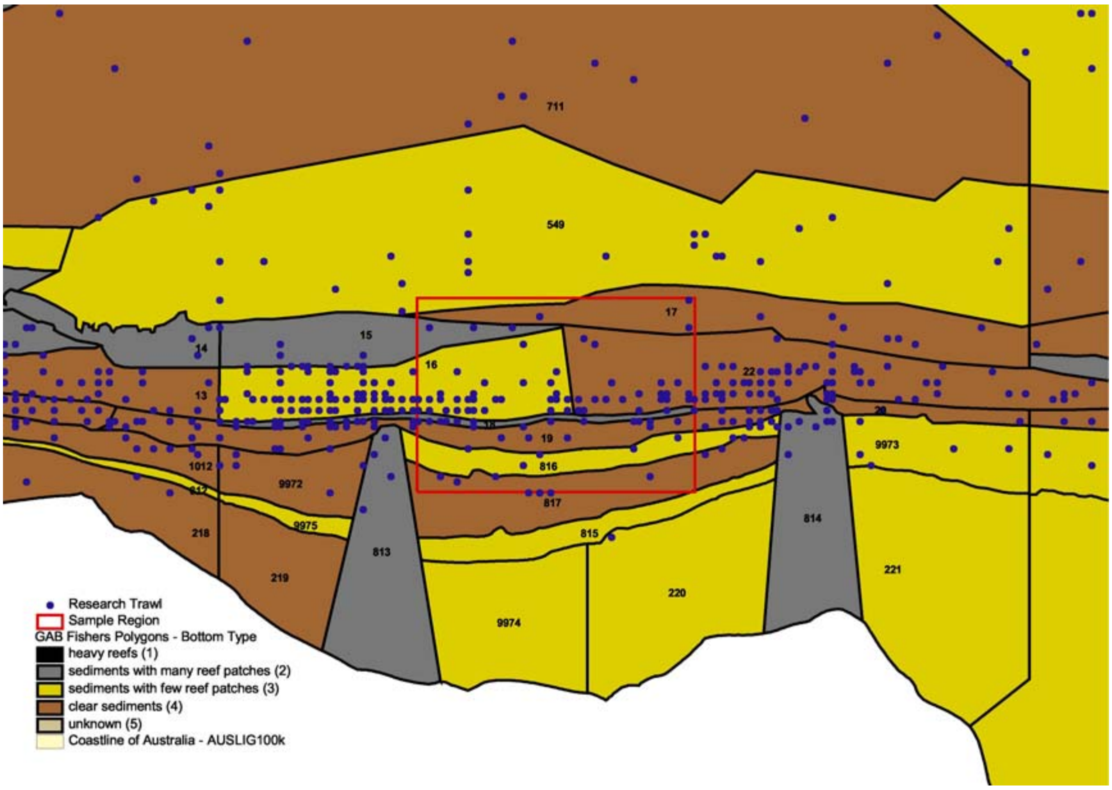


Figure 4.6.5.1 Map showing demonstration area and hypothetical closed area (red box) used to display the mapping of bottom types, and used to generate a set of example summary statistics for IFH (Table 4.6.5.2) and VBH (Table 4.6.5.3) within the closed area.

Table 4.6.5.1 Summary statistics for hypothetical closed area (red box in Figure 4.6.5.1) showed fishing ground polygons within closed area, their areas, bottom types and terrain descriptions.

Bottom type	Terrain description	No. of grounds	Area (km^2)
2	sediments with many reef patches	2	15.17
3	sediments with few reef patches	4	11.3
4	clear sediments	4	10.04

Table 4.6.5.2 Summary statistics for hypothetical closed area (red box in Figure 4.6.5.1) showed fishing ground polygons within closed area, their areas, bottom types, individual scores for each IFH and summed IFH score.

Ground ID	Area (km^2)	Bottom type	Important Fishery Habitat (IFH)						Importance (sum)
			1 Inner shelf	2 Paleo coast	3 Shelf edge	4 Canyon heads	5 Upper slope terraces	6 Sea mounts	
15	8.7	2							0
16	3.96	3							0
17	2.21	4							0
18	6.47	2				4	4		8
19	2.22	4					2		2
22	3.51	4			1				1
549	5	3		3					3
815	0.07	3				1	1		2
816	2.27	3				1	1		2
817	2.1	4				1			1

Table 4.6.5.3 Summary statistics for hypothetical closed area (red box in Figure 4.6.5.1) showed fishing ground polygons within closed area, their areas, bottom types, individual scores for each VBH and summed VBH score.

Ground ID	Area (km^2)	Bottom type	Vulnerable Benthic Habitat (VBH)								Importance (sum)
			1	2	3	4	5	6	7	8	
			Outer shelf (100-200)			Upper slope (200-700)			Mid-slope (>700)		
			muds >160 m	gravels >160 m	Rocky	fine slope/terr/ canyons	coarse 200-300	Rocky steep/ canyons	Coarse currents/ terraces	Debris steep/ canyons/ seamount	
15	8.7	2			2						2
16	3.96	3		2	2						4
17	2.21	4		2							2
18	6.47	2		2	4	2	2	2			12
19	2.22	4			2	2		2			6
22	3.51	4		2							2
549	5	3			2						2
815	0.07*	3									0
816	2.27	3				1	1				2
817	2.1	4						1			1

*note ground 815 is a polygon sliver (bottom right of red box)

5 Results

5.1 Fishing industry mapping data

There was successful engagement with industry contributors with knowledge of the offshore fishery, and methods established in the previous South East study (Williams et al. 2006) and modified for the current project, were successfully applied. Some additional development was also completed – for example, to store within-polygon level data such as features in a separate part of the spatial database. While data were provided in a variety of formats, reflecting in part the greater diversity of navigational (trackplotter) software available to fishers, all data were successfully captured. The quantity and quality of data provided by each operator was variable – as had been the case in the previous study – but collectively a large volume of suitable data were synthesised and added to a project database.

Overall, there was much greater knowledge of the eastern GAB compared to the west, and a broader knowledge by trawl sector due to a broader area fished (by depth and latitude). For example, there was good deepwater coverage west of 126ºE on mid-slope (Orange Roughy) grounds. Non-trawl contributors provided some information from areas that are unfished by trawl due to their rocky habitat types. For example, there was good coverage of rock lobster grounds from Kangaroo Island to Cape Adieu (short of the Head of the Bight) that enabled mapping of heavy reef. Some areas where there were few data included:

Trawl

- Only handwritten notes for shelf and upper slope west of 126º E.
- No data from steep eastern grounds
- No data from inshore west of WA border

Non-trawl

- Gillnet coverage best for Head of the Bight to West of Eyre Peninsula;
- WA grounds mapped from 126º E – 129º E
- Auto-longline data available in the east only

It was not possible to corroborate data in the same way that had been done in the South East study because often the only information available was from exploratory fishing or remote areas where only one fisher operates. Conversely there were good opportunities to corroborate on the main redfish and flathead grounds, despite the limited number of operators. These grounds are well known and there are fewer ‘special spots’ that are only known to one skipper. There was generally higher confidence in the boundaries of non-trawl grounds than in the bottom type information because less benthos is landed. However, records of sponge and coral in many of the gillnet shots provided useful insights to fauna on hard bottom.

Grounds were typically defined at relatively large scales (cf. the South East) because physical features were subtle and often fishing distribution was limited. As a result, it was often difficult to estimate the proportion of different bottom types and to classify the terrain types. This was particularly the case on the mid-slope where small structured features with aggregations of fishes (e.g. seamounts) were typically surrounded by very large areas that had not been fished. In these cases, the features were mapped separately for reference, but not included as separate polygons for analysis.

In summary, the data provided enabled a large fraction of the GAB to be mapped at the resolutions anticipated; ‘gaps’ were filled with polygons based on additional mapping data (see following section). The result was a segmentation of the GAB into 484 polygons; their boundaries are shown in Figure 5.1.1 . An example of the ways in which habitat attributes can be mapped into polygons is shown using habitat ‘terrain’ (bottom) type. These show the proportional make up of terrain types across the GAB fishery area is:

Type 1: heavy contiguous reef **– 1.5%**

Type 2: sediments with many reef patches (reef making up ~30-70%) – **24.9%**
Type 3: sediments with few reef patches (~5-30% reef) – **39.8%**
Type 4: clear sediments (reef less than 5%) – **27.0%**
Type 5: unknown - **6.8%**

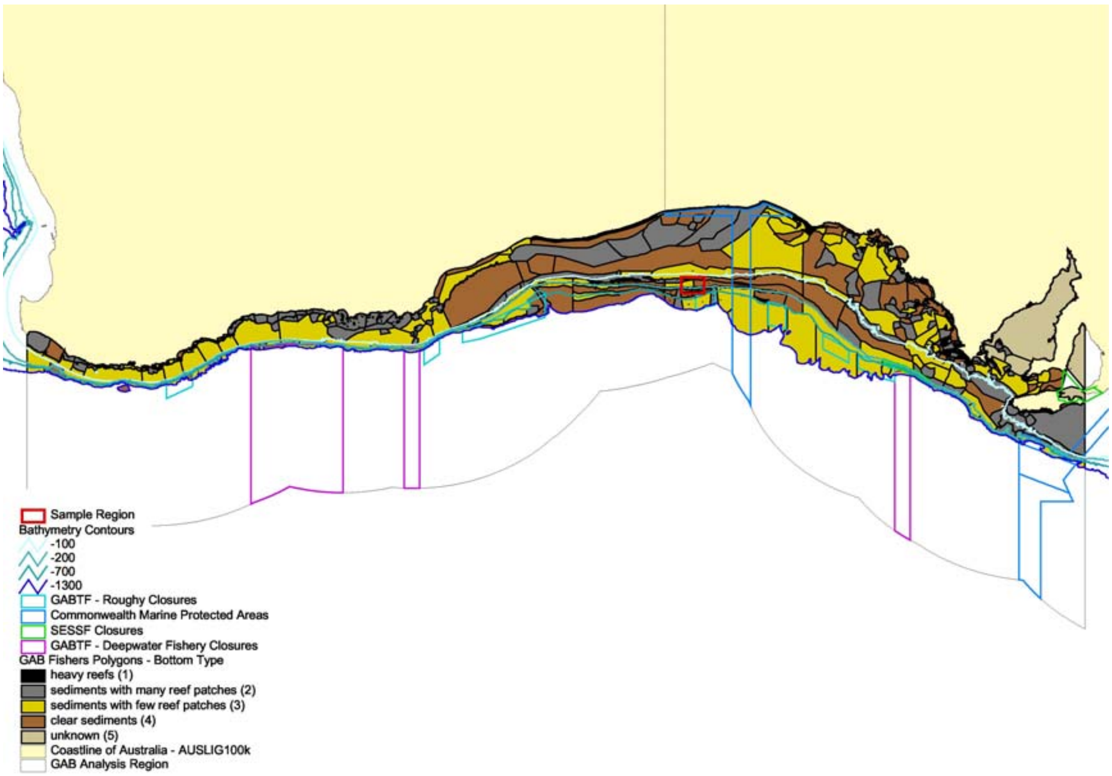


Figure 5.1.1 Boundaries of the 484 fishing ground polygons (black lines) within the GAB fishery area with bottom type (terrain) shown to demonstrate how database attributes can be thematically mapped into the polygon template.

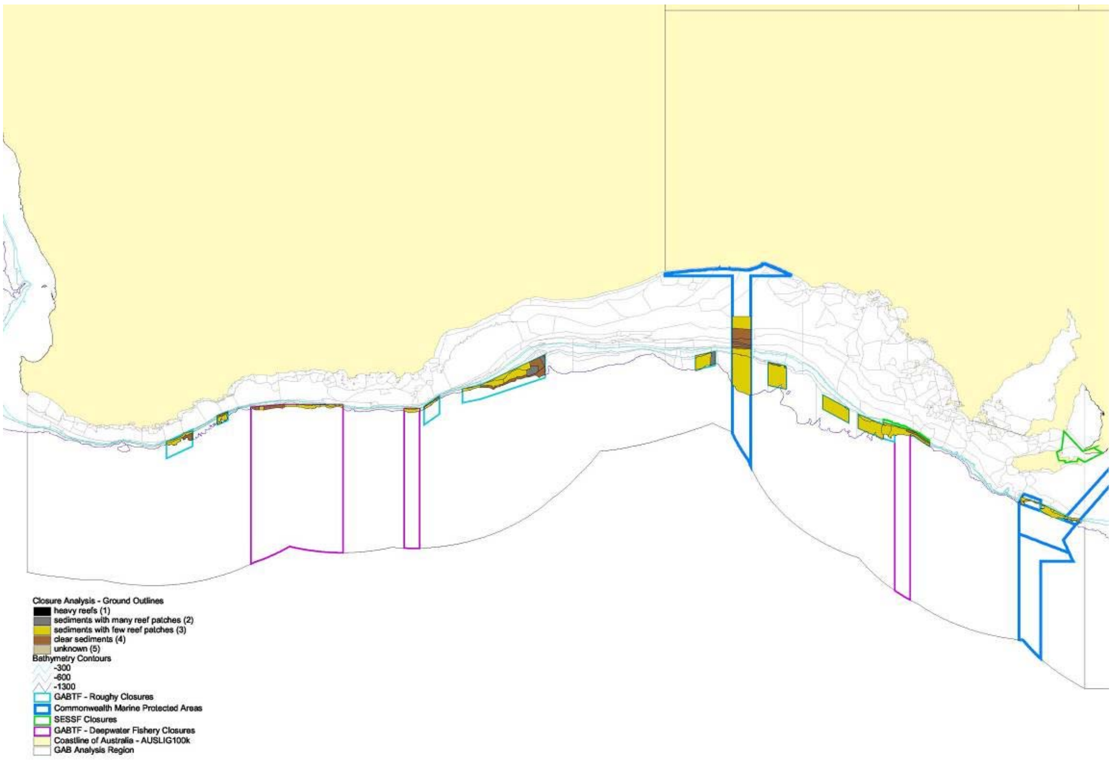


Figure 5.1.2 Boundaries of the 484 polygons (grey lines) within the GAB fishery area showing bottom type (terrain) within existing closed areas to demonstrate how database attributes can be extracted from thematic maps.

The way in which information can be extracted from this mapping is demonstrated in Figure 5.1.2: in this example, the terrain types within closures.

Industry have agreed to make the fishing ground boundaries and terrain types public (Figure 5.1.1), together with fishing ground names (Appendix F). However, fine scale feature mapping remains confidential. Future use of this confidential information may be considered on a case by case basis in accordance with the MOU (Appendix C). Parties considering further use of the data should contact the data custodian (CSIRO) or the appropriate industry representative for their sector (e.g. GABIA) in the first instance. Further details of the type of industry data that has been collated are given in Section 4.2 and for integrated analysis of key issues in Section 4.5.

5.2 Additional mapping data

The variety of biological and physical data sources and types contributing knowledge relevant to assessing the needs and opportunities for spatial fishery management in the GAB were summarised in Section 4.4. Despite the long history of sampling (dating back to the early 1900's), and the high detail provided by some research (e.g. the recent mapping and photographic surveys), much of the massive GAB fishery area (depth <1,500 m) remains poorly known in terms of habitat and species distributions. This is especially true of the western half and continental slope depths (> 300 m). Much of the data are of relatively poor quality, for example the very large numbers of trawl samples taken by Soviet research vessels lack reliable taxonomy and complete catch composition data. Modern high-resolution data are available for only small areas. Collectively, however, they have utility for addressing key issues and have been used to define polygons where there was an absence of fishers' information, to inform the development of species synopses (following sections), and to supplement the information on habitat distributions and roles. All data layers are managed for the project within the CSIRO data warehouse and are available to other spatially-based management or research projects.

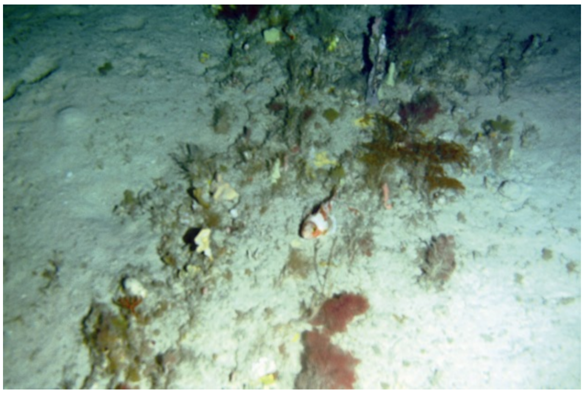
5.3 Photographic mapping survey

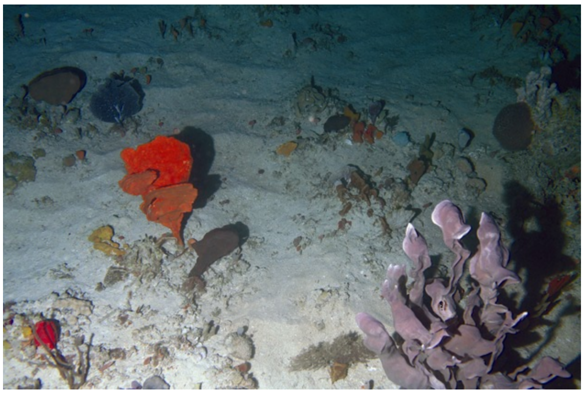
Overall the voyage was implemented according to the survey plan, although the details of the day to day operations were modified based on the skipper's extensive experience and the prevailing weather conditions. Only a small amount of time was lost due to bad weather. Sites were generally scoped out first by the skipper (interpreting echo sounder) to check for structure. Where possible, transition zones (soft to hard bottom) were included in the tows. Some targeted tows were to investigate hard bottom and fish marks. Two tows were targeted at the steeper sections at the head of canyons.

A variety of bottom types were observed across sites (Figure 5.3.1); these ranged from current swept sediments to high relief outcropping reef, and some steep and hard bottom types. Clear sediments without reef patches were dominant during the photo survey, corroborating fishing ground data from industry. Generally few fish were seen (many species avoid the camera system) but a large school of Bight Redfish were seen around some harder bottom with moderate relief. Observations of seabed invertebrates included sponges, bryozoans, a variety of mobile animals, and signs of burrowing fauna. Abundances of fauna were typically sparse on sediment areas while moderately dense sponge communities were seen on areas of hard pavement (that often had a veneer of fine sediments overlaying) or where reef subcrop and outcrop was evident. The inshore site at the head of the Bight brown macro algae ('cray weed') growing on extensive reef patches in 18-20 meters water depth.

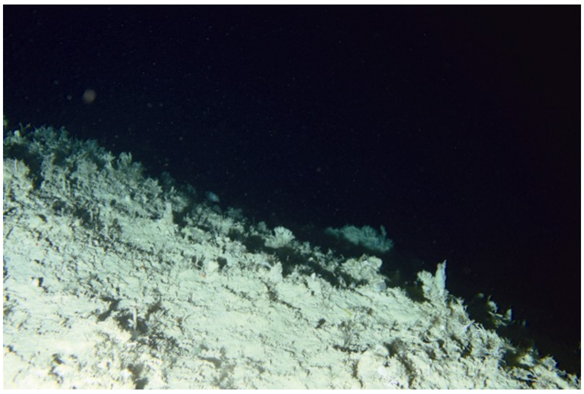
All details of the survey, including station positions, are summarized in Appendix D. Images will be stored in the CSIRO Data Centre Image Database.


(a) Op 16, 135 m

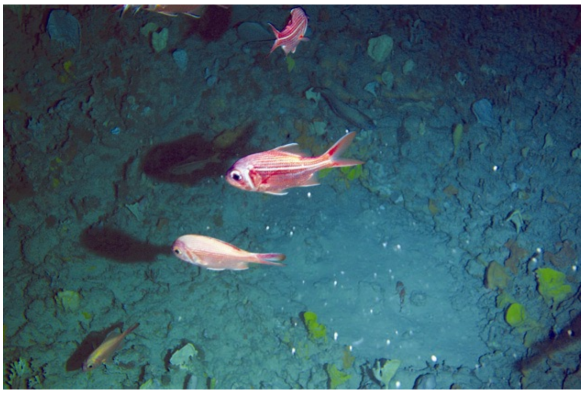

(b) Op 13, 138 m


(c) Op 27, 62 m

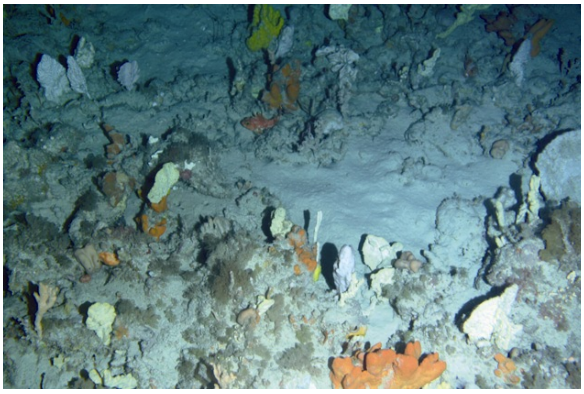

(d) Op 21 ~300 m


(e) Op 21 ~400 m


(f) Op 27 60 m

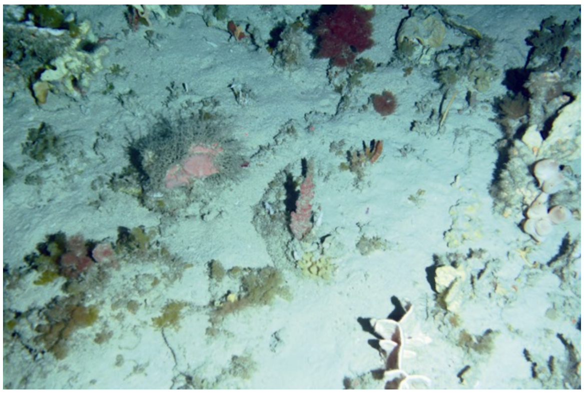


(g) Op 22, 135 m



(h) Op 22, 135 m

(i) Op 23, 125 m



(j) Op 23, 125 m

(k) Op 24, 18 m

(l) Op 25, 35 m

Figure 5.3.1 Selected still images showing a variety of the habitat types observed during GAB camera survey. Operation number can be cross-referenced to Table 1 and Figure 1 in the Voyage Report (Appendix D) for location; depth of photograph shown. <u>This selection is not representative of the overall proportions of habitat (terrain) types</u>; it emphasises variety and structured habitats, while most habitats seen were sediments – see Section 5.1).

The results of the survey are briefly discussed below. Although large areas of the study area are unstructured clear sediments, this discussion focuses on particular structured habitats because they are most relevant to key issues:

Vulnerable benthic habitats

The survey provided photographic data on seabed habitats for many areas of the GAB which were previously unsampled. Most survey locations correspond to fishing grounds, with many being areas identified by industry as being representative of key areas for particular fishery species. Image data were scored in the system used for the Ecological Risk Assessment to identify which potentially vulnerable habitats exist in the areas surveyed. This information feeds into the assessment of both vulnerable benthic habitats (VBH) and important fishery habitats (IFH) as detailed in later sections of this report.

Habitat associations of EPBC and fishery species
Two species, School Shark and Southern Dogfish (Southern Gulper Shark), with overfished status in the SESSF (Larcombe and Begg 2008) occur in the GAB and are included in our key EPBC list as key issues. Three key habitats have been identified for School Shark in industry data and the characteristics of these habitats were recorded: inshore flat pavement reef at the head of the Bight (operation 25, site 32), an ancient coastline at about 100 m (operation 37, site 39) and canyon heads at the edge of the shelf (operation 7, site 15). The location and characteristics of typical gulper shark habitat is separately reported in detail from the 60-mile closure based on additional CSIRO photographic data obtained in March 2008.

The inner shelf areas to the west of the Eyre Peninsula are important for the rock lobster fishery. Further west, gillnet fishermen report that three areas are of special significance: Ceduna (locations 39–40), West of Streaky Bay (locations 37, 38, 41) and west of Venus Bay (locations 20, 28, 29, 30, 31). Fishers' data indicates that some of the productive fishing areas on the inner shelf are relatively featureless sandy bottoms and fishers suggested other physical factors, such as water temperature may contribute to fishery production. The camera data indicates that each of the inner shelf areas has a mixture of rocky and sandy bottom. Some of the areas that are sandy on the surface of the seabed have large sponges attached to rocky subcrop, but others were sandy sediments devoid of visible fauna. There are currently no interactions of trawl methods with these inner shelf habitats.

5.4 Key species (EPBC assessed)

5.4.1 Orange Roughy

Summary
EPBC listing category: Conservation dependent
Relevant fishing sectors: Trawl
Data products: A detailed literature synopsis is provided in Appendix F
Habitat associations: IFH 6 – seamounts; VBH 7 & 8 – seamounts

Evaluation
As part of the current project, CSIRO worked with GABIA to produce maps and tables showing Orange Roughy shots across the fishery using 1988 – 2005 logbook data. This time period covers the main historical fishing for Orange Roughy in the GABTF and all commercial Orange Roughy fishing grounds were easily identified in this manner. The

proposed Orange Roughy “research zones” (Figure 4.1.5.1) were designed to capture >95% of the total Orange Roughy catches taken in the GABTF.

The analysis shows that for the entire period 1988–2005, which includes the relatively large catches taken in the early development of the fishery, over >95% of catches of Orange Roughy from the fishery are contained within the proposed research zones, MPAs and closed areas (Table 5.4.1.1). Of the 13,202 t of Orange Roughy landed in the GABTF over the last 20 years, this equates to only 467 t of Orange Roughy having been taken outside the proposed research zones and closures (Table 5.4.1.2). Over the 5 years (2001 – 2005), the proposed research zones encompass more than 99% of Orange Roughy taken in the fishery (Table 5.4.1.3).

Table 5.4.1.1 Proportion of Orange Roughy catches in and out of proposed research zones (using 1988 – 2005 logbook data)

Management zone	Proportion in proposed OR research zones (or closures)	Proportion out
Far West Zone	**97.63%**	2.37%
Western Zone	**94.00%**	6.00%
Central West Zone	**96.42%**	3.58%
Central East Zone	**97.19%**	2.81%
Eastern Zone	**97.17%**	2.83%

Table 5.4.1.2 Orange roughy catches taken in and out of proposed research zones with overall proportion of catches in research zones shown (using 1988 – 2005 logbook data)

Management zone	Total in zones (kg)	Total out (kg)	Total all (kg)	Proportion in zones
Far West Zone	1,593,614	38,627	1,632,241	97.63%
Western Zone	2,572,075	164,054	2,736,129	94.00%
Central West Zone	1,971,666	73,189	2,044,855	96.42%
Central East Zone	3,399,226	98,236	3,497,462	97.19%
Eastern Zone	3,198,243	93,007	3,291,250	97.17%
TOTAL	**12,734,824**	**467,113**	**13,201,937**	**96.46%**

Opportunities for further scenario evaluation

The level of protection provided for seamount habitats by the deepwater management strategy for Orange Roughy is further evaluated in Section 5.8.1.

Table 5.4.1.3 Orange roughy catches in and out of proposed research zones and the proportion by zone and total (2001 – 2005 logbook data)

Management zone	Total in zones (kg)	Total out (kg)	Total all (kg)	Proportion in zones
Far West Zone	307,190	240	307,430	99.92%
Western Zone	530,503	7,064	537,567	98.69%
Central West Zone	86,965	1,600	88,565	98.19%
Central East Zone	92,910	15	92,925	99.98%
Eastern Zone	41,025	242	41,267	99.41%
TOTAL	**1,058,593**	**9,161**	**1,067,754**	**99.14%**

5.4.2 Southern Dogfish

Summary

EPBC listing category: under consideration, public comment period closed
Relevant fishing sectors: Auto-longline (Trawl)
Data products: A detailed literature synopsis is provided in Appendix F.
Habitat associations: IFH 4 (canyon heads), IFH 5 (upper slope terraces); VBH 4, 5, 6

Evaluation

Survey data showed zero Southern Dogfish catches between the WA border and 132 (170 miles of longitude), despite weeks of fishing by two vessels in an area with no auto-longline fishing history (Figure 5.4.2.1). The upper slope in this area is relatively flat and the distance from the 300–600 m contour is typically 5 miles. However, high catches of Greeneye Spurdog were recorded in the area. This species is included in the upper slope dogfish management strategy and this area could be considered for the management of this species, depending on the extent of trawling. It is unlikely to be utilised extensively by auto-longline as ling and blueeye catches were low.

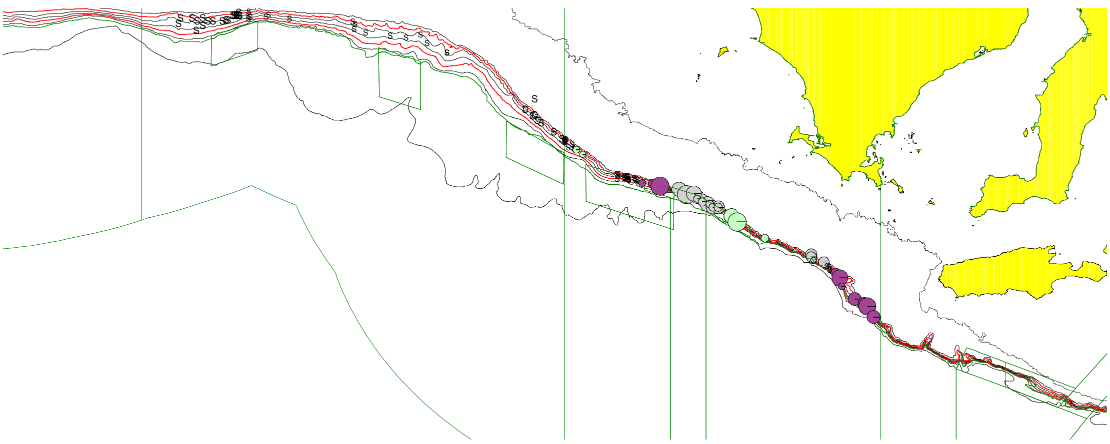


Figure 5.4.2.1 Capture locations of gulper sharks: Grey- *FV Diana*, green *FV Riba* voyage 1, purple, *FV Riba* voyage 2, open circles = zero catches

From 132º–133º 45’ (105 miles of longitude), only low or zero gulper catches were recorded. This slope in this area is medium – flat with the distance from the 300–600 m contour is typically 4–7 miles. Part of the area has had some fishing history and is referred to the “Ceduna Patch”. Anecdotal records indicate auto-longline sector catches of gulper sharks were higher during the earlier stages of fishing on the Ceduna Patch. Recent anecdotal information is that this area has been heavily fished by the auto-longline sector ‘against the fence’, or adjacent to the 60 mile closure and high dogfish catches have been taken.

The current 60 mile closure from 133º 45–134º 45’ (60 miles of longitude) is based on a area spanning 30 miles of longitude where high catches of both males and female Southern Dogfish were taken by the Diana and two adjacent areas each spanning 15 miles longitude to the east and west where high catches of the same species were taken by the Riba 2 on two separate voyages. The slope in this area is medium – steep with the distance from the 300–600 m contour is typically 1.5 miles in the east, opening up to around –4 miles in the west

From 134º 45’ - 135º 15’ (30 miles of longitude) there was only one sample taken and only a few Southern Dogfish were recorded but this area contains suitable steep habitat for southern Dogfish. However, anecdotal reports are that this area has been heavily fished, particularly ‘against the fence’ (eastern boundary of the 60 mile closure) since expansion of the auto-longline sector was permitted in this region. From 135º 15’ – 136 º 00’ (75 miles of longitude) high catches of Southern Dogfish were recorded by both the Riba and the Diana in the 2005 survey on steep ground. However such high catches have been absent from observer data in recent years since the expansion of the line sector in the region. There was no sampling east of 136 º because Southern Dogfish had previously been heavily targeted by gillnets south of Kangaroo Island and the sampling design specified lightly fished areas as higher priority.

Opportunities for further scenario evaluation

It is possible that additional populations of Southern Dogfish exist in natural refuges off southern WA. GABIA has proposed an extension of their current deepwater protection zone to increase possible protection for the species. The area is an extensive area of steep upper slope with at least seven canyons and is likely to represent suitable habitat for an effective closure. However there are no independent survey data to establish if the species is present in the area. A targeted WA state managed gillnet fishery once operated for Southern Dogfish out of Esperance. If a population was present in the area then this fishery may have had a localised impact. These data were examined with the aim of obtaining insights into historical species distribution and refining the location of the proposed additional closure. However the data did not have sufficient spatial resolution to be informative. Some of the operators in this region have been identified and in future it may be possible to contact them directly to see if private catch records could be analysed.

Overall the combination of current and proposed closures with comprehensive baseline studies implemented ahead of fishery expansion and ongoing monitoring provides a firm foundation for informed management of this species along the south coast. The greatest uncertainty is the population status in the west. The 60 mile closure in the east also offers protection of a number of high risk shark and ray species (See key issue species groups – Auto-longline Species Group).

5.4.3 School shark

Summary

EPBC listing category: Conservation Dependent
Relevant fishing sectors: Gillnet (trawl, auto-longline)
Data products: A detailed literature synopsis is provided in Appendix F.
Habitat associations: IFH 1 (structured inner shelf habitats), 2 (ancient coastline), 3 (shelf edge), 4 (canyon heads); VBH – 1, 2, 3

Evaluation

It is well known that School Shark occupy a wide range of patchy habitats from the shoreline to the 600 m contour (Appendix F). Electronic tagging data (West and Stevens 2001) indicates the species is highly mobile within this range and individuals show different patterns (Figure 5.4.3.1).

Combined electronic tagging data for 15 School Sharks from the GAB, eastern South Australia and northern Tasmania show School Shark spend 91% of their time at depths <200 m. The modal depth for females is on the inner shelf: 50–75 m, for males it is on the mid shelf: 75–100 m and males spend more time than females on the outer shelf at 150–200m. This suggests fishing shallower than 100 m will not necessarily avoid females and additional strategies are warranted.

Data for three individuals from the GAB appear to move between habitats from month to month or even day to day and different individuals show different patterns in the same month. Some individuals show dramatic deep diving patterns from 200–400 m. Depth data alone can not distinguish between vertical movements in the water column and movements near the bottom toward and away from the shore. Temperature data indicates a mixture of the two behaviours and potentially fishery catch data could be used to evaluate bathymetric distribution. Even without additional analyses it is clear that patterns of habitat use are complex therefore designing spatial management measures that are suitably focussed in space and time will be challenging.

Potentially strategies for avoiding School Shark in shallower waters could be better explored by re-scoring or existing IFH data at finer resolutions, collecting finer scale habitat data, or comparing habitat data from Tasmanian nurseries to areas in the GAB with the potential to support pupping or pregnant females. These approaches are beyond the original scope of this project but fishers knowledge (described by several gillnet fishers and reflected in catch data for the gillnet fishery) reveal patterns of habitat use that correspond with five habitat: Head of the Bight (<25 m), inshore areas with reef patches west of the Eyre Peninsula (50–70 m), ancient coast line between the WA/SA border and Port Lincoln (approximately 100 m), edge of the shelf 160 – 200 m) and canyon heads southwest on Kangaroo Island (300 – 600 m). These have a high degree of correspondence to IFHs 1 to 4.

The habitat types described in this section provide some insights into potential spatial management scenarios. Connectivity will vary, in space at least, across the region. Areas with greatest connectivity between habitats may offer the best prospects for integrating spatial closures. Four of these habitats are in closest proximity to each other west of the Eyre Peninsula and southwest of Kangaroo Island making the area a strong candidate for the development of additional management measures. The inshore area at the head of the Bight is also a strong candidate based on the high recent catches in survey data.

An additional consideration is the indirect impacts on School Shark via habitat damage. Two types of impacts have been considered in the past. Firstly damage by trawling at the edge of the shelf. A review of effort data found that gear overlap is fairly limited but does occur along the shelf edge at the west of the GAB from 129º–130 º. Observer data shows that gillnets remove some sponge and bryozoan on inner shelf areas with reef patches west of the Eyre Peninsula. A third type of habitat impact is likely to occur inshore, particularly within 3 nm of the shoreline. Here fishers say that School Shark are associated with two habitat types. Firstly heavy brown algae (“kelp”) attached to rocky shores. Secondly newborn pups (and presumeably pregnant females) are associated with fine red/brown algae on muddy sediments.

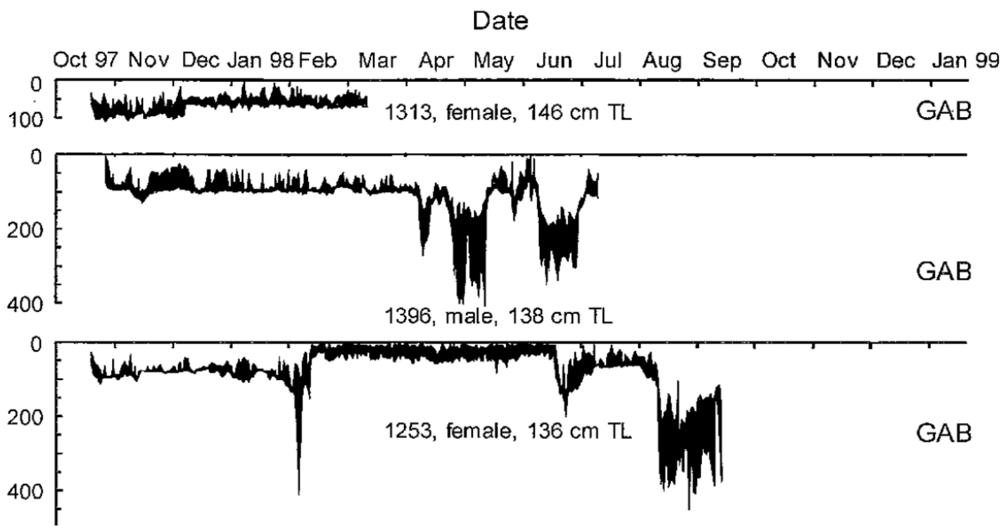


Figure 5.4.3.1 Daily depth range for three School Shark at liberty in the GAB for more than 1 month showing modality at certain depths correlated with Important Fishery Habitats: 50 m inshore reef patches, 100 m ancient coastline, 200 m shelf edge, 400 m edge of the photic zone. (modified after West and Stevens 2001).

5.5 Bycatch and byproduct species

5.5.1 Auto-longline Species Group

Summary

The analysis included two skates, two sharks and one scalefish. Literature sources indicate three species are concentrated on the upper slope: Blackbelly Lanternshark, Bight Skate and Grey Skate. The Greeneye Spurdog and Hapuku are also recorded from the outer shelf (Appendix E). Blackbelly Lanternshark are known to form aggregations (details in Appendix E) which makes them potentially more vulnerable to capture than the other species in this group.

The Bioregional data indicates all members of this group are concentrated in deep water with only one species extending onto the inner shelf and none extending inshore. Off southwest WA, the apparent density of observations is influenced by the scale of the polygons. Similarly the extent of distribution into mid-slope waters is influenced by the scale of polygons representing large grounds that are largely poorly known.

The integrated analysis results are consistent with published information showing the greatest concentration of catches along the upper slope. Catches also extend onto the outer shelf – representing Greeneye Spurdog and Hapuku, and onto the mid-slope, representing the deeper distribution limits of most of the species. Some species also occur in deeper water and to a lesser extent in shallower waters. There are few observations west of Esperance and little fishing effort there in the fishery data sets examined. Attempts to improve this analysis by inclusion of WA gillnet data were unsuccessful because the data lacked sufficient spatial resolution.

Evaluation

A significant proportion of upper slope bathome (300–650 m) is included in the GAB 60 mile closure. Hapuku and Greeneye Spurdog have some refuge from auto-longline methods inside 100 m, although they are encountered by other gear types. Similarly the deeper extremes of the depth ranges of these species offers some protection from auto-longline fishing inside deepwater closures. (See also notes under Southern Dogfish, Section 5.4.2).

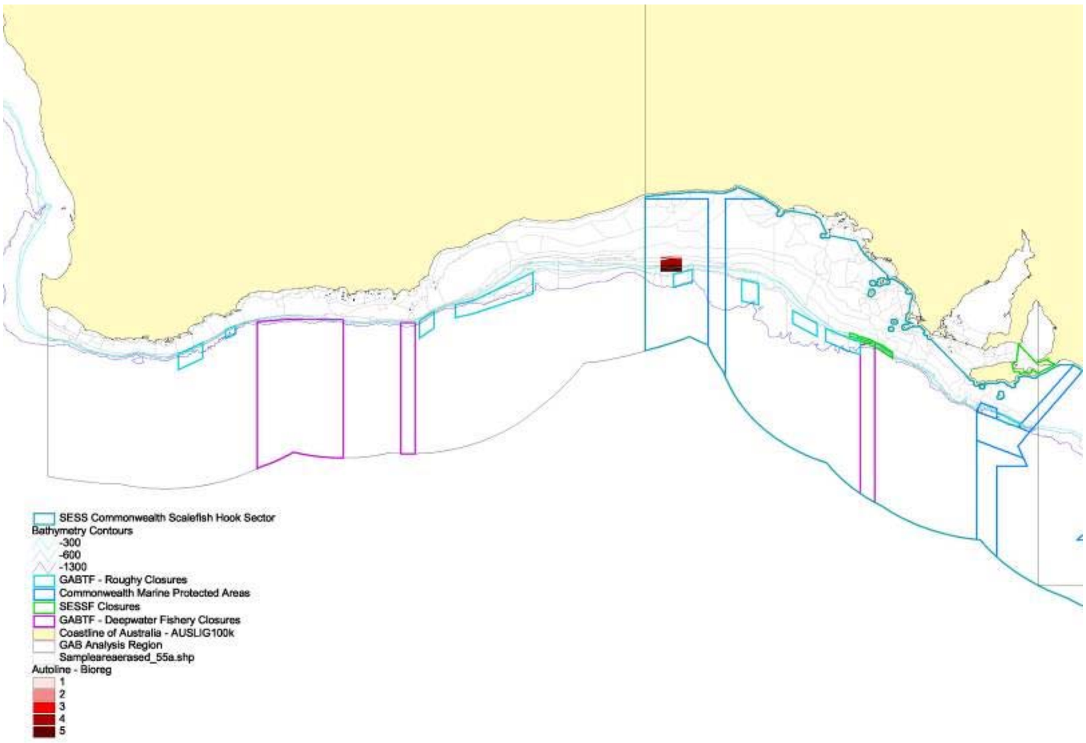


Figure 5.5.1.1 Distribution of Auto-longline Species Group (ASG) based on biogregionalisation data (thematic mapping is the number of ASG species present in each polygon). (*Demonstration area only shown; the remaining polygons remain blank to preserve confidentiality*.)

Figure 5.5.1.2 Distribution of Auto-longline Species Group (ASG) based on fishery catch data (thematic mapping is the number of unique observations of ASG summed for each polygon). (*Demonstration area only shown to preserve confidentiality*.)

Opportunities for scenario evaluation

Potentially auto-longline methods could expand westward to commonwealth managed upper- slope waters off Western Australia. The tools developed in this project could be used to examine the impact of the Southwest Bioregional Marine Planning process on any potential expansion.

5.5.2 Gillnet Species Group

Summary

After screening for data quality only three species could be included in analysis: Broadnose Sevengill Shark, Smooth Hammerhead and Whiskery Shark. This is partly due to the lack of historical observer data and consequent identification problems in fishery data (Table 4.6.2.1, Appendix E). These species have very different ecology and therefore do not lend themselves well to group wise analysis. Broadnose Sevengill Shark is widely distributed on a range of habitats. Smooth Hammerhead is demersal at the juvenile stage and more pelagic as an adult. The Whiskery Shark has strong affinities with hard bottom.

Evaluation

The BioReg analysis shows that Whiskery Shark and Smooth Hammerhead Shark are distributed across the mapped area, whereas the Broadnose Sevengill Shark does not occur in the west of the GAB

The integrated analysis of catch data indicates the highest number of observations of at least some members of this group were to the southeast of Kangaroo Island – an area favoured by gillnetters with extensive reef patches, and at the edge of the shelf off eastern Western Australia – outside the fishery boundary.

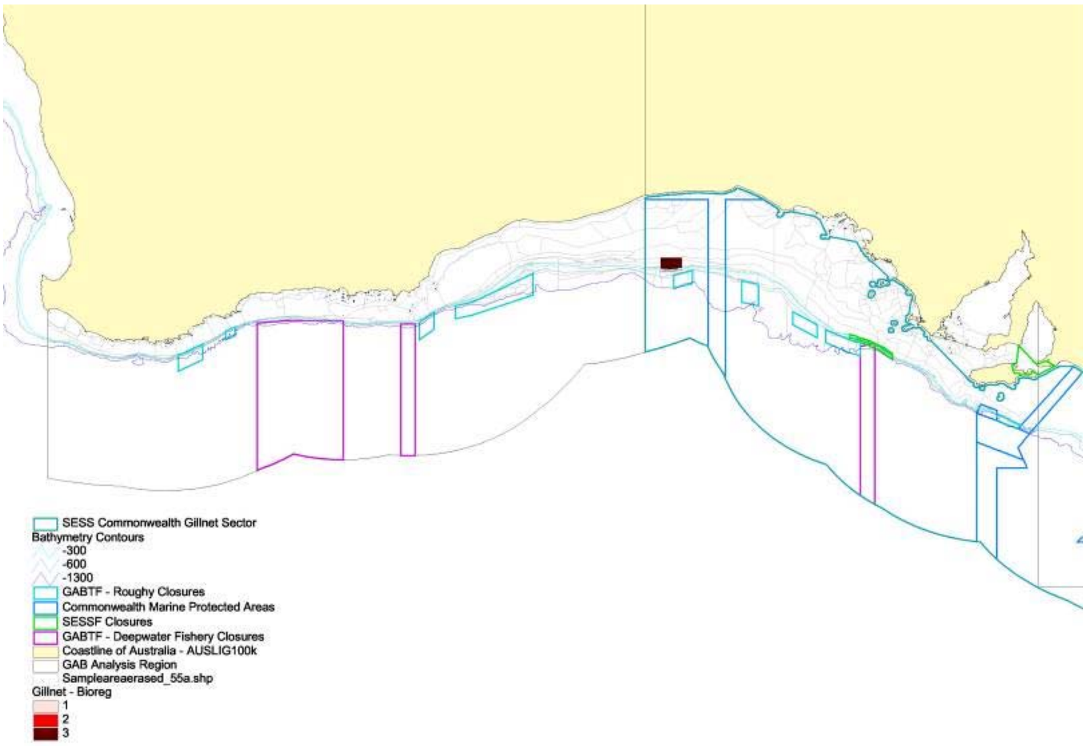


Figure 5.5.2.1 Distribution of Gillnet Species Group (GSG) based on biogregionalisation data (thematic mapping is the number of GSG species present in each polygon). (*Demonstration area only shown to preserve confidentiality.*)

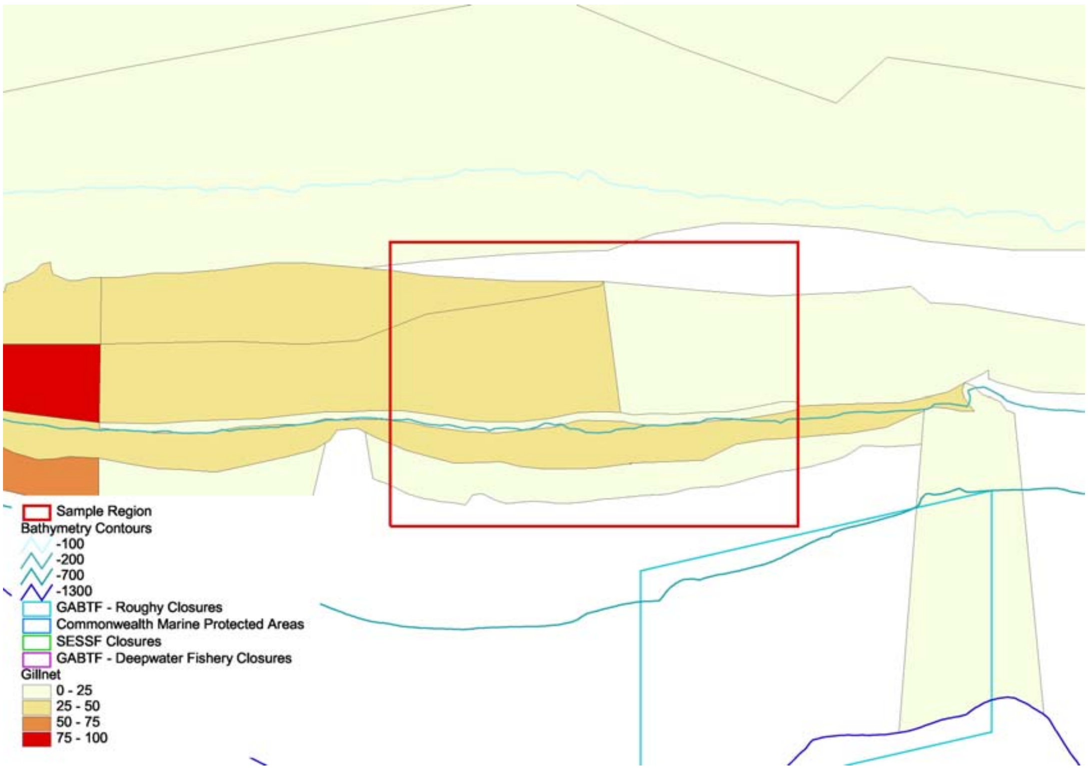


Figure 5.5.2.2 Distribution of Gill Species Group (GSG) based on fishery catch data (thematic mapping is the number of unique observations of GSG summed for each polygon). (*Demonstration area only shown to preserve confidentiality.*)

Opportunities for future scenario evaluation

It will be difficult inform an Ecological Management response for this group until more reliable species identifications and observer data are available. Even then this type of group analysis will be difficult because of the diverse ecology of the group.

5.5.3 Trawl Scalefish Group

Summary

Ten different species were included in the analysis (Table 4.5.2.1). These species have varying ecology, ranging from strong associations to soft sediment benthic (e.g. Deepsea (Spiny) Flathead) to reef associated (Gulf Gurnard Perch) to benthopelagic (Yelloweye Redfish).

Evaluation

The BioReg analysis indicates that the full set of these species can only be found at the edge of the shelf. Although extensive fishing grounds are closed to trawling inshore off South Australia, most contain only about half of the species of concern. Off Western Australia inshore, the result is influenced by the scale of the polygons and the narrowness of the shelf.

The integrated analysis indicates that the highest number of observations of some members of this group have been at the west of the GAB

Inshore areas can not provide protection for all members of this group. If the ecological risks associated with this entire group need further spatial management arrangements then these will need to be implemented at the edge of the shelf. Currently the main area closed to trawling in the area is the GAB Marine Park, although other fishing methods are still permitted.

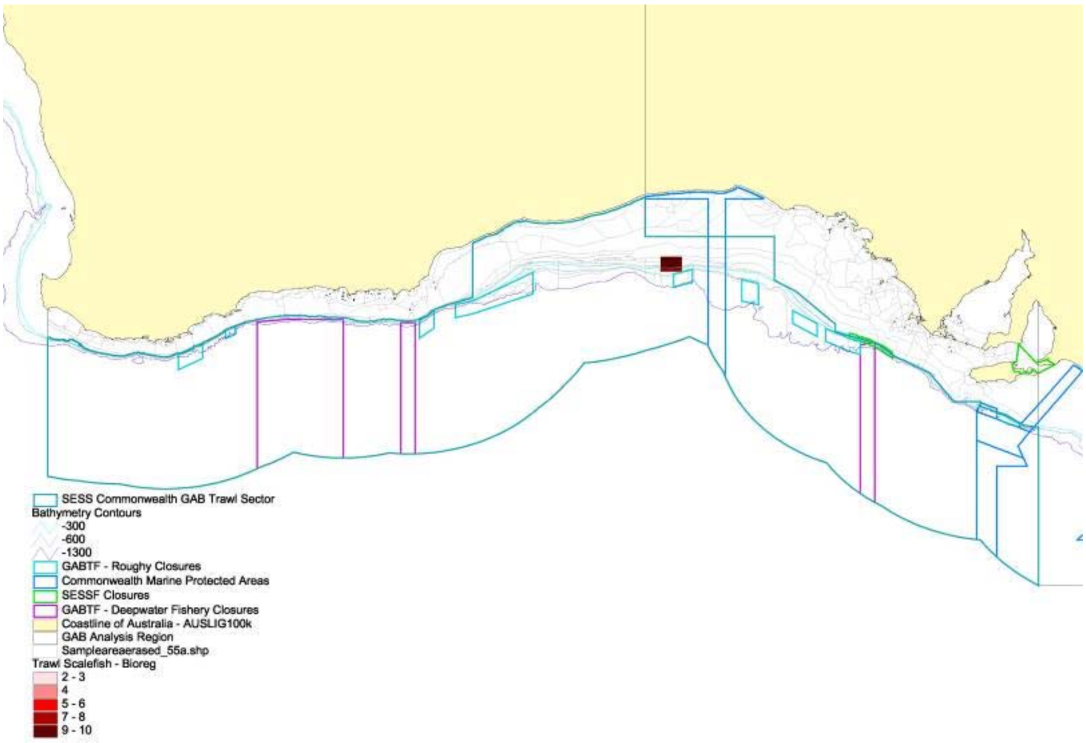


Figure 5.5.3.1 Distribution of Trawl Scalefish Group (TSG) based on biogregionalisation data (thematic mapping is the number of TSG species present in each polygon). (*Demonstration area only shown to preserve confidentiality*.)

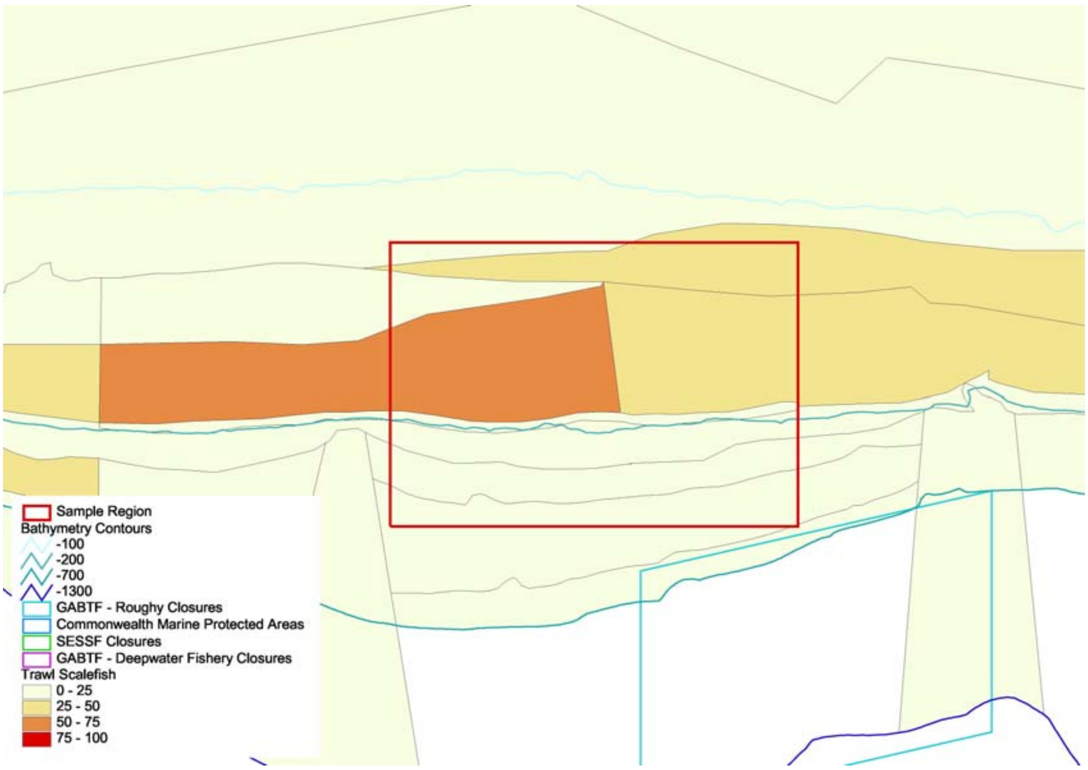


Figure 5.5.3.2 Distribution of Trawl Scalefish Group (TSG) based on fishery catch data (thematic mapping is the number of unique observations of TSG summed for each polygon). (*Demonstration area only shown to preserve confidentiality*.)

Opportunities for future scenario evaluation

Some species in this group occur in inshore areas where they potentially have some refuge from trawling, although they may be impacted by other fishing methods. Potentially these species could be managed in collaboration with the states. This might be in existing state closures that could be evaluated with the tools developed. In all likelihood there are also inshore areas with historically low fishing effort that could be acting as refuges. However, the limited spatial resolution of existing state fishery data would hamper evaluation of this type of potential refuge.

The species in this group that only occur at the edge of the shelf probably warrant species by species evaluation. The GABT is the primary sector fishing in this depth range.

5.5.4 Trawl Chondrichthyan Group

Summary

A large group of 19 species were included in the analysis (Table 4.5.2.1). These species have diverse ecologies ranging from mid-slope species to inshore with varying affinities to the bottom.

Evaluation

The Bioreg analysis indicates that the full set of species in this group can not be found in any single fishing ground but the fishing grounds containing the highest number of species, typically more than 15, are concentrated at the edge of the shelf and upper slope. Conversely for the most part inshore grounds contained 11 or fewer of these species. An exception was grounds off WA but this result was influenced by the scale of the polygons. The integrated analysis indicates that only polygons at the edge of the shelf had more than 50 observations of some members of this group. One polygon south of Kangaroo Island had more than 75 observations. Two inshore polygons had more than 25 observations, one at the west of the Bight and one near the head of the Bight.

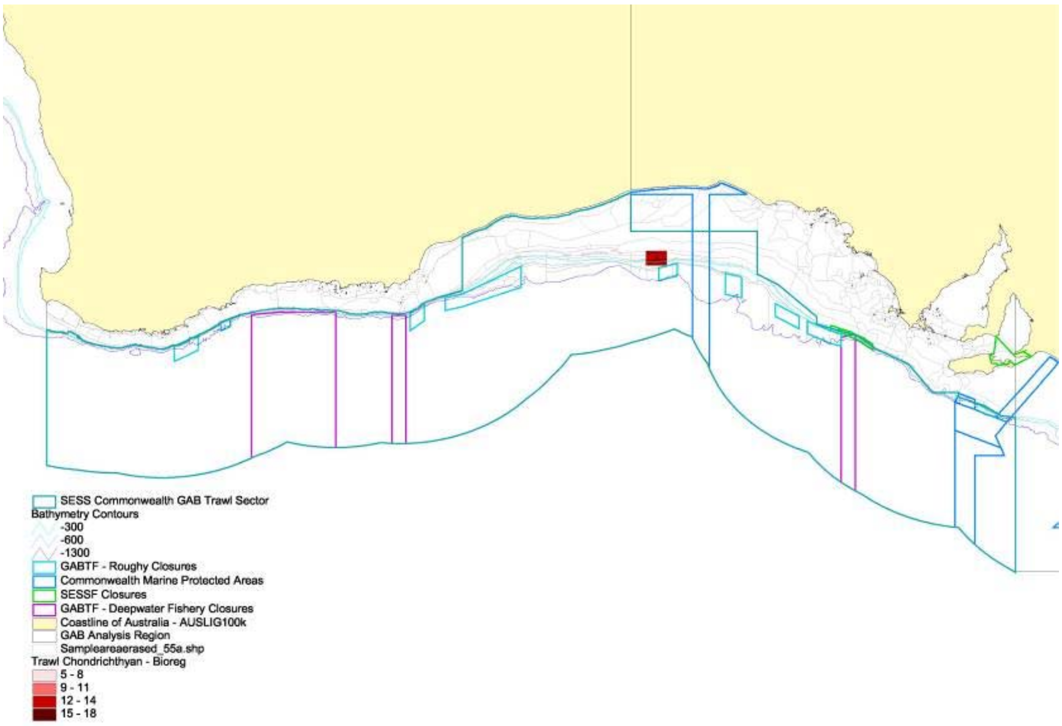


Figure 5.5.4.1 Distribution of Trawl Chondrichthyan Group (TCG) based on biogregionalisation data (thematic mapping is the number of TCG species present in each polygon). (*Demonstration area only shown to preserve confidentiality*.)

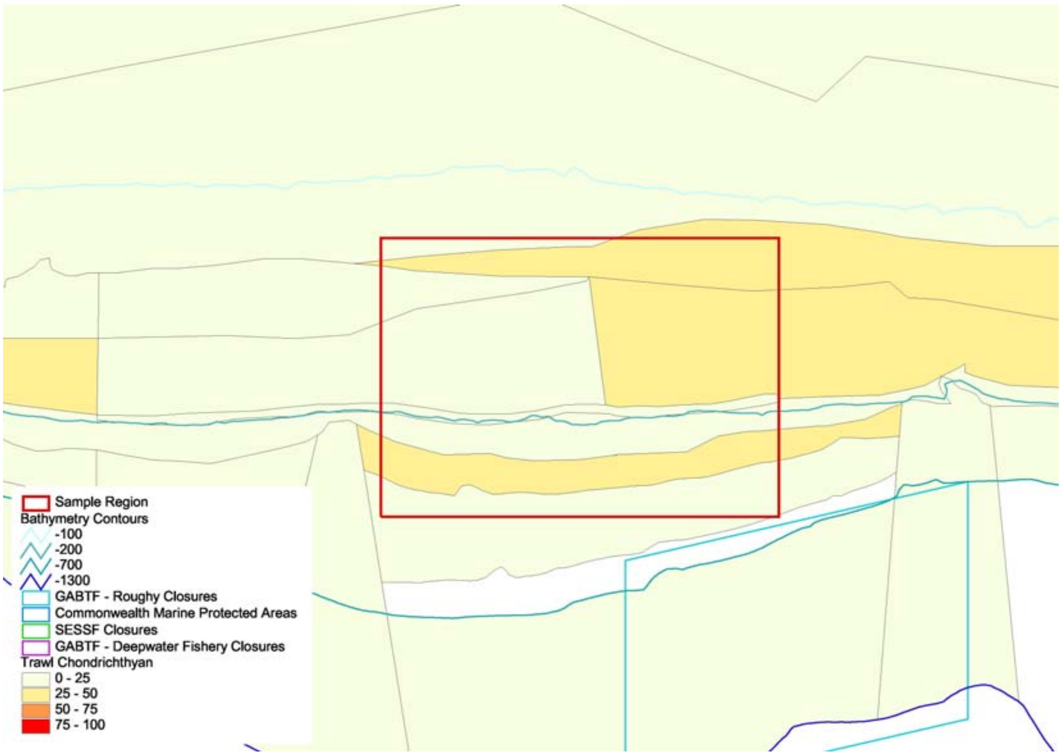


Figure 5.5.4.2 Distribution of Trawl Chondrichthyan Group (TCG) group based on fishery catch data (thematic mapping is the number of unique observations of TSG summed for each polygon). (*Demonstration area only shown to preserve confidentiality*.)

Opportunities for future scenario evaluation

Evaluation of this group was problematic due to the large number of species and diversity of habitats. Perhaps more useful evaluations could be based on a breakdown by bathome or by taxonomic groupings.

5.6 Important Fishery Habitats (IFH)

Summary

The data product is a spatial database showing the presence of each IFH type in each fishing ground polygon. This enables IFH scores (1 to 4) based on the abundance and confidence of the IFH occurring in the polygon to be mapped and summarised. In the example provided here, mapping shows sum of IFH scores for each polygon (range = 0 to 8) (Figure 5.6.1.), while summary statistics show the number of polygons containing each IFH, the total area of those polygons, and the fractions within the set of existing fishery closures (Table 5.6.1). For this snapshot, the fishery closures include the existing Commonwealth Marine Reserves, the Southern Dogfish Closure and the Deepwater Closures and GAB. A similar snapshot could be generated for IFHs individually, or any combination.

Evaluation

IFHs are distributed across a large number of fishing ground polygons (369 of 484). Structured inner shelf habitats (IFH 1) occur most frequently, while the other five IFHs (2-6) occur in a relatively small number of the total 484 polygons. Seamounts occur least frequently – in only 25 polygons. The proportions of IFH polygons in closed areas are relatively small (ranging from ~2 to 8%).

Two general aspects of this snapshot example are noteworthy. First, is that the constraint of mapping at polygon scale means the IFH areas within closures are not absolute measures of habitat areas, but instead, the areas of polygons containing IFH habitats. The absolute areas of IFH habitats conserved will be smaller in almost all cases, and in some cases such as seamounts, much smaller. However, in the absence of detailed mapping data, these estimates provide a useful index. Second, these values do not take account of IFH areas that are not fished. Thus, to address a different question, such as the interaction between a gear type and IFH, it would be possible to consider where natural refuges may also exist based on bottom type and the fishing effort footprint.

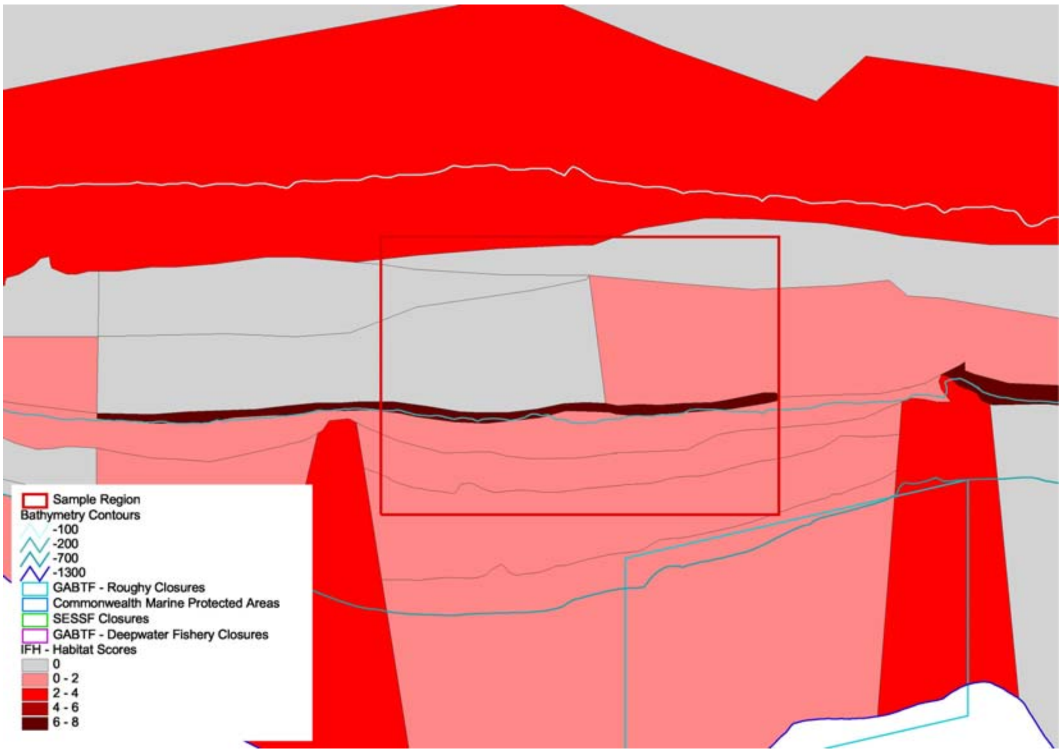


Figure 5.6.1. Distribution of Important Fishery Habitats (IFH) (thematic mapping is sum of IFH scores for each polygon). (*Demonstration area only shown to preserve confidentiality*.)

Table 5.6.1 Summary statistics for Important Fishery Habitats (IFH) showing the number of polygons containing each IFH, the total area of those polygons, and the fractions within the set of existing fishery closures. Note, while closures extend to EZ boundary (200 n.m.), our analysis extends only to 1300 m depths (see text and Figure 5.6.1).

HABITAT_CODE	No. of polygons	Total Area	Total area within closures	% reserved
IFH_1	221	160892	8211	5.10
IFH_2	65	64809	1224	1.90
IFH_3	42	25369	905	3.57
IFH_4	37	11612	848	7.31
IFH_5	44	13278	1053	7.93
IFH_6	25	29284	879	3.00
IFH_SUM	369	264058	12358	4.68

Opportunities for future scenario evaluation

Similar and more sophisticated analyses can be made for, during or after the implementation of Commonwealth Marine Reserves, or for fishery-specific spatial planning. IFH summaries can be applied to design and zoning, inventory, and target setting.

5.7 Vulnerable benthic habitats (VBH)

Summary

The data product is a spatial database showing the presence of each VBH type in each fishing ground polygon. This enables VBH scores (1 to 4) based on the abundance and confidence of the IFH occurring in the polygon to be mapped and summarised. Mapping shows sum of VBH scores for each polygon (range = 0–20) (Figure 5.7.1.) while summary statistics show the number of polygons containing each IFH, the total area of those polygons, and the fractions within the set of existing fishery closures (Table 5.7.1). For this snapshot, the fishery closures include the existing Commonwealth Marine Reserves, the Southern Dogfish Closure and the Deepwater Closures.

Evaluation

VBHs are distributed across relatively few fishing ground polygons (200 of 484). Rocky shelf habitats (VBH 3) occur most frequently, while the other seven VBHs occur in a relatively small number (<53) of the total 484 polygons. Seamounts occur least frequently – in only 25 polygons. The proportions of VBH polygons in closed areas are relatively small (ranging from ~2 to 12%).

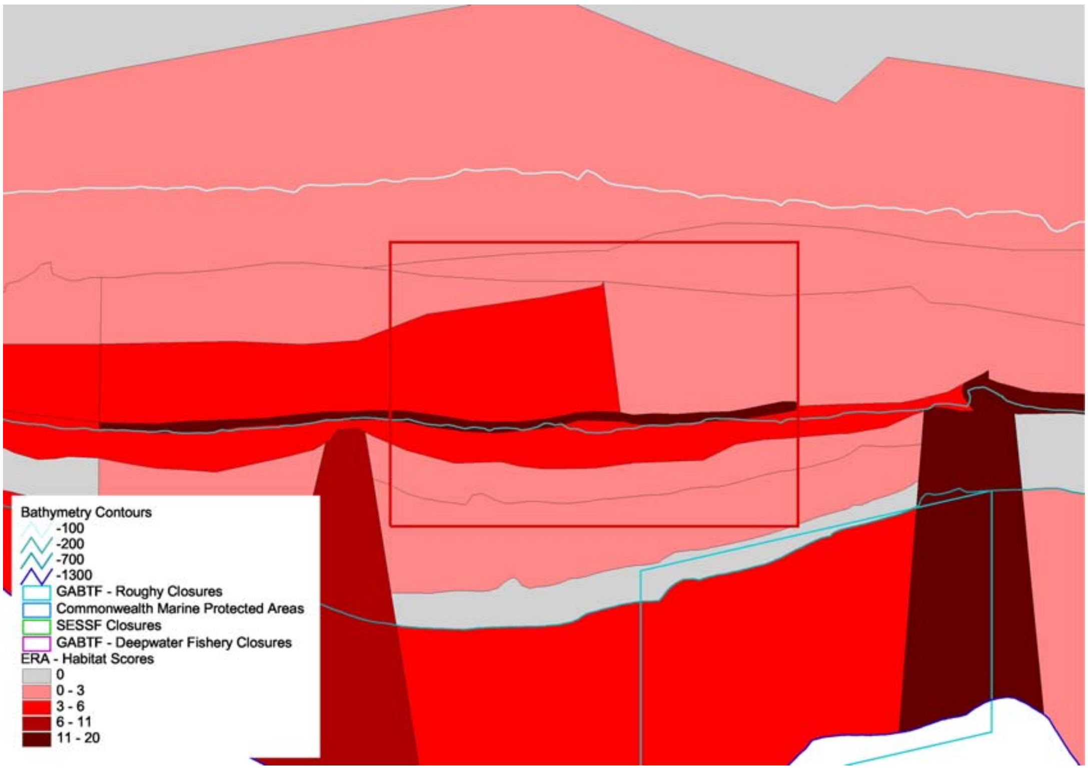


Figure 5.7.1 Distribution of Vulnerable Benthic Habitats (VBH) (thematic mapping is sum of VBH scores for each polygon). (*Demonstration area only shown to preserve confidentiality.*)

Table 5.7.1 Summary statistics for Vulnerable Benthic Habitats (VBH) showing the number of polygons containing each VBH, the total area of those polygons, and the fractions within the set of existing fishery closures (see text and Figure 5.7.1).

HABITAT_CODE	No. of polygons	Total Area	Total area within closures	% reserved
VBH_1	37	13906	431	3.10
VBH _2	47	19548	1162	5.94
VBH _3	87	85671	1772	2.07
VBH _4	49	15632	1773	11.34
VBH _5	14	4857	181	3.72
VBH _6	40	19315	1454	7.53
VBH _7	50	45201	5348	11.83
VBH _8	53	45495	5348	11.76
VBH _SUM	200	156031	8909	

Opportunities for future scenario evaluation

Similar and more sophisticated analyses can be made for, during or after the implementation of Commonwealth Marine Reserves, or for fishery-specific spatial planning. VBH summaries can be applied to design and zoning, inventory, and target setting.

5.8 Specific scenarios

Exploratory scenario mapping and analysis for key issues and closed areas has been deliberately kept to a minimum in this report because the near-term implementation of Commonwealth Marine Reserve network will profoundly change all results.

However, we have included two examples that demonstrate the versatility and utility of the data and analysis tools developed or integrated by the project:

- The first, at the request of the Steering Committee, provides a snapshot in March 2010 of the area of the trawl footprint in relation to closed areas, IFHs and VBHs.
- The second examines the conservation of seamounts.

5.8.1 Integrated area closure and bottom trawl fishery footprint scenario

This scenario examines the trawl footprint in relation to the total area of the fishery available to Commonwealth trawl, the areas closed to trawling – including and excluding the Orange Roughy Management Zones (Figure 5.8.1) (where fishing is regulated, but there is no explicit restrictions on habitat interaction), and in relation to the distribution of IFHs and VBHs. The scenario uses the cumulative trawl footprint through time, with trawl effort resolved at 1km^2 grid as present or absent, and assumes all closures have been in place for the total duration over which the trawl footprint is estimated (1986-2009). Polygons are selected where any individual IFH and VBH type scores a maximum value of 4 (meaning it is abundant and confidence is high).

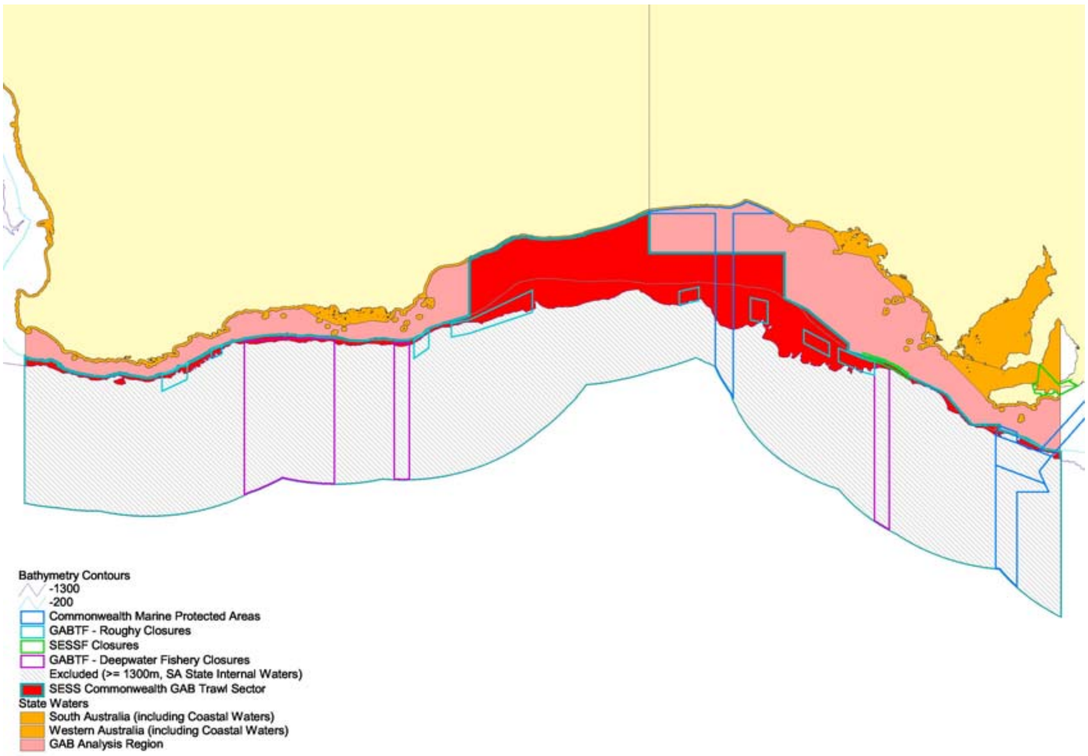


Figure 5.8.1 Map showing the area of the fishery available to Commonwealth trawl (red), the areas unavailable to trawling (pink and orange) including the Orange Roughy (OR) Management Zones (light blue) and marine reserves (see also Section 4.1 for more details of jurisdictional and closed area boundaries).

Steps in scenario – and see Figure 5.8.2 for schematic representation of the overlays

1. Total GAB fishery study area

The total area of the GAB is 1,025,083 km^2. However 645,981 km^2, almost two thirds of the region, is deeper than the 1,300 m isobath. These very deep waters are not fished because they are believed not to contain commercial fishery species and in any case are not accessible to current Australian fishing methods. Accordingly, they were excluded from further analyses. Of the remaining 360,000 km^2, a further 26,372 km^2, representing the St Vincent and Spencer Gulfs of South Australia were also excluded. The calculations below refer to the remaining 352,729 km^2 – the study area

Interpretation: a relatively very large fraction of total GAB is not relevant to calculations that consider habitats and ecosystems of the fishery area

2. Area available to trawl fishery

The area within the jurisdictional boundary of the GABTS is 143,346 km^2, only **40.6%** of the study area. By contrast the non-trawl sectors have access to a much larger proportion of the study area –182,201 km^2, with gillnet access to shelf (<183 m depths), including large areas available only to gillnet; autoline currently restricted to slope waters (>183 m) east of the South Australia/Western Australia border.

Within the area available to trawl, 9,860 km^2 (**7%**) is fully closed to trawling, and an additional 22,612 km^2 (+**9%** =**16%**) is within orange roughy closures.

Interpretation: These figures show that proportions and absolute areas are important for interpreting scenarios. Thus, (1) as a proportion, most (~60%) of the GAB fishery area is unavailable to trawl, but (2) there is a large area available for trawling (some 143,000 km^2). Within this, a relatively small fraction is closed to trawling.

3. Area of IFH

Total area of polygons scoring high (4) for any IFH = 19,540 km^2 i.e. 13.6% of the area available to trawling. The area of polygons scoring 4 for any IFH within closures (inc. OR zones) = 3,395 km^2 (17.37%). With OR zones removed, this drops to (619 km^2 (3.17%).

Interpretation: A relatively small fraction of the overall trawl area is highly scored IFH. Within the trawl area, the great majority (~83%) of areas scoring high for IFH are outside closures; this drops to 97% if OR zones (with no habitat protection) are excluded. Most of the IFH represented in closures is on the mid-slope and in Orange Roughy closures which provide no explicit habitat protection. IFH in other depth zones is poorly represented. The areas chosen for closures under-represent IFHs compared to the fraction of all grounds permanently closed to trawling (7%). Within the total trawl area, very little highly scored IFH is closed to trawling(~0.4%).

4. Area of VBH

Total area of polygons scoring 4 for any VBH = 19,036 km^2 i.e. 13.3% of the area available to trawling. The area of polygons scoring 4 for any VBH within closures (inc. OR zones) = 4,577 km^2 (**24.05**%). With OR zones removed, this drops to 675 km^2 (3.55%).

Interpretation: A relatively small fraction of the overall trawl area is highly scored VBH. Within the trawl area, the great majority (~76%) of areas scoring high for VBH are outside closures; this drops to ~96% if OR zones (with no habitat protection) are excluded. Most of the VBH represented in closures is on the mid-slope and in Orange Roughy closures which provide no explicit habitat protection. VBH in other depth zones is poorly represented. The areas chosen for closures under-represent VBHs compared to the fraction of all grounds permanently closed to trawling (7%). Within the total trawl area, very little highly scored IFH is closed to trawling(~0.4%).

5. Trawl footprint – IFH overlap

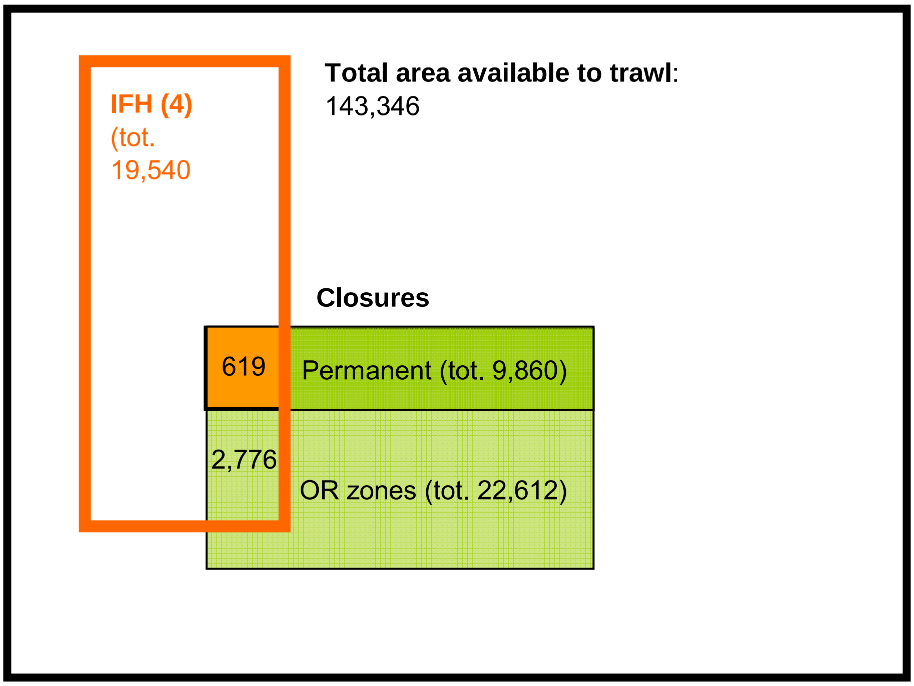
Total area of trawl footprint = 30,900 km^2 (**21.6%** of the area available to it) (Figure 5.8.2). Under the trawl footprint there is a collective area of polygons scoring IFH 4 = 2,200 km^2 (**7%**). Of the high IFH scoring polygons under the footprint, 868 km^2 (39%) is in closures; the proportion of high IFH scoring polygons in closures is 2.81% of total footprint. With OR zones excluded, it drops to 422 km^2 = 19%, or 1.4% of total footprint area. This represents the area in closures that have been introduced during the time span over which the trawl footprint has been estimated.

Interpretation: Trawling uses only about one fifth of the available area (is highly concentrated). It has a small (7%) overlap with high IFH polygons which is mostly with mid-slope polygons in OR zones; these are highly influential on summary values. There is considerable scope to include IFH in permanent closures without impinging on the current footprint. To maximise the benefit of IFH captured in closures, analysis would have to be done at the level of individual IFH types and for different fishery sectors separately.

6. Trawl footprint – VBH overlap

Under the trawl footprint there is a collective area of polygon scoring VBH 4 of 3,200 km^2 (10%). Of that 1600 km^2 is under closures = 50% of high VBH scoring polygons; the proportion of this in closures is 5.2% of total footprint. With OR zones excluded, it drops to 465 km^2 = 14.5%, or 1.5% of total footprint area

Interpretation: Comments applying to IFH apply similarly to VBH. In both cases, it is necessary to examine habitat types separately (rather than collectively as has been done here) to ensure that each IFH and VBH type has some permanent protection.



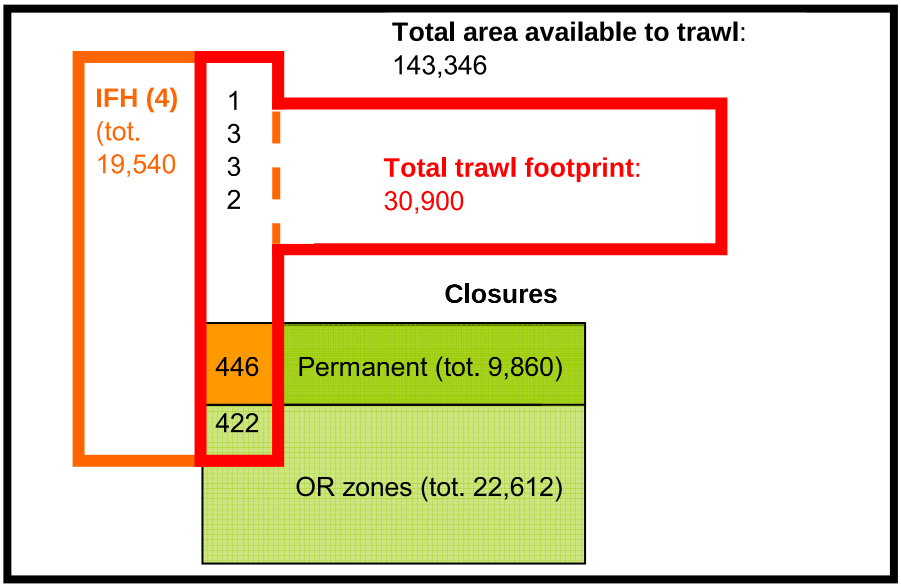


Figure 5.8.2 Schematic showing the areas (figures given are km^2) and overlaps of total area available to trawling, 'High IFH areas', (summed area of all polygons with a score of 4 for any individual IFH type), and trawl footprint (for the years 1986-2009).

5.8.2 Seamounts

Seamounts are regarded as vulnerable habitats due to the diversity and great longevity of many of the fauna that live on them, and the large size and/or delicate structure of some faunal elements such as large ‘tree-forming’ corals (Clark et al., 2010), and because the impacts on bottom trawl fishing on them can be long-lasting (Althaus et al. 2009). Of foremost importance on seamounts is the matrix forming stony coral (*Solenosmilia variabilis*) because it creates large areas of structured biogenic habitat that drives the overall faunal diversity by providing complex attachment surfaces and interstitial spaces. This species, known as ‘brain coral’ by GAB fishers, has a restricted distribution off temperate Australia because it occurs only in the depth range of ~600 to 1350 m (Althaus et al. 2009) (a very close overlap to the depth range of orange roughy), and occurs only on seamounts.

Which types of elevated seabed topography constitute ‘seamounts’ depends largely on whether a geological or ecological classification is used (Williams et al. 2009). A broad, ecologically-based definition of ‘seamount’ (Pitcher 2007) is relevant to considerations of fishery interactions because size-based geological criteria for defining seamounts are arbitrary. The occurrence of vulnerable fauna is not related to feature size, and vulnerable fauna do not occur on all seamounts. Thus, we use a definition that includes any seabed topography with a local scale elevation greater than ~50 m that occurs on the mid-slope (depths from ~750 to 1300 m). In common with the majority of seamounts in the relatively well-known cluster south of Tasmania (Althaus et al. 2009), most features in the GAB are small, with elevations of only 10s to 100s of m.

Evaluation

Fishers’ knowledge includes all of the relatively few locations of seamounts in the GAB, as well as good indications of which support corals – information that did not exist previously because there has been little scientific sampling of seamounts in the GAB. Thus, the total number of seamounts identified by fishers in waters deeper than 750 m was 27. This information is recorded in the project data set at ‘feature-scale’ but kept confidential as map products are not publicly available. Because it is unlikely that additional undiscovered seamounts are located in the GAB, these known locations provide the basis for considering what is worthy of protection. Spatial management could simply be based on capturing a certain proportion in closures, or could consider seamounts in the context of points of connectivity (sources and sinks) between the Indian Ocean and Tasman Sea. A key starting point is to examine which seamounts are already contained within closures.

Of the 27 seamounts mapped, none are entirely protected by Commonwealth Marine Reserves. Most (23) are enclosed in Orange Roughy Research Zones where fishing is regulated by a Total Allowable Catch. The remaining 4 seamounts lie outside closures. Thus, there is scope to bolster the Deep Water Management Plan by regulating where fishing occurs within the Orange Roughy Research Zones on a finer scale to protect the seamounts supporting corals. Discussions with fishers indicate that this can be achieved with minimal impost on catches of Orange Roughy, thereby providing a very significant conservation gain.

Opportunities for scenario evaluation

Without some targeted scientific sampling, there is unlikely to be any additional information on seamount habitats and fauna available in the GAB. Decisions can be made using the available information. What is needed is a method to more critically establish the distribution of brain coral and other corals on the 27 known seamounts, and to establish a way in which this information could be "released" or used.

6 Discussion

6.1 Integrating fisher and science data: methods and innovations

6.1.1 The relevance and importance of an integrated approach

The introduction of area closures in Australia's temperate deepwater fisheries acknowledges the need to supplement conventional input and output controls. This recognition is based on a review of the status of SESSF stocks in late-2002, strategic assessment of the SESSF, and initial findings from an evaluation of alternative management strategies. While there are now several fishery closures in place in the SESSF, most are for species-specific issues – although GABIA-proposed Deep Water closures have been implemented in the GAB. Strategically, the needs of the fishery will be better served by taking a synoptic view and establishing a network of closures that collectively address both immediate and longer-term issues. Marine Protected areas have the potential to complement fishery closures to address broader ecosystem goals. In this context, "synoptic" includes taking a multi-scale "seascape" view of the fishery region (Williams et al. 2005) that recognises the uses and needs of all fishery sectors, and considers the scales at which fishing occurs, ecological processes exist, and at which management actions are tractable, effective, and assessable.

For some sectors of the SESSF, effort expansion has been a concern, as reflected in the previous WTO (see 6.2.1). With the expansion of non-trawl methods and some gear overlap in the GAB it is likely that unfished refuge habitats and vulnerable habitats are decreasing. The extent to which this has occurred has not been quantitatively assessed, although the data compiled in this project would facilitate such an analysis if it was required

It was somewhat surprising to find that, despite the long history of sampling (dating back to the early 1900's), and the geographical scope of recent mapping (e.g. Heap and Harris, 2008), much of the massive GAB fishery area (depths <1,300 m) remains very poorly known in terms of habitat and species distributions. It needs to be emphasised that a vast increase in knowledge is required to move from simply describing the habitat types occurring within a specified area (e.g. as was done in the Ecological Risk Assessment for the Effects of Fishing (ERAEF) project (Daley et al. 2006), to mapping habitat distributions within that area. This is epitomised in the present study where the goal was to classify and map habitats in a way that captured their relevance to the suite of fishes that support a multi-sector commercial fishery. Thus, the mapping required is not only of habitats *per se* (here, simply 4 classes of bottom type), but also of the associations between habitat and fishery-relevant species. Similarly for species, more mapping data is required for areas where catches may never have been taken or recorded at sufficient (species-level) resolution, for example much of the western half of the GAB, and the continental slope (depths > 300 m).

The approach taken here to address both the issues of low data coverage (distribution and quality), and the needs for strategic planning, was to collate and integrate a variety of information. The method of data collection was based closely on that established in a similar project undertaken in the SEF area of the SESSF fishery (Williams et al. 2006). The incorporation and integration of fishers information and knowledge was based on the philosophy that integrated mapping can be superior to either industry or science data in isolation because it combines the strengths of industry knowledge – mapping, naming and repeated sampling of large areas over long periods – with detailed scientific observation of relatively small areas during infrequent surveys using novel samplers such as swath mapping and cameras. This was borne out in the SEF project, and again here in the GAB, where in both cases, credible data products have been produced.

6.1.2 Project conceptual framework and development

Although proven methods were employed in the GAB, there were also several important methodological developments made during this project. These were in four primary areas.

First, the data collection methods were adapted to suit the GAB region which is even larger than the SEF but has fewer operators. Fishery observers also contributed their knowledge and there was a higher reliance on non-fishery data to define the boundary and bottom types of areas in the western GAB. In this project, the knowledge of fishers from all three sectors was integrated into the final map set.

Second, a greater sophistication of the GIS database and mapping capability enabled more complex map products to be produced. This enabled some ‘within ground’ feature level mapping (although this remains confidential), more flexibility in dealing with logbook data summaries of catch and effort, and the development of a tool (the Polygon Analysis Tool – PAT) that automates the process of evaluating trade-offs to industry of closing areas by aggregating total catch (a linear proxy for dollar value) within any chosen box (including complex shapes) at various degrees of resolution by species and time period. This will enable rapid scenario development, for example during the process of defining boundaries and zoning plans for Commonwealth Marine Reserves.

Thirdly, data on species were explicitly included in data acquisition and analysis. This provided data products for individual species and groups of species, and, as importantly, enabled the mapping of habitats to be extended to mapping of habitats classified by their importance to the fishery based on species-habitat associations. Several compound metrics to describe the distributions and importance of habitats were developed and explored; their utility is discussed further in the following section.

Lastly, the methods developed, and the outputs of the project, benefitted greatly from the focus on key issues proposed by the Steering Committee at its first meeting.

The set of key issues – EBPC species, bycatch-byproduct species, important fishery habitats (IFH) and vulnerable benthic habitats (VBH) – generated the impetus to expand the breadth of the data analysed, and provided a focus for the outputs. The key issues aimed to address defined policy objectives of different government agencies for species or habitats components of the ecosystem.

Assessing bycatch/ byproduct species groups was conceptually the most strait forward policy objective to address. The functional objective was to provide a single map output for each group that could support an integrated Ecological Risk Management strategy, rather than a set of single species responses. Two approaches were used. Firstly an integrated approach using all fishery and science observations, and secondly the BIOREG approach, which is based on a very small number of high quality observations that are extrapolated over larger scales. The insights that could be gained from the extrapolated small data sets are limited. The integrated approach has potential for further development but only if more data can be collected with a greater spread of observations outside fished areas.

The level of success also varied between groups. It was most successful when applied to small (<10 species) groups that are mainly restricted to one bathome e.g. auto-longline species group. It was not possible to entirely depart from a species centric approach and catch maps were needed for thorough interpretation, together with literature information on habitat associations. An evaluation of the results from the byatch/ byproduct species groups indicates the basis for spatial management of the auto-longline sector in the east appears to have been well founded in baseline surveys and ongoing monitoring. For the west there is currently no effort and additional survey data would be required to form a strategy. For the trawl some concerns were raised in that both the species of concern and effort is concentrated along the edge of the shelf. This differs somewhat from the ERA Rapid 3 assessment that found no species in the trawl group to be at high risk. Assessment of the Gillnet sector group was problematic because historical observer data with reliable identifications are lacking.

The most difficult to define was ‘important fishery habitat’ as it relates to the broader ecosystem objectives of fishery and conservation policies which are also the least clearly defined policy objectives. Following discussion, it was agreed that in the context of this study, IFH was used to define habitat areas that provide ecological services linked to production of the fishery. The set of IFHs was corroborated by fishers and observers and was remarkably consistent with distribution patterns later identified from catch maps of non-target species. Typically, these were areas where biomasses of target and non-target fish species (including prey species) were linked to physical structures. Structured habitat in the GAB fishery included physical components (e.g. the rocky banks associated with the ancient coastline in ~100 m and mid-slope seamounts), and also biological structures such as concentrations of benthic invertebrates (e.g. sponges).

Assessing key (EPBC) species built on the concept of IFHs. A species by species approach was taken, which is required because the recovery plans for these species are species specific. The approach taken varied between species but was linked – to the extent possible to IFHs. The more IFHs a species was associated with, the more challenging it was to assess. The key species approach was most successful for Orange Roughy, a previously commercial species that has been well studied and could be linked to a single IFH – seamounts, which had already been mapped in detail at fine scales. In evaluation we found that all of the seamounts that have been identified can still be fished, although catches are limited by the research quota. It is not clear what if any of the broader ecosystem objectives of the Orange Roughy recovery program are addressed by research fishing, other than to establish a trend in abundance of the once targeted species. The key species approach was most challenging for School Shark. Even though this species is well known, it is a wide ranging species and was linked with multiple IFHs. This approach provided some new insights for this species and suggests that an effective network of closures will need to include three IFH types and consider connectivity because individuals use all three types which extend across the continental shelf. Potentially project data could be used to identify additional candidate closed areas for School Shark if habitat data were re-analysed at a finer scale with industry support. For Southern Dogfish, results were inconclusive, because this species is less well known and its specific habitat requirements are to date unclear – although are currently being studied. The project data also assisted GABIA to prepare a submission to the TSSC on this issue. The key points identified included identifying the key species of concern in the region, highlighting the current specific measures in place, and exploring additional candidate areas off Western Australia.

We believe the production of methods and results that are relevant to issues facing the fishery will increase their prospects for uptake when assessing the needs for fishery closures. Indeed, the first suite of analyses provided an informed alternative to the deepwater blanket closure for Orange Roughy. A set of deepwater closures was developed that met the expectations of the conservation plan for this species whilst enabling a continued commercial catch.

6.1.3 Strengths, limitations and future development of method

Much of the pre-existing information for the GAB is of relatively low resolution, for example the very large numbers of trawl samples taken by Soviet research vessels lack reliable taxonomy and complete catch composition data. Modern high-resolution mapping and biological data are available for only small areas. Collectively, however, all data made contributions to mapping by informing the development of species synopses, and to supplement the information on habitat distributions and roles. In the absence of fishers' information, low resolution data were often all that were available to inform the definition of polygons. Flags to data quality, and the uncertainty that accompanies poor data, is often difficult to capture and retain in databases and data products. Our attempts to do this included applying confidence scores to polygon bottom types and boundaries in the database of fishing grounds, the appraisal of species-distribution data sets (Table 4.6.2.2), and to the scoring of important fishery habitats (IFH) (Table 4.6.3.1).

Developing compound metrics (values) to map the distributions of species and habitats in relation to fishing ground polygons required that only a single value was given to each polygon. This is both a strength and a limitation of mapping at this combination of scales – a region of ~360,000 km^2 described by 484 polygons with an average size of 745 km^2.

The strengths are that the information summarised is at a scale that is relevant and useful to management issues; the mapping task and complexity of analysis is tractable; the detail of summary statistics is digestable for a broad range of stakeholders; and the spatial resolution is not problematic in terms of the "commercial in confidence" nature of fishing locations.

However, the limitations of these scales include that attributing only a single value per fishing ground polygon most often over-simplified the patchy distributions of habitats and species within each. Summary statistics, such as those provided for habitats, can show the membership of individual types (e.g. IFH or VBHs) to polygons, but this is not easily mappable. Over-simplification of thematic mapping within polygons is exemplified on the mid-slope where a small number of scattered seamounts, some of which support vulnerable and important fishery habitats and aggregated commercial fishes, are surrounded by large areas of homogeneous muddy plains. Individual seamounts in the GAB (typically <<10 km^2 in size) are captured in the database as features, but they cannot be seen on maps scaled to show grounds within a region that spans some 23 degrees of longitude (or >2,000 km) in width. As well, the locations of features (habitats) within grounds is often too fine to be made public – including to other fishers – a point made clear to fishers before any data were provided. An implication of patchy within-ground distribution of habitat is that it does not lend itself to species assessment by other methods that assume species are evenly distributed throughout their core range, e.g. ERA rapid Level 3 which was developed for the Gulf of Carpentaria – which, unlike the GAB, is a relatively large expanse of homogeneous habitat in the same depth range.

Developing compound metrics (values) to describe the distributions of <u>groups</u> of species and habitats in relation to management issues has another serious limitation – that members of a group may have disparate characteristics which are masked or lost in summary statistics or maps. This is exemplified by the Trawl Chondrichthyan Group (TCG) that contains 19 species with diverse ecology, bathymetric range and use of the water column. Thus, while mapping over the region at fishing ground scale provides a broad visualisation of where these sharks and rays are caught by trawl, it may not provide sufficient resolution of individual species (or their habitats) to sufficiently inform management considerations, such as closures aimed at bycatch reduction.

It is important not to over-analyse the results provided by the species group metrics as these are only at an exploratory stage of development. This is not problematic in the sense that many data are captured for individual species and habitats in the database; the answer to a management question may just require drilling-down further into the project data to produce more specific, or a greater number of, analytical outputs or maps. This issue was discussed with the Steering Committee, and it was decided that while additional maps would not be presented in this report (due in part to confidentiality requirements) it was important to emphasise that this could be done relatively simply compared to generating analyses based on groups of habitats or species.

In cases where project data lack sufficient spatial resolution for a particular question, such as locations of vulnerable fauna or species within grounds, it is also possible to use the existing scales and resolution of mapping as the basis for additional data collection. For example, fishers often have much within-ground information in trackplotter data that were deliberately not acquired by this project, while high resolution multibeam bathymetry exists for others. In both cases, identifying the necessary additional sources of data is greatly assisted by maps that show the seabed seascape at the 'intermediate' level of detail achieved here.

The structure and flexibility of the existing database will enable refinement or development of what is a legacy dataset which can be used into the future to assist with sustainable fishery planning in the GAB.

6.2 Utilising project outputs for spatial management

In this section we provide interpretion and summaries of project information relevant to informing area management (spatial and temporal) of the GAB. This is done in relation to key processes and policies, as stated in project Objectives 5 and 6.

6.2.1 Summary

Table 6.2.1. Summary of outputs from the project that inform the key issues related to spatial management in the GAB

Key issue	Ecosystem Component	Project outputs and potential opportunities for uptake
1. Key (Protected) species	Defined list of defined species units	Orange Roughy: spatial management plan implemented based on project outputs (Section 5.4.1; Moore & Knuckey 2007) • Distributions of all known OR habitats have been identified and mapped (inc. non-seamount features) • Trawl footprint analysed in detail • Further issues related to seamount have also been considered (Section 5.8.2) Southern Dogfish: • Contributes to the current design implemented in GAB • Distribution of catch rate information has informed selection of suitable areas for closures • Information on current spatial closures relative to catch distributions enables assessment of efficacy • Habitat information from western GAB has contributed to industry proposed additional closure • Catch rate data will enable similar assessments to be made for other species, eg. greeneye spurdog School shark: • Habitat associations have bee identified and mapped • Insights into connectivity provided • Distribution in relation to fishing methods on different habitats identified, i.e. the increment is to take spatial considerations from simply depth-bounded closures to

		habitat bounded closures • Relevant data sources identified and mostly collated • Highlighted that integration of footprint into habitat mapping not possible for non-trawl due to limitations of data's spatial resolution
2. Bycatch/ byproduct species	Defined list of species units (from ERA and ERM process)	All species groups • Synopses of species ecology, distribution and habitat associations provided Auto-longline: • More detailed distribution of this group and its overlap with habitats • Proportion of habitat and depth range can be estimated with respect to current closures Gillnet: • Project identified that the lack of consistent identifications (species-level) in catch data prevent any meaningful spatial analysis Trawl: • Distributions of species mapped
3. Vulnerable benthic habitats	Mappable list of defined habitat units	• Development and extension from ERA level 2 assessment of habitats ('what habitats are'), to a consolidation of types into a small number of mappable units, and mapping their distribution at "fishing ground" (polygon) resolution ('where habitats are' and 'how much of each') • Metrics that permit mapping at scales relevant to management and across the extent of the GAB, e.g. enabling regional scale analysis in relation to trawl footprint, providing focal points for trade offs, understanding distributions and use of particular vulnerable habitat types, e.g. seamounts, shelf edge bryozoan-based habitats
4. Important fishery habitats	Mappable list of defined habitat units	• Development of a habitat classification that explicitly uses the associations between a defined list of target and non-target species and habitats • Metrics that permit mapping at scales relevant to management and across the extent of the GAB, e.g. enabling regional scale analysis in relation to trawl footprint, providing focal points for trade offs, understanding distributions and use of habitats that are important to the GAB fishery

6.2.2 Strategic Assessment

Products, conclusions or opportunities from the project are listed here against the conditions and recommendations from the Department of Environment and Heritage (now DEWHA) contained in the last Strategic Assessment for the GAB. We list only those relevant to spatial management.

Conditions

1. *Condition 4: AFMA by the end of 2007 to ensure a defined process for expanding fishing effort in each sector of the SESSF to new areas and/or species, is implemented within the formal management arrangements of the SESSF*

   Fine scale mapping of effort (using the appropriate data filters and thresholds to ensure data quality), in conjunction with the multiple scales and diversity of mapped data generated or collated in this project will enable the fishing footprint to be understood. This is a vital step towards informed and effective regulation.

2. *Condition 5: develop formal recovery plans … priority for Eastern Gemfish and School Shark*

   Project data are relevant to the refinement of the conservation plan for School Shark

3. *Condition 6…The BAP should include specified targets for bycatch reductions…performance measures to evaluate effectiveness. (ISMP data indicates main discards in GABT are Latchet, stingarees, sponges and rays)*

   Project data have been demonstrated to be relevant to the refinement of the conservation of School Shark.

Recommendation

4. *Recommendation 3: Implement ERM framework to address high risks identified by the ERA Process, including habitats and species*

   ERM for habitats is being addressed through an FRDC project (2009/029 Ecological risk assessment for effects of fishing on habitats and communities) that will benefit from the methods development accomplished here. Outputs from this project provide additional insights to the methods used for species at Level 3 and for ERM.

Other

5. *‘Systematically assess spatial (and temporal) management requirements across the SESS’…’supported by appropriate evaluation mechanism to determine effectiveness’*

   Project results achieve some of the steps necessary to do this, while the data base provides the basis for a more rigorous examination of needs and for evaluation. A key missing element is a set of targets against which to assess. While the project undertook a review of existing literature on this topic, there is no easy answer to target definition and the development of targets for species and habitats is beyond the scope of the existing project.

6. *‘Apply a more consolidated approach, particularly for the high number of low productivity shark, ray and skate species’*

Compound metrics have been explored for this purpose. While several approaches have been discarded, others show promise. Further development is possible using existing data.

7. *'Implement a system of spatial (and temporal) management measures to address [high discard rates, numerous overfished species increasing fishing effort] and vulnerable non-quota species such as deepwater sharks.*

   There has clearly been some effective steps towards this goal, including for Orange Roughy through this project. This goal can be re-assessed following implementation of Commonwealth Marine Reserves as these will inevitably include many areas of relevance for the variety of species of interest.

6.2.3 Commonwealth Marine Reserves

A network of Commonwealth Marine Reserves (CMR) will be implemented in the Southwest Region (that spans the area from Shark Bay to Kangaroo Island) in 2010/11 as part of Australia's National Representative System of Marine Protected Areas (NRSMPA). The location of CMRs will follow guidelines designed on CAR principles ANZECC (1998), but will be influenced by a range of Key Ecological Features (KEF), parts of which may be captured within CMRs. KEFs relevant to the GAB fishery area are shown below in Figure 6.2.3.1 and Table 6.2.3.1.

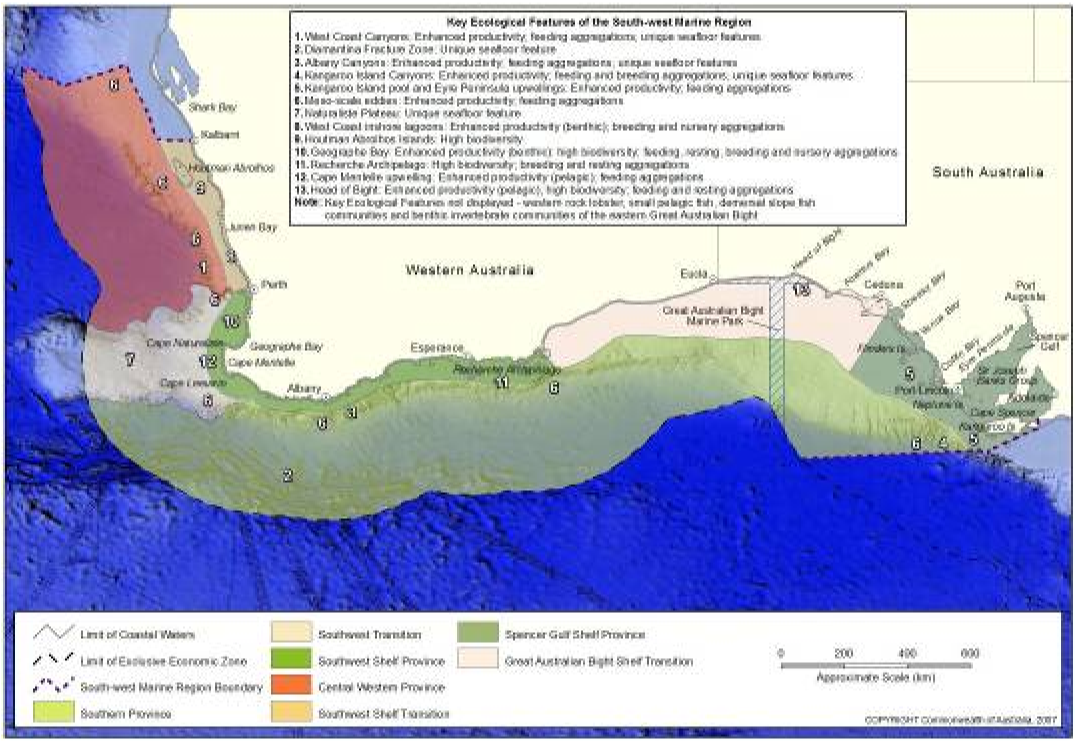


Figure 6.2.3.1 An indicative map showing the locations of key ecological features in the GAB.

Table 6.2.3.1. Key ecological features in the GAB fishery area of the South West Region that will influence the locations of Commonwealth Marine Reserves.

Key Ecological Features	Bioregions IMCRAv.4.0	Rationale
3. Albany Canyons Group and adjacent shelf break	**Southern Province**	Enhanced productivity; feeding aggregations; unique seafloor feature **The Albany Canyons, including 32 canyons along 700 km of continental slope, are believed to be associated with small periodic upwellings that enhance productivity and attract aggregations of marine life. Anecdotal evidence indicates that this area supports fish aggregations that attract large predatory fish, sharks and toothed, deep-diving whales such as the sperm whale.**
4. Kangaroo Island Canyons and adjacent shelf break	**Southern Province**	Enhanced productivity; feeding and breeding aggregations; unique seafloor feature **The Kangaroo Island canyons – a small group of steep-sided, narrow canyons – are associated with enhanced productivity that attracts aggregations of marine life. Seasonal upwellings are believed to be an important factor enhancing production. These upwellings support aggregations of krill, small pelagic fish and squid that in turn attract marine mammals (e.g. pygmy blue whales, fin whales, sperm whales, dolphins and New Zealand fur seals), sharks, large predatory fish and seabirds. Anecdotal evidence indicates that Orange Roughy, Blue Grenadier and western Gemfish aggregate and are thought to spawn in this area. Empirical evidence shows that Orange Roughy eggs occur in high densities. The canyons are also thought to be an important pupping area for School Shark and the adjacent shelf break is known for high yields of giant crab and southern rock lobster.**
5. Kangaroo Island pool and Eyre Peninsula upwellings	**Spencer Gulf Shelf Province**	Enhanced productivity; feeding aggregations **The Kangaroo Island pool and Eyre Peninsula upwellings are known to be associated with seasonal aggregations of marine life. The nutrient-rich upwellings enhance the production of plankton communities supporting seasonal aggregations of krill, small pelagic fish and squid which in turn attract marine mammals (e.g. toothed whales, dolphins and New Zealand fur seals), sharks, large predatory fish and seabirds.**
6. Meso-scale eddies **(several locations)**	**Central Western Province** **Southwest Transition** **Southern Province**	Enhanced productivity; feeding aggregations **Eddies and eddy fields form at predictable locations off the western and south-western shelf break (south-west of Shark Bay, offshore of the Houtman Abrolhos Islands, south-west of Jurien Bay, Perth canyon, south-west of Cape Leeuwin and south of Albany, Esperance and the Eyre Peninsula). The meso-scale eddies of this Region are important transporters of nutrients and plankton communities, taking them far offshore into the Indian Ocean where they are consumed by oceanic communities. Clockwise eddies are considered to play an important role in lifting deep water, which can be relatively cooler and richer in nutrients, toward the surface where it can enhance production of plankton communities that attract aggregations of marine life.**
11. Commonwealth waters surrounding the Recherche Archipelago	**Southwest Shelf Province** **Southern Province**	High biodiversity; breeding and resting aggregations **The Recherche Archipelago is the most extensive area of reef in the South-west Marine Region (35 203 km^2 of reef habitat). Its reef and seagrass habitat supports a high species diversity of warm temperate species including 263 known species of fish, 347 known species of molluscs, 300 known species of sponges, and 242 known species of macro-algae. The islands also provide haul-out (resting areas) and breeding sites for Australian sea lions and New Zealand fur seals.**
13. Commonwealth waters adjacent to the Head of Bight	**Great Australian Bight Shelf Transition**	Enhanced productivity (pelagic); high biodiversity; feeding and resting aggregations **An ecologically important hotspot of higher productivity occurs on the inner shelf at the Head of Bight. Satellite images show higher concentrations of chlorophyll (an indicator for phytoplankton) in this area. This is supported by anecdotal observations of higher concentrations of a number of species that appear to use relatively sheltered areas of mixed seagrass, sand and limestone reef as nurseries and feeding grounds. These include juvenile Australian Salmon, Mulloway, King George Whiting, School Shark, sea lions, dolphins and southern right whales. Studies of benthic epifauna also found high biomass and species diversity at the Head of Bight.**
16. Demersal slope fish communities	**Central Western Province**	Communities with high species biodiversity **Demersal slope fish assemblages in this bioregion are characterised by high species diversity. Scientists have described 480 species of demersal fish that inhabit the slope of this bioregion and 31 of these are considered endemic to the bioregion, demersal fish on the slope in this bioregion in particular have high species diversity compared with other more intensively sampled oceanic regions of the world. Below 400 m water depth demersal fish communities are characterised by a diverse assemblage where relatively small, benthic species (grenadiers, dogfish and cucumber fish) dominate.**

Key Ecological Features	Bioregions IMCRAv.4.0	Rationale
17. Benthic invertebrate communities of the eastern Great Australian Bight	**Great Australian Bight Shelf Transition**	Communities with high species biodiversity **Soft-sediment benthic invertebrate communities of the eastern Great Australian Bight shelf form some of the world's most diverse soft sediment ecosystems. A 2002 survey of benthic marine life sampled 798 species, including 360 species of sponge, 138 ascidians and 93 bryozoans, many of which were new to science. The shelf in this area of the Region is part of the world's largest cool-water carbonate province. Invertebrate skeletons and shells make up over 80 per cent of the shelf sediments.**

The size and location of new CMRs are an immediate key issue for fishery stakeholders. While it is uncertain whether project data will influence CMR boundary design, the project's products are available to assist in zoning, off-reserve management (e.g. the benefits for, and remaining needs from, fishery closures), and in *assessing* the fishery and conservation values of candidate areas.

The PAT tool will enable rapid and flexible scenario development as CMR boundaries and zoning plans are designed by automating the process of determining by aggregating total catch at various degrees of resolution by species and time period. This functionality was demonstrated at the penultimate Steering Committee meeting.

6.2.4 Stock Assessment

Stock assessments for many quota species in Commonwealth Fisheries are based on analysis of CPUE data as indicators of abundance. However other factors such as changes in catchability or distribution in fishing effort in respect to habitat can also affect CPUE in ways that may make patterns in data difficult to interpret.

Examining CPUE data using more spatially explicit approaches that consider habitat distribution have the potential to provide a better understanding of catch rates. For example, of species such as Bight Redfish and Jackass Morwong that are distributed across a wide range of depths including inshore waters.

6.3 Future development and use of this project data set

6.3.1 Describing the GAB against species and habitat metrics

The project shows how the GAB fishery could be evaluated against management goals for protecting species and habitats. Performance evaluation could be relative to other fisheries, or against spatial targets for species or habitat, or groups of either species or habitats. These developments would represent an evolution of the Ecological Risk Assessment for the Effects of Fishing (ERAEF) process by a spatially explicit evaluation of risk (e.g. incorporating the areal extents of vulnerable and important habitats). Two principal developments are needed to accomplish fishery evaluation against species and habitat metrics: first, relative or absolute targets are needed against which the effectiveness of spatial management can be assessed, and second, further development is needed of mappable compound metrics to describe distributions of multiple habitats or species. Both needs are noted below (Section 6.3.4) as suggestions for future research.

6.3.2 Utility of tools to interrogate logbook data and metrics

The Polygon Analysis Tool (PAT) will enable rapid and flexible scenario development within hypothetical or iterative closures, for example as CMR boundaries and zoning plans are designed. Its capability is based on automating the aggregation of total catch (and effort) at various degrees of resolution by species and time period. This functionality was demonstrated at the penultimate Steering Committee meeting. Considerable GIS functionality to extract summary statistics for the other metrics developed has been accomplished by the development of scripts to run queries on the project data base.

6.3.3 Future fishery expansion

At present, GAB fisheries are largely shelf based and concentrated in the eastern region. Fishing for Orange Roughy occurs on the slope, but is highly concentrated on seamount features. There has been some exploration of continental slope, and further development is recognised explicitly in management plans. The prospective benefits from the tools and data developed during this project stem principally from having a multi-scale and mappable ‘seascape’ perspective of habitats and species distributions across the entire fishery. This facilitates understanding of opportunities and risks across sectors during any planned expansion.

6.3.4 Suggestions for future research

- Define targets against which the effectiveness of spatial management can be assessed, including by reviewing the existing literature on target setting in other fisheries, and assessing the effect of the Commonwealth Marine Reserves (CMR) together with the existing network of fishery closures. We note that there is a cost-effective opportunity to capitalise on a considerable review of literature undertaken by this project.

- Further development of mappable compound metrics to describe distributions of multiple habitats or species. Several possibilities are illustrated in this report, but none are fully evaluated. Further development is possible using existing data.

- The Polygon Analysis Tool (PAT) will enable rapid and flexible scenario development within hypothetical or iterative closures as CMR boundaries and zoning plans are designed. Scenarios could include areas and proportions of habitats enclosed, and socio-economic implications (e.g. value of historical catch within closures, implications for redistribution of effort).

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8. Appendices

Appendix A: Industry Questionnaire

Details of fisher, boat and fishing gear

Name ______ **Fisherman code** ______

Job	Owner/ skipper	☐	from (year)	____	to ____
	Skipper	☐	from (year)	____	to ____
	Ex-skipper	☐	from (year)	____	to ____
	Boat owner	☐	from (year)	____	to ____
	Other ____	☐	from (year)	____	to ____
Fishery	Trawl	☐	from (year)	____	to ____
	Danish Seine	☐	from (year)	____	to ____
	Dropline	☐	from (year)	____	to ____
	Bottom longline	☐	from (year)	____	to ____
	Mesh net	☐	from (year)	____	to ____
	Trap	☐	from (year)	____	to ____
	Other ____	☐	from (year)	____	to ____

Home port ______

Main areas fished ______

Main target species ______

Mainly working

- on top (<70 fm) ☐
- on the shelf (70-80 to 120-140 fm) ☐
- over the edge (120-140 fm) ☐
- deep (> 150 fm) ☐
- deep-deep (>300-320 fm) ☐

How many days to you average at sea per year? ______

What's the average length of a trip (in days)? ______

Vessel

- Vessel name ______
- Vessel length (m) ______
- Vessel power (HP) ______
- Nozzle fitted ______
- Main sounder ______
- Main plotter ______
- C-plot or computer system? ______
- Net link/ net monitor ______

Your comments on boat and electronics, e.g. meet demands of the fishery? a good setup? When do you use monitor? Big impact on fishing capability?

General details of fishing gear

Especially mesh sizes, ground gear

Areas of the bottom: grounds and features

Area code [ ] **Depth range (fm)** [ ] **Fisherman code** [ ]

Area name [ ]

Alternative names [ ]

General use

- [ ] Trawl ground
- [ ] Non-trawl ground
- [ ] Fished in part: few shots/ little used
- [ ] Fished in part: detail undisclosed
- [ ] Untrawlable
- [ ] Unfished
- [ ] Unknown

Boundaries

CSIRO comments on boundaries (DD, depth distinct; DI depth indistinct; PD, physical distinct; PI, physical indistinct; A, Arbitrary; P, political; U, unknown)

North [ ]
South [ ]
East [ ]
West [ ]

Notes on boundaries:

Boundary confidence level (1-5): [ ]

Bottom type

Mapping category	What it looks like overall	What its made of (%)
	Flat	Mud - soft & boggy
1 **Heavy reef**	Sloping	Mud - compact
	Steep	Sand
2 **Reef patches (many)**	Undulating	Gravel (pebbles/shell)
	Rugged	Sandstone (compact)
3 **Reef patches (few)**	Bank	Rubble/ boulders
	Valley	Slabby
4 **Sediments**	Canyon	Mud boulders
	Hill	Heavy low reef (less than 0.5 fm)
5 **Unknown**	Seamount	Heavy high reef (more than 0.5 fm)
		Unknown

Bottom type confidence (1-5) [ ]

General description

General description of area including features, eg cliffs, pinnacles, and anything unusual ?

Appendix B: Memorandum of understanding (MOU)

CSIRO- Industry GAB mapping project

Memorandum of Understanding [signed separately with each Association]

Memorandum dated: , 2007

BETWEEN [GABIA/ OTHER ASSOCIATIONS]

AND CSIRO Marine and Atmospheric Research (CMAR), Castray Esplanade, Hobart, Tasmania, 7000

The purpose of this Memorandum of Understanding is to set out how CMAR will inform [GABIA/ OTHER ASSOCIATIONS] and individual fishers about results from the project, how [GABIA/ OTHER ASSOCIATIONS] will be incorporated into the project and provide support for it, and how project results will be released to a broader audience.

CMAR shall:

1. Maintain regular communication with [GABIA/ OTHER ASSOCIATIONS] (principally through the industry liaison officer, Dr Ian Knuckey), including providing updates on progress of the project for [GABIA/ OTHER ASSOCIATIONS] meetings

2. Include a representative of [GABIA/ OTHER ASSOCIATIONS] on the project Steering Committee, and cover the costs of their representative to attend the meetings

3. In the planning stage of the project, seek advice from key members of [GABIA/ OTHER ASSOCIATIONS], particularly working skippers, on the mapping method and questionnaire used for collecting information

4. Release map outputs in stages, seeking authorization for release.

5. Formally acknowledge industry and CSIRO as the sources of information for maps

6. Provide [GABIA/ OTHER ASSOCIATIONS] with a draft of the project final report for comment

7. Ensure [GABIA/ OTHER ASSOCIATIONS] are fully aware of the final report, its content and presentation prior to its public release

8. Develop a public relations strategy for the project and its outcomes

[GABIA/ OTHER ASSOCIATIONS] shall:

1. Provide public endorsement and support for the project

2. Authorise use of the [GABIA/ OTHER ASSOCIATIONS] logo on project updates, such as those distributed to Association members through other sources

3. Provide comment on the draft final report and published material for consideration by CSIRO

4. Contribute to developing the public relations strategy

Executed as a Memorandum of Understanding

Signed on behalf of [GABIA/ OTHER ASSOCIATIONS] and CSIRO

Appendix C: Annex to the MOU

Annex to MOU with Industry Associations:

internal CSIRO data security for FRDC-funded GAB mapping project

Purpose

The purpose of this Annex is to set out how CSIRO Marine and Atmospheric Research (CMAR) will arrange internal security for fishing industry data during and after the 2-year term of the project. The key issues are to:

- specify how the data will be protected during and after the project, and
- how to protect industry's IP in regard to the contract with FRDC .

Data types

The data types in question are derived from fishing industry information on fishing locations and related observations recorded in track-plotters, in personal logbooks and on paper charts. Data exist in electronic form in GIS maps and database records, and in paper form as a series of maps produced by CMAR.

Security measures for data

The following security measures are in place:

- every map printed as a paper copy is labeled with a code that records the contributor (by code number not name), the type of map, the area covered, the purpose of the map, and importantly, the copy number (i.e. the number of copies in circulation, usually 1 or 2)
- paper copies are stored at the CMAR Marine Labs in Hobart in a locked cabinet and locked office
- every paper map copy is registered and tracked in the project database
- firewalls and passwords protect the two existing copies of the electronic data (on the project computer and the backup on the central server, both in the CMAR Marine Labs in Hobart)
- confidentiality of derived data (maps) is assured by the approval procedures detailed in the MOU

Access to data

Industry has agreed to provide their data on the understanding that access to data is restricted to the project team and that release of data or data products at various levels of resolution is contingent upon approval by data contributors that own the data and/ or approval by the industry associations (e.g GABIA) according to a proforma as laid out in the MOU.

Here we agree formally that:

- during the project, access to data will be strictly limited to the members of the project team Alan Williams, Ross Daley, Mike Fuller and Bruce Barker (CMAR) and Dr Ian Knuckey (fishery consultant).
- at the end of the project, the contributors and Associations will be formally approached to consider options for storage, management and access to data.

We anticipate that these data will be a valuable source of information for industry and researchers well beyond the life of the project.

- the default arrangement will be that the master copy of the industry data is lodged in a secure area of the CMAR 'data warehouse' – but individual contributors and/or the Associations can specify an alternative arrangement. In the CMAR data warehouse, access to data is available only to individuals with a personalized access code that is provided by the database administrator; access will remain restricted to the project team.
- these data security arrangements are guaranteed by the senior manager of the project team, Dr David Smith
- changes to data access arrangements, such as the extension of access rights beyond the project team, requires the written approval of the relevant Association and Dr Smith's authorization; delegation of Dr Smith's authority requires the written approval of the relevant Association.

IP agreement with FRDC

Add these words to the IP section "Raw data are the property of the individual operators from who they were obtained. Supplementary data on oceanography, geology and other scientific data are the property of the organisation from which they were obtained. IP belonging to the project is restricted to the processes of integrating these data into electronic and the final hard copy habitat maps to be produced in the final report. Project IP has no anticipated commercial value."

Appendix D: GAB photographic survey: voyage report

Supporting sustainable fishery development in the GAB with interpreted multi-scale seabed maps based on fishing industry knowledge and scientific survey data

(GAB Habitat Mapping Project)

FRDC PROJECT NUMBER: 2006/036

Voyage Report - GAB Camera Survey

Bruce Barker, Ross Daley and Alan Williams

Background

A camera survey was planned as a core element of the project to complement the information available to describe the habitat types of GAB fishing grounds (Objective 1). It was also designed to validate (at point locations) some of the habitat information provided by industry (Objective 2). The intention was to involve industry in the survey design and implement it from an industry vessel. The data acquired would then feed into the process of map making, and an assessment of habitat vulnerability to fishing (Objectives 3 and 4). The project objectives are listed below for context:

1 Acquire, collate and map information on the spatial extent and use of the GAB seabed habitats from multi-sector fishing industry and scientific sources.

2 Validate and complement industry information gathered for Objective 1 by ground-truth sampling with cameras from a chartered industry vessel.

3 Integrate information from Objectives 1 and 2 to generate interpreted seabed maps at scales relevant to management needs: fishing grounds, features, terrains and bottom types.

4 Quantify habitat vulnerability using the ERA methodology and upload a representative set of video and photographic images into the CSIRO seabed image database

The survey was conducted from a chartered industry vessel – the FV Lucky S from Port Lincoln, which was selected for its suitability and following a call for expressions of interest. Photo data were taken using a portable camera and winch system developed by CSIRO.

A survey design was developed in conjunction with the project's steering committee, and with direct input from trawl and non-trawl fishers. An ambitious list of sampling sites was developed, and a rationale for each was provided (Appendix 1). The design included contingencies for bad weather and resulted in very little time being lost to weather.

Overall the voyage was implemented very successfully and according to the survey plan, with 39 operations at 35 sites completed along the ~1,200 nautical miles vessel track (Figure 1). In total, 13.6 hours of seabed video and ~ 2,500 high-resolution digital still images were taken in depths between 18 and 415 m. A variety of the habitat types observed is shown in Figure 2.

The success of the survey was greatly assisted by industry input: by Sekol Tuna Farming PL at the operational level on the vessel and during mobilization, and through the extensive knowledge and enthusiasm of Tim Parsons who skippered the vessel for the survey.

This report provides technical details, a voyage narrative, and a brief initial discussion of the results in the context of the key issues identified for the project.

Operational overview

Chartered vessel: FV Lucky S, Port Lincoln SA

Owner: Semi Soljarev (Sekol Tuna Farming PL., Port Lincoln SA)

Dates: 20th to 29th October 2008

From: Port Lincoln, South Australia; to Port Lincoln

Staff

Tim Parsons	Private	Skipper
Bruce Barker	CSIRO	Voyage leader
Jeff Cordell	CSIRO	Camera operations/electronics
Mark Green	CSIRO	Camera operations
Scott Ryan	Sekol	Engineer
Chris Meletti	Sekol	Deck
Shane Farrell	Sekol	Deck

CSIRO chartered the 29 m FV Lucky S for the camera survey component of the GAB mapping project. An experienced GAB trawl skipper (Tim Parsons) was available to run the vessel and contribute to the finer details of the sampling design based on extensive detailed fishing ground knowledge.

The CSIRO 'shallow' camera system was successfully deployed from this vessel. Setup included deck mounting the electric hydraulic winch (with 1,000 m fibre-optic cabling), mounting a gantry at the stern of the vessel and setting up the camera control console and associated electronics on the bridge of the vessel.

Typically the camera was towed near-bottom for 20 minutes at about 1.5-2 knots. The video was recorded to digital DV Cam tapes. High resolution digital still images were taken at 15 second intervals for the duration of the tows.

Overall the voyage was implemented according to the survey plan, although the details of the day to day operations were modified based on the skipper's extensive experience and the prevailing weather conditions. Only a small amount of time was lost due to bad weather. Sites were generally scoped out first by the skipper (interpreting echo sounder) to check for structure. Where possible, transition zones (soft to hard bottom) were included in the tows. Some targeted tows were to investigate hard bottom and fish marks. Two tows were targeted at the steeper sections at the head of canyons.

The voyage track for the survey is shown in Figure 1. A total of ~1,200 nautical miles were travelled during the survey. In total, 13.6 hours of seabed video imagery were recorded from 39 operations at 35 sites. Approximately 2,500 high-resolution digital still images were taken. Depths for camera tows ranged between 18 and 415 meters water depth.

A variety of bottom types were observed across sites (Figure 2); these ranged from current swept sediments to high relief outcropping reef, and some steep and hard bottom types. Generally few fish were seen (many species avoid the camera system) but a large school of redfish were seen around some harder bottom with moderate relief. Observations of seabed invertebrates included sponges, bryozoans, a variety of mobile animals, and signs of burrowing fauna. Abundances of fauna were typically sparse on sediment areas while moderately dense sponge communities were seen on areas of hard pavement (that often had a veneer of fine sediments overlaying) or where reef subcrop and outcrop was evident. The inshore site at the head of the Bight brown macro algae (cray weed) growing on extensive reef patches in 18-20 meters water depth.

The camera tow details are summarized in Table 1. All camera tow start and end points were approximated (estimated layback from vessel) and annotated to the GIS. The voyage track as recorded from GPS has been saved to file. Camera files include camera system information such as depth, position and time and will be used to rename all images to enable depth and geolocation information to be easily retrieved. Images will be stored in the CSIRO Data Centre Image Database.

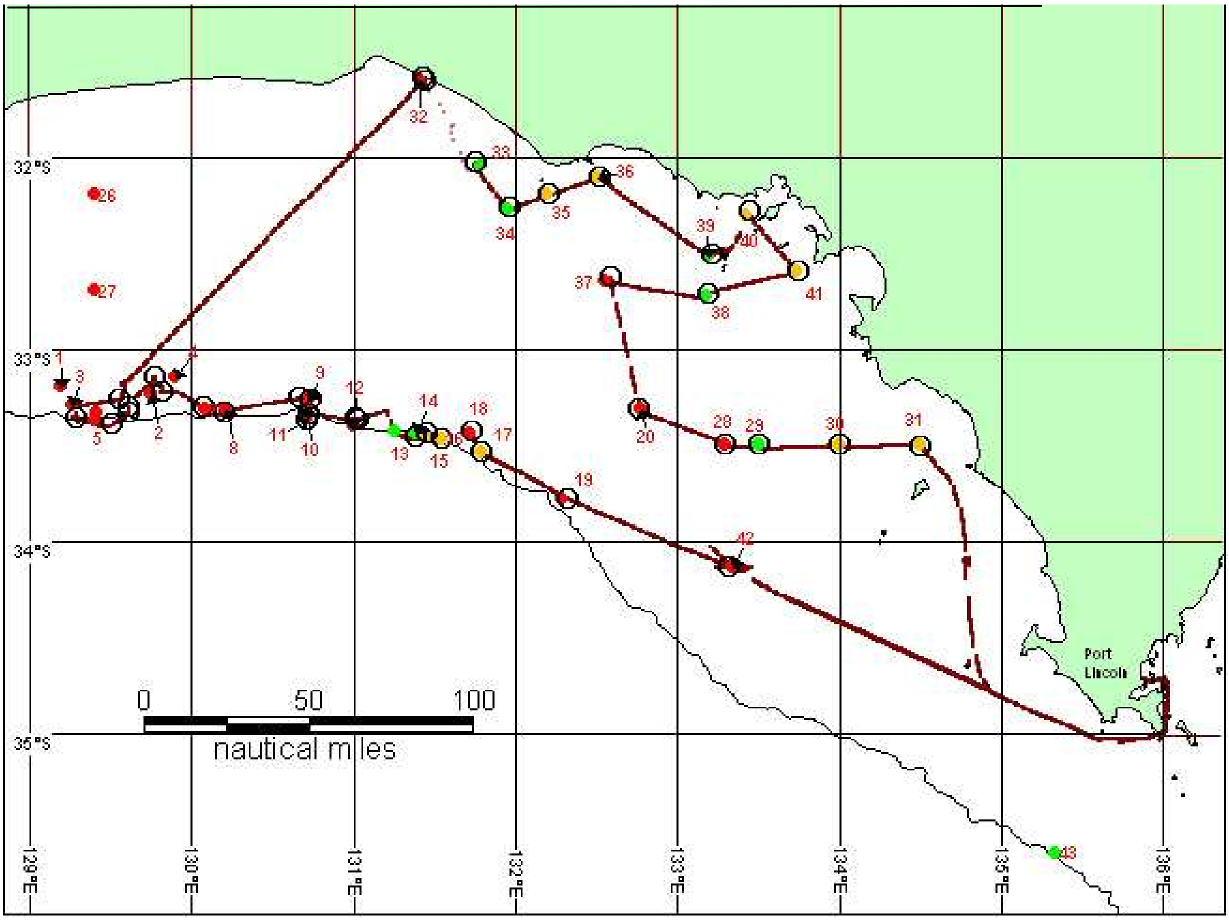


Figure 1. Map showing all potential photographic sampling sites for the GAB mapping camera survey, with those completed joined by the vessel track.

Voyage narrative

Monday 20th October
Following two days of loading and setup of gear on the Lucky S departed Port Lincoln at 1730 hours.

Tuesday 21st October
Steamed westward throughout the night and prepared the camera for the first deployment. During the first deployment - at about 40 meters - the cameras ceased to work and the tow was aborted to check. An over/under voltage relay was burned out so spent the remainder of the day replacing the components and checking for the cause of the problem.

Wednesday 22nd October
Whilst waiting for conditions to abate we ran various tests on the system. Once conditions were reasonable the camera was deployed at site #42 in ~98 meters revealing rippled sediments with sponges and bryozoans. Continued steaming westward to the next camera tow site.

Thursday 23rd October
Steaming westward continued until site #19 where the camera revealed patches of hard subcrop and schools of mackerel. With good weather forecast we operated around the clock for the next 2-3 days with only short periods between camera tows. Most of the offshore sites were completed (plus some extras) before a southwesterly change approached when we steamed to the inshore sites. Site #17 showed soft sediments with some sponges and bryozoans. Site #18 was featureless with occasional sponge and some gear marks. Site #16 consisted of fine sediments with some sponges and gear marks. Site #15 was to target the head of a canyon and a sloping bank but the camera set off to the side and missed the steeper part. Site #14 showed muddy bioturbated sediments and not much else. Attempted to use the Canon 400 D but it didn't work for this tow.

Friday 24th October
With continuing fine weather we continued to work around the clock to complete the offshore sites with several camera tows completed for the day.

Saturday 25th October
Left the offshore sites and began the long steam towards the head of the Great Australian Bight. This was an opportunity for all to get some much needed rest.

Sunday 26th October
With reasonable conditions we completed the 'inshore' camera tows. We deviated to the west again to pick-up the mid-shelf sites.

Monday 27th October
With mostly fine conditions we surveyed each site on the remaining eastward leg to 135 degrees E.

Tuesday 28th October
Available time was limited at this stage and it became obvious that any of the remaining eastern offshore sites or the Kangaroo Island contingency sites would be possible. Set course for Port Lincoln and steamed towards port through the night.

Wednesday 29th October
Arrive Pt Lincoln ~0430 hours. Pack up and off-loading of all camera equipment proceeded for the rest of the day.

Discussion

The results of the survey are briefly discussed in relation to the relevant key issues for the GAB fishery identified as focal points for the project:

Vulnerable benthic habitats
The survey provided photographic data on seabed habitats for many areas of the GAB which were previously unsampled. Most survey locations correspond to fishing grounds, with many being areas identified with industry as being representative of key areas for particular fishery species. Image data will be scored in the system used for the Ecological Risk Assessment to identify which potentially vulnerable habitats exist in the areas surveyed. This information will be analysed in conjunction with the mapping data to determine the extents of these habitats and their availability to various fishery sectors to determine whether they are at risk from fishing impacts.

Habitat associations of vulnerable species
Two species occurring in the GAB have overfished status in the SESSF: school shark and gulper shark (Larcombe and Begg 2008) – although neither of these species is currently targeted. Three key habitats have been identified for school shark in industry data and the characteristics of these habitats were recorded: inshore flat pavement reef at the head of the Bight (operation 25, site 32), an ancient coastline at about 100 m (operation 37, site 39) and canyon heads at the edge of the shelf (operation 7, site 15). The location and characteristics of typical gulper shark habitat is reported in detail from the 60-mile separately by the project leaders based on additional photographic data obtained in March 2008.

Benthic protection zone
Trawl fishers data indicates the area along the edge of the shelf within the BPZ was once a productive trawl ground and therefore had less benthos than some areas in similar depths to the west. The camera survey indicated a mixture of bottom types: sites 10 and 11 had fine sediments with limited sponges and attached invertebrates, while a third site had commercial fish associated with sponge on subcrop. These data will be examined together with CSIRO data taken in 2000. However, a quantitative comparison with other areas is beyond the scope of this project.

SWMPA Process
The area to the west of the Eyre Peninsula is currently under consideration for MPA status as part of the SWMPA Process. The inner shelf areas are important for the rock lobster fishery. Gillnet fishermen report that three areas are of special significance: Ceduna

(locations 39–40), West of Streaky Bay (locations 37, 38, 41) and west of Venus Bay (locations 20, 28, 29, 30, 31). Fishers data indicates that some of the productive fishing areas on the inner shelf are relatively featureless sandy bottoms and fishers suggested other physical factors, such as water temperature may contribute to fishery production. The camera data indicates that each of the inner shelf areas has a mixture of rocky and sandy bottom. Some of the areas that are sandy on the surface of the seabed have large sponges attached to rocky subcrop, but others were sandy sediments devoid of visible fauna.

Acknowledgements

An extremely high level of collaborative support was provided by industry for this survey. Mobilization required the help of several people, most importantly Semi Soljarev for making the Lucky S available and supplying a very willing and capable crew both on the boat, and at the SEKOL yard. Thanks to Troy (SEKOL boilermaker) for welding work on the winch and gantry. Special acknowledgement is due to Tim Parsons for the very considerable knowledge of GAB fishing grounds provided before and during the survey, and his professionalism as skipper of the vessel. Special thanks also to the Lucky S crew who skilfully assisted with all deck operations. As well, we also acknowledge Jeff Cordell and Mark Green of CSIRO who each made an essential contribution to the success of the survey.

Table 1 Camera tows conducted from FV Lucky S during the GAB Mapping project camera survey.

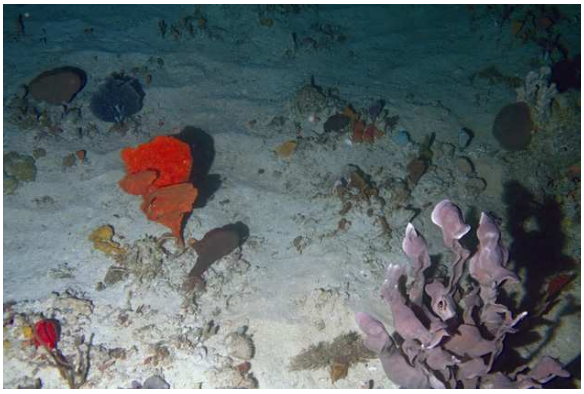
Operation	Site #	Start depth (m)	Finish depth (m)	Duration (mm:ss)	No. digital stills	Comments
1	42	99				Aborted due to system problems
2	42	99	99	20:00	78	Rippled sediments with sponges/bryozoans on ridges
3	19	139	139	20:22	75	Rippled sediments, schools of mackerel, some subcrop
4	17	167	225	29:01	141	Soft fine sediments on sloping bank with sponges and bryozoans
5	18	136	129	20:11	80	Mostly fine soft sediments with current ripples. Some patches with sponges. Gear marks
6	16	203	197	20:16	74	Initially flat fine sediments with sparse sponges and lots of gear marks (trawl). More sponges evident near end of tow.
7	15	200	260	20:10	86	Targeting head of canyon but camera set off to port of vessel so didn't see the expected steeper drop off. Muddy sediments with some burrows. Little evident fauna.
8	14	200	207	20:19	nil	Muddy bioturbated sediments
9	12	176	168	20:07	81	Flat soft sediments with little hard habitat structure. Heavily trawled.
10	10/11	175	175	21:37	81	Fine sediments with small attached inverts.
11	11	216	216	20:08	13	Fine flat sediments with a few small sponges. A few latchet.
12	9	120	122	20:03	84	Alternating smooth and current rippled soft sediments with occasional subcrop/outcrop. Attached inverts on harder bottom. Small rays.
13	BPZ	138	138	20:13	85	Very low relief subcrop with small sponges etc – patchy. A few flathead and latchet.
14	8	190	230	20:31	74	Fine muddy sediments with little bioturbation. Few fish or inverts evident.
15	7	155	174	25:05	99	Fine, flat sediments with patch of harder subcrop/outcrop (at ~10 mins) followed by soft sediments down slope.
16	2	133	137	22:51	90	Fine flat sediments with lots of bioturbation in sections. Hard and low outcrop near end.
17	4	123	126	20:15	81	Fine current rippled sediments with patches of bioturbation. Outcrop near end of tow.
18	2-1	144	145	20:12	79	Fine flat sediments with pebbles? Small outcrop but no attached inverts.
19	5	170	170	21:00	83	Low relief structure (narrow band on edge) with fish and few inverts.
20	6	245	265	20:16	80	Fine flat sediments with few inverts
21		265	412	53:33	184	Fine flat sediments with some bioturbation and sea cucumbers
22	R1	136	135	20:06	98	Hard and lumpy with sponges and redfish
23	R2	126	125	29:52	114	Mixed hard and rippled sediments with bioturbation. Some slabs
24	32-1	18	18	10:08	38	Hard lumpy bottom with 'cray weed' and

Operation	Site #	Start depth (m)	Finish depth (m)	Duration (mm:ss)	No. digital stills	Comments
						sand patches
25	32-2	27	41	20:10	96	Transition from hard pavement (without algae) and some sponges to sand with heavily rippled coarse sediments.
26	33	60	60	20:07	nil	Rippled fine sediments with some low relief rock
27	34	62	62	21:44	88	Current rippled sediments with some subcrop with sponges and corals. Also some outcrop.
28	35	61	62	20:00	72	Current rippled sands with some subcrop/outcrop
29	36	53	52	20:48	83	Rippled coarse sand sediments
30	39	50	59	20:03	35	Rough rocky bottom changing to sands
31	40	29	31	20:04	84	Sandy bottom with clumps of weed. Occasional seapen
32	41	45	45	20:12	80	Rippled sand sediments
33	38	66	70	20:06	nil	Rippled sand sediments grading to low relief subcrop and outcrop with sponges and corals
34	37	50	56	20:25	81	Rippled sandy sediments with low outcrop and subcrop with sponges and algae
35		96	94	20:13	80	Rippled sandy sediments
36	28	81	82	20:12	78	Rippled sandy sediments
37	29	78	75	22:02	103	Hard bottom with sponges and occasional corals
38	30	75	75	20:13	80	Mostly sandy rippled sediments with some subcrop and sparse sponges
39	31	59	58	22:08	95	Subcropping with sand ripples and sponges

Figure 2 Selected still images showing a variety of the habitat types observed during GAB camera survey. Operation number can be cross-referenced to Table 1 and Figure 1 for location; depth of photograph shown.

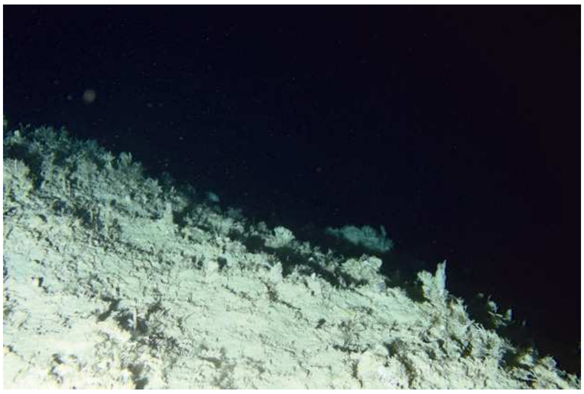
(a) Op 16, 135 m

(b) Op 13, 138 m



(c) Op 27, 62 m

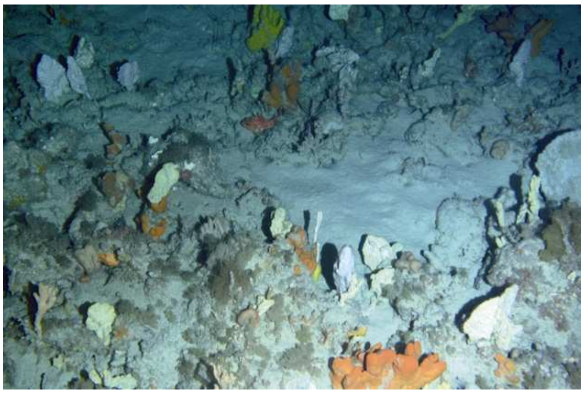
(d) Op 21 ~300 m



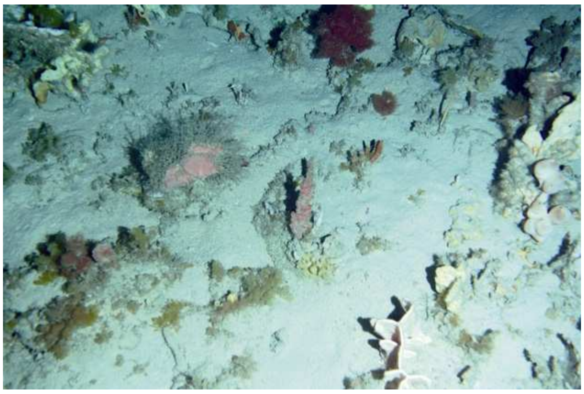
(e) Op 21 ~400 m

(f) Op 27 60 m


(g) Op 22, 135 m


(h) Op 22, 135 m


(i) Op 23, 125 m


(j) Op 23, 125 m


(k) Op 24, 18 m


(l) Op 25, 35 m

Appendix 1: Camera survey plan

Sector	Site no.	Site name	Ground name	Area code	Habitat type	Lat : long	Depth (m)	Rationale and link to objective
Trawl	1	West of BPZ 129 plate limestone	129 Inshore E	15	patchy thin sediments over exposed plate limestone	129º:12';33º:12'	115–125	Little trawled, potential refuge habitat
Trawl	2	West of BPZ 129 gravel	West BPZ inshore	16	open trawl ground with gravel	129º:45';33º:14'	127–165	Open ground that has yielded high flathead catches in the past
Trawl	3	West of BPZ 129 rough	West BPZ inshore	16	rough features (on an open plain)	129º:16';33º:18'	127–165	Biggest area of rough patcheson ground 16, potential refuge habitat
Trawl	4	west of BPZ 129 inshore	west of benthic strip inshore	17	sand waves	129º:54';33º:9'	110–135	trawl ground with unusual sand wave habitat
Trawl	5	129 edge	129 edge	18	narrow hard edge of the shelf with some slabs	129º:25';33º:20'	165–180	Essential fishery habitat, biologically productive ground. Refine exact location with Tim
Trawl	6	West of 130 canyon deep	West of canyon up slope	19	Undulating bottom with small canyons and minor banks, compact mud	129º:25';33º:22'	185–300	fishery habitat for gemfish and flathead
Trawl	7	130 Canyon	130 Canyon - BPZ Zone	20	Canyon between grounds 19 and 20	130º:5';33º:19'	165–220	fishery habitat, canyon
Trawl	8	130 west of BPZ deep	130 Canyon - BPZ Zone	20	soft and boggy	130º:13';33º:19'	165–220	fishery habitat for knifejaw, morwong, flathead (jemfish)
Trawl	9	130 BPZ backyard	BPZ Backyarders	23	reef patches with slabs	130º:43';33º:16'	132–145	was productive redfish ground, now a reserve.
Trawl	10	130 BPZ edge	BPZ shelf edge	22	Shelf edge, reserved	130º:43';33º:19'	165–220	compare reserved habitat to fished habitat (18)
Trawl	11	130 BPZ deep	BPZ Up Slope	21	soft and boggy	130º:43';33º:22'	165–220	compare reserved habitat to fished habitat (20)
Trawl	12	131 up slope 1	up slope 131	26	Shelf edge, sloping trawlable ground with gutters, mud	131º:0';33º:24'	165–240	high biological productivity at the end of the shelf, likely to be important habitat for a range of species

Sector	Site no.	Site name	Ground name	Area code	Habitat type	Lat : long	Depth (m)	Rationale and link to objective
Trawl	13	131 up slope 2	up slope 131	26	as above	131º:16';33º:26'	165–240	as above
Trawl	14	131 up slope 3	up slope 131	26	as above	131º:23';33º:26'	165–240	as above
Trawl	15	131 up slope 4	up slope 131	26	as above	131º:28';33º:28'	165–240	as above
Trawl	16	131 up slope 5	up slope 131	26	as above	131º:33';33º:28'	165–240	as above
Trawl	17	131 up slope 6	up slope 131	26	as above	131º:47';33º:32'	165–240	as above
Trawl	18	131 Cowrie shell patch	Cowrie shell patch	27	sand waves and cowrie shells, gravel	131º:43';33º:26'	124–165	habitat for redfish
Trawl	19	132 SE Run home	SE Run home	28	hard steep shelf edge, sponges	132º:17';33º:47'	130–165	sponge along inside edge, possible vulnerable benthic habitat
Trawl	20	133 inner	133 inner	34	narrow outer shelf with gutters	132º:47';33º:19'	130–165	high biological productivity at the end of the shelf, likely to be important habitat for a range of species.
Trawl extra	21	Jemfish west bank			bank	129º:12'	180–400	Some jemfish caught here
Trawl extra	22	Jemfish west Canyon			canyon	129º:17'	180–?	Canyon adjacent to jemfish ground
Trawl extra	23	Jemfish east flats			flats	129º:40'	180–400	Some jemfish caught here
Trawl extra	24	Jemfish T Plateau			plateau	129º:52';35º:25'	180?–400?	Plateau in the shape of an upside down T, productive gemfish grounds
Trawl extra	25	Ling Reserve			ling feature	134º:50'	400–500	Ling, King dory, grenadier
Gillnet	26	Eucla	Eucla terrace		Sandy	129º:24';32º:12'	50–60	Understand why this area that has sandy bottom like the surrounding area yields more commercial catches than adjacent sandy areas.
Gillnet	27	Eucla comparison	South of Eucla		Sandy	129º:24';32º:42'	50–150	compare this sandy area that has lower commercial catches to Eucla
Gillnet	28	Flinders shark 1	Venus bay outer	538	Inshore rocky, shelly	133º:18';33º:30'	10–100	Flinders transect 1/4 High gummy and school catches adjacent to a closed bay, whiskery,

Sector	Site no.	Site name	Ground name	Area code	Habitat type	Lat : long	Depth (m)	Rationale and link to objective
								whalers. Interest to SW MPA process
Gillnet	29	Flinders shark 2	west of anxious	568	sandy	133º:30';33º:30'	10–100	Flinders transect 2/4, sparse catches on sandy bottom
Gillnet	30	Flinders shark 3	Anxious bay outer	595	sandy	134º:0';33º:30'	10–100	Flinders transect 3/4, good catches on sandy bottom
Gillnet	31	Flinders shark 4	West Eyre outer sediments	596	sandy	134º:30';33º:30'	10–100	Flinders transect 4/4, deeper sandy bottom
Gillnet	32	Head Bight 1	Inshore		enclosed sandy	131º:30';31º:30'	0–20	Possible school shark pupping area, gummy
Gillnet	33	Head Bight 2	D' Entrcasteaux Reef		enclosed sandy	131º:47';32º:3'	30–70	gummy, cray
Gillnet	34	Head Bight 3	Nuyts Reef		enclosed sandy	131º:57';32º:17'	28–55	gummy, school, cray
Gillnet	35	Head Bight 4	Cape Adieu		enclosed sandy	132º:12';32º:12'	70–80	cray, gillnet
Gillnet	36	Head Bight 5	Fowlers Bay		enclosed sandy	132º:31';32º:7'	50–80	gummy, school
Gillnet	37	Ceduna 1	Yatala Reef		mixed	132º:33';32º:39'	60–80	gummy, school
Gillnet	38	Ceduna 2	Nuyts Archipelago		mixed	133º:11';32º:44'	30–80	gummy
Gillnet	39	Ceduna 3	St Francis Island		mixed	133º:11';32º:31'	30–80	gummy, cray
Gillnet	40	Ceduna 4	Denial Bay		mixed	133º:25';32º:18'	10–20	gummy
Gillnet	41	Ceduna 5	Brown Point		mixed	133º:44';32º:36'	10–30	school, gummy, cray
Gillnet	42	hard 100			hard mid shelf	133º:30';34º:30'	80–120	important hard ground for school shark. Possible old coastline
Gillnet	43	School shark Canyon Head			hard outer shelf	135º:30';35º:30'	150–250	area where school shark have in the past been targeted out deep
Multiple use KI	44	SW KI trawl	Cape De Cudic	35		135º:38';36º:37'	180–400	Market fishing, check details with Allan Wallace
Multiple use KI	45	SE KI trawl	KI - Hill	36		137º:25';36º:59'	180–400	Market fishing, check details with Allan Wallace
Multiple use KI	46	West KI	West KI		heavy cray bottom	136º:28';35º:58'	30–110	Very productive for cray and gillnetting near KI

Sector	Site no.	Site name	Ground name	Area code	Habitat type	Lat : long	Depth (m)	Rationale and link to objective
Multiple use KI	47	SW KI	SW KI		open cray bottom	136º:16';36º:12'	120–180	Very productive for cray and gillnetting, deeper water
Multiple use KI	48	Mixed gillnet	Mixed gillnet		mixed bottom, lower tide	138º:2';36º:13'	20–80	important habitat for byproduct species such as mako, whalers, whiskery, school shark
Multiple use KI	49	KI School shark	KI School shark		mixed bottom, stronger tide	136º:45';36º:16'	50–90	High historical school sharks
Multiple use KI	50	Market garden				136º:40'	148–500	market fishing at a range of depths for different species
Multiple use KI	51	King and ling				135º:42'	400–500	King dory and ling ground

Appendix E: Species synopses

Important fishery habitats identified in the catch-habitat summaries" 1-1=Structured inner shelf-prominent reef + warm water, 1-2=areas with few reef patches, 1-3 areas with prominent reef on deeper inner shelf, 2=paleo-coastline, 3=shelf edge, 4=canyons, 5=upper slope terraces, seamounts/hills. For details refer to section 4.5.3. Species in black included in shortlists for further analysis, species in red excluded

Appendix E1: Species synopses – EPBC Species.

Common	Habitat and Depth	Ontogenetic Pattern	Other Information	Catch-Habitat Summary (Section 4.5.3)
Orange Roughy				6
School Shark	Mainly demersal (Last, P.R. and J.D. Stevens, 1994 Sharks and rays of Australia. CSIRO, Australia. 513 p.), pelagic in the open ocean (Cox, G. and M. Francis, 1997 Sharks and rays of New Zealand. Canterbury Univ. Press, Univ. of Canterbury. 68 p.)	Often single sex and size (age?) schools. Known to pup in in estuaries and along coastal beaches (MG perscom). Mainly demersal but can be pelagic in open ocean. Also known to move up and down with day/night pattern.		1-1, 1-3, 3
Southern Dogfish	Biome = SD to USd. Depth range reported to be 208m - 701m (but see below); more commonly found at depths greater than 400m (White et al., 2008). In New South Wales, demersal on upper slopes, north to at least Crowdy Head, at depths of between 220m and 800m (Graham et al., 1997; New South Wales DPI, 2008b). Lightly-fished populations have been located in canyons off the coast of South Australia (R.Daley, CSIRO, pers. comm., cited by Forrest, 2008). In some parts of the range, occurs in untrawlable canyoned areas (Daley et al. 2002), but reportedly accessible by long-liners targeting Pink Ling (Genypterus blacodes) and Blue-eye (Hyperoglyphe antarctica) (Forrest, 2008).		Previously, and incorrectly, known as Centrophorus uyato (explanation, based on holotype, in White et al., 2008). Diet consists of bony fishes & cephalopods (Last & Stevens, 1994), but also includes crustaceans (Daley et al., 2002, cited by Pogonoski and Pollard, 2003). Has been fished heavily in New South Wales (Andrew et al., 1997; Graham et al., 2001; Graham, 2008). A recently announced deepwater spatial closure off SA is aimed at protecting populations of C. zeehaani (R. Daley, CSIRO, pers. comm., cited by Forrest, 2008).	4,5

Appendix E2: Species synopses – Auto-longline Species Group

Common	Habitat and Depth	Ontogenetic Pattern	Other Information	Catch-Habitat Summary
Bight Skate	Biome = SB to USd, but mainly recorded USs to USd. Occurs on soft bottoms on the outer continental shelf and upper slope, usually from 160m to about 700m (Paxton et al., 1989; Last, in Gomon et al., 1994; Shark Advisory Group, 2000; Last and Yearsley, 2002), but specimens from deeper waters have been recorded (e.g. Museum of Victoria record A6245; CSIRO Marine Research record H 613-1, Australian National Fish Collection, cited in OZCAM database, 2006). According to CSIRO et al. (2001) **the species is more common in the range 400m – 550m than at other depths.**			4, 5
Blackbelly Lanternshark	Biome = SB to MSs, but mainly USs to USd. Found on the outer continental and insular shelves and upper slopes (Compagno, 1984). Found near the sea floor (Grandpenin et al., 1991; Lehodey, 1991). Habitat includes sea mounts (Lehodey et al., 1992), but not exclusively, as evidenced by wide distribution. Depth range reported to be ~ 180m - 1000, but **mostly found from 400m - 800m** (Gomon et al., 2008). During a research fishing trip on seamounts of New Caledonia in 1991, 254 specimes of E. lucifer were collected, near the sea floor in an area of strong current (Lehodey et al., 1992). There are museum specimens from the Sponge Seamount (Richer de Forges, 2001) off eastern Australia (lat 24.89; long. 168.35), which has a base at ~ 1950m, summit at 450m, and is covered with sponge-like material.	Unknown	Distribution includes southern Atlantic, south-west Indian Ocean, Japan, New Zealand, eastern & southern australia (Gomon et al., 2008). Summary from Fishbase (Froese & Pauly, 2009): Its luminescent belly may attract prey (Cox and Francis, 1997), which consists mainly of squid (reported to bite squid bigger than itself), small bony fishes, and shrimps (Compagno, 1984). Often caught in large schools which may suggest that the luminescence may also be used to keep the group together in dark continental slope waters (Cox & Francis, 1997).	4, 5

Auto-longline species group continued				
Common	**Habitat and Depth**	**Ontogenetic Pattern**	**Other Information**	**Catch-Habitat Summary**
Greeneye Spurdog	Upper to mid continental slope off southern Australia from New South Wales to (at least) the Great Australian Bight (33° S, 129° E), likely further west into south-western Australia (based on fishing records). Known from depths of 200m – 1,360m (Australian Museum data; Last et al., 2007; Last & Stevens, 2009). Generally, spurdogs in the S. mitsukurii complex are found near or on the bottom, on **continental shelves and upper slopes**, and also on submarine ridges and seamounts (Cavanagh and Lisney, 2003).		Previously confused with Squalus mitsukurii (see White et al., 2007, for the recent description of this species in the mitsukurii complex). Spurdogs in the mitsukurii complex often occur in aggregations (Cavanagh et al., 2003), and east fishes, cephalopds & crustaceans (Compagno, 1984; Wilson & Seki, 1995) Heavily fished on the NSW slope during the 1970s and 1980s, and significant declines noted by the 1990s (Andrew et al., 1997; Graham et al., 2001). During the mid to late 1990s, this or a closely related species (recorded at that time as S. mitsukurii) was caught for an short, intense period by trawls off southern WA, and believed to have been depleted (R. McAuley, pers. comm., cited by Cavanagh and Lisney, 2003). Also a minor bycatch in the South Australian rock lobster fishery (SARDI data).	3, 4, 5
Grey Skate	Biome = USs to USd. Recorded depth range to date is 330m - 730m (rarely outside these depths), but more c**ommonly known from 400m - 600m** (Last, 2008). Extralimital records from the Great Australian Bight at depths of 155 m and 1050 m are unusual and may be erroneous (Last, 2008). Relatively narrow depth range. Note that when known by previous name (Raja sp. B), depth range was reported to be broader (to 950m).		Known from southeast of North Head in NSW (33°30′ S, 152°00′ E), and westward to at least Eucla, WA (33°20′ S, 128°15′ E). Off Tasmania, southward to at least Strahan (42°07′ S, 144°41′ E) off the west coast and Maria Island (42°41′ S, 148°25′ E) off the east coast; probably continuous around southern Tasmania; apparently absent from Bass Strait (Last et al. 2008).	4, 5

Auto-longline species group continued				
Common	**Habitat and Depth**	**Ontogenetic Pattern**	**Other Information**	**Catch-Habitat Summary**
Hapuku	Biome = IS to USd, mainly OS to USs. Found in temperate areas, mainly in deeper waters of the central continental shelf (about 100m) to the shelf edge and upper slope (Gomon, in Gomon et al., 1994). Adult Hapuku are demersal, generally occurring over reef / rough bottom, and they tend to remain in discrete rocky areas (e.g. around rocky outcrops) (Gomon et al., 2008). Also found over soft bottom (uncited reference, in AFMA, 2002a), and in canyon areas of the continental slope (Yearsley et al., 1999, cited by Bruce et al., 2002). The upper depth limit has been recorded as shallow as 50m (Gomon et al., 1994; National Institute of Water and Atmospheric Research Ltd, 2004). The lower depth limit may be about 640m (CSIRO et al., 2001) or as deep as 854m (Barreiros et al., 2004, cited in Froese and Pauly, 2009). In southern Australia, the species is normally found in mid and outer continental shelf and upper slope waters (100m - 400m). In New Zealand, Hapuku and occupy a wide depth and habitat range, from shallow rocky reefs and pinnacles, to the open seabed at 400m or deeper (Anonymous, 2004; N.Z. Ministry of Fisheries, 2006). The species is reported to be most common over or near rocky areas from ~ 125m to ~ 250m. Hapuku feed on a variety of fish (including both pelagic and bottom species), and benthic invertebrates. In New Zealand, Hapuku are reported to feed on Red Cod Pseudophycis bachus, Blue Cod Parapercis colias, Jackass Morwong Nemadactylus macropterus, Hoki Macruronus novaezelandiae, and calamari (New Zealand Ministry of Fisheries, 2004f).	The juveniles are thought to be pelagic, in surface waters well offshore, often in association with flotsam (Roberts, 1996, cited by Bruce et al., 2002). Juveniles switch to a demersal habitat at about 50cm total length (age approximately 3 – 4 years) (Francis et al., 1999, cited by Bruce et al., 2002).The smallest juveniles are virtually unknown, but are mottled, epi-pelagic or surface-dwelling, perhaps schooling in association with drifting vegetation (New Zealand Ministry of Fisheries, 2004f, 2006).	In New Zealand, Hapuku move seasonally in schools of several to over 100 fish (Anonymous, 2004). Northern schools move into deeper water during summer months, while in colder southern waters, Hapuku spend the summer in shallow coastal waters, and move into deeper water in winter (Anonymous, 2004). Although Hapuku in New Zealand are often taken around reef pinnacles, sea mounts and other structures, trawlers sometimes the species on flat and clear seafloor. According to the N.Z. Ministry of Fisheries (2006), it is not known whether this represents their normal habitat, whether they are dispersing by travelling from one rough ground to another, or whether they are on a purposeful spawning migration. A study in New Zealand (Beentjes and Francis, 1999) showed that some Hapuku can remain associated with an area for long periods (years), and others can migrate over considerable distances (e.g. 2 of 1623 tagged fish moved 1,389km over 10 years). Tagging of mostly immature fish in Cook Strait has shown a high level of local returns, but about 5% of these fish have moved up to 160 km north and south (New Zealand Ministry of Fisheries, 2006). In contrast to Hapuku from the South Island and Cook Strait, tagged Hapuku from the Poor Knight Islands showed very limited movements. Although small, immature Hapuku migrate as well as adults (i.e. some immature Hapuku travelled several hundred kilometres, during the N.Z. study), the results suggested that maturation and spawning stimulate migration (Beentjes and Francis, 1999)	3, 4, 5

Appendix E3: Species synopses – Gillnet Species Group

Common	Habitat and Depth	Ontogenetic Pattern	Other Information	Catch-Habitat Summary
Broadnose Sevengill Shark	Biome = IS to USs. Notorynchus cepedianus is a wide-ranging coastal species, particularly in temperate waters, and inhabits inshore bays, estuaries and other shallow waters, but is also found down to depths of more than 200m (see below). Sevengill Sharks prefer rocky bottom / reef habitats although they commonly occur over sandy and muddy substrates. In South Australia, there are records from sandy bottoms, patch reefs and bryozoans beds on the shelf, and also canyon areas in the Great Australian Bight and south of Kangaroo Island (CSIRO data). Other habitat examples are provided in section on Ontogenetic Pattern. The maximum recorded depth is 570m, according to IUCN (2002), Bester (2003c), and Kyne and Simpfendorfer (2007). It occurs on or near the bottom, but it may come to the surface in inshore areas (Last and Stevens, 1994, cited by Pogonoski et al., 2002). In Humboldt Bay in California, this species is normally found in the bay during the warmer months, and stays within the larger and deeper channels (Fritzsche and Cavanagh, 2007) Movements are co-ordinated with tidal cycles, moving into shallow bay areas with the rising tide and back out to deeper areas with the tidal fall.	Known to travel into estuaries to pup (M.G., pers comm.). Inshore bays and estuaries may be critical nursery area habitat. Smaller individuals reside in shallow water over continental shelves including bays and estuaries. It may sometimes be found in water less than 1m deep (IUCN, 2009). Nursery areas in South Australia are not well defined,. Common in bays and estuaries of southern Tasmania. Overseas studies indicate nursery areas are important (Lucifora, 2003; Lucifora et al., 2005, Dicken et al., 2006). There are regular sightings from the fringes of the kelp beds in the shallow waters of False Bay, South Africa. There are birthing and/or nursery areas in shallow coastal bays in California, such as San Francisco Bay, Monterey Bay and Tomales Bay (Castro, 1983; Russo, 2001), and Puget Sound in Washington State. Juveniles can occur in very shallow waters, such as the subtidal near marshes in the inner reaches of San Francisco Bay (Russo, 2001). apparently	The majority of the time, the Sevengill Shark swims slowly along the bottom substrate while occasionally cruising to the surface (Bester, 2003c). This species may travel in groups, in some areas (Ebert, 1991). In California waters, Notorynchus cepedianus apparently coordinates its movements with the tidal cycle, moving into shallow bays with the rising tide and out with its fall. These movements are important to both its breeding and feeding biology (Martin, 2003, citing studies by D. Ebert). In Tasmania, preliminary results from a tagging study have indicated that this species may move considerable distances over relatively short periods of time. One individual moved down the Derwent River approximately 30km over a 22 hour period (Barnett et al., 2007). In 1990 the Monterey Bay Aquarium captured a Broadnose Sevengill Shark in Humboldt Bay and transported it to an aquarium in Monterey (about 563km south of Humboldt). The shark was kept at the aquarium for 4 years, and then tagged and released near the aquarium in Monterey. In late 1996 the shark was recaptured in Humboldt Bay, very near where it had been previously captured in 1990. This may indicate a strong association with a "home range" or primary set of seasonal way points (Pelagic Shark Research Foundation, 2003). Catch rates in a study in Tasmania indicate seasonality in the use of coastal habitats with catch rates decreasing from summer through autumn to winter (Barnett, 2007). Frequently, N. cepedianus is the top predator in temperate, shallow marine environments (Castro et al., 1999).	Not restricted

Gillnet Species Group continued				
Common	**Habitat and Depth**	**Ontogenetic Pattern**	**Other Information**	**Catch-Habitat Summary**
Smooth Hammerhead	Biome = IS to SB, occasional records from USs. Occurs over continental and insular shelves, in warm and cool temperate seas, from 0m – 275m (Bester, 2003d; Nature Conservation Council of New South Wales, 2009); however the preferred depth is close to shore, in waters less than 20m (Bester, 2003d). Charter boat captures from the eastern Great Australian Bight, and recreational catches from the Murray Mouth indicate seasonal aggregation in shallow waters with sandy bottom, in some parts of South Australia. Often occurs at the surface in the open ocean, and can form enormous schools during migration to cooler latitudes during the summer months. The species is regularly recorded from inshore waters including coastal bays and estuaries, and in some areas (e.g. Florida) has been known to enter freshwater habitats (such as lagoons) along the coast (Bester, 2003d). In Virginia (USA), the species has been recorded from the shore, in deeper channels within shallow bays (Hoese, 1962), and it also occurs seasonally in shallow bays along the north-eastern coast (e.g. lower Chesapeake Bay). There are records from estuaries in Western Australia (e.g. Potter and Hyndes, 1994), and in Victoria, there is one museum record from the mouth of the Yarra River (Museum of Victoria record, 1932).	Little is known about the movement and migration patterns in Australian waters (Stevens et al., in Cavanagh et al., 2003). Seasonal aggregations occur in some coastal areas of South Australia. For example, in some years fishers have reported aggregations of Hammerheads at the Murray Mouth when adult Mulloway are present in the area (T. Kildea, pers. comm., 2001). Hammerheads have also been recorded off Spencer Gulf, Eyre Peninsula, Great Australian Bight and a number of other areas in South Australia. In some areas, the species can occur inshore in shallow waters along coasts, bays and harbours where the water is calm and the bottom sandy (Game Fishing Association of Australia, 1999, and South Australian recreational fishing reports). In northern Spencer Gulf, there is a seasonal presence of Hammerhead Sharks (including pregnant and birthing females), which feed on fish (FishInternet Australia 2001, and other recreational fishing reports).	Smooth Hammerhead is primarily a piscivore, and feeds on a variety of bony fishes including clupeids and small scombrids, as well as elasmobranchs such as smaller sharks (as well as its own species) and stingrays. A study of S. zygaena individuals taken in sports fishing catches off New South Wales, indicated that the main dietary component in that area was cephalopods. In 42 sharks, the frequency of occurrence was 76% cephalopods and 55% bony fishes (Stevens, 1984). In some areas of the northern hemisphere, skates and stingrays make up the majority of its diet in inshore locations. Invertebrate prey includes benthic crustaceans, shrimps and cephalopods (the latter particularly taken by juveniles < 200cm: Smale, 1991). In northern Europe, this shark feeds on herring and bass, while in North America, Spanish mackerel and menhaden are commonly consumed fish. Carangid fish have also been reported in the diet (e.g. Hawaii). The Smooth Hammerhead has also been observed scavenging from surface long-lines in the Mediterranean Sea (Bester, 2003d). In the Gulf of California, stomach contents for 27 individuals of S. zygaena, expressed as frequency of occurrence, included 58% bony fishes and 43% pelagic cephalopods (Galvan-Maganaet al. 1989, cited by Crow et al., 1996). Along the southern Brazilian coast, a study of stomach contents of Sphyrna zygaena specimens indicated that the important feeding categories were teleosts (78.6% frequency of occurrence) and cephalopods (60.7% frequency of occurrence), represented by the sardine Harengula clupeola and a squid (Loligo sp	3

Gillnet Species Group continued				
Common	**Habitat and Depth**	**Ontogenetic Pattern**	**Other Information**	**Catch-Habitat Summary**
Whiskery Shark	Biome = IS to SB, mostly OS and upper SB. A continental shelf species, to maximum depth of about 220m (Last and Stevens, 1994). Found on or near the bottom (Compagno, 1984). Commonly occurs near rocky bottom, beds of kelp or other macroalgae, or seagrass beds (Compagno, 1984; Simpfendorfer and McAuley, 2003).	Probably pupping in spring or early summer.	Diet consistent with hard bottom and soft bottom (Simpfendorfer et al., 2001). The diet is highly specialised, with cephalopods making up approximately 95% of food eaten (Simpfendorfer et al., 2001). Although it primarily feeds on benthic cephalopods (particularly octopus, but also squid), teleost fish and crustaceans, such as lobsters, are also taken (Kailola et al., 1993; Last and Stevens, 1994), and seagrass and peanut worms have also been recorded in the diet (Kailola et al., 1993).	1-1, 2, 3
Bronze Whaler	Found from surf zone down to at least 100 m			1,3
Dusky Shark	Surf zone down to 400 m.	Adolescents and adults appear to move inshore (less than 80 m) off WA during summer and autumn. Potentially distinct nursery areas in inshore..		1,3

Gillnet Species Group continued				
Common	**Habitat and Depth**	**Ontogenetic Pattern**	**Other Information**	**Catch-Habitat Summary**
Scalloped Hammerhead	NB species probably not present in Great Australian Bight, and records may be misidentifications. It is noted that hammerhead catches from previous GAB trawl surveys e.g. 1967-73 (Database Extent Maps in CAAB), have location points for S. zygaena that almost exactly matched those for S. lewini. Most of the distribution refs (e.g. White, in Gomon et al. 2008) don't include SA as part of the distribution of S. lewini. However, there are verified records from southern WA.	Juveniles often close inshore. Adult females rarely caught inshore and may live in deeper water only moving onto shelf to mate and pup. Vivaporous, litters 13-23. Pupping spring/early summer (Aust.). Californian studies show diurnal movements with nighttime foraging in deeper waters.		1, 3

Gillnet Species Group continued				
Common	**Habitat and Depth**	**Ontogenetic Pattern**	**Other Information**	**Catch-Habitat Summary**
Shortfin Mako	Biome = IS to USd, but mainly IS to OS. An extremely active, offshore littoral & epipelagic species found in tropical and warm temperate seas (Stevens, 2000, in IUCN, 2008). Shortfin Mako is an oceanic species, but sometimes found close inshore (Last and Stevens, 1994; Yamada et al., 1995, cited by Froese and Pauly, 2009). The species is usually observed in surface waters (Sommer et al., 1996), down to about 150 m (Yamada et al., 1995; Smith, 1997, cited by Froese and Pauly, 2009). The maximum reported depth is 740m (Cox and Francis, 1997; Passarelli et al., 2003). The Shortfin Mako is a true pelagic species, with a primarily temperate distribution, although they will inhabit the cooler, deeper water of tropical regions. In some tropical areas where the surface temperature is 27°C, water temperature may be as low as 15°C at depths of 30-60m. With the ability to elevate body temperature, makos are able to maintain themselves in temperatures of 5-11°C. In this sense the makos are somewhat "warm-blooded," meaning that heat in their blood is conserved within the body and not lost through the gills. However, the Shortfin Mako prefers water temperatures between 17-20°C. It has been hypothesized this species migrates seasonally to warmer waters, and this has been supported by tag and release studies (Passarelli et al., 2003).		Tagging in New Zealand indicates that seasonal migrations occur (Cox and Francis, 1997, cited by Froese and Pauly, 2009). Makos have the tendency to follow warm water currents in their most northern and southern parts of their range during summer months (Godknecht, 2003). Studies have shown that while Shortfin Makos follow warm water, they do so within the confines of a specific geographical area. Consequently, there seems to be limited genetic flow between these geographically distinct populations (Passarelli et al., 2003). Very little is known about the social habits of the Shortfin Mako, except that it is a solitary shark (Passarelli et al., 2003). The Shortfin Mako feeds on other fast-moving pelagic fishes such as swordfish, tunas, and various sharks (e.g. blue sharks, requiem sharks, hammerheads), as well as squid and other cephalopods. Bony fish that are common in the diet include mackerels, tunas, bonitos, anchovies, herrings, grunts, and swordfishes (the latter taken by large makos). The stomach contents of Mako Sharks caught in gillnets off Natal, South Africa, showed a 60: 40 ratio of shark to bony fish, while a study from the northeastern United States found 77.5 percent of the Mako diet was bluefish. Marine mammals (e.g. pinnipeds) and sea turtles are rarely ingested by this species, but are sometimes taken by larger individuals (Compagno et al., 1989; Last and Stevens, 1994; Godknecht, 2003; Passarelli et al., 2003).	1, 3 (juveniles), 4

Appendix E4: Species synopses – Trawl Scalefish Species Group

Common	Habitat and Depth	Ontogenetic Pattern	Other Information	Catch-Habitat Summary
Bigscale Rubyfish	Biome = OS to USs, mainly OS to SB. A schooling species that occurs close to the bottom, on the continental shelf and slope. Usual upper depth limit is ~ 130m (Kuiter, in Gomon et al., 994; CSIRO Marine Research et al., 2001), and the lower depth limit may be as deep as 413m (CSIRO Marine Research et al., 2001). Most published records are from the outer continental shelf and shelf break / uppermost slope, about 100m – 250m (CSIRO, 2009). It is supposed that P. macrolepis might also be associated with benthic rises (e.g. where food might concentrate) in some parts of its narrower geographic and depth range.			3
Blacktip Cucumberfish	Biome = IS to USd, mainly SB to USd. Demersal species on continental shelf and slope, on sandy and muddy bottoms (May & Maxwell, 1986; Paxton et al., 1989; Sato & Nakabo, 2002). Known from a broad depth range, between ~ 65m and > 600m (Glover, in Gomon et al., 1994; NIWA records, cited by CSIRO, 2009). Most records in southern Australia are from within the range 200m – 500m (CSIRO, 2009, and survey data references therein). In S.A., there are records from at least as shallow as 82m, as well as continental slope records from more than 400m (South Australian Museum data, cited by R. Foster, SAM, pers. comm., 2006; CSIRO data).		Considered to be an important food source for many" commercial fish species, including Blue Grenadier Macruronus novaezelandiae (Bulman & Blaber, 1986; Glover, in Gomon et al., 1994), & Deepwater Flathead (Coleman and Mobley, 1984), amongst others (see Bulman et al., 2001).	Not restricted

Trawl Scalefish Species Group continued				
Common	**Habitat and Depth**	**Ontogenetic Pattern**	**Other Information**	**Catch-Habitat Summary**
Deepsea (Spiny) Flathead	Biome = OS to MSs, but mostly USs to USd. Benthic species, which occurs over soft bottoms on the continental shelf and slope, usually between ~ 140m and 700m (May & Maxwell, 1986; Hoese et al., 2006, cited in Froese and Pauly, 2009). There are occasional records from waters shallower than 140m, and from deeper than 700m (e.g. 800m = CSIRO Ichthyology No. T433; also 1,058m = a specimen from NE of Wedge Island: CSIRO Ichthyology No. 2601-01, cited in OZCAM datbase, 2009). During a study of the fish fauna on the continental shelf of NSW and Vic., this species was reported to be one of the group which characterises the southern shelf break area (Williams and Bax, 2001).		In south-eastern Australia, a major discard species (tonnes) of otter trawls, in the South East Trawl fishery component of the SESSF (e.g. Wayte et al., 2004), and also in the deepwater sector of the ocean prawn trawl fishery in NSW (e.g. 78% occurrence in trawl hauls) (New South Wales DPI, 2004). In New Zealand, recorded from bottom trawls off the east coast of South Island (Beentjes, 2002, cited in Froese and Pauly, 2009).	Not determined
Deepwater Stargazer	Biome = IS to USd, and the broad range might indicate separate populations, or more than one species. Benthic in deeper waters, on mid to outer continental shelf, & upper slope. Depth range commonly cited in publications is 130m to 270m or to 320m, presumably based on trawl records (Maxwell, 1986, cited in Froese & Pauly, 2009; Gomon, in Gomon et al., 1994; Gomon et al., 2008). However, there are records reported to be this species, from deeper waters of the continental slope (CSIRO Marine Research data) and also shelf waters shallower than 130m. Examples from shallow waters include a specimen collected at 20 fathoms (36.6m) (Waite & McCulloch, 1915, cited by Eschmeyer, 2003); records from 42m (CSIRO Soela trawl survey record, 1981, & Courageous trawl survey record, 1978); 70m (CSIRO Marine Research - Ichthyology record CA 3683, and S.A. Museum record F08073), and less than 40m (S.A. Museum records F02783, F01742 and F01743, unverified).		In New Zealand, juveniles are bottom-dwelling around reefs and over rough ground (Paul, 2000). During the 1960s and early 70s, various “nursery areas” for Jackass Morwong (Tarakihi) were discovered, and these habitats had a dense, varied invertebrate benthic epifauna dominated by sponges and small bryozoa (Vooren, 1975). Bradstock and Gordon (1983) also reported the significance of coral-shaped bryozoan growths in Tasman Bay as a habitat for reef fishes. These bryozoan beds (largely comprising *Celleporaria agglutinans* and *Hippomenella vellicata*, commonly referred to as “cornflake coral” by fishers), also occur in Marlborough sound and other parts of New Zealand. The bryozoan beds at Tasman Bay are a significant nursery area for commercial fish species such as *N. macropterus*, Pink Snapper *Chrysophrys auratus*, and John Dory (*Zeus faber*), which eat the abundant and species-rich assemblage of invertebrates that are housed by the bryozoa (Godfriaux, 1974). The coralline grounds are particularly favoured by 3 year-old *N. macropterus* (20-27 cm long) (Vooren, 1975).	Not determined

Trawl Scalefish Species Group continued				
Common	**Habitat and Depth**	**Ontogenetic Pattern**	**Other Information**	**Catch-Habitat Summary**
Gulf Gurnard Perch	Biome = IS to SB, mostly IS to OS. A reef-dwelling species, that ranges in depth from 10m to more than 100m (see below), but is reportedly mostly found in the deeper part of the range (50+m) (Poss, in Gomon et al., 1994; Kuiter, 1996a; Australian Museum, 2005d). There are CSIRO survey records from the Great Australian Bight, reported to be records of N. bougainvillii from waters deeper than 100m, with examples including 130m, 135m, 140m, 200m, 240m and 250m depth (CSIRO Marine Research records, 1978 - 1981, cited in CSIRO, 2009). During a survey in south-western Australia, the species was recorded over reefs covered with macroalgae of medium density (Harvey et al., 2004). The species has also been recorded in sandy areas in W.A. (Hyndes et al., 1999).		The species is occasionally observed by divers on both natural reefs and artificial reefs and wrecks (e.g. see Baker, 2009 and references therein).	3
King Dory	Demersal species, found near the bottom from 400m - 1000m (in the Australian part of the range) (Gomon et al., 2008). In Great Australian Bight, caught with Orange Roughy (AFMA, 2008c). In South Africa (Walvis Ridge and off Capetown, to Algoa Bay), usually found from about 360 - 460m deep (Smith et al., 2003). It is widely distributed throughout New Zealand waters with most records from the Chatham Rise. In New Zealand, it was identified as a key species characterising the demersal fish community 350–550m on the Chatham Rise (Bull et al., 2001). In New Zealand, adults are most common between 400m and 600 m, but have a wide depth range, from 50m to 1,200 m (Anderson et al., 1998).	Juveniles are pelagic in surface waters up to a length of approximately 12cm (May & Maxwell, 1986), at which stage a metamorphosis occurs associated with the transition from a pelagic to a demersal habitat (James, 1976). In New Zealand, the geographical and depth distribution of immature (< 33 cm) fish is similar to that of adults (Hurst et al., 2000).	The main prey of King Dory are natant decapod crustaceans, followed by euphausid, mysid, galatheid, and nephropsid crustaceans, and fish (Clark & King, 1989). Blaber & Bulman (1987) reported that Hector's Lanternfish Lampanyctodes hectoris is a significant part of the diet. King Dory is likely to be prey of larger fish, and have occasionally been recorded in the stomachs of large ling (New Zealand Ministry of Fisheries, 2008).	Not determined

Trawl Scalefish Species Group continued				
Common	**Habitat and Depth**	**Ontogenetic Pattern**	**Other Information**	**Catch-Habitat Summary**
Latchet	Biome = IS to USs, mainly OS to SB. Latchets mostly occur in areas with sandy or muddy bottom (Gomon, in Gomon et al., 1994; Australian Museum, 2004p). In a survey of nearshore fishes in south-western Australia, Latchet was recorded rarely in soft-bottom habitat worked by trawls / dredge (Hutchins, 2005). Williams et al. (1996) characterised Latchet as one of the indicator species in “a southern community of the well-defined (continental) shelf break community” in south-western Australia, indicating that the species is more common on the outer continental shelf and upper slope than at other depths. Various published depth ranges include 35m–200m (Gomon, in Gomon et al., 1994; Australian Museum, 2004p); 20m – 220m (Sea-Ex Australia, 2004); 35m – 400m (May and Maxwell, 1986; Paulin et al., 1989), or 10m – 600m, but mostly within the depth range 50m – 400m (CSIRO et al., 2001; N.S.W. Department of Primary Industries, 2004).	Adults are found mainly on the outer continental shelf, and juvenile latchets are known to enter bays and estuaries, particularly in autumn (May and Maxwell, 1986; Sea-Ex Australia, 2004). Latchets are sometimes found in shallow estuaries in Tasmania (Gomon, in Gomon et al., 1994).	Throughout South Australia, Latchet is found in sandy and muddy habitats of the continental shelf. Previously, during the early decades of the 20th century, a number of records came from parts of both gulfs (e.g. South Australian Museum records), but many of the more recent records are from mid and outer continental shelf waters of the Great Australian Bight (GAB) (e.g. Museum of Victoria records, cited in OZCAM database, 2009). In South Australia, the species appears to be commonly recorded across the GAB. Bycatch sampling in the GAB during 2001-2002, showed that Latchet, which is not a target species, is nevertheless one of the most commonly recorded species in the GAB Trawl Fishery, & large quantities are discarded as part of the bycatch (Brown and Knuckey, 2002). Latchet eat small fish (Coleman & Mobley, 1984; Bulman et al., 2001). It is likely that Latchet feed mostly at night, based on trawl survey results in the Great Australian Bight, which showed that 87% of Latchet caught in the post-dawn trawl had food in their stomachs, compared with 25-30% at other times of the day (CSIRO Division of Fisheries and Oceanography, 1980).	3

Trawl Scalefish Species Group continued				
Common	**Habitat and Depth**	**Ontogenetic Pattern**	**Other Information**	**Catch-Habitat Summary**
Swallowtail	Biome = IS to USs, mainly OS to SB. A schooling species, commonly found on deeper reefs along the south coast, but also occurs over shallow reefs adjacent to deep water (Hutchins and Swainston, 1986). In some areas, divers have recorded the species swimming in schools, close to reef structures of high vertical relief. At Cape Forbin on north-eastern Kangaroo Island, the species has been recorded near a high relief cliff-edge reef that is densely covered with Scytothalia, Ecklonia, Acrocarpia, Sargassum and other large macroalgae (data by A. Brown, 2008). During a survey at the Investigator Group islands in the eastern GAB, Swallowtail were recorded in schools at a number of islands, at depths ranging from the shallow subtidal to 20m, mainly in the vicinity of reefs (Kuiter, 1983). The species is abundant around reefs at the Recherche Archipelago, and frequently seen over reefs in mainly bays of south-western Australia (Hutchins, 2005). During another survey in south-western Australia, Swallowtail were recorded on reefs with dense and medium cover of macroalgae (Ecklonia, and other macroalgae); also over deeper reefs (not vegetated), and low numbers were recorded in the vicinity of seagrass beds (Harvey et al., 2004).The species is reported to be recorded mainly on the continental shelf, within the depth range 100m – 200m, although there are records from as shallow as 10m, and as deep as 300m (CSIRO et al., 2001).		Swallowtail is a part of the diet of New Zealand Fur Seals Arctocephalus forsteri and Australian Fur Seal A. pusillus doriferus (Page et al., 2005; Caines, 2005). In one study, Swallowtail represented up to 5% biomass in some seasons, with frequencies of occurrence as high as 12% and 15%, according to seal species, gender and season sampled (Page et al., 2005).	3

Trawl Scalefish Species Group continued				
Common	**Habitat and Depth**	**Ontogenetic Pattern**	**Other Information**	**Catch-Habitat Summary**
Thetis Fish	A demersal, reef-dwelling species on continental shelf (May & Maxwell, 1986; cited in Froese & Pauly, 2009). However, in Tasmania, N. thetidis (particularly juveniles) have been reported from Heterozostera & Posidonia seagrass, sand & mud habitats (Jordan et al., 1998; DPIWE Tasmania, 2004i). To date, Thetis Fish has been found between 5m (Australian Museum, 2006l) & 288m (Motomura, 2003, cited in Froese and Pauly, 2009), but it is mainly recorded in deeper offshore waters of the continental shelf, below 100m (Poss, in Gomon et al., 1994). It is noted that CSIRO et al. (2001) reported the depth range to be 18m to 329m, with the species more common recorded in the range 100m – 200m. Many of the records from Great Australian Bight were collected within the range 40m – 250m (CSIRO Marine Research data, cited in CSIRO, 2009).	In Tasmania, *N. thetidis* (particularly juveniles) have been reported from *Heterozostera* & *Posidonia* seagrass, sand & mud habitats (Jordan et al., 1998; DPIWE Tasmania, 2004i).	It is noted that related species of gurnard perch in southern Australia eat small fish, squid, crabs and other small crustaceans, and marine worms (Bulman et al., 2001; DPIWE Tasmania, 2004i).	3
Tusk	Biome = OS to USs. Found in benthic habitats on outer continental shelf & upper slope (Daley et al., 1998), but occasionally found in shallower waters (Hutchins & Swainston, 1986). Reported depth range is ~ 130m – 420m (Daley et al., 1998) or 115m – 400m (Nielsen et al., 1999). CSIRO Marine Research, Museum Victoria, Australian Museum, & New South Wales Fisheries (2001) reported that maximum depth is about 520m, & that the species is commonly recorded in the 300m – 400m depth range. Habitat at the type locality for this species was edge of a submarine bank in Great Australian Bight (Eschmeyer, 2006).		Members of the family Ophidiidae are oviparous, with pelagic larvae. There is no special larval stage (Nielsen et al., 1999).	4, 5

Trawl Scalefish Species Group continued				
Common	**Habitat and Depth**	**Ontogenetic Pattern**	**Other Information**	**Catch-Habitat Summary**
Yelloweye Redfish	Biome = OS to USs, mostly OS to SB. Found near the bottom, in deeper offshore waters of the continental shelf & upper slope, usually from 80m to around 300m (Hutchins and Swainston, 1986; Kuiter, in Gomon et al., 1994), although there are isolated records, reported to be this species, from as deep as 560m (CSIRO et al., 2001; Gomon et al., 2008).		Yellow-eye Redfish of up to 51cm and over 2.5kg form schools on the shelf and upper slope (Daley et al., 1998). The species forms large schools in south-western Australia (Hutchins and Swainston, 2001).	3
Rough Flutemouth	Biome = IS to SB, mainly IS. Occurs in various reef habitats (including hard-bottomed areas with extensive soft corals, and reef patches near sand) (Gomon et al., 2008), but juveniles enter estuaries (Kuiter, 2009). Mainly in sub-tropical waters, but also found in deeper waters in the tropics, where there are cold upwellings (Kuiter, 2009). Published depth range reported to be from about 10m (Gomon et al., 2008) to 200m (May and Maxwell, 1986), but there are records from shallow waters (e.g. 3m: J. Baker, pers. obs., 2008). Adults usually in depths of 30m or more (Kuiter, 2009).	Juveniles enter estuaries (Kuiter, 2009).	Usually seen singly, or in small groups (Kuiter, 2009).	not applicable. Essentially out of range
Silver Warehou		Adults are usually demersal on the continental shelf and slope, occasionally occurring at the surface; subadults in surface waters (May, J.L. and J.G.H. Maxwell, 1986 Trawl fish from temperate waters of Australia. CSIRO Division of Fisheries Research, Tasmania. 492 p.); some evidence that they move into the middle water column at night (Boyes, J., 1983 Pelagic trawling off Tasmania takes warehou. Aust. Fish. 42(8):4-6.); 'Both' Williams and Bax 2001.		3,4,5

Appendix E4: Species synopses – Trawl Chondrichthyan Species Group

Trawl Chondrichthyan Species Group continued				
Common	**Habitat and Depth**	**Ontogenetic Pattern**	**Other Information**	**Catch-Habitat Summary**
Black Shark	Biome = IS to MSd (very broad depth range), but mostly USs to USd. Found from 40m -1,800m (Compagno, 1984), but mainly from 450m - 850m in Australian waters (Last & Stevens, 2009), and 200m - 600m in some other regions (Bester & Burgess, 2003), such as part of the Atlantic (Moreno, 1995). Found on outer continental & insular shelves & slopes (Compagno, 1984). Mainly found on or near the bottom, but also occurs well off the substrate, and often pelagic (Compagno, 1984; Mundy, 2005, cited in Froese & Pauly, 2009). There are various records from seamounts, such as the Sponge Seamount (Richer de Forges, 2001), the Plateau Seamount (Shcherbachev et al., 1985) and the Milwaukee Group Seamount (Yuryaku and/or Kammu) (Borets, 1986). There are also records from the vicinity of submarine banks, such as Georges Bank, in northern USA (Anonymous, 2002); Porcupine Bank off Ireland (Henderson et al., 2003), and various banks (Sarda, Voador, Cruiser and Princess Alice) in the Azores, north-east Atlantic (Perrotta, 2004). In New Zealand, there are occasional records from submarine banks such as the Chatham Rise, but the species is more commonly in that country in shallower waters (Wetherbee, 2000).	*Little information, but it is noted that in 2000 off the coast of Brazil, a neonate reported to be Dalatias licha was caught in surface waters by a long-line (Soto and Mincarone, 2001). Sex ratios and other data from fisheries (such as the Azores) indicate that pregnant females may occur in shallower water than males.*	Found singly or in small schools (Last & Stevens, 1994). Feeds mainly on deepwater bony fish, but also skates, other sharks, cephalopods (including squids and octopods), crustaceans (including shrimps, lobsters, isopods and amphipods), siphonophores, and polychaetes (Compagno et al., 1989, cited in Froese and Pauly, 2009; Bester & Burgess, 2003). Fishes ma+l23ke up the majority of their diet (Bester & Burgess, 2003). In New Zealand Orange Roughy Hoplostethusatlanticus forms part of the diet of this shark (Wetherbee, 2000). This species has been heavily fished at relatively shallow depths (70m - 200m) in the Azores since the 1970s (Perrotta, 2004), including numerous pregnant females, whose embryos are discarded, because the shark is caught for liver oil. In that area, females are reported to occur more frequently than males at these shallow depths on the shelf, compared with 300m - 480+m where males outnumber females in the population (Silva, 1987, cited by Perrotta, 2004).	*6*

Trawl Chondrichthyan Species Group continued				
Common	**Habitat and Depth**	**Ontogenetic Pattern**	**Other Information**	**Catch-Habitat Summary**
Brier Shark	Mid slope	unknown	See Daley et al 2002	6
Golden Dogfish	Biome = SB to MSd, but more commonly from USd to MSs. Globally, found from ~ 200m to more than 1,500m (2,080m, according to Kyne & Simpfendorfer, 2007, and Gibson et al., 2008), but more commonly between 650m - 1,000m. Off Australia the species is mostly known from 780m – 1,100m (Last & Stevens, 1994). Found on or near the bottom (Compagno et al., 1989), and habitats include submarine plateaus, banks and rises. In the Azores, C. crepidater has a depth range from 850 to 1600 m, with highest catch rates at 1,050m to 1,200m. During a survey in the Azores, males of C. crepidater were registered only at depths from 1000 to 1200 m, and the mean length increased with depth (Aranha et al., 2006). Examples of underwater features where this species occurs include the Cascade Plateau off Tasmania (CSIRO Ichthyology H 4873-01), Challenger Plateau off New Zealand (CSIRO Ichthyology H 2935-03); Rockall Plateau / Rockall Bank and Hatton Bank in the North Atlantic (Australian Museum data; also Clarke et al., 1999 and Shestopal et al., 2002); Wyvile Thomson Ridge in the NE Atlantic (Hareide et al., 2004); Mid-Atlantic Ridge and Reykjanes Ridge (Shestopal et al., 2002); West Norfolk Ridge (Wanganella Bank); Lord Howe Rise; Chatham Rise off New Zealand (where large catches have been taken by trawls) (Wetherbee, 2000), and Tasman Rise (Museum of Victoria data, cited in OZCAM database, 2009). Also found over seamounts (Morato and Pauly, 2004), with examples including the Corner Mountain and New England Seamounts (Kukuyev, 1982) and the Pedra Branca Seamount (Australian National Fish Collection data, cited in OZCAM database, 2009).		Feeds mainly on fish and cephalopods (Last & Stevens, 1994). Fish prey includes lanternfish / myctophids (Macpherson & Roel, 1987, cited in Forese & Pauly, 2009). During a study in the north Atlantic, stomachs from C. crepidater taken by long-line from 635m - 840m included squid, viperfish, deep-sea eel and lantern fish (Shestopal, 2002). In Australia, is a bycatch of fishing for Orange Roughy but flesh high in mercury (Last & Stevens, 1994; Gomon et al., 2008). The productivity of this species appears to be low, with age at maturity in Australia of 15 years at 64 cm (males) and 22 years at 82 cm (females), and longevity of around 60 years (S. Irvine, pers.comm., cited by Stevens, 2003).	6

Trawl Chondrichthyan Species Group continued				
Common	**Habitat and Depth**	**Ontogenetic Pattern**	**Other Information**	**Catch-Habitat Summary**
Gulf Catshark	Biome = IS to SB. Widespread on the continental shelf and slope edge, and, has been found in depths from less than 20m (South Australian Museum records; Museum of Victoria records, cited in OZCAM database, 2009) to more than 200m (Compagno, 1984; Last and Stevens, 1994). In the Great Australian Bight, the Gulf Catshark is found mainly in depths from 130m to 220m; off western Tasmania and Bass Strait, it is found mostly at depths of less than 100m, and is frequently found in seagrass beds near the coast in this area (Last & Stevens, 1994; Heupel and Simpfendorfer, in Cavanagh et al., 2003).	coastal seagrass beds.	The species may be relatively common in the Great Australian Bight (Heupel and Simpfendorfer, in Cavanagh et al., 2003). The Investigator Strait area / north coast of Kangaroo Island in South Australia is the type locality for this species (Zietz, 1908, cited by Eschmeyer, 2001). In a prawn trawl bycatch survey in upper Spencer Gulf during the early 2000s, in which 200 x 30-minute tows (covering approx. 4km2 per hour) were undertaken over 5 sites, only 1 Gulf Catshark was recorded (K. Rodda, SARDI, pers. comm., 2005; Dixon et al., 2005). Examples of locations in South Australia where the species has been recorded include Great Australian Bight; Investigator group of islands (e.g. Flinders I.); south-western Spencer Gulf (e.g. Dangerous Reef, Port Lincoln area, Peake Bay); eastern Spencer Gulf (e.g. Moonta); south-eastern Spencer Gulf (e.g. Corny Point, and Point Turton); northern Spencer Gulf; the metropolitan coast of Gulf St Vincent (GSV) and southwards to the Fleurieu Peninsula (e.g. O'Sullivans Beach, Aldinga, Cape Jervis and other locations); south-western Gulf St Vincent (e.g. Edithburgh area); southern Yorke Peninsula (e.g. Pondalowie, Stenhouse Bay and Marion Bay area); Investigator Strait / northern Kangaroo Island, north-eastern Kangaroo I. (e.g. Kingscote), and Robe in the upper south-east of S.A. (Zietz, 1908; Glover, 1979; Kuiter, 1983; Anonymous, 1993; Eschmeyer, 2001; Australian Angler's Association record, 1979; Heupel and Simpfendorfer, in Cavanagh et al., 2003; photograph by John Lewis, 2003; SARDI data, cited by K. Rodda, 2005; S.A. Museum data 2004, 2005, cited by T. Bertozzi, SAM, pers. comm., 2005; S.A. Museum records, cited in OZCAM database, 2009).	3

Trawl Chondrichthyan Species Group continued				
Common	**Habitat and Depth**	**Ontogenetic Pattern**	**Other Information**	**Catch-Habitat Summary**
Large Ornate Wobbegong	Biome = IS to OS. A common inshore bottom-dwelling shark of continental shelf waters, found in bays, on macroalgae-covered rocky reef areas, coral reefs (including lagoons and reef flats, reef faces, and reef channels), and around offshore islands (Compagno, 1984, 2005). Ornate Wobbegongs occur as solitary individuals or in aggregations, and are often found in clearer water than the closely related Orectolobus maculatus (Kuiter, 1993; Lieske and Myers, 1994, cited by Pogonoski et al., 2002). Divers (e.g. in W.A.) have also recorded Ornate Wobbegong in caves. In south-eastern Australia, Ornate Wobbegong has also been recorded in sponge beds, on artificial reef structures (e.g. geo-textile reefs & shipwrecks), and barren boulders. During a study in N.S.W., Ornate Wobbegongs showed preference for such reef habitats, compared with seagrass beds or stands of macroalgae (Carraro and Gladstone, 2006). During that study, Ornate Wobbegongs selected daytime resting positions with a “high topographic complexity and crevice volume” & did not select on the basis of prey availability (Carraro and Gladstone, 2006). The depth distribution of O. halei (previously as O. ornatus) may range from the shallowest inshore to at least 115m depth (Last & Stevens, 1994; OZCAM records, cited by Pogonoski et al., 2002; Compagno, 2005). Wobbegongs are usually nocturnal sharks, that rest on the bottom during the day in caves, under ledges on reefs, and in trenches, and seeks prey in reef habitat at night (Compagno, 2001, 2005). They are observed singly and often in aggregations during the day (Pollard et al., in Cavanagh et al., 2003), sometimes with several animals piled on top of one another (Compagno, 2005). There is evidence from fishing data and dive surveys that wobbegong habitat preferences are species-specific, with little overlap of species occurrence in the same area (Huveneers, 2007).	In South Australia, divers have observed aggregations of wobbegongs in southern Yorke Peninsula, an area characterised by high current flow and local scale eddies and gyres, sea surface temperature fronts, and high productivity (i.e. relatively high abundance of zooplankton on the eastern side of the Spencer Gulf mouth, off the “toes” of Yorke Peninsula) (Baker, 2004). There is evidence of strong site association in both species (Pollard et al., in Cavanagh et al., 2003). Wobbegongs have been shown to have short-term fidelity to a site, but may not be permanent residents, as they move out of an area over time, and are replaced by other temporary residents (Carraro and Gladstone, 2006; Huveneers et al., 2007a). During a study in New South Wales, localised movements of seven O. halei individuals were studied for about two years at Fish Rock, and three of these sharks were regularly detected (sometimes under the same rock, over many dives) for periods of approximately 4, 10 & 20 months, suggesting longer-term residency (Huveneers, 2007; Huveneers et al., 2007a).	Feeding occurs mainly at night, & includes large prey such as bottom-dwelling fishes, small sharks & rays; octopuses & other cephalopods; crayfish / lobsters, crabs & other crustaceans (probably taken by juveniles) (Last & Stevens, 1994; Australian Museum, 2003f; Compagno, 2005; C. Huveneers, pers. comm., 2007). Abalone has also been recorded in the diet (Kailola et al., 1993). During a study of wobbegongs in New South Wales, wobbegongs were recorded feeding mainly on octopus and reef fishes, but also on Port Jackson sharks, and rays. During that study, crustaceans were not recorded in the diet of adult wobbegongs (C. Huveneers, pers. comm., 2007). In that study of three species of wobbegong in N.S.W., diets did not vary between sexes, but inter-specific differences were evident, and were related to the total length of the shark. Results of a feeding study in N.S.W. showed that Orectolobus halei fed more frequently on bony fishes (11 families of fishes recorded in the samples) and chondrichthyans, but octopus was also recorded in the diet (Huveneers, 2007). Fishes recorded in the diet of O. halei include carangids such as Trachurus novaezelandiae, sciaenids (including mulloway), labrids (including Blue Groper Achoerodus), kyphosids (drummers), and scombrids (Huveneers, 2007).	1-1, + probably others.

Trawl Chondrichthyan Species Group continued				
Common	**Habitat and Depth**	**Ontogenetic Pattern**	**Other Information**	**Catch-Habitat Summary**
Spotted Wobbegong	Biome = IS to SB. Found in shallow coastal water (0m) usually down to the mid continental shelf (e.g. O. maculatus has been trawled from at least 110m) (Compagno, 1984; Last and Stevens, 1994), and there are occasional deeper records, such as 176m (museum data, cited by Pogonoski et al., 2002), and 218m (Kyne et al., 2005). The species is a bottom dweller in coastal bays, estuaries and channels, and open coastal waters. It is most common on macroalgae-covered rocky reefs (and in caves and under overhangs associated with reefs), and is occasionally seen over seagrass meadows; on rubble bottom; under piers / jetties, in shipwrecks; or lying over bare sand (Coleman, 1980; Compagno, 1984; Pogonoski et al., 2002; Australian Museum, 2003f). In the northern part of the distribution, the species has also been recorded on coral reefs (Compagno, 1984), and artificial geo-textile reefs (e.g. Jackson et al., 2004). Juveniles occur in estuaries and are occasionally found over seagrass beds (Lieske and Myers, 1994, cited by Pogonoski et al., 2002). Wobbegongs are usually nocturnal sharks, that rest on the bottom during the day in caves, under ledges on reefs, and in trenches, and seeks prey in reef habitat at night (Compagno, 2001, 2005). They are observed singly and often in aggregations during the day (Pollard et al., in Cavanagh et al., 2003), sometimes with several animals piled on top of one another (Compagno, 2005).	In South Australia, divers have observed spawning aggregations of wobbegongs in southern Yorke Peninsula, an area characterised by high current flow and local scale eddies and gyres, sea surface temperature fronts, and high productivity (i.e. relatively high abundance of zooplankton on the eastern side of the Spencer Gulf mouth, off the "toes" of Yorke Peninsula) (Baker, 2004).	Feeding occurs mainly at night, & includes large prey such as bottom-dwelling fishes, small sharks & rays; octopuses & other cephalopods; crayfish / lobsters, crabs & other crustaceans (probably taken by juveniles) (Last & Stevens, 1994; Australian Museum, 2003g; Compagno, 2005; C. Huveneers, pers. comm., 2007). Abalone has also been recorded in the diet (Kailola et al., 1993). During a study of wobbegongs in New South Wales, wobbegongs were recorded feeding mainly on octopus and reef fishes, but also on Port Jackson sharks, & rays. During that study, crustaceans were not recorded in the diet of adult wobbegongs (C. Huveneers, pers. comm., 2007). In that study of three species of wobbegong in N.S.W., diets did not vary between sexes, but inter-specific differences were evident, and were related to the total length of the shark. During the N.S.W. study, bony fishes (14 families) were also the most dominant food category for O. maculatus in terms of numbers & weight, with cephalopods constituting ~ 13 – 14% of the diet. Chondrichthyans (including juvenile triakid sharks) constituted ~ 7% of the diet by numbers and weight. Examples of bony fishes consumed by O. maculatus include Pagrus auratus (Pink Snapper), Scomber australasicus (Slimy Mackerel), Muraenesox bagio (Pike Eel), Scorpis species, kyphosids (drummer family), & various members of the Carangidae, Sciaenidae, Berycidae, Dinolestidae, Moridae, Labridae, Serranidae, Mugilidae, Monacanthidae & Diodontidae. (Huveneers, 2007). In Western Australia, a study showed that bony fishes were the dominant prey in the diets of wobbegongs, with occurrences of 67% in O. maculatus (Chidlow, 2003, cited by Huveneers, 2007).	1-1, 2, 3

Trawl Chondrichthyan Species Group continued				
Common	**Habitat and Depth**	**Ontogenetic Pattern**	**Other Information**	**Catch-Habitat Summary**
Melbourne Skate	Biome = IS to USs, mainly IS and OS. Occurs on the continental shelf, from the shallows (e.g. less than 5m) to 345m (Last & Stevens, 2009), but is mainly known from shelf waters, less than 200m. The species is more abundant in upper continental shelf waters (Last and Stevens, 1994; Last and Yearsley, 2002), and is found over soft bottom (Paxton et al., 1989), including sandy and muddy habitats. During a survey of nearshore habitats in Tasmanian bays, D. whitleyi was recorded over Heterozostera seagrass, and also over mud (Jordan et al., 1998). In parts of south-eastern Australia, it has also been recorded under jetties / piers, and around patch reefs near sand.		During a dietary study of skates in south-eastern Australia, shrimps, crabs, cephalopods, bony fishes and eels were reported to be the main components of the diet of D. whitleyi at different stages of growth (Treloar et al., 2006b). Smaller representatives preyed on numerous amounts of caridean shrimps, in particular Leptochela sydniensis (Treloar et al., 2007a). Shelf species such as D. whitleyi generally occupy a broader feeding niche than slope species, and prey on a larger diversity of prey including a variety of crustaceans (brachyurans, anomurans, achelates, carideans and dendobranchiates), cephalopods, elasmobranchs and bony fishes. A size-related change in diet is evident for this species (Treloar et al., 2007a). Examples of locations in S.A. where the species has been recorded include the Great Australian Bight (Brown and Knuckey, 2002; CSIRO Marine Research records, 1979 and 1981, cited in CSIRO, 2006); Spencer Gulf (Svane et al., 2007), northern Gulf St Vincent (GSV) (Currie and Hooper, 2006; Currie et al., 2007), and possibly southern metropolitan GSV (photograph by N. Skinner).	2

Trawl Chondrichthyan Species Group continued				
Common	**Habitat and Depth**	**Ontogenetic Pattern**	**Other Information**	**Catch-Habitat Summary**
Ornate Angelshark	Biome = IS to USs, but mostly found OS to USs. A demersal species, found on the continental shelf and upper slope, over rock and probably sand (Glover, in Gomon et al., 1994). Recorded depth range is around 50m – 400m (Glover, in Gomon et al., 1994), but many of the trawl-records from the Great Australian Bight are of specimens caught between 100m & 300m (e.g. CSIRO Marine Research data, cited in OZCAM database, 2007). In that area, the species is reported to be more common at about 300m than at other depths (Last & Stevens, 1994, cited by Kyne and Bennett, in Cavanagh et al., 2003, and Daley et al., 2006), but published evidence appears to be lacking. The Ornate Angel Shark inhabits deeper water than the Australian Angel Shark (Glover, in Gomon et al., 1994).		Examples of locations in South Australia where the Ornate Angel Shark has been recorded include south-western Spencer Gulf (Glover, in Gomon et al., 1994), and the western, central and eastern Great Australian Bight (Brown & Knuckey, 2002; Museum of Victoria data, cited in OZCAM database, 2009). There are trawl records (e.g. CSIRO Marine Research warehouse data) from right across the GAB, from the W.A. border, through to waters off the western side of southern Eyre Peninsula. Most records are from the Great Australian Bight, where the species is taken commercially (e.g. Brown & Knuckey, 2002; BRS, 2004). It is also possible that the species occurs in the lower south-east of S.A., because S. tergocellata has been recorded south-west of Portland (western Victoria), not far from the S.A. / Victorian border (Museum of Victoria data, cited in OZCAM database, 2009).	3

Trawl Chondrichthyan Species Group continued				
Common	**Habitat and Depth**	**Ontogenetic Pattern**	**Other Information**	**Catch-Habitat Summary**
Owston's Dogfish / Roughskin Dogfish	Biome = SB to MSd, mostly USd and deeper. A demersal species occurring from the shelf break (and as shallow as mid to outer shelf during vertical migration) to upper & middle continental slope (to at least 1,500m: Kiraly et al., 2003, cited in Froese & Pauly, 2009), and usually deeper than 500m (Paul, in Cavanagh et al., 2003) or deeper than 600m (Kyne and Simpfendorfer, 2007). In some areas, there are ocasional records deeper than the commonly published maximum of 1,500m (e.g. to 1,760m, at Walters Shoals in the Southwestern Indian Ocean: Parin et al., 1993). Individuals as shallow as 100m have been recorded (Yano & Yanaka, 1988; Cox & Francis, 1997, cited in Froese & Pauly, 2009). Known in some areas from submarine ridges (Kyne and Simpfendorfer, 2007), submarine banks, rises, plateaus & seamounts. Examples include the Northwest Hills and other parts of the Chatham Rise in New Zealand, where Orange Roughy aggregate (Wetherbee, 2000; McClatchie & Coombes, 2005; Smith et al., 2008); Challenger Plateau in the Tasman Sea (CSIRO Ichthyology data); St Helens Rise off Tasmania (CSIRO data) & the Norfolk Ridge and Lord Howe Rise (CSIRO data; Clark et al., 2004).	Segregation in time and space by sex, size and mature condition is a feature of dogfishes in this group (Paul, in Cavanagh et al., 2003; Braccini, 2006). For example, Yano and Tanaka (1988) reported that in Japan, pregnant females of C. owstoni (except when at full term) & those with mature ova separate from immature individuals and males, and are found in shallower water (e.g. as shallow as 100m - 300m, in that area). The depth migration may be related to breeding (Yana & Tanaka, 1988). This species may have mobile populations that migrate into exploited fishing grounds from other parts of the range (as with other deepwater sharks) (Paul, in Cavanagh et al., 2003, and IUCN, 2009).	Feeds on benthopelagic fish (Bulman et al., 2002) & cephalopods (Last & Stevens, 1994). In New Zealand Orange Roughy Hoplostethus atlanticus forms a significant part of the diet of this shark (Wetherbee, 2000). In Japan, females caught deeper than males. Occasionally caught on mid-water long-line (Last & Stevens, 1994). Part of its depth range coincides with that of some commercially important fishes such as Orange Roughy (e.g. in New Zealand: Smith et al., 2008) & oreos, although it extends somewhat deeper (Paul, in Cavanagh et al., 2003, and IUCN, 2009). Probably a species of low fecundity, slow growth and high longevity typical of others in the group. NB Between 1987 & 2000 (Laswon, 2001) or between 1990 & 1999 (Murray et al., 2002), observers on tuna long-line vessels in the Western & Central Pacific Ocean (WCPO), recorded 2,326 specimens of C. owstoni (= 2% of the shark bycatch over that period, according to Lawson, 2001). In 2000 and 2001, 456 and 126 specimens respectively were recorded by observers in the tune long-line catch in the WCPO (Murray et al., 2002).	6

Trawl Chondrichthyan Species Group continued				
Common	**Habitat and Depth**	**Ontogenetic Pattern**	**Other Information**	**Catch-Habitat Summary**
Peacock Skate	Biome = OS to USs, commonly recorded SB. Occurs over soft bottoms of the continental shelf (Paxton et al., 1989; Last & Stevens, 1994), & to a lesser extent on the continental slope (Last et al., 2008). The recorded depth distribution is around 75m (NB previously specified to be 30m) to around 430m / 450m (Paxton et al., 1989; Last & Stevens, 1994; Last & Yearsley, 2002; Last et al., 2008; Last & Stevens, 2009). According to CSIRO et al. (2001) the species is more common within the range 150m – 300m than at other depths.		Ranges from Clarence River in NSW to Eyre in Great Australian Bight (Last & Stevens, 2009). Most abundant & widely distributed skate in Australian waters.	No determined
Platypus Shark / Long-snout Dogfish	Biome = SB to MSd, mainly USs to USd. Previous depth range reported by Compagno to be 150m to 820m, mostly below 400m. Shcherbachev Yu (1987, cited by Kyne and Simpfendorfer, 2007, and Froese and Pauly, 2009) reported a depth range of 150 to 1,360m. In Australia, mainly in depth range 400m - 820m (Last & Stevens, 1994). There are shallow mid & outer shelf records in south-eastern Australia (e.g. 200m, from east of Eden: Museum of Victoria data; and 110m, from off Green Cape in Tasmania: Australian Museum data).Deep records in southern Australia include 1,145m from off Warnambool, and 1,050m from SW of Cape Leeuwin (CSIRO Ichthyology records H2646-04 and H3177-01). In some areas, this species is associated with seamounts, plateaus, ridges and rises, with examples including Tasman Rise (e.g. Museum of Victoria holds specimens from ~ 900-950m deep), Lord Howe Plateau (specimen from 850m: Museum of Victoria), Norfolk Ridge & Lord Howe Rise (Clark et al., 2004).		Feeds on bony fishes (Compagno et al., 1989). Historically, greatest catches from SETF. Research surveys on the NSW slope over a 20-year period have shown a decline from 15.7kg h-1 to 1.4kg h-1 for D. quadrispinosa (Stevens, in Cavanagh et al., 2003, citing Andrew et al., 1997 & Graham et al., 2001). Like the Centrophorus and Centroscymnus species, this is a shark of very low productivity (Forrest, 2008). Recent GABIA agreement to not target deepwater sharks such as this in the GAB (AFMA, 2008). AFMA reported that deepwater shark catches in GAB (including this species) increased in 2006, and that ISM program estimated a catch of 30t per annum, with 13% discard rate. Reportedly one of the species that will benefit from the Southern Dogfish closure off eastern GAB in South Australia, and also closure of 20% of deepwater grounds, and all Orange Roughy sites (AFMA, 2008).	4

Trawl Chondrichthyan Species Group continued				
Common	**Habitat and Depth**	**Ontogenetic Pattern**	**Other Information**	**Catch-Habitat Summary**
Portuguese Dogfish	Globally, occurs on or near the bottom of the continental slope and abyssal plain in depths from 270–3,700m; but in Australia, more commonly found in waters 770m–1,400m (Last & Stevens 1994). In Australia, catch rates are generally highest in depths greater than 1,000m (Daley et al. 2002). Surveys conducted in Portugal never found this species in depths shallower than 800m (uncited reference; Stevens and Correia, in Cavanagh et al., 2003).	There appears to be sex and size segregation by depth. For example, smaller specimens at greater depths and pregnant females at shallower depths (Yano & Tanaka, 1988; Girard & Du Buit, 1999, cited by Stevens & Correia, in Cavanagh et al., 2003).		6
Sawtail Catshark	Biome mainly OS to USs, but overall includes USd. Demersal on the outer continental shelf and upper slope (Compagno, 1984; Compagno and Niem, 1998). The species has a recorded depth range of 128m–823m (Last and Stevens, 1994; Compagno and Niem, 1998) or 150m–640m (Last and Stevens 2009), but it has been recorded in shallower waters (85m) off south-eastern Queensland (P. Kyne, pers. obs., cited by Kyne and Bennett, in Cavanagh et al., 2003). CSIRO et al. (2001) reported that in southern Australia, F. boardmani is mainly found within the depth range 200m–450m.	Appears to sometimes aggregate by sex (Last & Stevens, 1994).		4, 5

Trawl Chondrichthyan Species Group continued				
Common	**Habitat and Depth**	**Ontogenetic Pattern**	**Other Information**	**Catch-Habitat Summary**
Sharpnose Sevengill Shark	Biome = OS to USd. Has a wide-ranging but patchy distribution in tropical and temperate waters of continental and insular shelves and upper slopes (Casto et al., 1999; Paul and Fowler, in Cavanagh et al., 2003; Bester, 2003f). Demersal to semi-pelagic, probably ranging well into mid-water (Paul and Fowler, in Cavanagh et al., 2003). H. perlo is usually found on or near the bottom, but occasionally observed close to the surface (Bester, 2003f). Generally, H. perlo is found offshore, but occasionally occurs close to the coast, where the sea floor shelves steeply, and also often on the deeper boundaries of offshore banks. H. perlo is also found around islands which descend abruptly into deep water. The species possibly aggregates near seamounts, and Morato and Pauly (2004) listed H. perlo amongst "important seamount species". Centres of abundance may be at outer shelf, slope, and oceanic seamounts (Paul and Fowler, in Cavanagh et al., 2003). During a survey of the Norfolk Ridge and Lord Howe Rise (Clark et al., 2004), 2 individuals were observed in the vicinity of seamounts. In 1998, during a survey of the Great Meteor Seamount (south of the Azores, in the Atlantic Ocean), 75 specimens of H. perlo (including juveniles) were recorded in bottom trawls, traps and long-lines, from around the plateau of the seamount (Uiblein et al., 1999). In the Greater Meteor area, this species is reported to be associated with plateaus, near the sea floor (Fock et al., 2002). There is also a record at 740m deep from the Sloping Rise seamount (south of the Grand Banks of Newfoundland). The species is reported to be abundant around the Azores area, at depths to about 600m (Kukuvev, 1982). Other slope records include the Cayman Trench off Jamaica (McLaughlin and Morrissey, 2004), and the Okinawa Trough (records from 240 – 515m) and Kyushu Palau (records from 370m) off Japan (Nakaya and Shirai, 1992).	Ontogenetic pattern not known. In the USA, NOAA has mapped "essential habitat" for this species as being the shelf break (about 200m deep) off South Carolina, southern Florida, Mississippi, Louisiana, and Texas. Sharpnose Sevengill Shark is variously reported to occur at depths between 100m to 400m (Compagno and Niem, 1998; Yamada et al., 1995); 180m to 450m (Castro, 1983; Castro et al., 1999), or 300m – 600m deep (Paul and Fowler, in Cavanagh et al., 2003); however the species has been caught in deeper waters, such as 740m (Kukuyev, 1982) and 1000m (Last and Stevens, 1994; Yamada et al., 1995; Australian Museum, 2003l). CSIRO et al. (2001) reported that in southern Australia, H. perlo is mainly found within the depth range 250m – 500m, within a broad overall depth range of about 195m – 950m. Paul and Fowler (in Cavanagh et al., 2003) stated that occasional reports from shallow water are possible misidentifications.	The diet of H. perlo is highly specialised, with relatively lower prey diversity (compared with the diet of the related coastal Notorynchus cepedianus). Small, medium and large individuals of H. perlo use different strategies for handling different prey groups (Braccini, 2008). Globally, Sharpnose Sevengill Shark feeds on marine invertebrates including shrimp, crabs, lobsters, squid, cuttlefish, octopus, as well as small bony fish, such as hake, and small sharks and rays (Compagno et al., 1989; Sierra et al., 1994; Cortes, 1999; Bester, 2003f; Havforskningsinstituttet, undated). During a survey in the Azores area, stomach contents of caught specimens of H. perlo included squid, horse mackerel, moray, longfin cod, mora, shrimp, blue-mouth, octopus, conger eel, greater forkbeard (Shestopal et al. 2002). A study in southern Australia, showed that H. perlo preys largely on deepwater teleosts, mainly Toothed Whiptail Lepidorhynchus denticulatus, with larger individuals (901 to 1365mm TL) also consuming high proportions of large predatory teleosts of the families Gempylidae and Trichiuridae. The Cardinalfish (Apogonops anomalus) is also an important prey item in number, mass and occurrence. Cephalopods are a lesser component of the diet (Braccini et al., 2004; Braccini, 2008). Like N. cepedianus, H. perlo consumes prey that migrate from deep to coastal waters (e.g. ommastrephid squid and gempylid fish) (Braccini, 2008). Feeding and activity increase during the night time hours (Bester, 2003f).	4

Trawl Chondrichthyan Species Group continued				
Common	**Habitat and Depth**	**Ontogenetic Pattern**	**Other Information**	**Catch-Habitat Summary**
Short-tail Torpedo Ray	Biome = OS to USd, but mostly recorded OS. Reported from over sand and mud bottoms, and also rocky reefs (Michael, 1993, cited in Froese & Pauly, 2009). The recorded depth range is about 90m–750m (Last & Stevens, 1994; Compagno & Last, 1999).		Torpedo Ray is reported to be part of the bycatch in prawFn trawling in Spencer Gulf. During a bycatch survey in 2001 and 2002, 12 specimens were caught in 515 trawl shots (Dixon et al., 2005).	2

Trawl Chondrichthyan Species Group continued				
Common	**Habitat and Depth**	**Ontogenetic Pattern**	**Other Information**	**Catch-Habitat Summary**
Smooth Stingray	Biome = IS to SB in Australia, mainly IS and OS. D. brevicaudata is found in a variety of habitats. Examples include shallow coastal bays (where it is found on sandy bottoms, or near seagrass and/or low profile reef); under piers / jetties; in estuaries (e.g. Gray et al., 2005); large inlets; harbours; near coastal rocky reefs (and coral reefs, in southern Queensland); around shipwrecks (e.g. Queensland Department of Environment and Resource Management, 2009); offshore islands; continental "drop-offs"; open sea floor and occasionally near the surface over the outer shelf (Michael, 1993; Edgar, 2000; Duffy and Paul, in Cavanagh et al., 2003). D. brevicaudata often occurs in shallow water off sandy beaches where it remains for extended periods, partly buried beneath the sediments (Last, in Gomon et al., 1994). In Victoria, during summer months Smooth Stingrays are found in water as shallow as 1m or less, especially where fish are being cleaned (e.g. near boat ramps or piers) (Aquatic Adventures Rye, 2008). In Victoria, this species is reported to be common both on nearshore reefs (Edmunds and Hart, 2003) and "open sediment surfaces" (Parks Victoria, 2003). In Tasmania, the species has been recorded in a number of habitats, including shallow rocky reefs (e.g. Stuart-Smith et al., 2008). At north-west and eastern Lord Howe Island, a benthic survey showed that D. brevicaudata was one of several species that characterised open sandy seafloor habitat in deeper waters (Speare et al., 2004). In New Zealand, this species is commonly observed at the interface between reefs and soft sediments (Langlois, 2005).	Juveniles of D. brevicaudata have been taken well offshore in pelagic trawls (P.R. Last, unpubl. data, cited by Last and Yearsley, 2002) and may have the capacity to disperse across the Tasman Sea (Last and Yearsley, 2002). Smooth Stingray is often seen in aggregations (Michael, 1993). Francis (1996) reported that in New Zealand, the species is common around the North Island, and small numbers may move southwards during summer and autumn. During summer, large mid-water aggregations are found at several locations around the Poor Knights Islands, New Zealand (Le Port et al., 2005). In this region, D. brevicaudata individuals aggregate seasonally in areas of high current flow. The purpose of these aggregations is unknown, but they may be related to mating (Duffy and Paul, in Cavanagh et al., 2003).	Adults are commonly found off beaches and in lower estuaries of southern Australia, during summer and autumn (Last and Stevens, 1994). A surveys of the fish fauna of sandy habitats in southern New South Wales and eastern Victoria showed highest numbers of D. brevicaudata in autumn (Williams and Bax, 2001). The species is reported to move into shallow water during warmer seasons (Anderson and Willis, 2003). In Spencer Gulf in south Australia, a prawn trawl bycatch survey in 2001 and 2002 showed that Smooth Stingray was most prevalent in the catch in November of one year, particularly in the South Gutter (in central Spencer Gulf), where up to 5 per trawl shot were recorded (Dixon et al., 2005). The results might indicate seasonal aggregation in that area. In New Zealand, a study in which two individuals were tagged with pop-up satellite archival tags 62 and 151 days, indicated that neither ray moved large distances (≤ 25 km) from the tagging locations, but they showed a seasonal shift to deeper waters, progressively increasing time spent at greater depths and decreasing time spent at shallow depths towards winter. In addition, one ray displayed strong diel vertical movements (Le Port et al., 2008). The Smooth Stingray feeds mainly on large molluscs (particularly bivalves buried in sand, but also abalone on reef) and crustaceans, including Blue Swimmer Crab Portunus pelagicus (H. Smith, unpubl. data, cited by Kangas, 2000) and possibly also Western Rock Lobster Panulirus cygnus); also squid (e.g. Smale et al., 2001), and small benthic fishes (Shepherd, 1973, cited by Mayfield et al., 2002; Michael, 1993; Last, in Gomon et al., 1994; Shepherd, 1998; Smith, unpubl. data, cited by Kangas, 2000; Smale et al., 2001; MacArthur et al., 2007	1-2, + others not yet defined

Trawl Chondrichthyan Species Group continued				
Common	**Habitat and Depth**	**Ontogenetic Pattern**	**Other Information**	**Catch-Habitat Summary**
Southern Fiddler Ray	Biome = IS to SB, but mostly found IS to OS.The species is common in shallow habitats near the coast, such as shallow subtidal sand flats (Last, in Gomon et al., 1994), and other sandy and muddy bottoms; also amongst seagrasses of various species; and on and near reefs (e.g. Hutchins, 2005); and in mixed habitats (e.g. soft bottom habitats with sponges, sparse seagrass etc) (Michael, 1993; Reardon, in Cavanagh et al., 2003; Parks Victoria, 2003; Harvey et al., 2004). The species is particularly common on nearshore sand flats in South Australia (Last, in Gomon et al., 1994), and is often seen by divers around jetties, wharves and near seagrass meadows (Last & Stevens, 1994). It occasionally enters estuaries (e.g. Hammer, 2006). During a survey in south-western Australia, T. dumerilii was recorded in various habitat types classified as bare sand; vegetated sand; seagrass beds of sparse and medium density; reef with macroalgae of medium density; sand-inundated reefs with sparse macroalgae, and rhodolith beds (Harvey et al., 2004). Highest numbers were recorded in the latter two habitat types (Harvey et al., 2004). The species has also been recorded in lagoon-like estuaries (e.g. Potter et al., 1996). Ranges from the intertidal to around 180m (Michael, 1993, cited in Froese & Pauly, 2009), but most records are from the shallow half of the range.		Fiddler rays have protrusible jaws that enable them to pick up and manipulate their prey, and they feed on benthic molluscs, crustaceans, and small fishes on shallow mud, sand, cobble and seagrass bottoms (Carpenter and Niem, 1999). Young T. dumerilii feed mainly on small crustaceans (e.g. mysids, carids, pinnotherids, amphipods and isopods (Marshall et al., 2007). Generally, adult Southern Fiddler Ray eat benthic fauna such as crustaceans (including Blue Swimmer Crab Portunus pelagicus (Smith, unpubl. data, cited by Kangas, 2000). A study in W.A. showed that although small crustaceans dominated the diet of small fiddler rays, as body size increased, bony fishes, pilumnid and portunid crabs, and molluscs became important dietary components. Overall, the diet consisted predominantly of crustaceans (73%), fish (17%), polychaete worms (5%) and molluscs (3%) (Marshall, 2004; Marshall et al., 2007). In the W.A. study, dietary composition underwent a cyclical seasonal change, and differed among locations, indicating some degree of opportunistic feeding (Marshall, 2004; Marshall et al., 2007). In Spencer Gulf in South Australia, baiting experiments using some of the most common bycatch species in prawn trawls (e.g. blue-spotted goatfish Upeneichthy vlamingii, calamari Sepioteuthis australis, Degen's leatherjacket Thamnaconus degeni and sand trevally Pseudocaranx wrighti) indicated that T. dumerilii were one of the main benthic scavengers of these items (Svane et al., 2008).	3

Trawl Chondrichthyan Species Group continued				
Common	**Habitat and Depth**	**Ontogenetic Pattern**	**Other Information**	**Catch-Habitat Summary**
Spikey Dogfish	Soft sediment distinct (Williams and Bax 2001)	Young mostly pelagic off the outer shelves (Compagno, L.J.V., D.A. Ebert and M.J. Smale, 1989 Guide to the sharks and rays of southern Africa. New Holland (Publ.) Ltd., London. 158 p.);		3
Wide Stingaree				not determined
Southern Chimaera	Biome = USd to MSs. Little information about habitat available, but noted to occur in slope waters, including plateaus. Shallow records from GAB likely to represent other species, given the slope distribution of Chimaera fulva (see Didier et al., 2008). Records to date have been from mid continental slope, from east of Broken Bay in New South Wales (33°33′ S, 152°09′ E) to west of Shoal Point in Western Australia (28°00′ S, 112°41′ E), including Tasmania, at depths of 780– 1,095m (Didier et al., 2008).		Previously known as Chimaera sp. A (Last & Stevens, 1994). The type locality is south-east of Cape Everard, Victoria. A number of records have come from east of Broken Bay, east of Sydney and east of Jervis Bay (NSW); south and south-west of King Island (TAS); west of Cape Sorrell (TAS), also Cascade Plateau in the Tasman Sea; Great Australian Bight in South Australia (e.g. confirmed records from 852m to 952m) and Western Australia (e.g. examples from 993m–1020m); also west of Shoal Point, west of Leander Point, west of Madurah, west of Bunbury and south of Cape Leeuwin (WA) (Didier et al., 2008).	4, 5

Appendix F: Summary list of fishing ground polygons

Example extract from data showing a few fields for a selection of grounds

GAB_ID	AREA KM	DEPTH MIN	DEPTH MAX	AREA_ID	AREA_Name	AREA BottomType	AREA Boundary Confidence	AREA Bottom Confidence
1	775.92615	-92	-178	1379	125 Inshore	3	4	5
2	947.47157	-85	-306	1380	126 Inshore	3	4	5
3	37.17535	-127	-202	1381	Heartbreak ridge	2	5	5
5	586.53924	-144	-1356	1550	Coral Hill Canyon	2	2	5
6	2241.22302	-612	-1357	1383	Mud lump	4	2	5
7	312.24869	-166	-347	1384	Gemfish 1	3	3	1
8	387.14129	-175	-347	1385	Quiet zone upper slope	3	4	3
9	387.56136	-165	-377	1386	Upper slope gemfish ground 2	4	3	3
10	167.21328	-116	-130	1388	Skinny patch	2	4	4
11	463.48623	-118	-186	1389	Boarfish	3	4	4
12	232.57837	-123	-187	1390	Dead patch	3	3	3
13	727.2077	-122	-205	1391	128 - 129 degrees	4	4	4
14	250.61773	-112	-133	1392	129 inshore W	2	5	3
15	419.64057	-122	-133	1393	129 inshore E	2	3	3
16	743.81674	-127	-189	1394	West of Benthic Protection zone inshore	3	4	4
17	772.25992	-109	-146	1396	West of benthic strip inshore	4	4	4
18	104.53521	-160	-230	1397	129 edge	2	4	4
19	519.10168	-160	-392	1398	West of 130d 06m - canyon upper slope	4	4	4
20	105.80793	-151	-278	1399	130 canyon Benthic Protection Zone	4	4	4
21	142.03627	-172	-270	1413	Benthic Protection Zone upper slope	4	4	4
22	1190.10557	-131	-184	1414	Benthic Protection Zone shelf edge	4	4	4
23	136.86536	-134	-153	1415	Backyarders	2	4	4
25	95.45701	-534	-636	1400	131 - grennas	3	2	4
26	272.79884	-167	-313	1401	Upper slope 131	3	3	4
27	2300.08127	-119	-280	1402	Cowrie shell patch	4	4	4
29	395.57087	-442	-1306	1404	Hamburger - Racetrack	3	4	4
201	226.49495	-651	-1813	1476	Albany Management area	3	2	4
205	391.74874	-676	-1628	1474	Far West Hills	3	2	2
206	289.73466	-672	-1450	1475	Far West Plain	4	3	4
207	700.72728	-624	-1736	1477	Far West Canyons	3	2	4
208	118.44322	-614	-1546	1478	Bremmer Roughy Management Area	3	2	3
209	210.03266	-675	-1652	1479	Bremmer - Closure	3	2	4
210	208.98886	-725	-1949	1480	Far West GABIA Closure	3	1	4
211	464.92222	-684	-1445	1481	West GABIA Big Closure	3	1	4
212	591.71975	-653	-2220	1482	Between the West GABIA closures	3	1	4
213	253.82595	-613	-1973	1483	West GABIA Small closure	3	1	4
214	50.71422	-642	-1367	1484	GABIA SW Small - Humdinger west	3	2	5
215	118.95679	-622	-1506	1485	Humdinger West - Research Zone	3	2	5
216	232.17344	-634	-1624	1486	Humdinger West - Humdinger	3	2	2
217	209.71484	-581	-1648	1487	Humdinger mud lumps	3	2	4
218	4057.35254	-401	-1818	1501	WA-Border	4	4	4
219	403.64772	-638	-1771	1502	Border - Lomvar	4	4	4
220	924.63883	-687	-1330	1503	Longva Research Zone	3	4	3
221	1226.14453	-667	-1349	1504	Longva - Benthic	3	5	3
222	3437.58591	-679	-1320	1505	Benthic Zone mid slope	3	5	5
223	2648.19479	-688	-1309	1506	Benthic - United Nations	3	4	5
224	2241.25715	-691	-1303	1507	United Nations AFMA Research Zone	3	2	3
225	6496.39494	-671	-1338	1508	United Nations - Knob	3	2	3
226	6077.75589	-454	-1338	1509	The Knob	3	2	2
227	1891.47358	-438	-1374	1510	The Knob - Racetrack	3	2	4
251	169.77185	-160	-907	1513	Against the Fence	3	2	3
252	305.92381	-156	-1641	1514	Southern Canyons	3	3	3
253	286.72982	-191	-1085	1515	Plateau	3	3	3
254	271.52279	-118	-1453	1516	Cape de Cudic/Murray	3	3	3
255	3219.7945	-196	-765	1517	West of the fence	3	3	3
256	1216.61904	-175	-715	1518	Peninsula ground	4	3	3
257	1528.30057	-195	-710	1519	Ceduna Terrace	4	3	3
501	89.14383	-60	-70	1741	Cape Blanch outer	2	2	3
502	241.58495	182	-122	1692	Kangaroo West Cray	1	3	3
504	279.55109	67	-86	1874	Gambier Islands	2	2	3
505	182.91176	100	-84	1689	Sleaford	2	3	3
506	301.22021	20	-48	1716	Spilsby	2	2	3
507	276.19575	24	-31	1688	Joseph Banks	2	2	3