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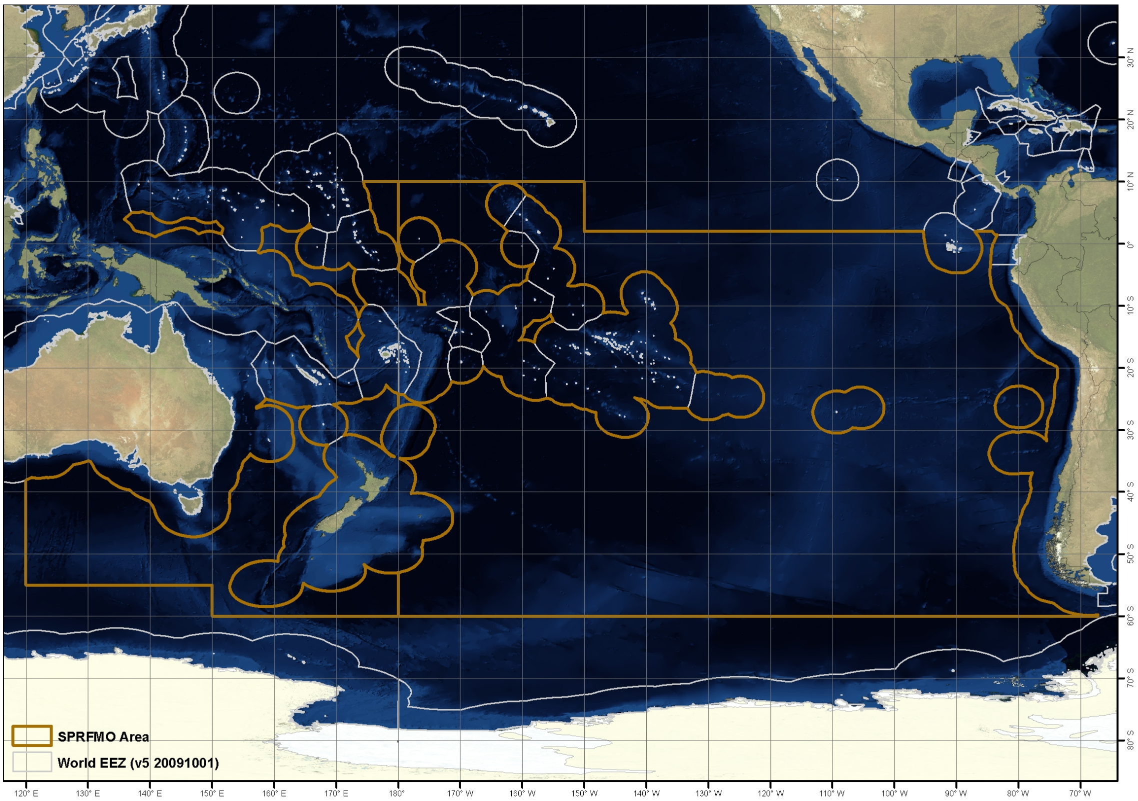
Bottom Fishery Impact Assessment



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Australian report for the South Pacific Regional Fisheries Management Organisation (SPRFMO)

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Important Disclaimer

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List of Acronyms

AAD – Australian Antarctic Division, Department of Sustainability, Environment, Water, Population and Communities
ABARES – Australian Bureau of Agricultural and Resource Economics and Sciences
AFMA – Australian Fisheries Management Authority
BFIA – Bottom Fishery Impact Assessment
BFIAS – Bottom Fishery Impact Assessment Standard
CAAB – Codes for Australian Aquatic Biota
CCAMLR – Convention on the Conservation of Antarctic Marine Living Resources
CenSeam – Census of Marine life, Seamounts Program
CSIRO – Commonwealth Scientific and Industrial Research Organisation
CTD – Conductivity, Temperature, and Depth
DAFF – Department of Agriculture, Fisheries and Forestry
DFAT – Department of Foreign Affairs and Trade
DSEWPaC – Department of Sustainability, Environment, Water, Population and Communities
EEZ – Exclusive Economic Zone
EU – European Union
FAO – United Nations Food and Agriculture Organization
GEBCO – General Bathymetric Chart of the Oceans
GIS – Geographical Information System
HIMI – Heard Island and McDonald Islands
ICVMS – Integrated Computer Vessel Monitoring System
IUCN – International Union for Conservation of Nature
MFish – Ministry of Fisheries (New Zealand)
MPA – Marine Protected Area
NAFO – Northwest Atlantic Fisheries Organization
NEAFC – North East Atlantic Fisheries Commission
NIWA – National Institute of Water & Atmospheric Research (New Zealand)
RFMO – Regional Fisheries Management Organisation
SAI – significant adverse impact
SEAFO – South East Atlantic Fisheries Organisation
SPRFMO – South Pacific Regional Fisheries Management Organisation
SWG – Science Working Group of the South Pacific Regional Fisheries Management Organisation
UNGA – United Nations General Assembly
VLIZ – a Maritime Boundaries Geodatabase
VME – Vulnerable Marine Ecosystem

Executive summary

Objective and result of the benthic fishing impact assessment

This Bottom Fishing Impact Assessment (BFIA) conducted for Australian vessels fishing in the area of application of the *Convention on the Conservation and Management of High Seas Fishery Resources in the South Pacific Ocean* (SPRFMO Area), concludes that the current overall risk of significant adverse impacts (SAI) on vulnerable marine ecosystems (VMEs) by Australian vessels fishing with bottom trawls and bottom-set auto-longlines is low. The BFIA concludes that the current overall risk of SAI on VMEs from mid-water trawling and drop-lining by Australian vessels is negligible [Section 4.3].

The BFIA forms part of Australia's response to United Nations General Assembly (UNGA) Resolutions 61/105 and 64/72, the interim measures adopted by participants in negotiations to establish the South Pacific Regional Fisheries Management Organisation (SPRFMO), and the *FAO International Guidelines for the Management of Deep-sea Fisheries in the High Seas* (FAO 2008).

The BFIA considers impact, risk and existing monitoring, management and mitigation measures in assessing the potential for SAI on VMEs, and has, to the extent possible, followed the guidelines provided in the 'Revised Draft Bottom Fishery Impact Assessment Standard' (BFIAS) developed for the SPRFMO Area (SPRFMO 2009) [Section 4.2].

Description of proposed fishing activities

The assessment uses data from 2002-2009, the period for which reliable data were available when the assessment commenced. In response to the SPRFMO interim measures, Australia implemented an interim fishing 'footprint' which restricts fishing by Australian vessels to its collective (all gears combined) distribution of fishing activity for the period 2002-2006 [Section 3.1.2].

There are currently seven Australian high seas permits that allow bottom fishing in the SPRFMO Area using one or a combination of demersal trawl, midwater trawl, longline, traps and dropline. The number of active Australian vessels has decreased from a maximum of eleven in 2003 to three in 2009. Descriptions of gear types and fishing methods are provided [Section 2].

Mapping and description of proposed fishing areas

This BFIA defines 'fishable areas' as depths of <2000 m that make up 1.1% of the ~59 million km^2 SPRFMO Area. Interactions of fishing with potential VME areas occur on the continental shelf and slope (0-1500 m depths) that make up 0.64% of the SPRFMO Area [Section 3].

In this BFIA, the fishable area is divided into five ecologically-meaningful zones (bathomes) that reflect the depth-correlated composition and structure of marine biota such as deep water corals that characterise VMEs, and reflect the distributions of targeted commercial fish species. Bathomes act as coarse spatial scale indicators for potential VME locations against which to measure the distribution of fishing effort [Section 3]. Similarly, seamounts have also been used as indicators of VME locations because they often support VMEs and are reliably mapped at ocean basin scale [Section 4.1.4]. Major 'fishing grounds', identified from spatial concentrations of fishing activity, provide useful sub-areas for data analysis and reporting [Sections 3.1.3 and 4.2].

Impacts assessment methods

This BFIA has focussed primarily on the risk of direct impacts by bottom fishing on VMEs characterised by benthic fauna because of the potential for widespread and long-lasting effects. There is less emphasis on the status of deep water stocks because impacts assessment requires knowledge of total catch by all fleets in the SPRFMO Area.

Assessing the potential for significant adverse impacts on VMEs needs to consider 'impact' and 'risk' (the intensity, duration, spatial extent and cumulative effects of fishing activities), and define the dependency of these elements on spatial and temporal scales. In this BFIA, the 'overall risk' is considered as the risk remaining after monitoring, management and mitigation measures are accounted for. This BFIA used a qualitative framework because data paucity and knowledge uncertainties preclude a quantitative analysis of risk – especially of cumulative impacts. Semi-quantitative metrics are incorporated for fishing intensity, and the overlap of fishing with the predicted locations of VMEs in bathomes and on seamounts [Section 4.2].

The BFIA process commences with a scoping stage to identify the issues of relevance (concern) and to provide context [Section 4.1]. Issues considered in this BFIA include:

- Australia's management arrangements and fisher's operational measures
- the potential impacts of different fishing gears on VMEs
- the use of indicators (surrogates) to define VME distributions
- the spatial dependencies of impact/ risk assessment, including data quality issues
- the 'evidence of VME process'

Despite the potential for demersal trawling and auto-longlining to impact VME fauna at fine ('site') scales, and for these impacts to persist and to accumulate through time, the current risk of SAI at the scale of the fishery was considered as low when the following factors are accounted for:

- low current fishing effort by Australian vessels
- few areas of high fishing intensity
- restriction of fishing to a 'footprint' area which has predominantly low overlap with the bathomes and seamounts most likely to support VMEs
- limited spatial extent of Australian fishing effort which has low spatial overlap with the bathomes and seamounts most likely to support VMEs
- management arrangements to monitor and mitigate impacts and risks.

Although there is a low current risk of SAI, ongoing monitoring, management and mitigation measures are necessary because the assessment of risk also has to consider possible future impacts. There is (1) the potential for risks to increase if effort levels increase or expand within or beyond the current fishing footprint, and (2) a high degree of uncertainty about many of the key elements relevant to assessing and managing impact and risk to VMEs in the SPRFMO Area. If effort levels or the spatial extent of Australian effort expands by a material amount, then monitoring, management and mitigation measures will need to be reviewed to ensure that the risk of SAI remains low. Ultimately, assessing the risk of SAI may require the context of all nations' fishing activities because persistent (long lasting) impacts are cumulative at the scale of the fishery [Section 4.3].

Status of deepwater stocks to be fished

The long-term sustainability of deep-sea stocks is assessed only on the basis of trends in historical catch and effort because quantitative methods of stock assessment (including those based on harvest strategies) require estimates of total catches in the SPRFMO Area (from all Flag States and non-signatories). Historical trends of Australian catch and effort are provided for the SPRFMO Area for the assessment period (2002 to 2009) [Sections 5].

Monitoring, management and mitigation measures

Australia has adopted management measures for fishing by Australian vessels in the SPRFMO Area. These measures include mandatory levels of observer coverage, move-on requirements triggered by levels of evidence of VMEs (50 kg bycatch of corals and sponges), restrictions on fishing methods and gear types, and restricting the spatial extent of fishing by Australian vessels to a 'footprint' based on its collective (all gears combined) distribution of historical fishing activity for 2002-2006 [Section 4.1.2]. This assessment explicitly acknowledges the many key sources of uncertainty that underlay the BFIA process, which serve to increase risks of SAI. This BFIA identifies several opportunities for scientists, managers, fishery observers, and the fishing industry to reduce uncertainty, both in relation to the knowledge supporting impacts assessments, and to achieving management goals [Section 6].

Bottom Fishery Impact Assessment

1. INTRODUCTION

1.1 Australia's international commitments

The United Nations General Assembly (UNGA), in considering the implementation of the United Nations Convention on the Law of the Sea, adopted Resolution 61/105 in 2006 and Resolution 64/72 in 2009 (UNGA Resolutions). Those resolutions call on States to take action immediately, individually and through regional fisheries management organisations and arrangements, to adopt conservation and management measures to ensure the long-term sustainability of deep sea fish stocks and to prevent significant adverse impacts (SAI) to vulnerable marine ecosystems (VMEs). Paragraph 83(a) of resolution 61/105 and paragraph 119(a) of resolution 64/72 call on States to assess, on the basis of the best scientific information available, whether individual bottom fishing activities would have SAI on VMEs, and to ensure that if it is assessed that those activities would have a SAI, they are managed to prevent such impacts or not authorised to proceed.

On 14 November 2009, the International Consultations on the Establishment of the Proposed South Pacific Regional Fisheries Management Organisation (SPRFMO) concluded with the adoption of the *Convention on the Conservation and Management of the High Seas Fishery Resources of the South Pacific Ocean* (Convention). Until such time as the Convention enters into force, establishing SPRFMO, and conservation and management measures are adopted, Australia has consented to implement the interim management measures adopted by the participants to the International Consultations, including those adopted in May 2007 with respect to bottom fisheries. The interim measures in respect of bottom fisheries were developed in response to UNGA Resolution 61/105 and the *FAO International Guidelines for the Management of Deep-sea Fisheries in the High Seas* (FAO 2008). The main requirements of the interim measures in respect of bottom fisheries are to:

- limit bottom fishing effort or catch in the SPRFMO area of competence (SPRFMO Area) to existing levels (average annual levels over the period from 1 January 2002 to 31 December 2006) in terms of the number of fishing vessels and other parameters that reflect the level of catch, fishing effort and fishing capacity;
- not expand bottom fishing activities into new regions of the SPRFMO Area (as mapped in the SPRFMO joint bottom fishing footprint);
- assess whether individual bottom fishing activities would have SAI on VMEs and close such areas to bottom fishing or implement measures to prevent such impacts, and
- starting in 2010, before opening new regions of the SPRFMO Area or expanding fishing effort or catch beyond existing levels, establish conservation and management measures to prevent SAI on VMEs and the long-term sustainability of deep-sea stocks from individual bottom fishing activities or determine that such activities will not have adverse impacts.

An additional interim measure was agreed in 2009 to prohibit the use of deepwater gillnets in the SPRFMO Area until relevant conservation and management measures are adopted by the future Commission. Vessels must give advance notice to the Interim Secretariat where they intend to transit the SPRFMO Area while carrying gillnets.

In response to the UNGA Resolutions and as part of Australia’s temporary measures for the SPRFMO Area, Australia has adopted a variety of management measures for the SPRFMO Area (Section 4.1.2).

This BFIA is part of Australia’s overall commitment to the UNGA resolutions 61/105 and 64/72, and to the *FAO International Guidelines for the Management of Deep-sea Fisheries in the High Seas*. A similar and separate BFIA has been prepared for the Southern Indian Ocean Fisheries Agreement (SIOFA).

1.2 Process to assess impact of Australian vessels

This Bottom Fishery Impact Assessment (BFIA) documents the bottom fishing effort in the SPRFMO Area from 2002 to 2009, the quantity and composition of the retained catch, and the mapped distribution of fishing effort at a fine scale resolution, and assesses whether individual bottom fishing activities of Australian vessels have SAI on VMEs in the SPRFMO Area. This requires several steps including (1) defining VMEs; (2) determining the distributions of VMEs – noting that these are not explicitly mapped and that ‘indicators’ (surrogates) must be relied upon in the absence of evidence showing where VMEs are located; (3) estimating the nature, extent and persistence of impacts from different fishing gears – that vary with fishing intensity, and between gears and VMEs; and (4) assessing how the current management arrangements reduce the impact or risk of SAI on VMEs.

This BFIA considers effort from 2002 to 2009. This period was chosen because, at the time the assessment was commenced, this was the period for which reliable data were available. Effort mapping for this period is considered at 6 minute (0.1º) grid square resolution for individual gear types (referred to in this BFIA as ‘effort distribution’). Additionally, in response to the SPRFMO interim measures, Australia has defined an interim fishing ‘footprint’ based on the collective (all gears combined) distribution of historical fishing activity for 2002 to 2006 in 20 minute grid squares (20’ blocks). This is used to restrict the spatial extent of bottom fishing activities.

The assessment methods follow, to the extent possible, the guidelines provided in the revised draft ‘Bottom Fishery Impact Assessment Standard’ (BFIAS) developed for the SPRFMO Area (SPRFMO 2009). That draft standard has been developed using a range of currently available information in response to UNGA Resolution 61/105, particularly the *FAO International Guidelines for the Management of Deep-Sea Fisheries in the High Seas* (FAO 2008). Assessment of individual activities of Australian operations needs to be considered in the context of the cumulative impact of fishing through time and by vessels from other Flag states. It will be important for Australia to input to SPRFMO along with other member nations, to allow for broader assessments of any impacts.

The SPRFMO Area is the high seas of the Pacific Ocean within the boundaries described in Article 5 of the Convention. It has a complex boundary (Figure 1.2.1 inset), and a total area of 52,889,134 km^2. All data summaries reported here are restricted to spatial data that falls within the SPRFMO Area, as defined by a shapefile constructed from the description in Article 5 of the convention and the EEZ boundaries as published in the VLIZ Maritime Boundaries Geodatabase (VLIZ 2010).

Australian fishing vessels have been active only in the western and central part of the SPRFMO Area (120ºE to ~150º W) (see Figure 1.2.1).

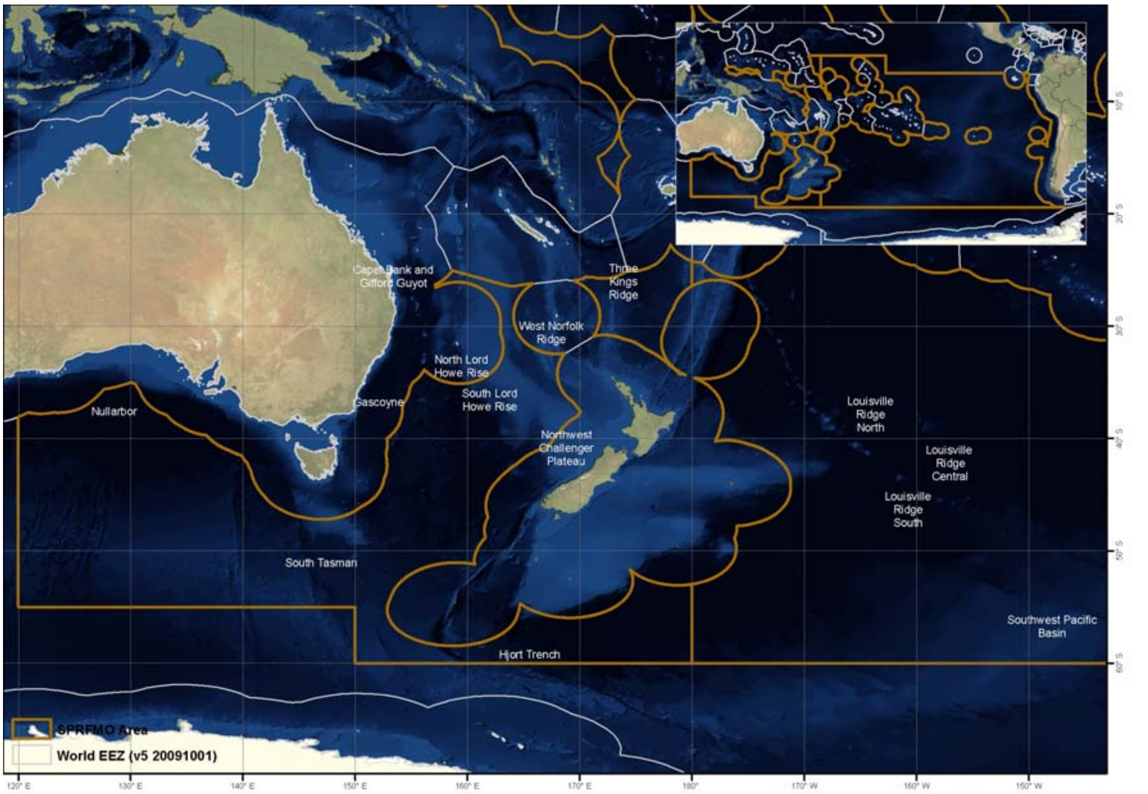

Figure 1.2.1 Map of the SPRFMO Area bounded by the global EEZ (VLIZ 2010) with world topography underlay (NASA Blue Marble – Stockli et al. 2005). Inset shows the entire SPRFMO Area, the main map shows the western and central sub-area where Australian fishing vessels have been active.

Identification and assessment of risks of SAI to VMEs requires clear and specific operational definitions of VMEs and of SAI (SPRFMO 2009). Guidelines provided by the FAO (FAO 2008) have improved and expanded definitions relevant to UNGA Resolutions 61/105 and 64/72, and are incorporated in the SPRFMO assessment template (SPRFMO 2009). These include definitions for vulnerability and risk, VMEs, biologically important factors, SAI, and a hierarchy of bottom fishing impacts. Details of these definitions are provided in Section 4.1.1 (and see Appendices 1-3).

It is important to recognise that evaluating the likelihood and extent of potential interactions of fishing with VMEs is constrained by the lack of data on distributions of seabed biodiversity, and hence the mappable distributions of VMEs. Assessing impact by the Australian fleet in the SPRFMO Area relies on using seabed topographical features, especially seamounts, as ‘surrogates’ or ‘indicators’ for VME distributions – as has been the case for other BFIAs, e.g. by New Zealand (MFish 2008). But because the suitability of individual topographic features as habitats for VMEs is highly variable, e.g. the great majority of SPRMFO seamounts may be too deep to support high abundances of coldwater corals, assessment is also reliant on analysis of habitat suitability. Such analyses are becoming available for high seas areas including the SPRFMO Area (e.g. Tittensor et al. 2009; Clark and Tittensor, 2010) and are reviewed by Penney (2009). Indicators for potential VME locations used in this assessment are ‘bathomes’ (ecologically meaningful depth ranges within fishable depths), and seamounts.

The BFIAS also suggests considering biogeographic zones and proximity measures in the assessment, but we have not included these factors due to the absence of a single established mapping of biogeography for the deep Pacific Ocean, and the considerable additional complexity of including proximity/ connectivity measures in the structure of an impact assessment.

1.3 Data preparation and summary

1.3.1 Logbook and observer data

This assessment used fisheries data from the AFMA logbook database. Principal data used were position, date, time, fishing method, effort as reported for the different gears (hours fished, hooks set, or number of standard sets) and catch weight per species for each fishing operation (trawl shot or line set).

Observer data is collected by AFMA and managed separately from logbook data. The observer database was obtained from AFMA and summarised for the relevant years (see Section 4.1.5).

1.3.2 GIS Data Sources

This BFIA relied on the best data sets available at the time of the commencement of this assessment to assess, describe and map the distribution of potential VME indicators and distributions of Australian fishing activities.

Spatial analysis of the fishing logbook database relied on a variety of other mapping data for the SPRFMO Area; the most recent and fine-scale information sources were used:

- SPRFMO boundary — supplied by SPRFMO Secretariat (December 1, 2010)
- Global EEZ — VLIZ Maritime Boundaries Geodatabase (VLIZ 2010)
- GEBCO Bathymetry — The GEBCO_08 Grid a global 30 arc-second grid (GEBCO 2008)
- World topography — NASA Blue Marble (Stockli *et al*. 2005)
- New Zealand fishing grounds — New Zealand Biodiversity Information System (MFish 2008)
- Global distribution of seamounts (point data)— CenSeam 2010 (unpublished data)
- Global distribution of seamounts (polygon data) — Yesson et al. (2011)

1.3.3 Spatial processing

Operations for the SPRFMO Area were selected from general high seas logbook data using the start coordinates of fishing operations occurring within the SPRFMO Area boundary as defined by its GIS shape file. Operations represent the unit of logbook recording which is equal to one trawl shot or one longline/dropline set. Gridded analysis for two spatial scales, 20’ x 20’ (the standard SPRFMO footprint grid cell) and 0.1° x 0.1° (6 minutes – approaching the limit of logbook resolution of 1 minute) was generated in Oracle using Oracle spatial intersect functions SDO_RELATE.

To map fishing effort distribution, fishing operations were assigned to grid cells based on their start position only if no end point was reported. Where an end point was reported, and the length of a straight line between start and end points was $\geq$6 km, all grid cells (of either scale) touching any segment of the straight line were retained as part of the fishing effort distribution. Six kilometres is used in domestic Australian deepsea fisheries as a limit for filtering tow lengths as part of data quality assurance; it was assumed to be a realistic limit for high seas data. Fishing effort distribution will be underestimated by logbook records that lack an end position.

Overlap analyses between the 0.1° mapped fishing distribution and depth zones (at 30 arc seconds, 0.2 n.m. resolution) were performed in ArcGIS using the Intersect analysis function. Areas for calculating the proportion overlap between fished grid cells and depth zones were calculated using a Lambert Azimuthal Aqual Area projection centred on the SPRFMO Area (PROJECTION: Lambert Azimuthal Equal Area, DATUM: WGS84, SPHEROID: WGS84, Central_Meridian: 75.0, Latitude_Of_Origin: -20.0). Where grid cells containing fishing effort crossed the SPRFMO boundary they were clipped to the boundary extent. It should be noted that the depths reported here refer to the centroid depths of the grid-cells, derived from the bathymetry grid, not the reported operation depth. The form of the analytical result is therefore limited by the resolution of the underlying data (also see Section 4.1.4).

1.3.4 Queries and Filters

Fishing operations were allocated to a sub-fishery based on their spatial location (occurring within the SPRFMO Area) and gear code. Gear flagged as trawl were allocated to either demersal or midwater trawl based on ‘trawl type’ (stratum) recorded in logbook entries. For operations in 2002-2003 where logbook entries did not specify the type of trawl (provision for entering trawl type was implemented in logbooks after 2003), shots were allocated to midwater trawl based on the catch ratio of orange roughy (CAAB code: 37255009, FAO code: ORY, *Hoplostethus atlanticus*) to alfonsino (CAAB code: 37258002, FAO code: BYS, *Beryx splendens*) being <3. This ratio ensured that the main target species for midwater trawls, alfonsino, was identified. The ratio also corresponded well with ratios observed where the stratum was recorded. Shots not identified using this method as midwater trawl were allocated to demersal trawl. Line methods were selected based on spatial occurrence within the SPRFMO Area, and gear types: AL: Auto-longline, BL: Bottom line and DL: Dropline. Gillnet operations (GN) were selected based on spatial occurrence within the SPRFMO Area.

2. DESCRIPTION OF THE PROPOSED FISHING ACTIVITIES

There are currently seven Australian high seas permits allowing bottom fishing, all of which authorise fishing in the SPRFMO Area. The gross tonnage of vessels to which high seas permits are attached has been provided the SPRFMO interim secretariat. The fishing methods permitted under the concessions are one or more of the following methods: demersal trawl, midwater trawl, longline, traps and dropline. Fishing methods have been specified on Australian high seas permits since 2008. Prior to 2008, deepwater gillnetting was allowed and used but formed a very minor part of the fishery (occurring in two years, 2002 and 2003, within a restricted area). Deepwater gillnet methods have been banned in the SPRFMO Area (from February 2010) until relevant conservation and management measures are adopted by the future Commission.

The number of Australian vessels active in the SPRFMO Area has decreased from a maximum of eleven in 2003 to three vessels in 2009. The operators of the licensed vessels have indicated to AFMA that they intend to use demersal trawl, midwater trawl, traps and demersal line (auto-longline and dropline) methods in the current fishing year.

2.1 Vessels and gears

2.1.1 Trawl

A total of 15 Australian vessels trawled in the SPRFMO Area between 2002 and 2007, with no trawling in the SPRFMO Area in 2008 and 2009 (Table 2.1.1.1). The fleet mostly used demersal trawls, although three vessels deployed both demersal and midwater trawls between 2002 and 2006 and one vessel fishing in 2002 only used midwater trawl. A maximum of nine Australian vessels were active in any given year (Table 2.1.1.1 & Figure 2.1.1.1).

Details of gears used currently were obtained by direct communication with the relevant companies. A critical aspect of understanding gear types in the context of benthic impacts was the distinction between midwater and demersal trawls. We confirmed the component of fishery operations recorded in the logbook as ‘midwater’ uses a net with large meshes (i.e. 20 metre diagonal meshes in the wings of the net), i.e. it is a pelagic net designed for off-bottom fishing. However, these nets do have a sacrificial footrope in case the net touches the bottom, suggesting that the midwater net is fished close to the bottom, and can touch down at least occasionally. One high seas trawl operator described his demersal trawl net as a simple 2 seam ‘cut away’ roughy demersal trawl with 80 metre sweeps and 40 m bridles. The headline length is 38 metres and the 30 metre footrope has 12 inch rubber bobbins. This operator fished to 1400 metres water depth and target species were orange roughy (*Hoplostethus atlanticus*), dory (oreosomatids), alfonsino (*Beryx splendens*), cardinal fish (*Epigonus* spp.) and blue-eye trevalla (*Hyperoglyphe antarctica*). This trawling operation typically fished with the trawl doors just off bottom. Demersal trawls used by other operators in the SPRFMO Area are of a similar design, but there are no records that detail which parts of the demersal trawl gear contact the seafloor.

Table 2.1.1.1 Active trawl vessels in the SPRFMO Area between 2002 and 2009 showing the target stratum and the number of operations (trawl shots).

Vessel	Stratum	Total no. Operations	2002	2003	2004	2005	2006	2007	2008	2009
Total no.	demersal	14	7	9	6	3	3	2	0	0
vessels	midwater	4	2	0	0	1	1	0	0	0
1	demersal	2		2						
2	demersal	61		61						
3	demersal	15	10	5						
4	demersal	19		19						
5	demersal	31	25		6					
6	demersal	2		2						
7	demersal	11	10	1						
8	demersal	455	151	108	108	52	29	7		
9	demersal	17	16		1					
10	demersal	1			1					
11	demersal	63	63							
12	demersal	234		13	4	18		199		
	midwater	25				25				
13	demersal	89					89			
	midwater	310					310			
14	demersal	101	38	26	14	17	6			
	midwater	2	2							
15	midwater	10	10							

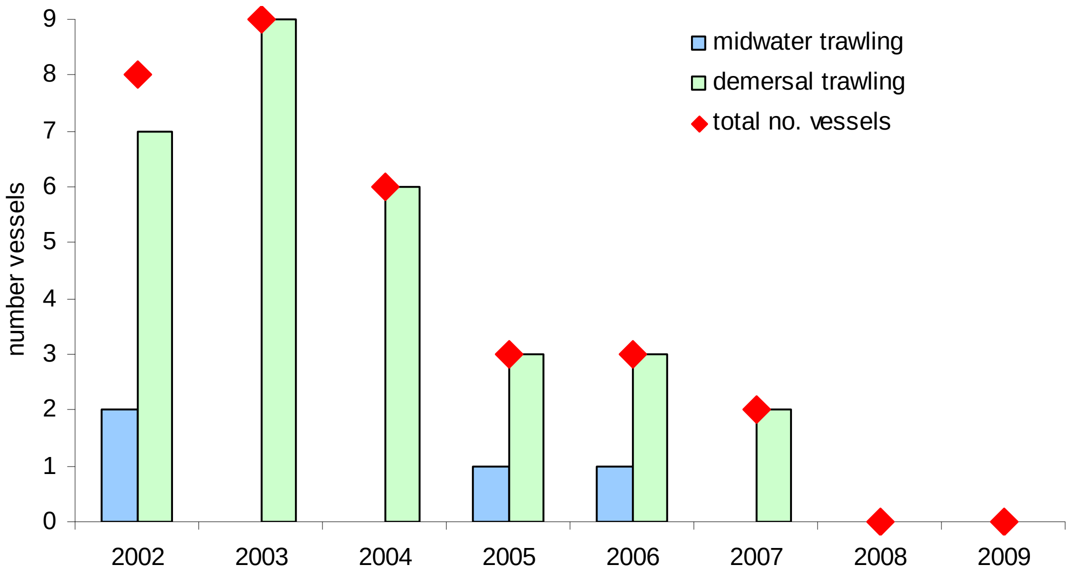

Figure 2.1.1.1 The number of trawl vessels operating in the SPRFMO Area by year (red diamond), overlaid with the gear types employed. Note a single vessel can pursue more than one trawling method

2.1.2 Demersal lines

A total of six Australian vessels fished with demersal lines in the SPRFMO Area between 2002 and 2009 with the five active vessels recorded in 2006 being the maximum operating in any one year (Table 2.1.2.1). Both auto-longline and droplines were used in this fishery; in general one or the other gear was used exclusively. Both types of gear were deployed by one vessel in 2002, otherwise one or the other gear was used exclusively (Figure 2.1.2.1).

Table 2.1.2.1 Active vessels using demersal line fishing methods in the SPRFMO Area between 2002 and 2009 showing the line deployment method and the number of operations (line sets).

Vessel	Line Method	Total no. Operations	2002	2003	2004	2005	2006	2007	2008	2009
Total no. vessels	AL	4	2	1	1	0	3	1	2	2
	DL	3	2	2	2	3	2	1	1	1
1	AL	117					9	20	68	20
2	AL	78	22	7	4		13		22	10
3	AL	3					3			
4	AL	2	2							
	DL	45	3	2	24	10	6			
5	DL	1				1				
6	DL	36	3	4	7	8	7	4	1	2

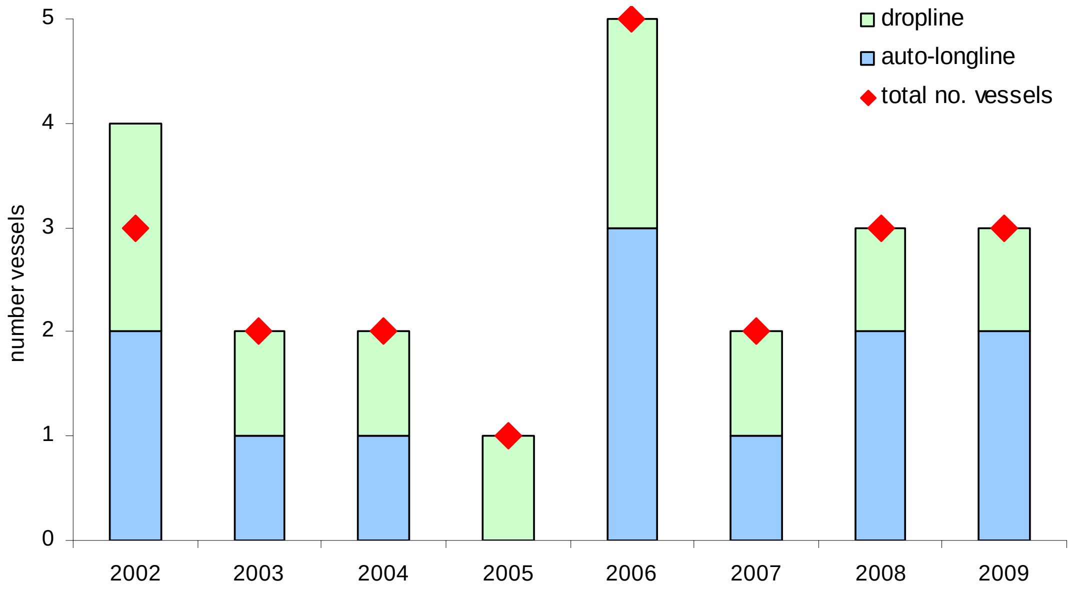

Figure 2.1.2.1 The number vessels using demersal line fishing methods operating in the SPRFMO Area by year (red diamond), overlaid with the gear types employed. Note a single vessel can pursue more than one line fishing method

Details of gears used currently were obtained by direct communication with the relevant companies. Auto-longline equipped vessels utilize technology that enables semi-automated setting of large numbers of baited hooks in a short time. Part of this gear is an auto-baiter that can bait ~2 hooks per second whilst the mainline is shot from the stern of the vessel. Gear specifications for auto-longline differ between ‘fresher boats’ and ‘processing vessels’. The former have a bottom set mainline that is 9-11 mm and can be weighted. Snoods of ~ 300 mm length with a 12/0 to 14/0 hook are spaced between 1 to 1.4 meters apart along the mainline. The longline is set with a 75 kg weight at each end and, depending on the target species, either floated up off the seabed using midwater floats that are clipped onto the line during deployment, or allowed to settle onto the seabed, sometimes with a weight midway along to prevent dragging. Droplines are lines set vertically with a single weight (~ 40kg) at the bottom and a large float at the surface with around 100-200 hooks attached at the bottom part of the vertical line. The maximum depth fished by ‘fresher boats’ is reported as being ~1,500 meters.

Auto-longline gear deployed by ‘processing vessels’, i.e. Australian flagged vessels processing at sea, is an auto-lining system made by Mustad and Best Fishing Gear (BFG). The ‘backbone’ of the line is made by AS Fiskevegn, it is weighted (50 gm/m) with a diameter of 11.5 or 12.0 mm. Nylon cord snoods of 42 cm and coloured blue are spaced at 1.4 m; each with a 20 Gauge, size 15/0 Mustad hook. Each magazine of backbone usually consists of 900 hooks giving a total magazine length of 1260 m; generally six magazines (range 4-8) are set per line. Attached to either end of the deployed magazines is a length of nylon free-line (anchor line) measuring 100-200 m. This free-line is attached to one or two 40 kg grapnel anchors with a 20 kg chain also attached. A nylon downline is used to connect the anchor line on the seafloor to the windy buoys and GPS buoy on the surface (Figure 2.1.2.2). Lines are shot from the stern of the vessel, and retrieved through the hauling station located on the starboard side. The depth potentially fishable by ‘processing vessels’ is reported as being up to 2,400 meters, however, under the current practice, auto-longline fishing does not exceed 2000 m depth.

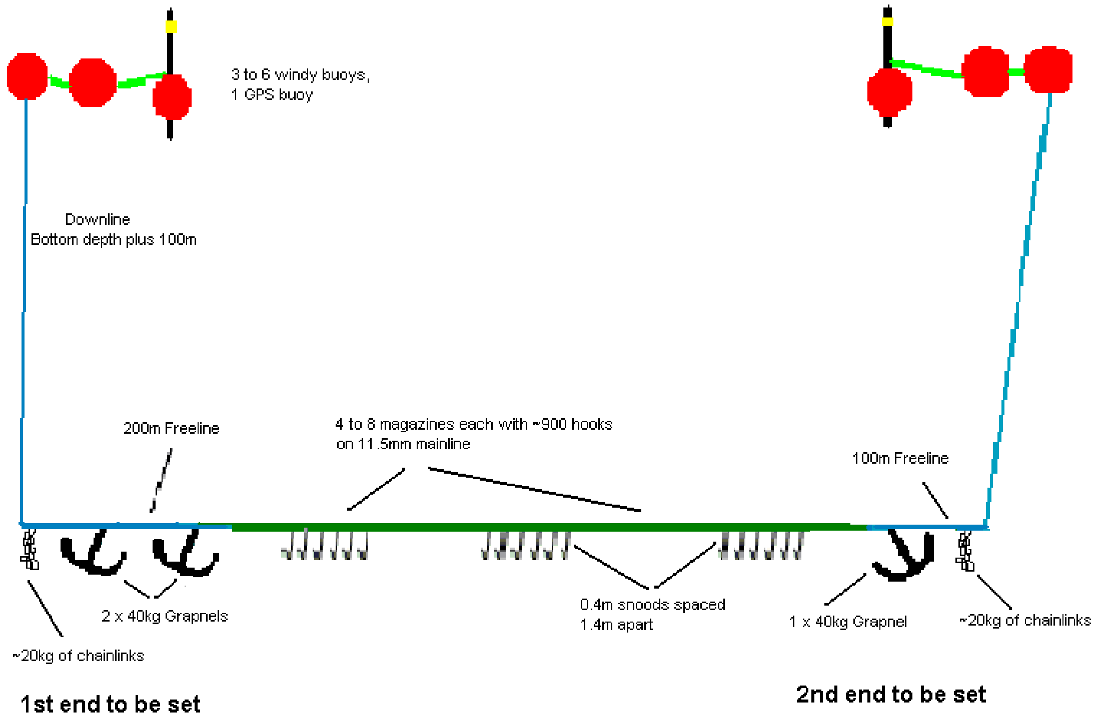

Figure 2.1.2.2 Diagrammatic representation of the set-up of auto-longlines as used by ‘processing vessels’

2.1.3 Gillnet

Pursuant to the SPRFMO interim measure on deepwater gillnets deepwater gillnet methods have been banned in the SPRFMO Area since 1 February 2010 until relevant conservation and management measures are adopted by the SPRFMO Commission. Gillnetting has not been authorised under Australian permits since fishing methods were specified in 2008; prior to 2008 deepwater gillnetting was allowed and used in the SPRFMO Area, but formed a very minor part of the fishery. The description of deepwater gillnet gear given here is general rather than specific to the Australian fleet. The AFMA logbook records show one vessel used this fishing method in the SPRFMO Area in 2002/03.

In general, gillnets for use in offshore fisheries have features and components to enable them to effectively fish deepwater in areas with hard bottom types and high current. The footline of the gillnet is usually heavily weighted with lead to ensure the net sinks rapidly and stays stationary on the seabed. Special deepwater floats that are strong enough to withstand the pressure and have sufficient buoyancy to make the net stand upright and continue fishing in areas of considerable current are used. The nets stand about two metres up from the seabed and are anchored with heavy (50-100 kg) grapple anchors at each end to stop them being dragged across the bottom. A fleet of nets could stretch for several hundred metres. Surface lines with large, highly visible floats assist with recovery of the nets; at times the surface floats are equipped with transmitting beacons and/or lights.

3. MAPPING AND DESCRIPTION OF PROPOSED FISHING AREAS

3.1 Definition of fishing areas

3.1.1 Fishable areas

The first step towards defining the fishing interaction with, and impact on, VMEs is to define the ‘fishable area’. In this assessment, the potential fishable area was defined as depths <2000 m (Figure 3.1.1.1).

The fishable area can be usefully subdivided into five primary divisions (bathomes) that reflect the depth-correlated composition and structure of marine biota (Last et al. 2010; Table 3.1.1.1). In the context of benthic impacts of fishing, bathomes are relevant to the distributions of targeted commercial fish species and therefore the distribution of fishing effort, and to the distributions of faunal components such as deep water corals that characterise VMEs. For example, *Solenosmilia variabilis*, a matrix-forming stony coral that is common on southern Australian and New Zealand seamounts and has been shown to be vulnerable to bottom trawling, only occurs on the deep upper continental slope and shallow mid-slope depths (Althaus et al. 2009). It is important to appreciate that each of the bathomes in the fishable area makes up less than 1% of the total SPRFMO Area; depths greater than 2000 m make up ~99% of the area (Table 3.1.1.1).

Table 3.1.1.1 The SPRFMO Area divided into five ecologically meaningful bathomes (*sensu* Last et al. 2010)

Bathome	**Name**	**Area (km^2)***	**Percentage of total SPRFMO Area**
0 – 200 m	Continental shelf	3,946	0.01
201 – 700 m	Shallow upper continental slope	43,079	0.07
701 – 1000 m	Deep upper continental slope	65,519	0.11
1001 – 1500 m	Shallow mid-continental slope	260,802	0.44
1501 - 2000 m	Deep mid-continental slope	273,389	0.46
Combined depths >2000 m		58,385,246	98.90
TOTAL		59,031,981	100.00

* all areas are ‘plan areas’ i.e. do not take account of the nature of underlying topography

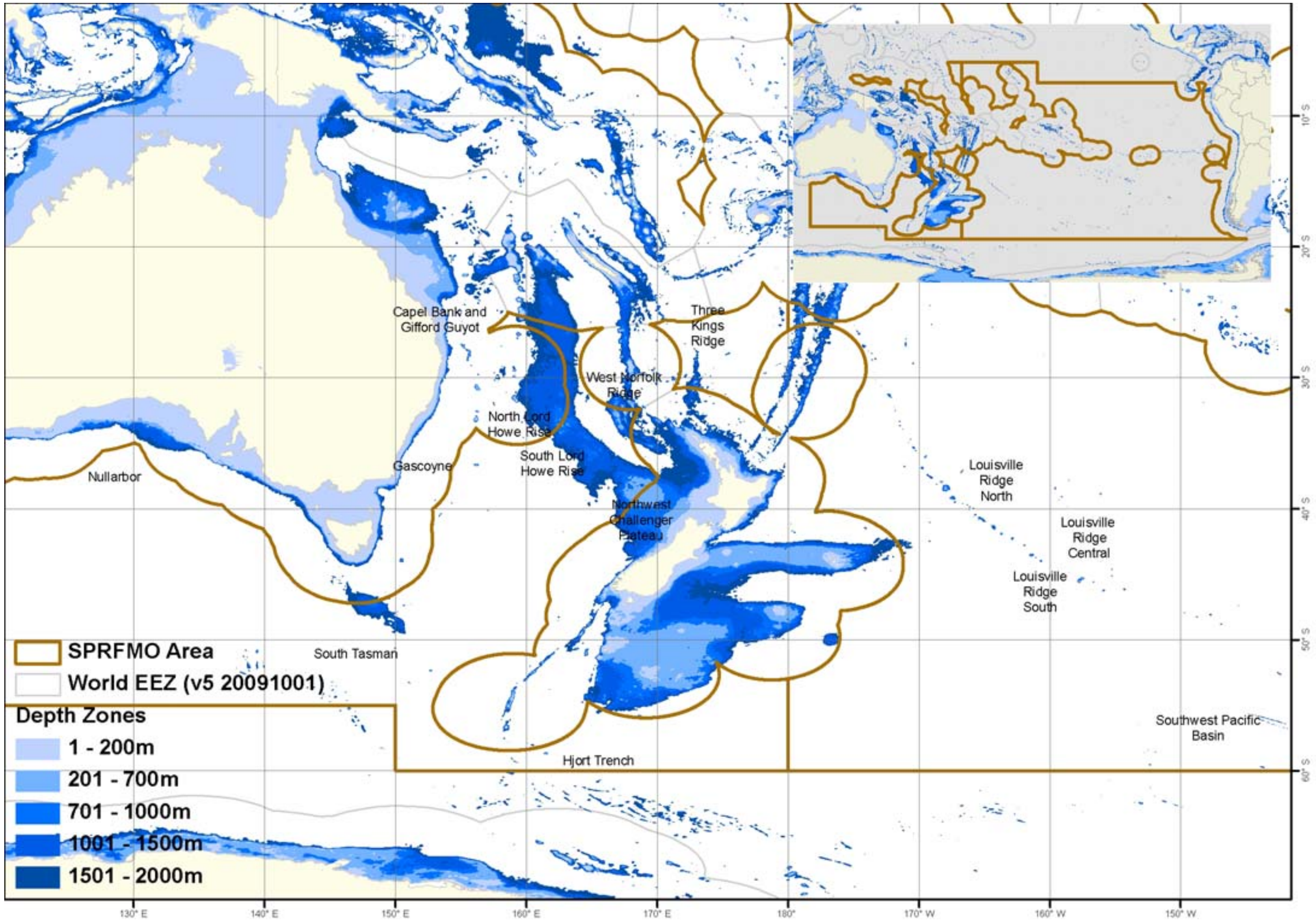

Figure 3.1.1.1 Map of the entire SPRFMO Area (inset) and sub-area used by Australian vessels (main map) with bathymetry contours showing fishable areas (≤ 2000 m) defined from GEBCO Bathymetry (GEBCO 2008) and divided into ecologically meaningful depth zones (bathomes *sensu* Last et al 2010). Depths beyond 2000 m are left white.

3.1.2 Footprint

The value of mapping an index of relative past effort was noted by the SPRFMO SWG at their 4th meeting in 2007. An index such as the total number of trawls in each grid cell ('block') would enable different approaches to management and mitigation measures to be tailored to the level of past impact, the likelihood of encounters with VMEs and the importance of different areas to the fishery, e.g. as has been done for the New Zealand fleet (MFish, 2008). A spatial resolution of 20' (~20 n.m.) to map consolidated effort within the SPRFMO Area between 2002 and 2006 was adopted at the Fourth International Meeting on the Establishment of the proposed SPRFMO in 2007 (Figure 3.1.2.1). Note, however, that in this Australian BFIA, the distribution of fishing effort is also mapped at fine resolution (0.1° or 6' grid cells) over the period 2002 to 2009 and classified into six bathomes (five covering fishable areas $\leq$2000 m) for individual gear types (see Section 1.3.3) to ensure that impact is assessed at the finest possible resolution (see Section 4.1.4).

Under the interim measures developed in response to UNGA Resolution 61/105 and the *FAO International Guidelines for the Management of Deep-sea Fisheries in the High Seas* (FAO 2008) Australia committed to not expand bottom fishing activities into new regions of the SPRFMO Area, outside of the footprint, prior to having established conservation and management measures to prevent SAI on VMEs (see Section 1.1). The footprint covers 0.16% of the SPRFMO Area, but overlays up to 37% of the area of individual bathomes in the fishable area (Table 3.1.2.1). The historical Australian fishing effort has been focussed on three distinct and separate regions: (1) the South Tasman region, (2) the Tasman Sea region (including Lord Howe Rise, Norfolk Ridge, Challenger Plateau), and (3) the Louisville Ridge east of New Zealand. Fishing distribution mapping has therefore been stratified by these fishing areas (see Section 4.1.4).

Table 3.1.2.1 The Australian footprint (20' grid, 2002-2006) in the SPRFMO Area divided into five ecologically meaningful bathomes (*sensu* Last et al. 2010)

Bathome	Name	Australian footprint area (km^2)	Percentage of total bathome in SPRFMO Area
0 – 200 m	Continental shelf	1,014	25.70
201 – 700 m	Shallow upper continental slope	8,883	20.62
701 – 1000 m	Deep upper continental slope	23,986	36.61
1001 – 1500 m	Shallow mid-continental slope	33,425	12.82
1501 - 2000 m	Deep mid-continental slope	9,557	3.50
>2000 m**		18,199	0.03
TOTAL		95,064	0.16

* all areas are 'plan areas' i.e. do not account of the nature of underlying topography

**coarse resolution (20' grid) mapping results in apparent fishing in depths >2000 m.

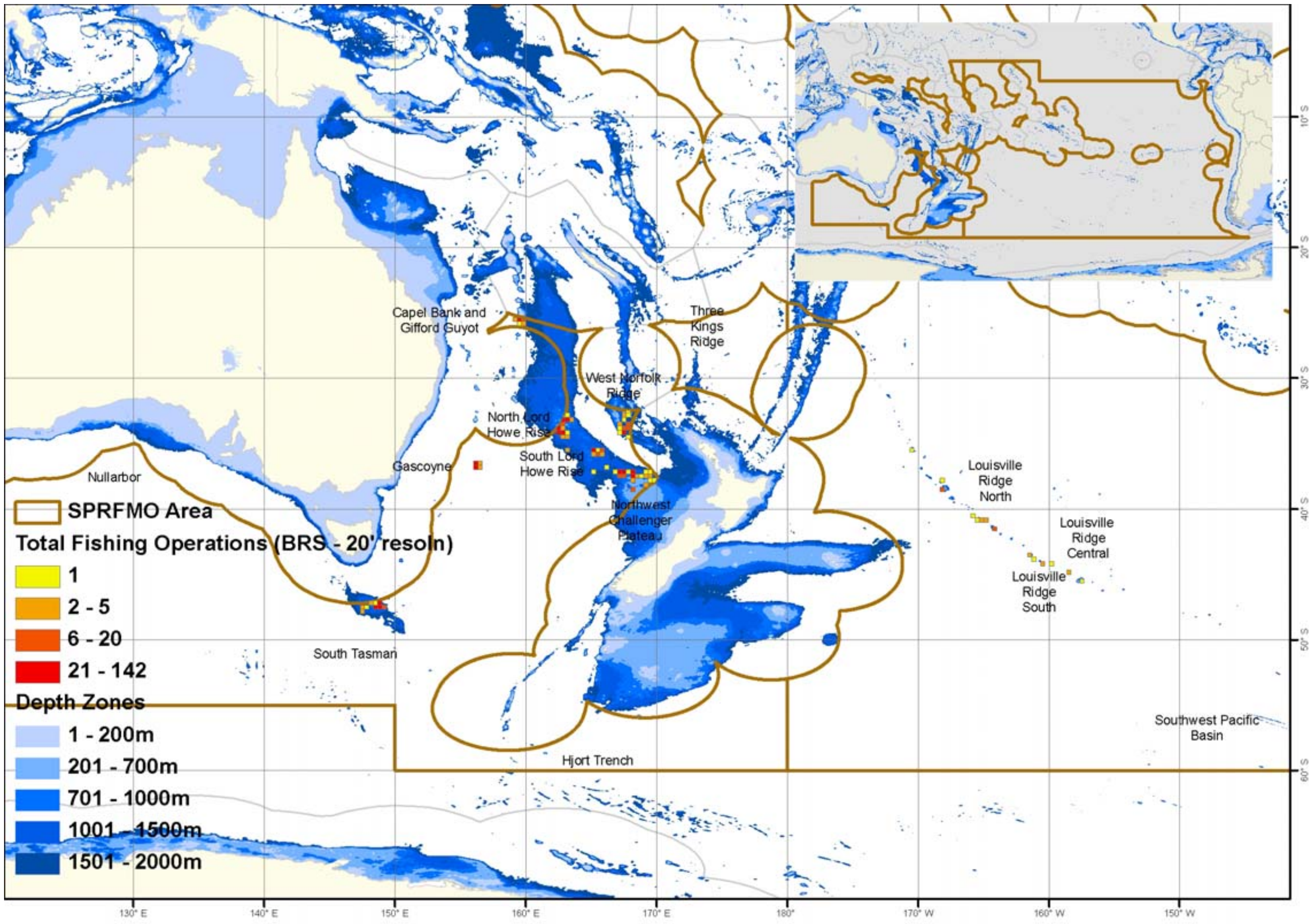

Figure 3.1.2.1 Footprint and effort (2002-2006) for all gears combined, at the resolution of the standard 20' blocks prepared by ABARES and submitted to the SPRFMO interim Secretariat. Effort is based on data from SPRFMO Area only, although some individual grid-cells may partially overlap EEZs. The insert shows the total SPRFMO Area.

3.1.3 Fishing grounds

In their report to SPRFMO, the New Zealand Ministry of Fisheries identified 11 distinct sub-areas within the SPRFMO Area that were the focus of past fishing activities; these areas are described as the primary ‘fishing grounds’ (MFish 2008). These fishing grounds provide a useful way of describing the distribution of the Australian effort which can be overlaid on the MFish (New Zealand) boxes and adding, where appropriate, fishing grounds based on the historical Australian fishing footprint. For ease of definition and mapping, the fishing grounds are defined as rectangular boxes; some of these overlay adjacent EEZs but areas and analyses only consider the region within the SPRFMO Area (Figure 3.1.3.1). The great majority of the Australian fishing footprint (2002-2006) at 20’ block resolution can be summarised using the 11 New Zealand fishing grounds plus two additional grounds (Gascoyne and Capel Bank & Gifford Guyot) (Figure 3.1.3.1). Small areas of effort lie outside these 13 boxes on the Challenger Plateau (three 20’ blocks) and on the NW end of the Louisville Ridge (one 20’ block). Three of the New Zealand fishing grounds (SW Pacific Basin, the Hjort Trench and the Three Kings Ridge) contain no historical Australian fishing effort.

Collectively, the 11 New Zealand and two additional Australian fishing grounds identified based on the 20’ footprint submitted to SPRFMO encompass over 1 million square kilometres – ~2% of the SPRFMO Area – and are focussed on ridges and plateaus, where the seafloor rises to <2000 m (Table 3.1.3.1). Their total individual areas range between 6,000 and 256,000 km^2 and they collectively cover between 2 and 67% of the respective bathomes in the SPRFMO Area (Table 3.1.3.1).

The historical (2002-2006) Australian footprint is concentrated in the fishing grounds in the Tasman and Coral seas between Australia and New Zealand, with limited effort in the three fishing grounds on the Louisville Ridge (Figure 3.1.3.1).

Table 3.1.3.1 The areas of the New Zealand fishing grounds identified by MFish (2008) in the SPRFMO Area and two additional grounds identified based on Australian trawl and line fisheries 2002-2006 (*), by ecologically meaningful bathomes (*sensu* Last et al. 2010). Areal values: planar areas from SPRFMO Area only.

Fishing ground	**Continental shelf** 0 - 200m	**Shallow upper continental slope** 200 - 700m	**Deep upper continental slope** 700 - 1000m	**Shallow mid-continental slope** 1000 - 1500m	**Deep mid-continental slope** 1500-2000m	>2000 m	**Total**
South Tasman Rise			2,619	16,272	15,485	96,482	130,858
North Lord Howe Rise		1,111	9,408	5,260	28		15,807
South Lord Howe Rise			3,379	9,404	572	8	13,363
West Norfolk Ridge	765	5,947	4,648	7,467	5,587	2,292	26,706
Northwest Challenger Plateau		18,246	12,860	22,929	8,356	2,509	64,900
Three Kings Ridge	54	940	1,316	5,931	8,893	88,721	105,855
Louisville Ridge North	82	757	1,185	1,345	1,176	99,396	103,941
Louisville Ridge Central		142	733	1,313	1,337	228,127	231,652
Louisville Ridge South	1	384	256	377	590	254,772	256,380
Hjort Trench	25	65	38	78	340	31,057	31,603
Southwest Pacific Basin		-	16	79	136	5,836	6,067
Gascoyne*	13	269	73	112	144	24,510	25,121
Capel Bank & Gifford Guyot*	69	1,108	331	922	14,802	51,251	68,483
Total	1,009	28,969	36,862	71,489	57,446	884,961	1,080,736
Percent of bathome in the SPRFMO Area	26%	67%	56%	27%	21%	2%	2%

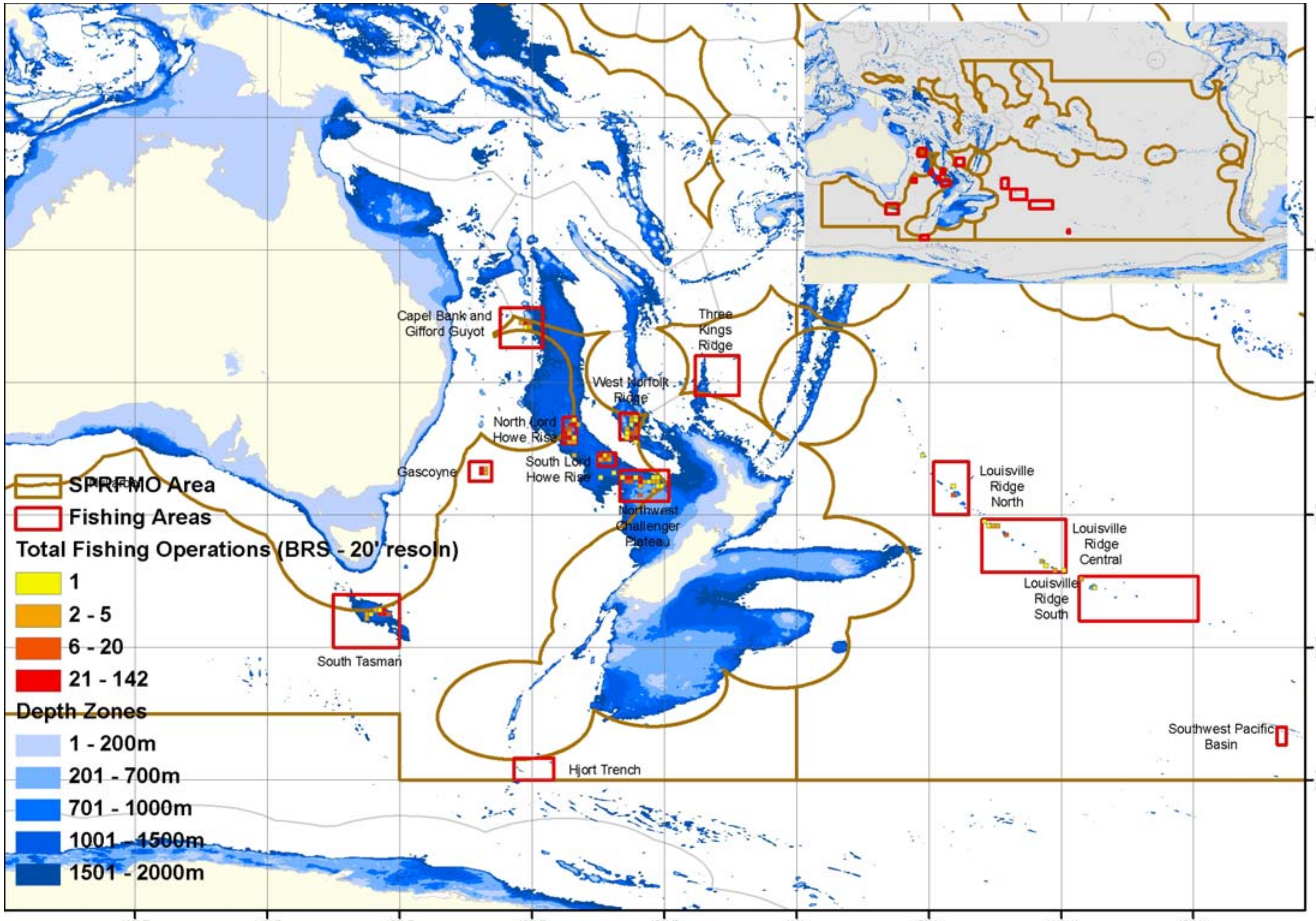

Figure 3.1.3.1 SPRFMO fishery sub-areas based on ‘fishing grounds’ used by the New Zealand fleet (MFish 2008). Australian vessels use two additional grounds (Gascoyne and Capel Bank & Gifford Guyot) but have not historically fished in three of the New Zealand fleet’s grounds (SW Pacific Basin, the Hjort Trench and the Three Kings Ridge). Note: for ease of definition and mapping, the fishing grounds are defined as rectangular boxes; some of which overlay adjacent EEZs; analyses only consider fishing effort within the SPRFMO Area.

3.1.4 Closed areas

SPRFMO interim measures do not specify any closures in the SPRFMO Area. The New Zealand management approach applied a spatially tiered system of closures and fishing areas to the 20’ blocks of their footprint in the SPRFMO Area (MFish 2008; Penney et al. 2009; see Section 4.1.2).

The South Tasman Rise was closed as part of an orange roughy stock management arrangement between Australia and New Zealand. New Zealand had not included the South Tasman Rise in their footprint, despite the region being identified as a fishing ground; New Zealand vessels stopped fishing this area in 2001 (MFish 2007). Similarly, AFMA have closed the South Tasman Rise to Australian fishing effort inside and outside the EEZ boundary since 2007 (MFish 2007), removing nine of the 20’ blocks of the Australian footprint from permits. Thus, the majority of the South Tasman Rise fishing ground within the fishable area (see Table 3.1.3.1) has been closed to fishing since 2007 by Australian and New Zealand management arrangements.

4. IMPACTS ASSESSMENT

4.1 Scoping the issues of concern

The aims of ‘scoping’ in the initial step of a fishing risk assessment are to establish context (including a description of the fishery), identify and document objectives, and identify the hazards (here, direct fishing impacts) to the assets of interest (here, VMEs) (e.g. Hobday et al. 2011). In this BFIA, the fishery description and the BFIA objectives have been provided in earlier sections; here we provide context to the assessment and identify other relevant issues by:

- defining VMEs and significant adverse impact (SAI) and providing an interpretation for the assessment approach used (Section 4.1.1)
- summarising Australia’s current monitoring, management and mitigation measures (as these are important for evaluating the overall risk of fishing activities) (Section 4.1.2)
- providing a rationale for the potential impacts of different fishing gears – which may vary with depth (fauna encountered), intensity, habitat type, and to some extent with the way the gear is deployed (Section 4.1.3)
- describing the opportunities and constraints to mapping VMEs and the relevance of this information to assessing impact and risk (Section 4.1.4)
- documenting the process for collecting and interpreting evidence of VMEs (Section 4.1.5)

4.1.1 Defining and identifying VMEs and SAI

Definitions of VME and SAI

In this BFIA, we provide formal definitions of VME and SAI together with an interpretation and context for VMEs in the high seas (mostly deep water) environment, and their potential vulnerability to fishing activities. The interpretation starts by examining the ecological traits of key component taxa, and the ways in which fishing may adversely impact them (this section), and is followed an explanation of how potential impacts can be evaluated as risks.

UNGA Resolution 61/105 calls upon States and regional fisheries management organisations or arrangements:

> 83 (a) To assess, on the basis of the best available scientific information, whether individual bottom fishing activities would have significant adverse impacts on vulnerable marine ecosystems, and to ensure that if it is assessed that these activities would have significant adverse impacts, they are managed to prevent such impacts, or not authorized to proceed.

However, the UN resolution does not give a formal definition of VMEs. In reference to a legal Act established in response to the UNGA 61/105 resolution (‘Council Regulation (EC) No 734/2008 of 15 July 2008 on the protection of vulnerable marine ecosystems in the high seas from the adverse impacts of bottom fishing gears’), the European Union provides these definitions of the key terms (EU 2008):

> **Marine ecosystem**: a dynamic complex of plant, animal and microorganism communities and their nonliving environment interacting as a functional unit.
>
> **Vulnerable marine ecosystem**: any marine ecosystem whose integrity is threatened by significant adverse impacts resulting from physical contact with bottom gears in the normal course of fishing operations, including, inter alia, reefs, seamounts, hydrothermal vents, cold water corals or cold water sponge beds. The most vulnerable ecosystems are those that are easily disturbed and in addition are very slow to recover, or may never recover.
>
> **Significant adverse impacts**: impacts which compromise ecosystem integrity in a manner that impairs the ability of affected populations to replace themselves and that degrades the long-term natural productivity of habitats, or causes on more than a temporary basis significant loss of species richness, habitat or community types.

These definitions are reflected in the *FAO International Guidelines for the Management of Deep-Sea Fisheries in the High Seas (FAO 2008)* that determine (1) there are benthic marine ecosystems (i.e. assets) potentially vulnerable to threats (VMEs), and (2) that potential threats to VMEs exist in the form of bottom fishing activities. The FAO guidelines provide examples of the habitats and fauna that may represent VMEs (see Appendix 1). Particular classes of seabed topographic features, for example, seamounts, are explicitly identified as indicators for potential VMEs by UNGA 61/105, EU (2008) and FAO (2008). It is the component taxa of the communities likely to be supported by these features (e.g. cold water corals, see next Section) that are vulnerable to gear impacts.

Identification of VMEs and vulnerability of fauna

The FAO (2008) suggested five criteria that should be used to identify VMEs: uniqueness or rarity, functional significance of the habitat, fragility, life-history traits of component species (slow growth rates, late age of maturity, low/ unpredictable recruitment, longevity), and structural complexity (see Appendix 2). Examples of potentially vulnerable species groups, communities and habitats provided by the FAO (2008, see Appendix 1) were subsequently refined in a CCAMLR workshop on the identification of VMEs (CCAMLR 2009) into seven criteria to evaluate benthic taxa that constitute VMEs:

- habitat forming
- longevity
- slow growth
- fragility
- larval dispersal potential
- lack of adult motility
- rare or unique populations

CCAMLR (2009) also provided a ranking of 22 taxa (varying from phylum to class level) on each of those criteria (CCAMLR 2009 – Table 1 reproduced in Appendix 3). Six major taxa ranked high for four or more of the seven criteria:

- Porifera (sponges)
- Scleractinia (stony corals)
- Gorgonacea (octocorals)
- Stylasteridae (hydrocorals)
- Bryozoa (lace corals)
- stalked crinoids (sea lilies)
- chemosynthetic communities.

These taxa, with the exception of bryozoa and the chemosynthetic communities, are listed in the classification guide for potentially vulnerable taxa in the SPRFMO Area (Tracey et al. 2007; Parker et al. 2009a) that was presented at the SPRFMO 7th meeting of the SWG.

The taxa listed in Tracey et al.'s (2007) classification guide were considered in this BFIA to inform our assessment of VME evidence and the likely location of VMEs (Section 4.1.5). The presence of a single individual/ colony of a VME taxon may not indicate the presence of a VME, as many VME component taxa are not solely associated with these features and may occur in other types of ecosystems (Rogers et al. 2008). None of the definitions of VMEs or guidelines to identify VMEs identify explicit reference points for density or abundance of indicator species or communities (Auster et al. 2010). Thus, thresholds for identifying VMEs are left open for interpretation. In a recent practical application, Post et al. (2010) identified dense coral-sponge communities on the upper continental slope of the George V Land in the CCAMLR area of competence as a VME. Post et al. (2010) defined 'dense' as 'nearly continuous cover' of the seabed, as viewed by video. This measure is possible where *in situ* image data are available from e.g. scientific surveys or cameras mounted on commercial gear. In the absence of such empirical data on the presence and density of VME taxa, deciding on what level of VME taxon bycatch constitutes 'evidence of VME' depends on the taxon, the quantity in the bycatch, as well as on the gear used and the frequency of encounters (Rogers et al. 2008). These authors give practical guidelines of quantities of bycatch and frequencies of encounters that '*may be associated with the existence of VMEs*' for different gears (reproduced in Appendix 4), with the caveat that they '*will have to be tailored to regional requirements or through the* *application of adaptive management strategies, altered in response to new or specific data related to an area*'.

4.1.2 Australia's management arrangements

Commercial catch and effort returns

Australian high seas permits set out specific reporting requirements. These include:

- the requirement to fit Integrated Computer Vessel Monitoring Systems (ICVMS)
- manual position reporting in the event of the failure of the ICVMS
- pre-departure reports, including estimated time and date of departure and area of destination
- notification prior to mooring or anchoring including details of the date and estimated time that unloading will commence
- reporting of encounters with VMEs
- shot by shot logbook, trip catch disposal record and transit form reporting requirements.

Scientific observer coverage and data collection

For high seas permits authorising trawling, an authorised observer must be carried at all times the vessel is fishing. For non-trawl fishing by high seas permit holders, there is mandatory coverage for the first trip and ongoing coverage of at least 10% annually.

Observer duties during fishing operations in the high seas fisheries include wildlife observations (including the recording of warp strikes by seabirds) during the setting and hauling of gear during daylight hours, biological data collection from fishes, including length frequencies and catch composition of target species, and bycatch monitoring. Bycatch monitoring includes observation of hauls, identification of bycatch species and catch composition reporting of weights and counts by species. When onboard, the observer is involved in the process of determining if bycatch of VME taxa exceeds the trigger limits (currently >50 kg of coral and sponges). On return from a voyage, the observer is required to present a report to AFMA and the collected data is entered into the AFMA observer data base.

Permit requirements

In response to the UNGA Resolutions, and as part of Australia's response to the SPRFMO interim measures, Australia has adopted the following management measures for high seas fishing activities by Australian flagged vessels in the SPRFMO Area:

- mandatory 100% observer coverage for trawl operations
- mandatory coverage of the first trip and ongoing coverage of at least 10% annually for non-trawl operations
- upon encountering trigger levels of evidence of VMEs (such as corals and sponges), there is a requirement to cease fishing within a five nautical mile radius of the shot and to report the encounter. The area is then closed to all operators using that method of fishing for the life of the permits. The trigger level for the SPRFMO Area is 50 kg

- restrictions on fishing methods and gear types, including not permitting the use of deep water gillnets
- seabird bycatch reduction measures in the line fisheries, through requirements to deploy tori lines;
- species catch prohibitions (e.g. Black Cod)
- ICVMS and logbook reporting requirements on a shot by shot basis
- bottom fishing effort is spatially confined within the Australian historical footprint (2002-2006) – see Section 1.1.

Closures and the move-on rule

In addition to limiting the extent of fishing via a fishing footprint, two spatial management approaches to avoid SAI on VMEs are: (1) closures that may be implemented in areas where VMEs are known or likely to occur; and (2) move-on rules enforced upon detection of evidence of VMEs (i.e. bycatch of 'trigger levels' of VME taxa during fishing operations), in areas where there may be little other information available (Parker et al. 2009a; Auster at al. 2010). Auster et al. (2010) present a decision support diagram that includes 'explicit steps regarding the identification of VMEs and decision criteria for encounters while fishing'; this diagram is a modified version of a diagram developed for FAO 2008 (Auster et al. 2010 – Figure 1, reproduced in Appendix 5). Presently, there are no closures in the SPRFMO Area based on catches of trigger levels of VME evidence. Closed areas defined by New Zealand are 20' blocks with a history of low fishing effort and some additional 20' blocks where historical effort was higher, to ensure representativeness in regard to depth and topography (Penney et al. 2009).

Under the current Australian permit conditions the use of all methods (as stated in permits) is permitted in the Australian footprint, and a move-on rule is enforced where, on detection of 'evidence of a VME', a temporary closure of 5 n.m. radius surrounding the location of the trigger operation is enforced for all Australian flagged vessels using the same gear. The closure is effective for the life of the current permits and is reviewed when new permits are issued. In addition, Orange Roughy stock management arrangements between Australia and New Zealand have effectively closed the South Tasman Rise to Australian fishing effort inside and outside the EEZ boundary since 2007 (MFish 2007), removing nine of the 20' blocks of the Australian SPRFMO footprint from permits, which include the majority of the South Tasman Rise fishing ground in the fishable area (<2000 m) (see Table 3.1.3.1).

The New Zealand management approach in the SPRFMO Area applied a spatially tiered system of closures and fishing areas to the 20‘ blocks of their footprint (MFish 2008; Penney et al. 2009). In this system, Penney et al. (2009) classified the 20‘ blocks making up the New Zealand trawl footprint from 2002-2006 into three categories:

- 'open' (previously heavily fished – i.e. >50 trawl operations over the period 2002-2006)
- 'move-on' (moderately fished – i.e. 3-50 trawl operations over the period 2002-2006)
- 'closed' (lightly fished – i.e. <3 trawl operations over the period 2002-2006).

'Move-on' events require a vessel to cease fishing within a 5 n.m. radius of a trawl operation where 'evidence of VMEs' was found (Penney et al. 2009; Parker et al 2009a). The permanency of move-on closures is subject to review of all new 'evidence of VME' data on a regular basis (Penney et al. 2009).

The Australian footprint (2002-2006) is contained within the New Zealand trawl and line footprints in the northern Tasman Sea (Lord Howe Rise, Norfolk Ridge Challenger Plateau) and on the Louisville Ridge, with the exception of four 20' blocks that have minimal effort reported (<3 operations) between 2002-2009. The Australian footprint (2002-2006) includes ten 20' blocks that have been closed to trawling by New Zealand vessels. There is one cell in each of the North Lord Howe Rise and West Challenger Plateau fishing grounds, six (including two of New Zealand 'line only' footprint cells) on the West Norfolk Ridge, and two on Louisville Ridge. In the closed grid cells on the Louisville Ridge New Zealand observer data recorded 'evidence of VMEs'.

Detection of 'Evidence of VME'

The detection of 'evidence of VMEs' underpins move-on rules and decisions. Auster et al. (2010) acknowledge that decision-making for the protection of VMEs needs to be adaptive, because new information regarding the locations of unmapped VMEs is most likely to emerge during the course of commercial fishing operations.

Australia has adopted protocols which, similar to other RFMOs such as NEAFC, SEAFO and NAFO, use a broad definition of 'evidence of VMEs' (corals and sponges) but with lower trigger threshold of 50 kg for coral and sponge compared to the RFMOs – thresholds of coral (60 kg) and sponges (800 kg). New Zealand has adopted a protocol using a scoring system based on weight or presence of a series of VME indicator species. New Zealand's bycatch weight thresholds for individual coral taxa are lower than the 50 kg combined total specified by Australia – (30 kg for stony corals, 6 kg for hydrocorals and 1 kg for each of black, soft and fan corals) – see Parker et al. (2009a). These more closely reflect the weights Rogers et al (2008) suggest for discussion by management agencies (Appendix 4). For line fishing methods, CCAMLR has adopted different triggers of 10 kilograms or 10 litres of specified VME indicator species when recovered from a single line section. This comparison, the paucity of detailed data in observer records, and the scattered records of invertebrate bycatch (including VME taxa) in AFMA's databases, indicate a need for consideration of different thresholds for different gears and the relative priority for collecting information on VME taxa among the long list of observers' other at-sea duties. Some features of the Australian, New Zealand and CCAMLR arrangements are shown below (Table 4.1.2.1).

Table 4.1.2.1 Summary of three different arrangements for identifying and resolving VME taxa, and trigger weights and rules for 'move-on' provisions

Observer program	Identification guides	Triggers	Detail of recording
Australian high seas observer program	**VME-Taxa**: Tracey et al. (2007) – 10 Taxa **General bycatch**: some observers use Hibberd and Moore (2009)	>50 kg of sponges and/or corals collected in one operation (trawl shot or line set)	VME taxa recorded at coarse level of detail; trigger identification coarse, assessment of 50 kg volume; one trigger threshold for all gears
New Zealand high seas observer program	**VME-Taxa**: Tracey et al (2007) – 10 Taxa	Scoring system based on weights and/or presence (diversity) of a series of VME indicator species collected in one operation (see Parker et al. 2009a)	VME taxa recorded at coarse level; trigger identification moderately complex scoring system dependent on VME identifications; only for trawl gear
CCAMLR observers	**VME taxa** guide: Parker et al. (2009c) – 23 taxa **General bycatch**: Hibberd and Moore (2009) (Australian HIMI observers)	>10 kg/ 10 litres of VME indicator species collected in one operation (Parker et al 2009b; Tracey et al 2010)	VME taxa recorded in much detail; trigger identification relatively coarse but easily assessed; one trigger (trigger applies to longline operations only)

Gear specific impacts (Section 4.1.3) support the case for gear-specific and/or taxon specific trigger limits for move-on rules – especially for auto-longline, for which there is no realistic expectation of landed bycatch comparable to trawl. We note that the SPRFMO 8th SWG meeting considered reviewing weight thresholds of VME taxa for different gears but concluded, '*The proposed thresholds are based on analyses of trawl data and so analyses to determine thresholds for longline and other gears are still required. It was noted that CCAMLR has undertaken an analysis of the interaction of benthic longlines and VMEs. The CCAMLR analysis will be considered inter-sessionally and relevant aspects may be included in the BFIAS*', the 9th SWG subsequently noted, '*It may also be appropriate for different thresholds for different gear types*'.

The complexity and management requirements for a system such as that used by New Zealand to determine 'evidence of VMEs' in the SPRFMO Area may be difficult to justify given the small size and low effort by Australian vessels in the SPRFMO Area, while the intermediate complexity of the CCAMLR approach seems both appropriate, and would allow consistency across Australian fishing permits.

The collection of reliable data by independent observers is essential because there is a paucity of data from high seas areas, but critically because enforcing move-on rules (as applied by Australia in the SPRFMO Area) depends on defining 'evidence of VMEs' in real-time during commercial fishing operations (e.g. Parker et al. 2009a; Auster et al. 2010). Because of the need for a high level of confidence in the accuracy of taxon identifications, Parker et al. (2009b) and Tracey et al. (2010) compared VME identifications determined by observers at sea on New Zealand vessels with identifications made by taxonomists on return of the vessel. Overall they found a high level of agreement for most of the VME taxa specified for the CCAMLR area of competence (Parker et al. 2009c). These studies showed the level of confidence in identifications is directly dependent on the amount of training and experience observers have in dealing with the variety of invertebrate taxa specified in the VME identification guides (Tracey et al. 2010).

Operational measures to minimise benthic impacts

This section incorporates comments from Australian fishing industry operators about operational actions to mitigate the impacts of fishing on VMEs. The comments were taken as notes during and after a meeting to discuss the BFIA:

- demersal trawl operators minimise bottom contact by targeting their gear specifically at fish schools or particular seabed features, and, in general, fish with the trawl doors off bottom
- auto-longline operators minimise impact by ‘peeling’ the gear off the bottom in a straight line during retrieval to minimise lateral movement of the gear, and, depending on target species, will float the main line off the bottom.
- mid-water trawlers use trawl nets with weak links that break if the gear hits bottom. This frees the gear and avoids damage to benthic habitats and the loss of the gear.

4.1.3 Impacts of different fishing gears

Bottom fishing is defined as fishing with any gear type likely to come in contact with the seafloor or benthic organisms (FAO 2008). It is well established that all bottom fishing gears have the potential to impact seabed communities but have different levels of impact depending, among other factors, on the physical shape and weight of the gear and the way it is deployed (e.g. Kaiser et al. 2006; Rogers et al., 2008). The Australian fishery in the SPRFMO Area has, historically, employed five separate bottom gear types: demersal trawl, midwater trawl, auto-longline, dropline and gillnet, although the use of gillnets is no longer permitted under the Australian fishery permit conditions (Section 2.1.3). Current permit conditions (AFMA unpublished 2011) also allow the use of traps in the SPRFMO Area. Because fishing impacts are cumulative, multiple deployments of low impact gears in the same area have the potential to damage seabed communities over time, and also negatively influence their recovery in a similar way to a lower number of deployments by high impact gears. Assessing the interactions of fishing gears with VMEs therefore needs to consider the potential impacts of all fishing gears used in high seas areas.

A semi-quantitative scheme for rating gears for benthic habitat impacts (Chuenpagdee et al. 2003) was suggested as the default for the 2009 Draft SPRFMO BFIAS (SPRFMO 2009, Table 2). The possibility of updating this scheme was discussed by the 8th and 9th meetings of the SPRFMO SWG, but the 9th SWG meeting concluded that ‘in the absence of new scientific information the SPRFMO Deep Water Science Group agreed to maintain the current Table 2 [in the BFIAS].’

However, this BFIA considers that two modifications to the Chuenpagdee et al. (2003) scheme may be necessary. In order of importance they are:

(1) increased rating of bottom-set auto-longline to reflect a higher likely impact on VME fauna than has been previously recognised. The rationale is the accumulating evidence for impact by bottom set (auto-) longlines on many elements of Chuenpagdee et al.’s (2003) ‘biological habitat’ which represent VME fauna (i.e. erect and often large and/or delicate animals typically characterised by slow growth rates and long life spans). Data sources to support this proposal include:

- Munoz et al. (2011) – documented bycatch of deepwater corals and sponges, and higher catch per unit of effort of fishes in coral areas.

- CCAMLR (2009) – acknowledged 'that simply on the basis of the characteristics of the gear, especially the potential for movement of the mainline and hooks during the soak period, there was considerable potential for differences [between types of bottom-set longlines] in the interaction of the gear with benthic organisms' and that 'a primary factor influencing the potential impact of different longline gear types was the extent of lateral movement of the mainline in contact with the sea floor during line retrieval.'
- Parker et al. (2009b) – 29% of 1522 observed longline segments in the Ross Sea caught VME indicator organisms as fishing bycatch.
- Parker and Bowden (2010) – identified 13 major benthic taxa as potentially vulnerable to auto-longline gear in the Ross Sea based on medium or high scores against factors including size, longevity, growth rate, fragility, and their presence in fishing bycatch retained by New Zealand scientific observers.
- Post et al. (2010) – identified a hydrocoral as a key VME indicator taxon, which, based on its fragility, makes it particularly vulnerable to shearing forces exerted by bottom longline gear used in East Antarctica.
- Tracey et al (2010) – 34% of 1707 observed longline segments in the Ross Sea caught VME indicator organisms as fishing bycatch.
- Sharp et al. (2009) – sources of impact from bottom longlines are from the backbone (mainline), and anchors and chains. The mechanism is lateral shearing that occurs when the gear moves on the bottom – e.g. during retrieval (citing work by the Australian Antarctic Division).

(2) a sub-division of the mid-water trawl category to recognise that some gear designs used by Australian vessels and possibly other Flag states, enable a minimal level of bottom contact by nets that are primarily fished off the bottom when certain benthopelagic species are targeted. The rationale and supporting evidence is provided in Table 4.1.3.1.

Table 4.1.3.1 Ratings of benthic habitat impact for gear types used by Australian vessels in the SPRFMO Area on a scale from 1 (very low) to 5 (very high) as defined by Chuenpagdee et al. (2003) but showing proposed considerations.

	Benthic habitat		
Gear class	**Physical**	**Biological**	**Suggested consideration**
Demersal trawl	5	5	None proposed
Midwater trawl	1	1	Mid-water trawls for certain benthopelagic species are designed to withstand some bottom contact
Trap	3	2	None proposed
Demersal auto-longline	2	2	Rating should be increased to reflect a higher likely impact on biological habitat that has been previously recognised.
Hook and line (Dropline)	1	1	None proposed

4.1.4 Mapping indicators to infer spatial distributions of VMEs

The FAO guidelines for VME mapping (FAO 2008) note that 'where site-specific information is lacking, other information that is relevant to inferring the likely presence of vulnerable populations, communities and habitats should be used' (SPRFMO 2009). There are two physical topographical seabed indicators presently available at ocean basin scale that can be used for this purpose and both are evaluated here in Section 4.1.4: (1) ecologically meaningful depth ranges (bathomes) and (2) seamounts. Maps of other topographical or hydrophysical features that potentially support VMEs (submarine canyons and trenches, hydrothermal and cold seeps) are incomplete at ocean basin scale and/or their surrogate potential has not been validated. The accuracy of GIS data-overlays and resultant summaries are highly dependent on the spatial scales of the data that is used to map VME indicators and fishing effort, as discussed below.

Spatial dependencies for VME and effort mapping

Because assessing the impact of bottom contact fishing on VMEs depends in part on estimating the areal overlap of impact with VME distribution, it is necessary to examine the sensitivity of the overlap metric to the spatial resolution of the underlying data sets, and to understand the real scale at which VMEs may exist. Spatial scale dependencies can be illustrated with an example of a well-studied cluster of small seamounts south of Tasmania which was mapped in detail in 2006 using multi-beam acoustics (Appendix 6). This cluster of volcanic cones was intensively, but selectively, trawled for orange roughy, and trawling effort mapped at 1 km grid cell resolution. Analysis showed that all the shallow peaks (<1000 m depth) – which included the largest seamounts – were heavily impacted (Koslow et al. 2001), while a series of smaller features in close proximity remained very lightly fished or unfished (Appendix 6). Scientific surveys using both epibenthic samplers and imaging technology have confirmed the presence of VME taxa and communities in structural refuges on the larger, impacted seamounts (Althaus et al. 2009) and intact VME communities on adjacent features (Williams et al. 2010). In summary, this example shows that the distributions of VME indicators (bathomes and seamounts) and targeted fishing effort can, and frequently does, exist at finer scale than the standard 20’ blocks.

The dependencies of scale are shown by the grid cell examples ranging from 1° x 1° to 1 km x 1 km grid cells. The grid cells presented in Appendix 6 correspond to the resolution of various data sets used directly or indirectly in this BFIA:

- 1º — global scale predictive models such as the suitability of seamounts for stony corals (Tittensor et al. 2009); the model resolution is limited to this scale by the 1° resolution of the underlying physical data sets such as global salinity, temperature and oxygen.
- 20’— the standard cell-size for footprint reporting in the SPRFMO Area confirmed by the 9th SWG meeting.
- 0.1° — the limit of resolution for gridding AFMA logbook data in the high seas fisheries for data collected at 1 minute, ~0.02º, resolution; the scale of fishing effort distribution used for spatial overlays in this BFIA.
- 1 km — the scale of fishing effort mapping typical in Australian domestic fisheries, the scale reported by Australian scientific observers in CCAMLR, and the scale of some predictive environmental modelling (e.g. Davies and Guinotte, 2011).

The finest scale (1 km grid) permits an understanding of the direct impacts of fishing on individual indicator features – including to determine whether fishing and VME overlap is finely concentrated in space, resulting in high cumulative impact on, for example, a single seamount (a VME indicator). On the other hand, the finest scale may also show potentially unimpacted refuge areas, e.g. on a partially fished seamount or on adjacent features (Appendix 6). The potential relevance of increasing the spatial resolution from the standard 20’ block used for reporting purposes in the SPRFMO Area was discussed in the 8th and 9th meetings of the SWG, but in the 9th SWG meeting ‘*it was agreed that there would be no suggested change to the current standard 20 x 20 minutes, at this time.’* Our example serves to illustrate some of the potential insights gained from finer resolution mapping.

Thus, in this BFIA we use two scales for mapping fishing effort: 20’ (20 n.m., the standard SPRFMO footprint block) and 0.1º (6’or 6 n.m. – the limit of logbook resolution). Here we examine the effect of resolving fishing effort distribution at either of these scales, together with two methods of defining seamount VME indicators (point definition of seamount peak, and polygon definition of seamount boundary). Comparing the two seamount definitions serves to contrast the relative utility of the best available data sets, including their content (i.e. numbers and locations of seamounts): Yesson et al. (2011) and the unpublished Census of Marine Life Seamounts on Line database collated by CenSeam (and kindly provided by M. Clark of NIWA).

As noted above (Section 1.3.3) depths reported for area calculations in this BFIA refer to the centroid depths of the 0.1ºgrid-cells, derived from the bathymetry grid, not the reported operation depth. This resulted in a skewing towards deeper distribution of effort (see Figure 4.1.4.1a) compared to the distribution of the reported tow depths (e.g. see Table 4.1.4.3), which stems from the limitations of the bathymetry data and the scales at which fishing effort can be gridded.

The effect of a coarser spatial scale (20’ blocks) of effort mapping was predictably to increase estimates of overlap with respect to bathomes and seamounts. Finer scale mapping provides a better resolution of where fishing occurs (Figure 4.1.4.1) within bathomes and on individual seamounts, and also shows where un-impacted areas may remain on fished seamounts – especially where individual trawl tracks can be interpreted from recorded start and end positions. Effort data recorded by sea-going observers at even finer scale (increased recording accuracy from degrees and minutes to decimal degrees to at least three places of decimal), would further improve the resolution of mapping and provide consistency with data collected in the CCAMLR area of competence. Uncertainties in impact assessment could be reduced by recording fishing start and end location more accurately, including as ‘gear on-bottom’ positions, and is recommended for future data collection. For all our summaries and descriptions of spatial overlays of effort we used the fine-scale 0.1º fishing effort distribution.

An overall comparison of the content of the CenSeam (unpublished) and the Yesson et al. (2011) data sets (Figure 4.1.4.2) revealed several relevant characteristics in the context of impact assessments. First, there is good correspondence of the data for many seamounts, but not a one-to-one match in either the numbers of seamounts or their locations; there are also some inconsistencies between seamount depths and the GEBCO 2008 bathymetry dataset. This is to be expected given the different sources of data and mapping methods used to compile each seamount data set. The Yesson et al. (2011) data tended to overestimate the number of seamounts and knolls, especially where the topography is complex, e.g. along ridges. There are many locations where multiple seamounts are defined in close proximity which leads to overlapping polygons. In contrast, some seamounts appear to remain undetected, for example in the CenSeam point data near the South Tasman Rise (Figure 4.1.4.2c). In many instances, however, the accuracy of the bathymetry data may be unknown precluding any validation of one or other data set. As well, the CenSeam data may underestimate the number of shallow seamounts relevant to this study because summit depth data was not recorded for 21% of the seamounts in the SPRFMO Area. It is likely that both data sets underestimate the number of smaller features, irrespective of whether they explicitly distinguish knolls from seamounts. The CenSeam data set principally includes smaller features from survey data sets (e.g. those off southern Tasmania mapped by CSIRO) where they have been provided directly to the CenSeam database. Detection of small features in the Yesson et al. (2011) data is dependent on the quality of the bathymetry data.

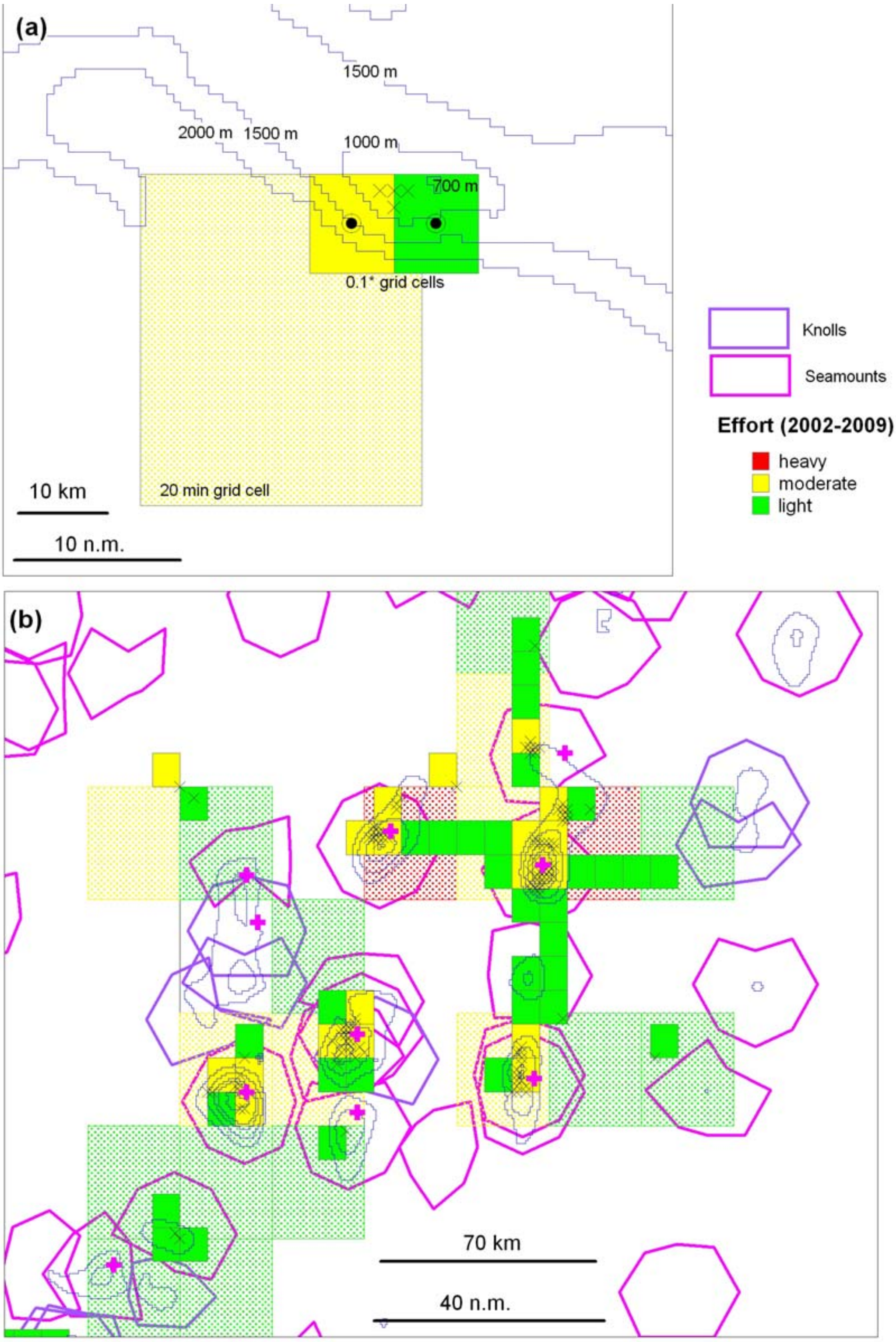

Figure 4.1.4.1 Illustration of the dependencies of overlap estimates on spatial scale of fishing effort grids and the type of data describing seamounts (point vs. polygon) using undisclosed example areas; (a) close-up of a ridge (target symbols: centroids of the 0.1° grid cells used for assigning depth; crosses: tow start positions) with 20' (hashed) and 0.1° (filled) grid cells graded by demersal trawl effort), and (b) scattered peaks (contours 200, 700, 1000, 1500, 2000 m depth) overlaid with Global seamounts data – pink crosses: CenSeam unpublished, outlines: seamounts and knolls Yesson et al (2011), 20' (hashed) and 0.1° grid cells (filled) graded by demersal trawl effort and tow start positions (x) are overlaid.

Seamounts were assigned to grid cells (20' or 0.1°) either containing a seamount peak (CenSeam data) or where a polygon(s) extended into a cell (Yesson et al. 2011 data). Where an effort grid cell contained overlapping seamount polygons, each seamount was flagged as having fishing effort, but each seamount polygon was counted only once in summations of potentially impacted features.

Even at the 20’ grid scale, many of the seamount peaks identified in the CenSeam point data lay just outside of the effort grid cell, while the polygons of Yesson et al. (2011) features were more likely to be identified under the footprint because of their larger extent. On balance, we used the Yesson et al. (2011) polygon data for spatial overlays of fishing effort on seamounts in the SPRFMO Area, and in fishing ground subareas, because polygons are a better spatial representation of seamount extent. Use of polygons vs. peak locations also reduces the uncertainty about fishing effort distribution stemming from missing operation end positions.

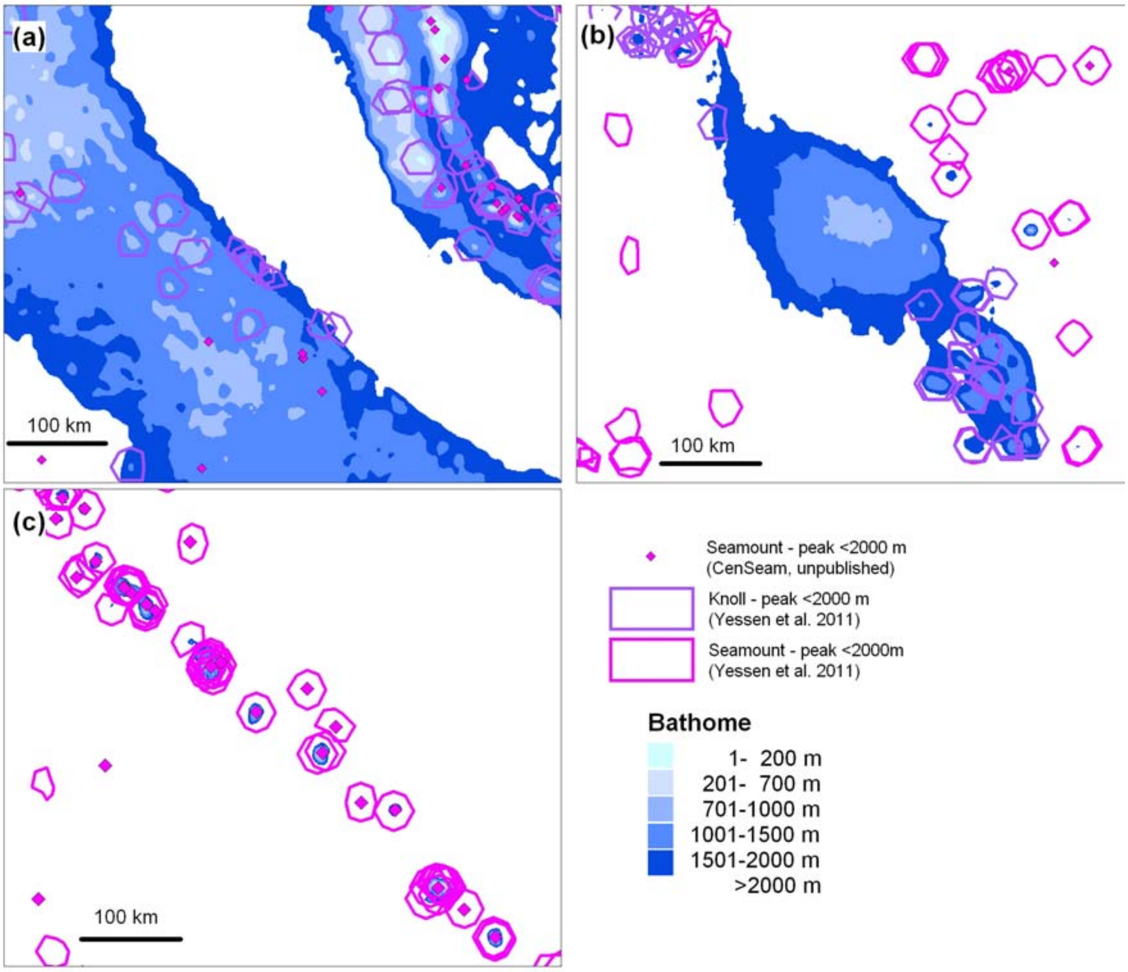

Figure 4.1.4.2 Comparison between global seamounts data sets overlain on global bathymetry coloured by ecologically meaningful bathomes: CenSeam (unpublished) compilation of seamount peak locations from nine data sources; Yesson et al (2011) algorithm-based analysis of 30-arch bathymetry outlining seamount and knoll polygons. Only features with peak depths <2000 m are mapped. Locations: (a) Lord Howe Rise and West Norfolk Ridge, (b) South Tasman Rise, (c) Louisville Ridge.

VME indicator mapping

Depth

In the absence of maps of VMEs, depth is a suitable coarse-scale indicator for mapping at ocean basin scale because it is the strongest environmental correlate of community structure in deep marine environments (e.g. Ponder et al., 2002; Carney et al. 2005; Last et al., 2005; Clark et al. 2010). The factors governing evolution of biota are temporally evolving, depth-related processes (e.g., depth-layering of water masses), contemporaneous physiological constraints on species depth distributions, and depth-related differentiation in habitat distribution defined by geophysical constraints (Last et al. 2010). Thus, many taxa characterising VMEs are restricted to particular depth zones (bathomes), with large invertebrate benthic fauna typically most diverse and most abundant within a 'zone of importance' in depths <1500 m (Williams et al. 2009), including on seamounts and in submarine canyons. For example, demosponges exist in depths <1000 m (Williams et al. 2010), while the dominant mesh building stony coral (*Solenosmilia variabilis*) exists in depths <1400 m (Clark et al. 2010). A circum-global band between 20º-50º S of very high habitat suitability (>50%) for seamount stony corals at depths between 0-750 m and moderate suitability (~30%) at depths <1500 m was predicted by Tittensor et al. (2009) this was confirmed by recently by more fine-scale analyses of Davies and Guinotte (2011).

Mapping of bathomes (Table 3.1.1.1) showed that 0.6% of the SPRFMO Area overlies the band of high habitat suitability (depths <1500 m) (Table 3.1.1.1). Thus, depth-related surrogacy for VME fauna is better captured by our bathomes (0-200 m, 200-700 m, 700-1000 m, 1000-1500 m, 1500-2000 m and >2000 m) compared to those recommended by Clark (2008; SPRFMO 2009) (0-200 m, 200-800 m, 800-2000 m, >2000 m) because they more precisely represent ecological structure.

Seamounts

At a finer spatial scale than bathomes, maps of topographical or hydrophysical features have high potential to define VME distributions. However, it is important to understand that data sets of geomorphic features for the vast expanses of high seas areas and the deep ocean have been collated only recently and that they are still evolving. At this point in time there is only broad-scale mapping for seamounts. Other features identified by FAO (FAO 2008) as potentially supporting VMEs (submarine canyons and trenches, hydrothermal and cold seeps) are incompletely mapped at ocean basin scale and/or their surrogate potential has not been validated.

The first freely available, detailed global map and dataset for seamounts (defined by elevation of ≥1000 m) was produced in 2004 by Kitchingman and Lai (2004) under the *Sea Around Us* Project (http://www.seaaroundus.org). Subsequent compilations that added lists of unpublished/ grey literature data sets, and/or applied finer scale bathymetry data were those of Hillier and Watts (2007) and Allain et al. (2008). In 2010, the Census of Marine Life Seamounts Program (CenSeam) completed a compilation of a global dataset of seamount point locations with summit depths and other ancillary data from nine datasets (Kitchingman and Lai 2004; Hillier and Watts 2007; Rowden et al. 2008; Allain et al. 2008; CSIRO, Hobart - unpublished 2009; SeamountCatalog http://earthref.org; Seamounts Online http://seamount.sdsc.edu, as cited in CenSeam 2010 unpublished). Parallel to this work, Yesson et al. (2011) produced and published a new data set of 'seamounts' using global bathymetry at 30 arc-sec resolution. A brief comparison of these two contemporary datasets (provided above) indicated the Yesson et al. (2011) dataset is better suited to an overlap analysis of fishing effort for the reasons outlined in the 'Spatial dependencies' section above.

Yesson et al. (2011) used a geological definition to separately recognise large seamounts (with elevation ≥1000 m) and small knolls. There is no difference between large seamounts and smaller knolls in their potential suitability to support VMEs – the critical element is the depth range they occupy, not total elevation (Williams et al. 2009). For this reason we combine both feature types under the term ‘seamount’ in later sections of this report.

We estimated a total 32,091 seamounts lie within the SPRFMO Area (Table 4.1.4.1); using a geological definition, 4,966 are large seamounts (>1000 m elevation) and 27,125 are smaller knolls (Yesson et al. 2011). Virtually all knolls (99%) and 66% of the seamounts peak below 2000 m.

Of the total 32,091seamount features (seamount + knolls), 1030 (3%) have reported summit depths in the key bathomes for VME fauna – the zone of importance (<1500 m depths) (Williams et al. 2009) (Table 4.1.4.1). In this report we refer to these shallow seamounts as ‘potential VME seamounts’ to differentiate them from the vast majority of seamounts peaking in depths >1500 m, and beyond the depths at which fishing, and therefore fishing impact, may occur (>2000 m; Table 4.1.4.1).

Within the fishable area (<2000 m) a total of 1972 (6%) seamounts is identified, nearly half of these (942, 48%) peak below the zone of importance. The key sub-areas used for fishing (‘fishing grounds’, see Section 3.1.3) encompass a disproportionally higher number of potential VME seamounts – 115 (11%) of the total number in the SPRFMO Area (Table 4.1.4.1). We note that the six potential VME seamounts on the South Tasman Rise (Table 4.1.4.1) are effectively protected from Australian and New Zealand fishing effort under the current management arrangements – and none of those six have historical Australian fishing activity.

We note that much of the fishable area in the SPRFMO Area – especially in the Tasman Sea region – is on rises and ridges not classified as seamounts by Yesson et al. (2011); these features rise above the 1500 m contour and potentially support VMEs, but mapping at ocean basin scale is incomplete and/or their indicator potential has not been validated.

Table 4.1.4.1 Distribution of seamount features (seamounts + knolls) reported by Yesson et al. (2011) in the key bathomes for VME fauna (<1500 m), in fishable depths (<2000 m), and in ecologically meaningful bathomes (*sensu* Last et al. 2010) over the SPRFMO Area and fishing grounds.

	Potential VME seamounts 1-1500m	**Fishable depth 1-2000m**	**Continental shelf 1-200m**	**Shallow upper continental slope 201-700m**	**Deep upper continental slope 701-1000m**	**Shallow mid-continental slope 1001-1500m**	**Deep mid-continental slope 1501-2000m**	**>2000m**
Total no. in SPRFMO	1030	1972	84	225	207	514	942	30119
Total no. in fishing grounds	115	144	5	44	33	33	29	216
Overlay by fishing grounds								
South Tasman	6	9	0	0	0	6	3	30
North Lord Howe Rise	3	3	0	3	0	0	0	0
South Lord Howe Rise	2	3	0	0	1	1	1	0
West Norfolk Ridge	12	13	0	8	3	1	1	0
Northwest Challenger Plateau	1	1	0	0	1	0	0	0
Three Kings Ridge	31	37	0	11	4	16	6	24
Louisville Ridge North	14	14	2	6	6	0	0	21
Louisville Ridge Central	23	27	0	6	14	3	4	39
Louisville Ridge South	12	16	1	9	1	1	4	79
Hjort Trench	1	8	0	1	0	0	7	12
Southwest Pacific Basin	8	11	0	0	3	5	3	1
Capel Bank and Gifford Guyot	0	0	0	0	0	0	0	2
Gascoyne	2	2	2	0	0	0	0	8

Map and overlay of fishing effort on VME distribution

The Australian 20’ combined (across gears) footprint used for permit conditions overlays 44 (4%) ‘potential VME seamounts’ (Table 4.1.4.2); most of them peak in upper slope depths. A total of 15 (1%) of the 1030 potential VME seamounts lay under the finer-scale (0.1°) Australian effort distribution (combined for all gears) from 2002-2009.

Table 4.1.4.2 Distribution of seamount features (seamounts + knolls) reported by Yesson et al. (2011) in the key bathomes for VME fauna (<1500 m), in fishable depths (<2000 m), and in ecologically meaningful bathomes (*sensu* Last et al. 2010) over the SPRFMO Area, the Australian footprint and the Australian effort distribution combined for all gears.

	Potential VME seamounts 1-1500m	**Fishable depth 1-2000m**	**Continental shelf 1-200m**	**Shallow upper continental slope 201-700m**	**Deep upper continental slope 701-1000m**	**Shallow mid-continental slope 1001-1500m**	**Deep mid-continental slope 1501-2000m**	**>2000m**
Total no. in SPRFMO	1030	1972	84	225	207	514	942	30119
Total no. (and %) under	44	49	3	14	24	3	5	2
Australian footprint	4.3%	2.5%	3.6%	6.2%	11.6%	0.6%	0.5%	<0.1%
Total no. (and %) under under	15	15	2	4	7	2	0	1
Australian effort distribution	1.5%	0.8%	2.4%	1.8%	3.4%	0.4%	<0.1%	<0.1%

The principal fishing methods used by Australian fishing vessels in the SPRFMO Area from 2002 to 2009 were demersal and midwater trawling and line methods. Summaries of the distribution of total effort (number of operations) for demersal and midwater trawling, auto-longline and dropline over the fishing grounds identified in Section 3.1.3 showed that trawlers preferred the South Tasman Rise (now closed), Lord Howe Rise and Challenger Plateau grounds, while the two additional Australian fishing grounds were principally targeted by line operations. Industry members indicated that, in the near future, there would be little change to the fishing methods, fishing intensity and species targeted within the SPRFMO Area.

The Australian effort (2002-2009) was thematically mapped, graded by the fishing effort intensity (all gears combined) per 20’ block into three categories: light (<3 operations), moderate (3-50 operations) and heavy (>50 operations), following the general approach used in the New Zealand BFIA for the SPRFMO Area (MFish 2008) (Figure 4.1.4.3). Note, however that while the New Zealand approach shows only trawl effort, effort across all gears was combined in this BFIA. Further, and reflecting the data available, the time period adopted in this BFIA for aggregating effort was 2002 to 2009, as compared to the approach used by New Zealand which is aggregated for 2002 to 2006.

We mapped the effort distribution at 0.1° grids for each gear separately to provide a more detailed analysis of fishing effort distribution over the ecologically meaningful bathomes (*sensu* Last et al. 2010) identified in Section 3.1.1, as well as in relation to the seamounts (Yesson et al. 2011) described above.

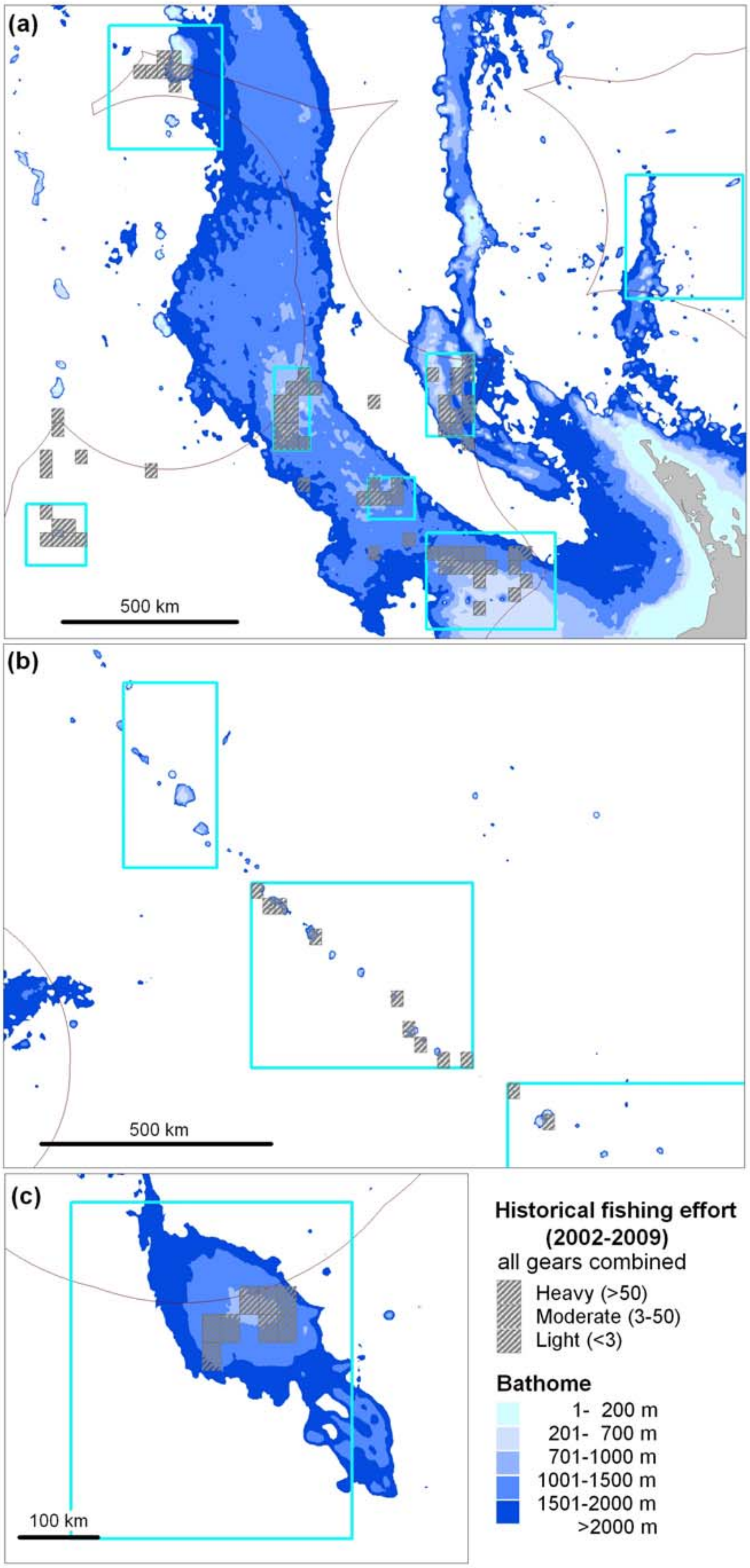

Figure 4.1.4.3 Australian effort distribution and intensity (number of operations of all gears combined) in 20' grid cells (masked due to commercial in-confidence rules). (a) Tasman Sea region, (b) Louisville Ridge, (c) South Tasman Rise (note that this has been closed to Australian and New Zealand effort since 2007). SPRFMO Area boundary: brown line; Australian footprint: black grid cells; fishing grounds: light blue rectangles.

Demersal trawl

Between 2002 and 2009 a total of 1101 demersal trawl operations was reported in the in the SPRFMO Area. The total historical cumulative demersal trawl effort distribution (0.1° grid cells) was ~15,000 km^2, but as proportions of each bathome, all overlaps were small. Trawling was negligible on the continental shelf, and the overlap was less than 1.7% on the shallow upper continental slope (<700 m depth) (Table 4.1.4.3). Relatively high demersal trawl effort on the deep upper continental slope and mid-continental slope (700-1500 m) translated into larger areal overlaps (~6.6% and 2.14% respectively). The overlaps were low in deeper bathomes, although the footprint in depths >2000 m appeared to be relatively large.

Of the 1030 potential VME seamounts in the SPRFMO Area, 13 (1.3%) lay under the Australian demersal trawl effort distribution from 2002-2009 (Table 4.1.4.3).

Table 4.1.4.3 Distribution and overlap of the Australian demersal trawl effort (number of reported operations and total areas) in the SPRFMO Area between 2002 and 2009 in relation to VME indicators (ecologically meaningful bathomes and seamounts). Depth distribution of operations uses the reported fishing depth; overlap is calculated at 0.1° resolution and shown as % of total areas of bathomes and total number of seamounts in the SPRFMO Area.

			Australian effort distribution (0.1° resolution)		Seamounts	
Bathome	**Name**	**No. ops. reported**	**Area (km2)**	**%**	**No.**	**%**
No depth reported		20				
0 - 200m	Continental shelf	3	1	0.02	0	0
200 - 700m	Shallow upper continental slope	197	740	1.72	4	1.78
700 - 1000m	Deep upper continental slope	746	4,336	6.62	7	3.38
1000 - 1500m	Shallow mid-continental slope	135	5,579	2.14	2	0.39
1500-2000 m	Deep mid-continental slope	0	634	0.23	0	0
> 2000m		0	3,623	<0.01	0	0
TOTAL in SPRFMO Area		1101	14913	0.03	13	0.04

The demersal trawl fishery concentrated mostly on the fishing grounds between Australia's and New Zealand's EEZs in the Tasman Sea region and the South Tasman Rise, which has been closed since 2007, where the effort was generally moderate but also exceeded 50 tows between 2002-2009 in a series of 20' blocks. Low to moderate demersal trawling effort was targeted at the shallow peaks along the Louisville Ridge east of New Zealand. In addition, a few probably exploratory operations were reported in the Gascoyne region.

Midwater trawl

Between 2002 and 2009 a total of 347 midwater trawl operations was reported in the SPRFMO Area. The total historical midwater trawl effort distribution was ~3,200 km^2, as proportions of each bathome, all overlaps were small (< 3%). The largest area of midwater trawl effort distribution of ~2,100 km^2 was on the deep upper continental slope; midwater trawling did not occur on the continental shelf and was negligible in depths >1,500 m according to the operation depths reported in the logbook data (Table 4.1.4.4). The reported depths may be gear depth rather than bottom depth.

Of the 1030 potential VME seamounts in the SPRFMO Area, two seamounts (0.19%), both peaking on the shallow upper slope, lay under the Australian midwater trawl effort from 2002-2009 (Table 4.1.4.4).

Table 4.1.4.4 Distribution and overlap of the Australian midwater trawl effort (number of reported operations and total areas) in the SPRFMO Area between 2002 and 2009 in relation to VME indicators (ecologically meaningful bathomes and seamounts). Depth distribution of operations uses the reported fishing depth; overlap is calculated at 0.1° resolution and shown as % of total areas of bathomes and total number of seamounts in the SPRFMO Area.

			Australian effort distribution (0.1° resolution)		Seamounts	
Bathome	**Name**	**No. ops. reported**	**Area (km2)**	**%**	**No.**	**%**
No depth reported		1				
0 - 200m	Continental shelf	11	0	0	0	0
200 - 700m	Shallow upper continental slope	328	587	1.36	2	0.89
700 - 1000m	Deep upper continental slope	7	2,102	3.21	0	0
1000 - 1500m	Shallow mid-continental slope	0	376	0.14	0	0
1500-2000 m	Deep mid-continental slope	0	25	0.01	0	0
> 2000m		0	101	<<0.01	0	0
TOTAL in SPRFMO Area		347	3191	0.01	2	0.01

The midwater trawl fishery concentrated mostly on the boundary of Australia's EEZ in the North Lord Howe Rise fishing ground where effort was moderate to high. Some light effort was reported from the other three fishing grounds in the northern Tasman Sea. No midwater trawling was reported from the Louisville Ridge or from the South Tasman Rise.

Auto-Longline

Between 2002 and 2009 a total of 200 auto-longline operations was reported in the SPRFMO Area. The overlap of auto-longline historical effort distribution was highest in the shallowest three bathomes (<1000 m depth), with the largest area (~1068 km^2) on the shallow upper continental slope (Table 4.1.4.5). On the mid-continental slope bathomes (1000-1500 m and 1500-2000 m) the areas were smaller (~500 and 435 km^2 respectively), but, as proportions of each bathome, all overlaps were <0.2% (Table 4.1.4.5). The auto-longline effort distribution in depths >2000 m appeared to be relatively large (Table 4.1.4.5) but is likely be an artefact stemming from the scales at which fishing is recorded and the limitations of the bathymetry data, rather than targeted fishing in these depths (see 'Spatial dependencies' section above).

Of the 1030 potential VME seamounts in the SPRFMO Area, two seamounts (0.19%), both peaking on the continental shelf, lay under the Australian auto-longline effort from 2002-2009 (Table 4.1.4.5).

Table 4.1.4.5 Distribution and overlap of the Australian auto-longline effort (number of reported operations and total areas) in the SPRFMO Area between 2002 and 2009 in relation to VME indicators (ecologically meaningful bathomes and seamounts). Depth distribution of operations uses the reported fishing depth; overlap is calculated at 0.1° resolution and shown as % of total areas of bathomes and total number of seamounts in the SPRFMO Area.

			Australian effort distribution (0.1° resolution)		Seamounts	
Bathome	**Name**	**No. ops. reported**	**Area (km2)**	**%**	**No.**	**%**
No depth reported						
0 - 200m	Continental shelf	99	244	6.19	2	2.38
200 - 700m	Shallow upper continental slope	92	1,068	2.48	0	0
700 - 1000m	Deep upper continental slope	5	742	1.13	0	0
1000 - 1500m	Shallow mid-continental slope	3	506	0.19	0	0
1500-2000 m	Deep mid-continental slope	1	434	0.16	0	0
> 2000m		0	1,401	>0.01	0	0
TOTAL in SPRFMO Area		200	4395	0.01	2	0.01

Australia’s auto-longline fishing effort between 2002 and 2009 did not exceed 50 sets per 20’ block. It was concentrated on three small areas: the Gascoyne seamount, the southern reaches of Capel Guyot near the intersection of Australia’s and New Caledonia’s EEZs and the South Tasman Rise which is now closed to Australian fishing vessels, some probably exploratory operations were reported in the North Lord Howe Rise and in the West Norfolk Ridge fishing grounds.

Dropline

Between 2002 and 2009 a total of 82 dropline operations was reported in the SPRFMO Area. The total dropline historical effort distribution was ~3,700 km^2, but as proportions of each bathome, all overlaps were < 2%. Dropline fishing effort distribution was largest on the upper continental slope (200-1000 m depth), and in depths greater than 2000 m (Table 4.1.4.6) – although records from >2000 m depths are likely to be an artefact stemming from the scales at which fishing is recorded and the limitations of the bathymetry data, rather than targeted fishing in these depths (see ‘Spatial dependencies’ section above).

Of the 1030 potential VME seamounts in the SPRFMO Area, three seamounts (0.29%), peaking on the continental shelf and shallow upper slope, lay under the Australian dropline effort from 2002-2009 (Table 4.1.4.6). One additional seamount peaking below 2000 m was also under the dropline effort distribution.

Table 4.1.4.6 Distribution and overlap of the Australian dropline effort (number of reported operations and total areas) in the SPRFMO Area between 2002 and 2009 in relation to VME indicators (ecologically meaningful bathomes and seamounts). Depth distribution of operations uses the reported fishing depth; overlap is calculated at 0.1° resolution and shown as % of total areas of bathomes and total number of seamounts in the SPRFMO Area.

			Australian effort distribution (0.1° resolution)		**Seamounts**	
Bathome	**Name**	**No. ops. reported**	**Area (km2)**	**%**	**No.**	**%**
No depth reported		21				
0 - 200m	Continental shelf	5	43	1.08	2	2.38
200 - 700m	Shallow upper continental slope	56	652	1.51	1	0.44
700 - 1000m	Deep upper continental slope	0	752	1.15	0	0
1000 - 1500m	Shallow mid-continental slope	0	365	0.14	0	0
1500-2000 m	Deep mid-continental slope	0	324	0.12	0	0
> 2000m		0	1,571	< 0.01	1	<0.01
TOTAL in SPRFMO Area		82	3707	0.01	4	0.01

Australia’s dropline fishing effort between 2002 and 2009 did not exceed 50 sets per 20’ block. It was concentrated on three fishing grounds in the Tasman Sea region – Gascoyne, Capel Bank and North Lord Howe Rise. Few exploratory operations were reported in the West Norfolk Ridge and the South Tasman Rise fishing grounds.

4.1.5 Evidence of VMEs

Scientific survey results

Detailed analysis of survey results is outside the scope of this BFIA, but we note that the northern Tasman Sea and Coral Sea region has been subject to some scientific surveys by New Zealand, New Caledonian and Australian scientists. Data collections were in general focussed within the relevant jurisdictional waters, but some extended into the high seas of the SPRFMO Area. In particular, New Zealand surveys have collected fisheries related data from the Wanganella Bank (West Norfolk Ridge) and the Challenger Plateau. The New Caledonian research was focussed on the seamounts in the Coral Sea, including the Capel Bank region, reporting diverse seamount related fauna (Richer de Forges 1990). A wide-ranging biodiversity survey of the Lord Howe Rise and Norfolk Ridge in 2003 (NORFANZ) was undertaken in collaboration by Australian, New Zealand and New Caledonian scientists (Williams et al. 2006). A few sampling locations of this survey lay within the SPRFMO Area (Williams et al. 2006). Based on data taken during the NORFANZ survey, Williams et al. (2011a) reported that the diversity of cnidarians (mostly coral species) was lower in the region of the South Lord Howe Rise fishing grounds, compared to the region of the West Norfolk Ridge fishing ground. Anderson et al. (2011) reported that no dense habitat forming biota was observed on volcanic cones, seamount ridges and sediment covered plateaus of the Lord Howe Rise and Gifford

Guyot within Australia’s EEZ. However, a diverse emergent fauna, including cold water corals, was observed on hard, outcropping substrates of cones and ridges.

Summary of observer data

Some industry participants have stated that the cost of carrying an observer is one of the primary reasons for reduced trawl effort since 100% observer coverage was introduced. This is particularly the case for trawl vessels with limited endurance and where the ratio of steaming to fishing days is high.

Following a peak auto-longlining effort (~750,000 hooks) in 2008, effort levels in 2009 dropped back to less than 300,000 hooks (see Section 5.1.3). For the SPRFMO Area no observer data are available for 2008 and the still considerable effort in 2009 (~ 290,000 hooks) resulted in little bycatch records in the observer data base: sea anemones (1.24 kg), starfish (0.1 kg) and some crustaceans (40.08 kg crabs, 0.6 kg slipper lobsters). No sponge or coral bycatch was reported. Anemones and one type of seastar – brisingids – are taxa listed on the evidence of VME identification guide used by New Zealand observers (MFish 2008; Parker et al. 2009a), contributing to the biodiversity factor of the New Zealand VME scoring scheme regardless of the weight of the taxa caught.

Most of the 2008 and 2009 auto-longline effort was concentrated on two seamount features. From the lack of VME taxa reported it appears that these features do not support VME taxa in sufficient density, but there is uncertainty about this observation because not all auto-longline catches were observed; there was target coverage in these years of 10%.

History of trigger actions

No catches of trigger level coral and sponges have been reported in the SPRFMO Area since the trigger limit thresholds (50kg) were introduced. Thus, no move-on actions have been triggered.

Australian effort in areas with VME evidence

There is no evidence of substantial (i.e. trigger threshold, >50 kg) catches of VME taxa from Australian fishing operations in the SPRFMO Area in the observer data collected to date. In the absence of Australian data we compared the overlay of Australia’s footprint on regions where VME taxa have been reported by the New Zealand fisheries assessment (MFish 2008) and in the wider literature.

The Australian footprint overlays seventeen 20’ blocks where the New Zealand report identified evidence of VMEs (although the threshold score of 3 for ‘evidence of VME’ was not reached in most locations), as shown in Figures 23 & 24 of the New Zealand fisheries assessment (MFish 2008). Most of these grid cells (12) were designated ‘open’ by the New Zealand management arrangements, and two were in ‘move-on’ cells. These grid cells are all situated within the three fishing grounds in the northern Tasman Sea. The remaining three cells of the Australian footprint that overlay 20’ blocks where New Zealand observer data detected evidence of VMEs are on the Louisville Ridge; two of these were closed to New Zealand vessels by New Zealand management arrangements (MFish 2008).

The Lord Howe Rise appears to support VME taxa such as coldwater corals and sponges and represents suitable habitats for scleractinian corals (Davies and Guinotte 2011), however, based on survey data to date (Williams et al 2006, 2011a; Anderson et al.2011; Przeslawki et al.

2011), the distribution of these taxa appears to be sparse and patchy. The NORFANZ survey (Williams et al. 2006) reported coral and/or sponge catches from samples taken with orange roughy trawls (equivalent gear used by commercial fisheries) in four 20’ blocks of the Australian footprint, two each in the West Norfolk Ridge and in the South Lord Howe Rise fishing grounds. Anderson et al. (2011) describe the benthic epifauna on volcanic cones, seamount ridges and sediment covered plateaus of the Lord Howe Rise and Gifford Guyot within Australia’s EEZ. They found that sessile emergent filter feeders (e.g. cold-water corals and sponges) were only observed in conjunction with outcropping rocky substrates (thus mostly associated with peaks and ridges). While they describe the epifauna of these habitats as a ‘diverse mixture of cold-water corals’ and dead coral rubble, they did not observe dense habitat-forming biota (Anderson et al. 2011). In a direct comparison of raised and subdued features in the Lord Howe Rise region, Przeslawki et al. (2011) found that raised features such as knolls, pinnacles and seamounts were more likely to support emergent filter feeding epifaunal communities than subdued features such as basins and plateaus.

Evidence presented by Anderson and Clark (2003) suggests that the South Tasman Rise supports a dense habitat forming matrix of coldwater corals, which again is supported by the most recent models of habitat suitability for scleractinians (Davies and Guinotte 2011). Anderson and Clark (2003) reported high bycatch of coral (many records of 1-15 t) on the South Tasman Rise for the period of 1997-2000. The coral taxa included the stony corals (scleractinians) *Solenosmilia variabilis*, *Desmophyllum dianthus* and *Enallopsammia rostrata*, as well as octocorals (Alcyonaceans) and black corals (Antipatharians). The Australian footprint overlays the area of Anderson and Clark’s (2003) study, but it is closed to Australian and New Zealand fishing effort under current management arrangements.

Incidental mortality of Threatened, Endangered and Protected species

Logbook data from 2002 to 2009 and observer reports from 2007 to 2011 recorded no interactions with threatened or endangered species, as defined under Australian law. Observer reports contain one incident of seabird mortality in the SPRFMO Area – a migratory grey petrel caught on a longline in 2009. Under Australian law, grey petrels are protected but not considered to be threatened or endangered.

4.2 Risk assessment

4.2.1 Context to impact and risk assessment frameworks for VMEs

An assessment of risk to an asset by a potentially threatening process (or ‘hazard’), e.g. the risk of a SAI by bottom fishing on VMEs, needs to take account of the potential impact of each threatening process, the asset’s vulnerability, the effect of impacts on the asset, past and future exposure of the asset to the threat, and the cumulative effects of impacts through time and space (the balance between continued impact, recovery and mitigation). ‘Residual risk’ is the risk of effects from continuing exposure after management and mitigation measures are accounted for. Useful summaries of these concepts in the context of VMEs, and the distinctions between impact assessment and risk assessment, are provided by Sharp et al. (2009), Martin-Smith (2009) and Hobday et al. (2011).

The draft BFIAS provided by the SPRFMO SWG (SPRFMO 2009) is a template for this evaluation of Australian vessels in the SPRFMO Area. Although termed an ‘impact’ assessment, the BFIAS specifies that elements of risk, management and mitigation are also considered.

It is not possible to consider ecological risk for VMEs of high seas areas in a quantitative way due to several key uncertainties in the data (Section 4.1.4, ‘Spatial dependencies’), and the absence of key data on cumulative impacts. A full ecological risk assessment for VMEs in high seas areas, and the development of risk management frameworks, will ultimately need to account for the potential cumulative effects across different fishing gears, across Flag States, and across other threatening processes – deep sea mining, hydrocarbon extraction, pollution, ocean acidification and others (Glover and Smith 2003).

4.2.2 The BFIAS and alternative approaches

The draft BFIAS provided by the SPRFMO SWG (SPRFMO 2009) identifies the risk being determined as the risk of not achieving the stated objective – that there is no SAI from bottom fishing on VMEs, i.e. ‘no impacts which compromise ecosystem integrity in a manner that impairs the ability of affected populations to replace themselves and that degrades the long-term natural productivity of habitats, or causes on more than a temporary basis significant loss of species richness, habitat or community types’, in the SPRFMO Area.

The potentially threatening process being evaluated is the direct impact of fishing gear on the seabed during fishing. Other potential impacts from fishing, e.g. anchoring, effluent discharge are not issues for impact and risk assessment of VMEs in deepwater fisheries.

The BFIAS states, ‘the level of risk posed by each activity (hazard) should be assessed in a transparent, scientific manner. Determining the level of risk for each activity should be based on quantifiable criteria where possible. However, it is likely qualitative criteria will be needed due to data gaps, where this is the case, qualitative judgements should be underpinned by quantitative analyses where possible and sufficient documentation should be provided to enable the SWG to determine if the assigned risk levels are appropriate.

In determining the level of risk (low, medium, high) posed by an activity, the elements that should be specifically evaluated are:

1. Intensity – The intensity or severity of the impact at the specific site affected. This may be quantified by previous studies or an expert evaluation of the magnitude of the impact, e.g. None (no detectable impact); Low (some physical damage to some taxa/colonies); Medium (substantial damage to a small proportion of colonies/taxa, or small damage to a large number of taxa at the site, likely to modify biological and ecological processes e.g. reproduction) or High (significant damage to a significant proportion, where environmental functions and processes are significantly altered such that they temporarily or permanently cease).

2. Duration – how long the effects of the impact are likely to last.

3. Spatial extent – The spatial impact relative to the extent of the VMEs (e.g. will fishing impact 5%, 30% or 80% of the VME distribution) and whether there may be offsite impacts (e.g. will reproduction be impacted at a broader spatial scale).

4. Cumulative impact – The frequency of the impact will influence the risk, with activities occurring repeatedly at a site likely to have a greater risk. This will depend on the amount of fishing effort and should be considered in relation to the recovery of the VMEs/taxa.

BFIAS 'overall risk'

The overall risk ranking of an activity is then evaluated from the combination of the criteria used. The method for combining these criteria to assign low, medium or high risk to an activity should be detailed in the assessment report.

Low: Where the impact will have a negligible influence on the environment and no active management or mitigation is required. This would be allocated to impacts of low intensity and duration, but could be allocated to impacts of any intensity, if they occur at a local scale and are of temporary duration.

Medium: Where the impact could have an influence on the environment, which will require active modification of the management approach and / or mitigation. This would be allocated to short to medium-term impacts of moderate intensity, locally to regionally, with possibility of cumulative impact.

High: Where the impact could have a significant negative impact on the environment, such that the activity(ies) causing the impact should not be permitted to proceed without active management and mitigation to reduce risks and impacts to acceptable levels. This would be allocated to impacts of high intensity that are local, but last for longer than 5-20 years, and/or impacts which extend regionally and beyond, with high likelihood of cumulative impact.

The risk assessment should be based on criteria that are independent, such that they provide separate measures of risk. Criteria should also be quantifiable, preferably with the method of quantification and ranking categories determined beforehand.'

The BFIAS is yet to be finalised. For this BFIA we have also considered the approaches used for avoiding SAI on VMEs in the CCAMLR area of competence (Constable and Holt 2007; Martin-Smith 2009; Sharp et al. 2009), the Ecological Risk Assessment for the Effects of Fishing framework used to assess risk within Australian domestic fisheries (Hobday et al. 2011), some relevant scientific literature (key elements of which are summarised in the context of benthic fauna by Parker et al. (2009a) and Williams et al. (2011b), and the BFIA for the New Zealand fisheries (MFish 2008). The key elements of these other studies relevant to this BFIA are discussed below.

The concept underlying our assessment is an exposure-effects framework (Sharp et al. 2009; Williams et al. 2011b) which is better suited to assessing risks posed by ongoing effects, such as fishing impacts on benthos, than likelihood-consequence frameworks (e.g. Martin-Smith 2009). A strength of exposure-effects frameworks is their ability to deal with the spatial and temporal dependencies of many risk elements. Exposure refers to the impact which, because it is not directly measureable, needs to be described in terms of its nature and extent. The effect refers to the ecological consequences of the impact. We note, however, that much of the underlying ecology linking impact to effect and risk remains unknown for deep ocean benthic ecosystems, and ecological responses are affected simultaneously by other environmental and biological influences interacting at a range of spatial and temporal scales (Sharp et al. 2009).

Sharp et al. (2009) provide an operational framework for BFIA in CCAMLR which provides a template to systematically assess impacts in a way that permits comparison of different fisheries and gears, and thereby offers the prospect of estimating cumulative impact. However, despite the considered and detailed calculation of the cumulative spatial extent of effort distribution in the Ross Sea for the history of the New Zealand fishery (total area seabed contacted by longlines), Sharp et al (2009) acknowledge the calculations of cumulative impact on VME organisms are subject to considerable uncertainty. This was primarily due to (1) the unknown relationship between impacted areas and the spatial distribution of VMEs, (2) no knowledge of the ecological consequences of impacts, and (3) untested assumptions about the mobility of longlines during fishing (especially when retrieved). A key problem in assessing cumulative impacts is the likely complex, non-linear relationship between impact and risk, which means that impact is unlikely to be simply additive across sources (Sharp et al. 2009).

The same key uncertainties apply to any framework developed for BFIAs of Australian fishing activities in the SPRFMO Area. The poor knowledge of VME distribution at fine scales prevents accurate calculation of spatial overlap of fishing with VMEs. Estimates of overlaps with bathomes (depth zones), as calculated here and by Sharp et al. (2009), will underestimate the degree of interaction with VMEs because (1) VME taxa are not homogeneously distributed within bathomes and are likely to be spatially concentrated, and (2) fishing effort distribution is not independent of VME distribution, i.e. fishery target species are often concentrated at the same finer scale locations as VMEs – e.g. seamount peaks and the heads of submarine canyons (Lorance 2002; Genin 2004; Watson et al. 2007; Rogers et al 2008; Post 2010; Vetter et al. 2010; Section 4.1.4). Resolving the spatial scale of analysis by using seabed topography to indicate where VMEs are more likely to be located can help to reduce this ‘VME distributional uncertainty’. However, datasets of topographic features and predictive methods used to infer their suitability for supporting VMEs are also prone to a range of uncertainties including data density and resolution, and scaling issues (Section 4.1.4).

The additional difficulties for this BFIA of Australian vessels in the SPRFMO Area are insufficiently resolved effort distribution data to accurately map impact extent (and hence overlap with VME indicators) for the primary fishing gears (longlines and trawls) at finer scales than 0.1º. All data grids are limited to 0.1º spatial resolution and many operational end points are missing – although this resolution will more accurately define overlap than the 20’ standard for footprint analysis.

4.2.3 Framework used for Australian BFIA in the SPRFMO Area

The combination of key uncertainties, untested assumptions and coarsely resolved data restricts the value of detailed calculations of bottom contact (e.g. following the method of Sharp et al. 2009) and constrains the opportunities to develop a semi-quantitative assessment framework. The mix of impact and risk elements in the SPRFMO draft BFIAS, and the need to assess both ecological and management risk, have lead us towards developing a predominantly qualitative approach to this assessment. Rankings are substantiated, to the extent possible, with quantitative estimates of particular elements (overlaps of effort and VME indicators). Estimates of our confidence in rankings are provided, and key uncertainties in underlying data are identified. We follow approaches in CCAMLR in seeking to define and quantify as clearly as possible, the nature, extent and spatial distribution of potential impacts by Australian fisheries on VMEs, but without reference to the anticipated ecological consequences to communities or populations – which are largely unknown. Our assessment deals primarily with the potential threat to VMEs from bottom trawl and auto-longline fishing because of the low impact and negligible effort for other gear types.

The term ‘overall risk’ in the BFIAS is used to define the potential risk stemming from the combination of the individual elements of impacts and risk (intensity, duration, spatial extent and cumulative impact) (see Section 4.2.1). In this BFIA we follow Australia’s ERAEF method used to assess and manage risks in its Commonwealth fisheries by also considering the extent to which overall risk is influenced by risk-reducing management measures and other factors including uncertainties. This additional process of assessing the ‘residual risk’ is incorporated within AFMA’s ecological risk management process because it more accurately represents overall risk and helps clarify if/ what further (quantitative) assessment is necessary (e.g. AFMA (2010).

4.3 Assessment of ‘overall risk’

As noted above (Section 4.2.3) overall assessment of risk is mainly qualitative, and in this BFIA accounts for risk reduction by existing management measures. Impact ratings are substantiated, to the extent possible, with semi-quantitative estimates of particular elements (e.g. overlaps of effort and VME indicators to define ‘spatial extent’) and extended as estimates of risk. Estimates of confidence and identification of key uncertainties in underlying data are provided because these also influence the assessment of overall risk (low confidence or higher uncertainty usually equates to higher risk). Key uncertainties indicate priorities for future data collection or analytical methods development.

Risk ratings extend the descriptions of impact to descriptions of exposure by providing context (the magnitude and trend of fishing effort, and whole-of-area measures). Although arbitrary thresholds are used to define risk ratings (Table 4.3.1.2), they provide a more transparent way of assessing SAI than a purely descriptive account of impact. Management, mitigation and monitoring measures also need to be accounted for when analysing risk because they influence (typically reduce) the assessment of overall risk.

While this approach to completing a BFIA does not provide a completely developed framework, it does contain components that can be emulated in BFIAs completed by other Flag States, and potentially included in a ‘whole-of-area’ assessment by the SPRFMO SWG.

4.3.1 Demersal trawling

The potential impacts of demersal trawling on VMEs evaluated using the four elements of the draft BFIAS are ‘potentially high’ for intensity, ‘long’ in terms of their duration, ‘low’ in spatial extent but with ‘definite’ cumulative impact (Table 4.3.1.1). The overall risk of SAI of demersal trawling by Australian vessels in the SPRFMO Area, which accounts for potential impact together with the trends in exposure, and existing management, mitigation and monitoring measures, is evaluated as currently low, although with the potential to increase to medium (Table 4.3.1.1).

The low overall risk of SAI accounts for several factors that moderate the risk, particularly the management and mitigation measures applied to Australian vessels, including limits on the amount of fishable seabed available for fishing, an ‘evidence of VME’ process with validation and move-on provisions, and infrastructure that transparently supports monitoring and compliance. Our evaluation of low overall risk also considers the low exposure of VMEs to fishing impact from Australian vessels because there are few issued permits and no trawling in the SPRFMO Area in 2008 and 2009.

Low overall risk is qualified with a potential medium rating that reflects the influence of factors that may serve to increase risk if they occur. These include the potential for effort to expand within or beyond the Australian fishing footprint in the future. High levels of uncertainty regarding key aspects of exposure and effect also increases the risk of SAI. Some uncertainties are specific to impacts and risks from demersal trawling, while others are common to all fishing methods (Table 4.3.1.1). The single greatest uncertainty in assessing the risk of SAI is the lack of knowledge of the activities by other Flag States and unrecorded fishing, which contributes an unknown (but likely relatively large) cumulative impact in space and time (Table 6.1.1).

As required by the draft BFIAS, the rationale for the impact and risk ratings are described below against the identified elements of impact and risk (Table 4.3.1.1), together with a description of the type of resulting impact. Semi-quantitative measures are summarised in Table 4.3.1.2. The key sources of uncertainty influencing the BFIAS are documented in Section 6 (see summary Table 6.1.1).

Impact description (What will be affected and how?)

The potential risks of fishing impacts to deepwater benthic fauna, which are adapted to stable and quiescent environmental conditions, are high relative to fauna from shallower depths (Williams et al. 2011b). The potential negative impact of demersal trawls on many VME taxa by degradation or removal of biological and physical habitat is well established (Watling and Norse 1998; Koslow et al. 2001, Hall-Spencer et al. 2002; Clark and Koslow 2007; Althaus et al. 2009; Clark and Rowden 2009). Negative effects of bottom-contact fishing on marine benthic systems have been well documented, and include reductions in biodiversity and biomass, homogenization of the substratum, and disruption of ecosystem processes (Thrush and Dayton 2002). Despite the impact being variable with depth (faunal composition) and trawl intensity (e.g. Kaiser et al. 2006), and habitat type (rocky bottom may have inaccessible refuges), and to some extent with the way the gear is rigged and the navigational and fishing monitoring equipment employed (e.g. see MFish 2008, Section 4.1.2), the nature of the potential impact of demersal trawls on VME fauna is made with high confidence.

BFIA element 1: Intensity (Magnitude of impact is 'none', low, 'medium' or high' at the specific site affected?)

The severity of demersal trawl impact on VME fauna needs to consider fishing intensity (density and distribution of effort with defined areas), but is also partly assessed by inference because there are few (if any) direct *in situ* observations of impact in the SPRFMO Area. Evaluation can, however, be made with a medium to high degree of confidence because fishing effort intensity has been mapped at sub-block scale (0.1°), and because there are observational studies of trawl impact on VME taxa made elsewhere that relate directly to BFIAs for deep water fisheries (see Impact Description above).

Intensity mapping of Australia’s demersal trawl effort, from 2002 to 2009 in the total Australian footprint of 93 blocks, shows effort had been distributed over six fishing grounds in 68 of the 20’ blocks, with heavy effort (>50 tows) in nine blocks, and moderate (3-50 tows) in 30 blocks. The intensity metric is conservative (total individual trawl tows in 20’ blocks over eight years), and the proportion of blocks in the footprint with high effort is small (< 10%) (Table 4.3.1.2). No potential VME seamounts are in blocks with high effort by Australian trawlers between 2002 and 2009.

The severity of the impact may depend on the intensity of trawling and on the taxa encountered. However, individual trawl tows have the potential to have severe impacts, particularly on large, erect and delicate fauna, as exemplified by long-lived ‘tree-forming’ corals. This is reflected in differential bycatch weight thresholds for black corals, soft corals and fan corals in New Zealand’s management arrangements – see Parker et al. (2009a). Severity of impact also depends on the site-scale spatial extent of fishing, i.e. whether all parts of a site potentially representing a VME are impacted. Widespread site-scale impact has been observed, for example on some individual seamounts, although in many locations it is likely that some fauna remains unimpacted in natural refuges inaccessible to fishing gear. A key uncertainty is whether partly impacted areas remain viable as ecologically functioning communities. (Additional uncertainty is whether site-scale intensity of impact has effects at larger scales; it is quite plausible that impacts affecting reproductive function at sites which are important upstream sources of propagules will also impact downstream VMEs.)

This combination of factors, together with additional uncertainty about the extent to which landed bycatch underestimates fishing impact, results in the intensity of impact being rated as potentially high at individual site scale – with potential for ecological effects at broader scales.

BFIA element 2: Duration (How long the effects of impacts are likely to last.)

The duration of impact may be taxon dependent, but because VME taxa are typically slow growing and long-lived (e.g. Clark et al. 2010), there is a justifiably high confidence in evaluating the duration of impact (recolonisation by VME taxa) as long (decades to centuries, or longer). Whether heavily impacted VMEs will return to original ecosystem structure and function is uncertain (Williams et al. 2010).

BFIA element 3: Spatial extent (The spatial impact relative to the extent of VMEs.)

Rating the ‘spatial extent’ of impact is highly dependent on the spatial and temporal scales of reference (Section 4.2). This BFIA for Australian vessels uses a conservative metric (all 0.1º grid cells containing any fishing effort) to estimate overlap of trawling with the distributions of VME indicators (bathomes and seamounts) for the total historical extent of fishing between 2002 and 2009.

The proportional overlaps of trawling with all bathomes and with seamounts were low (< 7% and mostly < 2%) at the whole-of-fishery scale (Table 4.3.1.2) indicating that the historical impact had been low in terms of spatial extent. However, higher proportions of each bathome and a greater number of seamounts are available to Australian vessels within the defined management footprint. The current footprint prevents fishing in 73-87% of each of the important VME bathomes (in 0-1500 m depths, Williams et al. 2009; Tittensor et al. 2009) and 95% of the potential VME seamounts (Table 4.3.1.2) – although 37% of the deep upper continental slope is available for trawling. This shows that the spatial extent of impact has the potential to expand, and therefore the overall risk of SAI has the potential to increase. However, trawling effort (vessels, hours and operations) has declined strongly, and no trawlers were active in 2008 or 2009. In combination with the historical effort mapping, this indicates that the future spatial extent of impact is likely to remain low.

Rating the risk of SAI is also subject to several key uncertainties. Important among these are having no accurate estimates of overlap of Australian trawl effort distribution with VME distribution because neither are precisely mapped at 'site’ scale. Additionally, there has been no evaluation of whether there is fine scale co-location of fishery resources with VMEs at the site or feature scale, e.g. whether both VMEs and fishing impact are concentrated in places such as seamount peaks and canyon heads. A high degree of co-located VME fauna and fishing effort has the potential to greatly increase impact and risk. Furthermore, analysis and interpretation of information at multiple spatial and temporal scales is required to understand the ecological effects of fishing impacts on ecosystem processes such as dispersal and recruitment.

This combination of factors, results in the spatial extent of impact being rated as low (‘site specific at local scale’), but with potential to increase (medium) if effort increases and expands to new areas, or if management regulations change to permit trawling outside the current footprint.

Table 4.3.1.1 Summary of impact and risk assessment of bottom trawling and auto-longline fishing on VMEs using elements of the SPRFMO BFIAS. Detail for the rationale is provided in Table 4.3.1.2

Elements of impact/ risk assessment from the BFIAS	**Impact rating for trawl and auto-longline**	**Analytical measures used to assess impact and risk from demersal fishing**	**Monitoring, management and mitigation measures that reduce uncertainty and risk**	**Rationale for overall risk rating of SAI by Australian vessels as 'LOW'**		**Events with potential to increase risk of SAI by Australian vessels**
				Demersal trawl	**Auto-longline**	
1. Intensity Severity of impact is 'none', 'low', 'medium' or high' at the specific site detected?	High (trawl) Medium (auto-longline)	Demersal fishing intensity at 0.1º resolution mapped over VME indicators (ecologically meaningful depth zones and seamounts) to determine overlap. Measured as grid cells containing fishing effort (not refined as swept area).	The spatial extent of Australian fishing is limited by management measures to a defined footprint. Australia has implemented an ‘evidence of VME’ process with validation steps and move-on provisions. Australia has management infrastructure that transparently supports monitoring and compliance - including ICVMS and reporting requirements using a shot by shot logbook record, trip catch disposal record, and a transit details form. Australian vessels with high seas permits have mandatory observer coverage. Fine scale spatial analysis of Australian fishing effort distribution provides semi-quantitative measures of exposure.	The severity of demersal trawl impact on VME fauna is potentially high at individual sites, but fine scale (0.1º resolution) analysis shows there are few areas of high fishing intensity. Most sites within the Australian footprint have experienced low or medium effort, and the measure used is conservative. No potential VME seamounts are in blocks fished with high effort by Australian trawlers between 2002 and 2009.	The severity of demersal longline impact on VME fauna is potentially medium at individual sites, but fine scale (0.1º resolution) analysis shows no sites within the Australian footprint fished with auto-longline have experienced heavy effort, and the measure used is conservative. There are no potential VME seamounts fished with high effort by Australian auto-longline between 2002 and 2009.	Change of management arrangements leads to effort expanding beyond the currently defined Australian fishing footprint. A material increase in the number of permits leads to effort increasing within the currently defined Australian fishing footprint. Relaxation of 'evidence of VME' reporting, e.g. increased VME taxa trigger thresholds, leads to unrecognised impacts. Decreased observer coverage leads to unrecognised impacts. Improved knowledge of the activities by other Flag States shows the 'whole-of-area' cumulative impact in space and time provides new perspective on the potential risks by individual Flag States including Australia.
2. Duration Expected duration of impact is 'short', 'medium', 'long' ?	Long (both)	Inference. [Duration (persistance) of impact is taxon dependent, but many/ most VME taxa are long-lived; some corals and sponges are among the oldest living animals. Longevity and recovery rates of VME taxa are supported by published studies.]		Persistant impacts (and cumulative impacts) are both indicators of high potential risk, but are moderated by spatial patterns of intensity (mostly low) and extent (spatially regulated).	Persistant impacts (and cumulative impacts) are both indicators of high potential risk, but are moderated by spatial patterns of intensity (mostly low) and extent (spatially regulated).	
3. Spatial extent The spatial impact relative to the extent of VMEs	Low (both)	Demersal fishing effort distribution at 0.1º resolution mapped over VME indicators to determine overlap within ecologically meaningful depth zones (bathomes) and on seamounts. Measured as grid cells containing fishing effort (not refined as swept area).		VME taxa are potentially severely impacted at site scale, but proportional overlaps with VME indicators (bathomes and seamounts) were historically low. Effort levels have declined and effort extent is restricted to historical footprint. Majority of area/ occurence of VME indicators lie outside footprint: fishing is prevented in the majority (> 63%) of each of the important VME bathomes (in 0-1500 m depths) and on 95% of the potential VME seamounts.	VME taxa may be impacted at site scale, but proportional overlaps with VME indicators (bathomes and seamounts) were historically low. Effort levels are low and effort extent is restricted to historical footprint. Majority of area/ occurence of VME indicators lie outside footprint: fishing is prevented in the majority (> 63%) of each of the important VME bathomes (in 0-1500 m depths) and on 95% of the potential VME seamounts.	
4. Cumulative impact Repeated impacts may accumulate in time and space	Definitely cumulative (both)	Spatial-temporal patterns [Recovery times (decades to centuries or longer) greatly exceed intervals between fishing (days to years) at specific sites where VME fauna exist or existed. Taxa longevity and recovery rate are supported by published studies.]		Trend of effort levels strongly decling with no active Australian trawlers in 2008 and 2009. There is low exposure of VMEs to fishing impact from Australian demersal trawling because there are few issued permits.	Trend of effort levels variable but there is low exposure of VMEs to fishing impact from Australian auto-longlining because there are few issued permits.	

Table 4.3.1.2 Summary data to assess risks of demersal trawling and auto-longlining impacts on VMEs.

	Australian trawling			**Australian auto-longline**			**High Seas fleet (cumulative)**		
Maximum no. vessels in any year (2002-2009)		14 (2002)			3 (2006)			?	
No. vessels in 2009		0			2			?	
No. permits issued in 2011		2			4			?	
Trend in total effort		Strong decline			Low but variable			?	
	H (>30%)	**M (10-30%)**	**L (<10%)**	**H (>30%)**	**M (10-30%)**	**L (<10%)**	**H (>30%)**	**M (10-30%)**	**L (<10%)**
Proportion of each bathome available for fishing (footprint)									
Continental shelf (0 – 200 m)		25.7			25.7		100		
Shallow upper continental slope (201 – 700 m)		20.6			20.6		100		
Deep upper continental slope (701 – 1000 m)	36.6			36.6			100		
Shallow mid-continental slope 1001 – 1500 m)		12.8			12.8		100		
Deep mid-continental slope (1501 - 2000 m)			3.5			3.5	100		
Proportion of each bathome fished between 2002-2009 (effort distribution)									
Continental shelf (0 – 200 m)			<0.1			6.2	?	?	?
Shallow upper continental slope (201 – 700 m)			1.8			2.5	?	?	?
Deep upper continental slope (701 – 1000 m)			6.6			1.1	?	?	?
Shallow mid-continental slope 1001 – 1500 m)			2.1			0.2	?	?	?
Deep mid-continental slope (1501 - 2000 m)			0.2			0.2	?	?	?
Proportion of footprint with high intensity fishing (total: 93 blocks)			9.6			0			
Proportion 'potential VME seamounts' under Australian footprint (total: 1030)			4.3			4.3	?	?	?
Proportion 'potential VME seamounts' fished between 2002-2009 (total: 1030)			1.3			0.2	?	?	?
Proportion 'potential VME seamounts' with high intensity fishing effort (total 1030)			0			0	?	?	?
Proportion 'potential VME seamounts' with moderate intensity fishing effort (total 1030)			0.7			0.2	?	?	?
Proportion of any bathomes protected in fishery closures*		None			None				
Continental shelf (0 – 200 m)		None			None		?	?	?
Shallow upper continental slope (201 – 700 m)							?	?	?
Deep upper continental slope (701 – 1000 m)							?	?	?
Shallow mid-continental slope 1001 – 1500 m)							?	?	?
Deep mid-continental slope (1501 - 2000 m)							?	?	?
Proportion of potential VME seamounts protected in fishery closures (total 1030)		None			None		?	?	?
Proportion of any types of VMEs protected in fishery closures							?	?	?

* the South Tasman Rise is temporarily closed to Australian vessels

BFIA element 4: Cumulative impact (Repeated impacts may accumulate in time and space.)

The impact of demersal trawling on VME fauna is definitely cumulative in space and time because recovery times (decades to centuries or longer) greatly exceed intervals between fishing (days to years) at specific sites where VME fauna exist or existed. Knowledge of the historical impact by Australian vessels is limited by a paucity of information on the identity and quantity of VME fauna damaged or removed, and lack of direct *in situ* observations of VMEs present. Australian management regulations have required 100% observer coverage since 2008, and improved monitoring (e.g. identification of VME bycatch) will reduce uncertainties about the realised impact of demersal trawls on VMEs in the SPRFMO Area. The key uncertainty is cumulative impact; the largest challenge to effectively manage VMEs in the SPRFMO Area is to estimate the cumulative effects of impacts across Flag States.

4.3.2 Demersal (auto-) longlining

The potential impacts of demersal auto-longline fishing on VMEs evaluated using the four elements of the draft BFIAS are ‘potentially medium’ for intensity, ‘long’ in terms of their duration, ‘low’ in spatial extent but with ‘definite’ cumulative impacts) (Table 4.3.1.1). The overall risk of SAI of demersal auto-longlining by Australian vessels in the SPRFMO Area, which accounts for potential impact together with the trends in exposure, and existing management, mitigation and monitoring measures, is evaluated as currently low, although with the potential to increase to medium (Table 4.3.1.1).

The low overall risk of SAI accounts for several factors that moderate the risk, particularly the management and mitigation measures applied to Australian vessels, including limits on the amount of fishable seabed available for fishing, an ‘evidence of VME’ process with validation and move-on provisions, and infrastructure that transparently supports monitoring and compliance. Our evaluation of low overall risk also considers the low exposure of VMEs to fishing impact from Australian vessels because there are few issued permits.

Low overall risk is qualified with a medium rating that reflects the influence of factors that serve to increase risk. These include the potential for effort to expand within or beyond the Australian fishing footprint in the future. High levels of uncertainty regarding key aspects of exposure and effect also increases the risk of SAI. Some uncertainties are specific to impacts and risks from demersal auto-longlining, while others are common to all fishing methods (Table 4.3.1.1). The single greatest uncertainty in assessing the risk of SAI is the lack of knowledge of the activities by other Flag States and unrecorded fishing, which contributes an unknown (but likely relatively large) cumulative impact in space and time.

As required by the draft BFIAS, the rationale for the impact and risk ratings are described below against the identified elements of impact and risk (Table 4.3.1.1), together with a description of the type of impact resulting. Semi-quantitative measures are summarised in Table 4.3.1.2. The key sources of uncertainty influencing the BFIAS are documented in Section 6 (see summary Table 6.1.1).

Impact description. (What will be affected and how?)

The potential risks of fishing impacts to deepwater benthic fauna, which are adapted to stable and quiescent environmental conditions, are high relative to fauna from shallower depths (Williams et al. 2011b). There is potential for demersal longline impact on large, erect and delicate VME taxa such as sponges and tree-forming corals through degradation or removal, and a higher likely impact than previously recognised (Section 4.1.3) – and see Chuenpagdee et al. (2003, Figure 6) who rate this gear as having ‘medium impact’ based on its relative severity of collateral impacts compared to other fishing gears. Because the impact is expected to vary with depth (faunal composition), and habitat type (rocky or very steep bottom may have inaccessible refuges), and because there are few empirical data on the nature of the potential impact of demersal longline on VME fauna, this description is made with medium confidence.

BFIA element 1: Intensity (Magnitude of impact is 'none', low, 'medium' or high' at the specific site affected?)

The severity of demersal auto-longline impact on VME fauna needs to consider fishing intensity (density and distribution of effort with defined areas), but is also partly assessed by inference because there are no direct *in situ* observations of impact in the SPRFMO Area. Evaluation can, however, be made with a medium degree of confidence because fishing effort intensity has been mapped at sub-block scale (0.1º), and because there some observations of VME bycatch by auto-longline made elsewhere, and expert-based first principle evaluations, that relate directly to BFIAs for deep water fisheries (see Impact Description above and Section 4.1.3).

Intensity mapping of Australia’s demersal auto-longline effort, from 2002 to 2009 in the total Australian footprint of 93 blocks, shows effort had been distributed over five fishing grounds in 17 of the 20’ blocks, with no heavy effort (>50 sets) and moderate (3-50 sets) in nine blocks. The intensity metric is conservative (total individual auto-longline sets in 20’ blocks over eight years), and the proportion of blocks in the footprint with high effort is zero (Table 4.3.1.2). No potential VME seamounts are in blocks with high effort by Australian auto-longliners between 2002 and 2009.

The severity of the impact may depend on the intensity of auto-longline fishing and on the taxa encountered. However, while auto-line sets have the potential to have impacts, particularly on large, erect and delicate fauna, as exemplified by long-lived ‘tree-forming’ corals, there is considerable uncertainty about resultant impact (see Section 4.1.3). As well, different management regulations apply in different areas, e.g. New Zealand has no trigger thresholds for auto-longlining in the SPRFMO Area, while there are triggers in the CCAMLR area of competence. Severity of impact also depends on the site-scale spatial extent of fishing, i.e. whether impact affects all parts of a site potentially representing a VME. There are no published or widely-available records of direct observations of demersal auto-longline impact, although in many locations it is likely that fauna remains unimpacted in natural refuges inaccessible to fishing gear. A key uncertainty is whether partly impacted areas remain viable as ecologically functioning communities. (Additional uncertainty is whether site-scale intensity of impact has effects at larger scales; it quite plausible that impacts affecting reproductive function at sites which are important upstream sources of propagules will also impact downstream VMEs.)

This combination of factors, together with additional uncertainty about the extent to which landed bycatch underestimates fishing impact, results in the intensity of impact being rated as potentially medium at individual site scale – with potential for ecological effects at broader scales.

BFIA element 2: Duration (How long the effects of impacts are likely to last.)

The duration of impact may be taxon dependent, but because VME taxa are typically slow growing and long-lived (e.g. Clark et al. 2010), there is a justifiably high confidence in evaluating the duration of impact (recolonisation by VME taxa) as long (decades to centuries, or longer). Whether heavily impacted VMEs will return to original ecosystem structure and function is uncertain (Williams et al. 2010).

BFIA element 3: Spatial extent (The spatial impact relative to the extent of VMEs.)

Rating the 'spatial extent' of impact is highly dependent on the spatial and temporal scales of reference (Section 4.2). This BFIA for Australian vessels uses a conservative metric (all 0.1° grid cells containing any fishing effort) to estimate overlap of auto-longlining with the distributions of VME indicators (bathomes and seamounts) for the total historical extent of fishing between 2002 and 2009.

The proportional overlaps of auto-longline with all bathomes and with seamounts were low (< 6% and mostly < 1%) at the whole-of-fishery scale (Table 4.3.1.2) indicating that the historical impact had been low in terms of spatial extent. However, higher proportions of each bathome and a greater number of seamounts are available to Australian vessels within the defined management footprint. The current footprint prevents fishing in 74-87% of each of the important VME bathomes (in 0-1500 m depths) and 95% of the potential VME seamounts (Table 4.3.1.2) – although 37% of the deep upper continental slope is available for auto-longlining. This shows that the spatial extent of impact has the potential to expand, and therefore the overall risk of SAI has the potential to increase. However, effort (vessels, hours and operations) has been low (two vessels in 2009). In combination with the historical effort mapping, this indicates that the future spatial extent of impact is likely to remain low.

However, rating the risk of SAI is also subject to several key uncertainties. These include no accurate estimates of overlap of Australian effort distribution with VME distribution because neither are precisely mapped at 'site' scale, and no evaluation of fine scale co-location of fishery resources with VMEs at the site and sub-local scales (<20' grids). Furthermore, impacts on ecosystem function and process (= effects) requires description at ecologically relevant spatial, temporal and environmental scales.

Rating the risk of SAI is also subject to several key uncertainties. Important among these are the considerable uncertainty about the nature of the impact of auto-longlines on VME taxa (Section 4.1.3), and having no accurate estimates of overlap of Australian auto-longline effort distribution with VME distribution because neither are precisely mapped at 'site' scale. Additionally, there has been no evaluation of whether there is fine scale co-location of fishery resources with VMEs at the site or feature scale, e.g. whether both VMEs and fishing impact are concentrated in places such as seamount peaks and canyon heads. A high degree of co-located VME fauna and fishing effort has the potential to greatly increase impact and risk. Furthermore, analysis and interpretation of information at multiple spatial and temporal scales is required to understand the ecological effects of fishing impacts on ecosystem processes such as dispersal and recruitment.

This combination of factors, results in the spatial extent of impact being rated as low ('site specific at local scale'), but with potential to increase (medium) if effort increases and expands to new areas, or if management regulations change to permit auto-longlining outside the current footprint.

BFIA element 4: Cumulative impact (Repeated impacts may accumulate in time and space.)

The impact of demersal auto-longlining on VME fauna is definitely cumulative in space and time because recovery times (decades to centuries or longer) greatly exceed intervals between fishing (days to years) at specific sites where VME fauna exist or existed. Knowledge of the historical impact by Australian vessels is limited by a paucity of information on the identity and quantity of VME fauna damaged or removed, and lack of direct *in situ* observations of VMEs present. Australian management has had a target of 10% observer coverage since 2008, and improved monitoring (e.g. identification of VME bycatch) will reduce uncertainties about the realised impact of demersal longlining on VMEs in the SPRFMO Area. The key uncertainty is cumulative impact; the largest challenge to effectively manage VMEs in the SPRFMO Area is to estimate the cumulative effects of impacts across Flag States.

4.3.3 Other fishing methods

Midwater trawling and droplining have not been assessed as part of this BFIA due to the low rating of these gears for impacts on benthic habitats and negligible levels of effort.

5. INFORMATION ON STATUS OF DEEPWATER STOCKS TO BE FISHED

Historical trends of catch and effort are provided for the SPRFMO Area for the period 2002 to 2009. No stock impact assessment is provided as part of this BFIA because there have been no stock assessments for the Australian fishery in the SPRFMO Area to this point in time.

5.1 Historic catch and effort trends (2002-2009)

5.1.1 Demersal Trawl

Annual fishing effort by demersal trawling in the SPRFMO Area varied considerably from 100 hours to ~225 hours from 2002 to 2007, and has been nil in 2008 and 2009 (Figure 5.1.1.1a). Over all years, effort was mostly applied in depths of 700-1000 m (>350 hours), and secondarily (<100 hours) in depths either side of this bathome (Figure 5.1.1.1b).

Orange roughy (*Hoplostethus atlanticus*) was the main target species, making up >70% of the total demersal trawl catches. The second most commonly caught species (12%) was spikey oreo (*Neocyttus rhomboidalis*); both these species were principally caught on the deep upper slope (700-1000 m; Figure 5.1.1.1b). The remainder of the catches comprised a mix of alfonsino (*Beryx splendens*), smooth oreo (*Pseudocyttus maculatus*), armoured gurnards (*Satyrichthys moluccense*) and 68 other species (Figure 5.1.1.1a). Alfonsino and armoured gurnards were mainly caught on the shallow upper slope (200-700 m), the smooth oreo on the deep upper slope (700-1000 m), and the spikey oreo on the shallow mid-slope (1000-1500 m; Figure 5.1.1.1b).

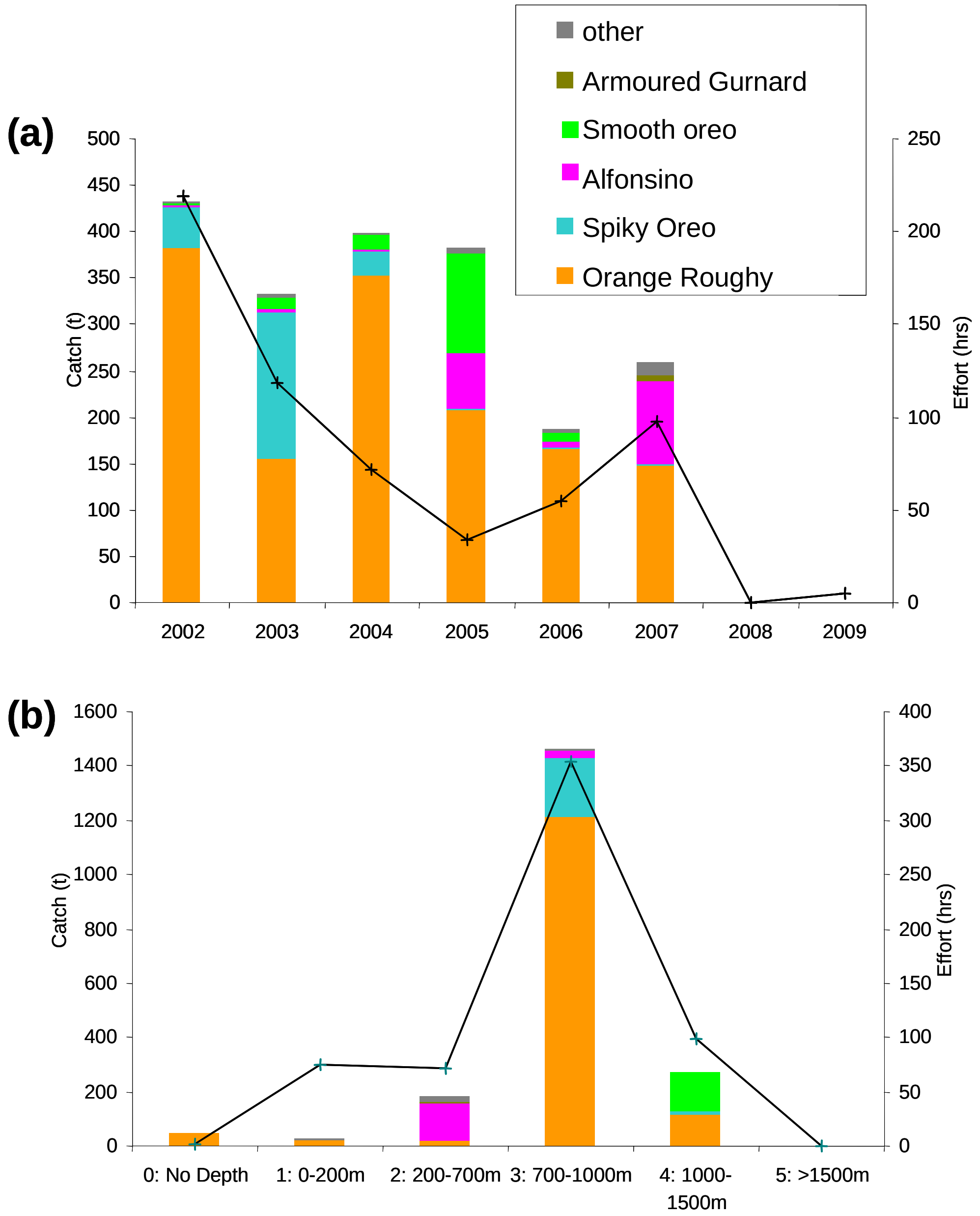

Figure 5.1.1.1 Total catch and effort in the SPRFMO Area by demersal trawl (a) by year, (b) by depth zone for the period 2002-2009, showing the five most commonly caught species and ‘other’. Effort in hours (black line).

5.1.2 Midwater Trawl

Midwater trawling was conducted within the SPRFMO Area in four years over the 2002-2009 period. Fishing effort by this method peaked in 2006 at 69 hours, with 22 hours reported in 2005, and negligible effort in 2003 and 2004 (Figure 5.1.2.1a). Most midwater trawl effort (~90 hours) was concentrated on the shallow upper slope (200-700 m), with <10 hours in 0-200 m and 1.5 hours in 700-1000 m (Figure 5.1.2.1b).

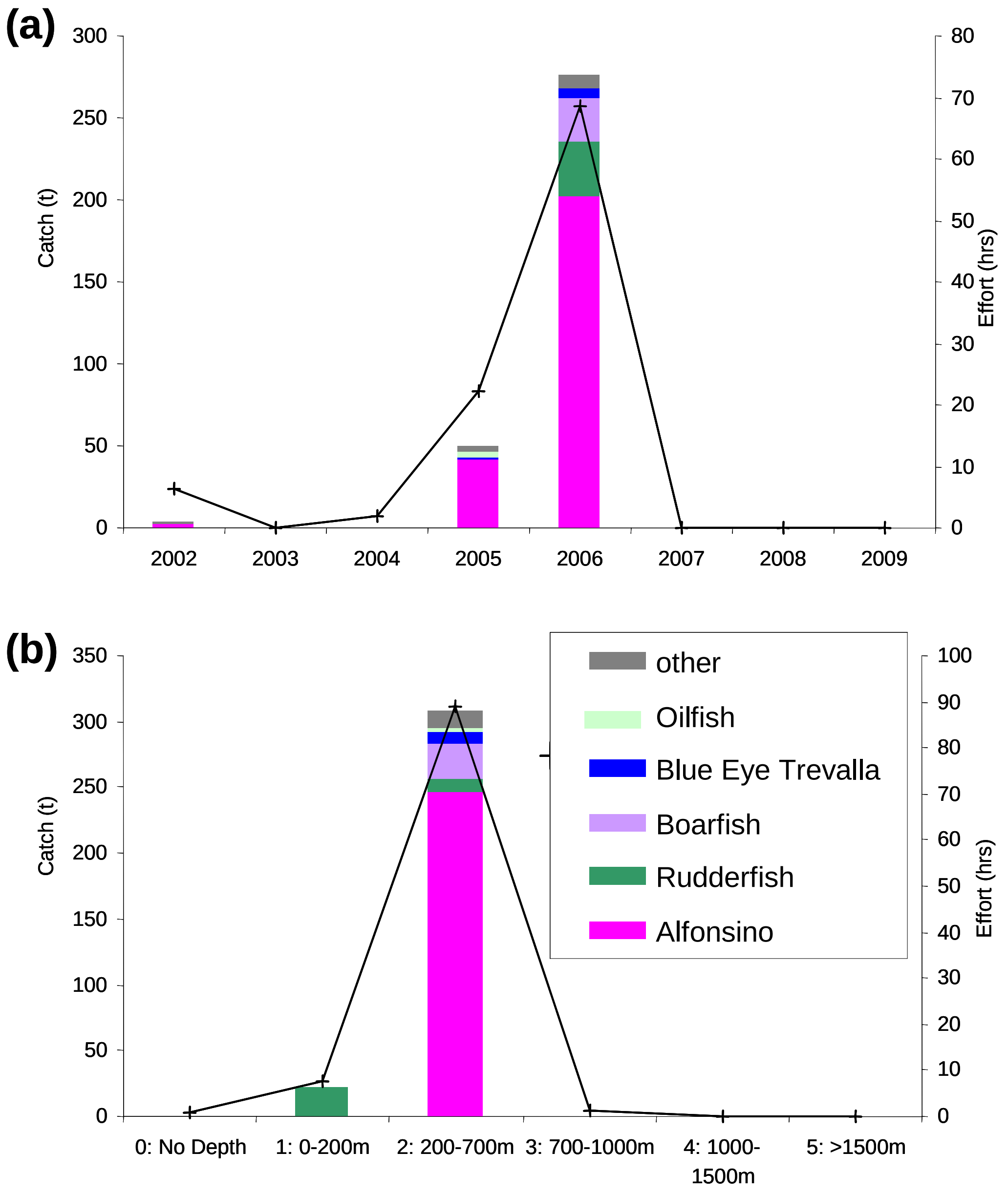

Figure 5.1.2.1 Total catch and effort in the SPRFMO Area by midwater trawl (a) by year, (b) by depth zone for the period of 2002-2009, showing the five most commonly caught species and 'other'. Effort in hours (black line).

Alfonsino (*Beryx splendens*) was the main target species of midwater trawling, making up >70% of the total catches on the shallow upper slope (200-700 m; Figure 5.1.2.1b). The second most commonly caught species (10%) was rudderfish (*Centrolophus niger*) that was caught shallower (Figure 5.1.2.1b). The remainder comprised a mix of boarfish (Family Pentacerotidae), blue eye trevalla (*Hyperoglyphe antarctica*), oilfish (*Ruvettus pretiosus*) and 14 other species (Figure 5.1.2.1a).

5.1.3 Auto-longline

Fishing effort by auto-longline within the SPRFMO Area peaked in 2008 at ~750,000 hooks set. In other years effort has generally been between ~190,000 and 300,000 hooks set however, it was considerably lower (<100,000 hooks set) in 2003-2005. Over all years, effort was mostly applied in the two shallowest bathomes (0-700 m; Figure 5.1.3.1b). None of the operations failed to report effort or depth, although the 1500-2000 m depth for one operation in 2007 was probably reported incorrectly.

Auto-longlining targeted mainly red finned emperor (*Lethrinus miniatus*), yellowtail kingfish (*Seriola lalandi*), jackass morwong (*Nemadactylus macropterus*), sea bream / snapper (*Gymnocranius* spp.) and blue eye trevalla (*Hyperoglyphe antarctica*); collectively, these five species accounted for >70% of total catches 2006-2009; in 2002 yellowtail kingfish, jackass morwong dominated the catch, while in the low effort years (2003-2005) small catches of 96 other species were reported (Figure 5.1.3.1). The two targeted bathomes had similar species mixes in the catches, with the exception of blue eye trevalla replacing sea bream snapper on the shallow upper slope (200-700 m; Figure 5.1.3.1b)

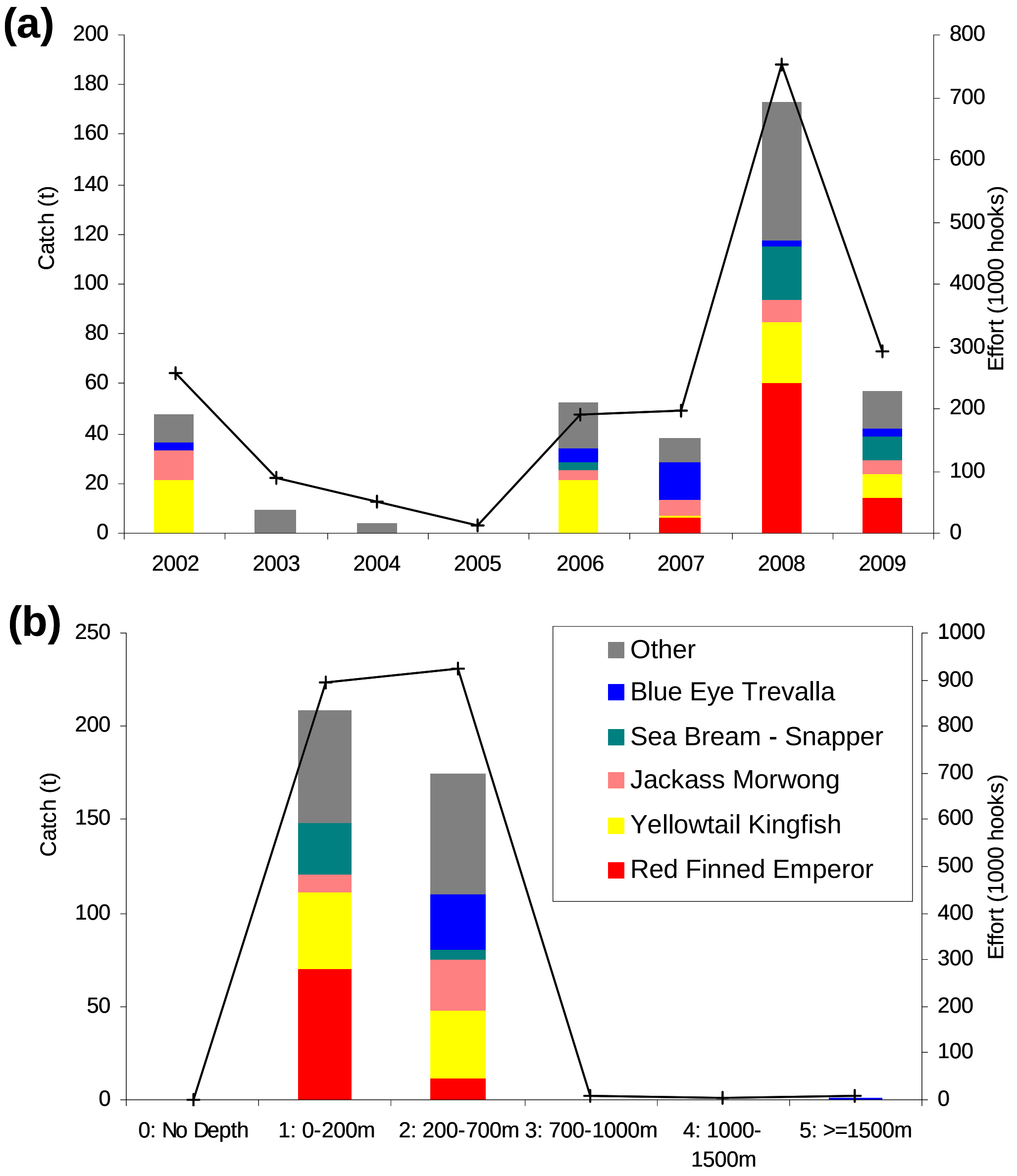

Figure 5.1.3.1 Total catch and effort in the SPRFMO Area by auto-longline (a) by year, (b) by depth zone for the period of 2002-2009, showing the five most commonly caught species and ‘other’. Effort = number of hooks set x 1000 (black line).

5.1.4 Dropline

Total annual fishing effort by dropline peaked with >500 standard drops in 2004 and gradually decreased to <40 standard drops in 2008/ 09 (Figure 5.1.4.1). Over all years, dropline effort was targeted at the shallow upper slope (200-700 m; >900 lines deployed) with some additional effort on the continental shelf (0-200 m; Figure 5.1.4.1b). Only one of the operations failed to report effort, however depth was not reported for 24% of the operations.

Droplines targeted mainly blue eye trevalla (*Hyperoglyphe antarctica*), bar rockcod (*Epinephelus ergastularius and E. septemfasciatus*) and ocean blue eye (*Schedophilus labyrinthica*) on the shallow upper slope; collectively, these three species accounted for >80% of total catches 2002-2009. 'Mixed reef fish', Yellowtail kingfish (*Seriola lalandi*) and 20 other species contributed the remaining <20% of the total caches (Figure 5.1.4.1a). Considering the species distributions (Figure 5.1.4.1b) it can be assumed that the operations without recorded depth were from the shallow upper slope (200-700 m).

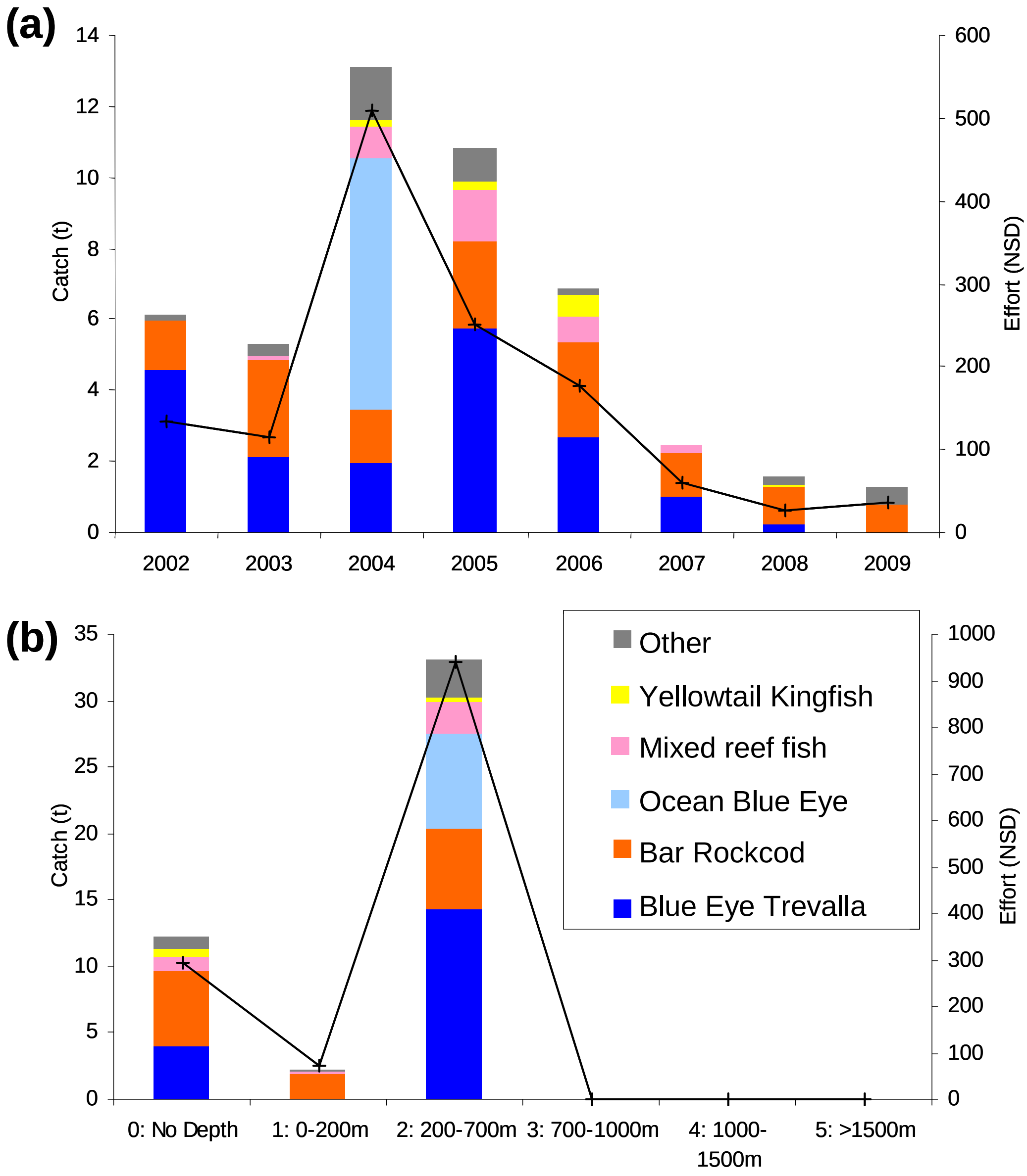

Figure 5.1.4.1 Total catch and in the SPRFMO Area by dropline (a) by year, (b) by depth zone for the period of 2002-2009, showing the five most commonly caught species and 'other'. Effort = number of standard drops.

5.1.5 Gillnet

The AFMA logbook records show 473 deepwater gillnet operations in the SPRFMO Area in two years prior to permit conditions being amended to prevent gillnetting, reporting catches of 192 t in 2002 and 68 t in 2003. The majority of the catches (~60%) by gillnets were ocean blue eye (*Schedophilus labyrinthica*) and king morwong (*Nemadactylus* sp.), with an additional ~30% of the total catch made up of blue eye trevalla (*Hyperoglyphe antarctica;* 18%), jackass morwong (*Nemadactylus macropterus*; 6%) and oilfish (*Ruvettus pretiosus*; 4%). The remaining catch was spread over a further 33 commercial species.

6. MONITORING, MANAGEMENT AND MITIGATION MEASURES

The BFIA conducted for Australian vessels fishing in the SPRFMO Area identifies that the risk of SAI on VMEs is low for the two primary demersal fishing methods used (demersal trawling and auto-longlining). It is negligible (considered, but, having regard to impact and effort, not formally assessed) for other methods (midwater trawling and droplining).

Ongoing monitoring, management and mitigation measures are necessary to address the potential impacts arising from demersal trawling (high) and demersal auto-longline fishing (medium). The risk ratings need to acknowledge the scope for risks to increase, and the high degree of uncertainty about many of the key elements relevant to assessing and managing impact and risk to VMEs in the SPRFMO Area.

Perhaps the single greatest source of uncertainty is the lack of knowledge of the cumulative impacts of fishing across Flag States. This provides context with which to interpret individual BFIAs. Collating the BFIAs, and determining the activities of non-member nations, is also necessary to understand the risks associated with any future increase or expansion of fishing by individual Flag States including Australia.

Australia’s proposed future monitoring, management and mitigation measures for the SPRFMO fishery will be presented in a separate report prepared by AFMA.

6.1 Enhanced monitoring, management and mitigation

Australia’s fishery logbook system records the distribution of fishing effort and levels of targeted catch, and bycatch – including of VME taxa. This provides the basis for evaluating the level of seabed impact by Australian vessels in the manner reported in this BFIA. Logbook data collection is supported by mandatory observer coverage (100% for bottom trawl, and the first trip and ongoing coverage of 10% annually for demersal longline), and satellite vessel monitoring systems and logbook reporting requirements on a shot by shot basis (see Section 4.1.2). Measures implemented by Australia to manage the risk of SAI by Australian fishing include currently restricting fishing to a ‘footprint’ area, and implementing an ‘evidence of VME’ and move-on protocol in the entire Australian fishing footprint (see Section 4.1.2). If effort levels or the spatial extent of Australian effort expands by a material amount, monitoring, management and mitigation measures will need to be reviewed to ensure that risk of SAI remains low.

There is presently scope to reduce uncertainties in knowledge underlying completion of this (and future) risk assessments, and to increase certainty about the effectiveness of management implementation, with a range of actions involving fishery managers, scientists and industry operators (Table 6.1.1). These include:

- targeted spatial management measures to protect areas where VMEs are predicted to exist – including by using industry-provided acoustic data (depth, species) to define the boundaries of key fishing areas, and potential VME areas that are presently unfished, or unfishable because of the seabed terrain
- improved logbook recording of vessel position to permit fine-scale and consistent mapping of fishing effort distribution (including higher accuracy and specified gear on-bottom recording)
- achieve a higher level of observer coverage of auto-longlining to reduce uncertainty about impacts by this method – including through use of 'e-monitoring' (see below)
- collect VME evidence using cost-effective camera-based methods to supplement existing observer coverage:
    - 'e-monitoring' with deck based cameras of sufficient resolution to cost-effectively and more comprehensively identify VME taxa in fishing bycatch
    - identify potential VME taxa/ regions with compact cameras mounted on fishing gears (ruggedized equipment suited to this application requires little additional development by the AAD and CSIRO to be used for monitoring purposes)
- support research to define VMEs and assist predictive models with ongoing data collection using other in-water sensors such as mini-CTDs to record attributes of water column structure
- improving the 'evidence of VME' protocol by
    - increasing the reliability of VME taxa identification with formalised training and a dedicated logsheet
    - improving compatibility of observer databases to merge information currently residing in different databases
    - targeted collection of selected biological specimens – including for research that identifies regional substructure to inform VME management

Table 6.1.1 Summary of elements of impact and risk showing the key sources of uncertainty that affect the confidence of ratings, and the opportunities that exist to reduce uncertainty. Numbers in square brackets indicate relevance to the individual elements of impact.

Elements of impact/ risk assessment from the BFIAS	Confidence in LOW risk rating	Key sources of (risk increasing) uncertainty for Australian BFIA	Opportunities to reduce knowledge and implementation uncertainties in Australian BFIA
1. Intensity Severity of impact is 'none', 'low', 'medium' or high' at the specific site detected?	Low/ medium	The extent to which landed bycatch underestimates fishing impact is not known, but is expected to be high. [1, 3] Knowledge of the identity and quantity of VME fauna impacted is limited by the resolution of the bycatch data collected, and lack of direct *in situ* observations of VMEs present. [1, 2] Neither fishing effort distribution nor VME distribution are precisely mapped at 'site' or any coarser scale. [1, 3] It is not known if VMEs and fishing effort is co-located at fine spatial scales, or if there are ecological dependencies of target species on VME areas. [1, 3] There is little information on the recovery trajectories by different and variously impacted deep ocean VME communities, and the potential for a variety of persistent stable states during recovery. [2] There is little knowledge of regional scale (biogeographic) substructure [3] Few empirical data link impacts to effects on ecosystem function and processes at ecologically relevant spatial, temporal and environmental scales. [1,2, 3, 4] Cumulative impacts will occur across Flag States but are undocumented [1, 2, 3, 4]	Improved indentification and standard recording of VME bycatch [1, 2] Verified reporting of VME bycatch for all operations, i.e. presence AND absence recorded [1, 2, 3] VMEs and VME indicators mapped at ecologically relevant scales - local and site - including with cameras [1, 2, 3] Accurately recorded on-bottom fishing positions [1, 3] Baseline information and data established for representative VMEs within the SPRFMO Area [1, 2, 3, 4] Targeted collection of biological material to identify regional (biogeographic) sub-structure [2, 3] Further development and validation of methods to predictively map VME distributions [3] Re-evaluate risks when collated information on all fishing footprints is available to estimate the cumulative extent of impact, and to refine 'whole-of-area' precautionary management measures [4]
2. Duration Expected duration of impact is 'short', 'medium', 'long' ?	High		
3. Spatial extent The spatial impact relative to the extent of VMEs	Medium		
4. Cumulative impact Repeated impacts may accumulate in time and space	High		

6.2 Scientific research

The 'data-poor' reality for most of the SPRFMO Area means that mapping VMEs may be limited to estimating their associations with seabed topography (seamounts and, potentially, other geomorphic features) and depth zones (bathomes). In data-poor cases, precautionary decisions need to be made about risks of localised impacts on habitat types with restricted distributions, and fragmentation leading to the associated loss of connectivity between types. We concur with the New Zealand BFIA (MFish 2008) that the effective protection of VMEs in the longer term is likely to require the regional implementation of a series of spatial closures that protect adequate and representative areas of VMEs. This acknowledges that some key uncertainties (e.g. ocean basin scale mapping of VMEs) will remain unknown for a long time relative to the accumulation of impacts in time and space. Identifying suitable areas for closures will be aided by identifying regional substructure (biogeographic patterns), and environmental modelling that predicts locations of VME fauna. These research areas are a focus for international scientists, including from Australia, New Zealand, the United States of America, Canada, Chile and the United Kingdom, and will benefit from data collected in the SPRFMO Area.

Future risk assessment will ideally include a focus on ecological effects such as maintaining population connectivity and trophic relationships. This will require integrating many ecologically relevant data sources, and then building the concept of ecological resilience into management planning (Thrush and Dayton 2010). Maintaining the overall resilience of seamount benthic ecosystems, currently the best indicator type for the locations of VMEs, will be assisted by protecting intact habitats on shallow seamounts to mitigate against the impacts of climate change, and, over a range of depths, especially <1500 m, on clusters and isolated seamounts (Williams et al. 2010).

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9. APPENDICES

Appendix 1 – Examples of potential VMEs

Examples of potentially vulnerable species groups, communities and habitats, as well as features that potentially support them according to the FAO guidelines, Annex 1 (as quoted in the SPRFMO Bottom Fishing Impact Assessment Standard – SPRFMO 2009):

The following examples of species groups, communities, habitats and features often display characteristics consistent with possible VMEs. Merely detecting the presence of an element itself is not sufficient to identify a VME. That identification should be made on a case-by-case basis through application of relevant provisions of these Guidelines, particularly Sections 3.2 and 5.2.

Examples of species groups, communities and habitat forming species that are documented or considered sensitive and potentially vulnerable to DSFs in the high-seas, and which many contribute to forming VMEs:

i. certain coldwater corals and hydroids, e.g. reef builders and coral forest including: stony corals (Scleractinia), alcyonaceans and gorgonians (Octocorallia), black corals (Antipatharia) and hydrocorals (Stylasteridae);

ii. some types of sponge dominated communities;

iii. communities composed of dense emergent fauna where large sessile protozoans (xenophyophores) and invertebrates (e.g. hydroids and bryozoans) form an important structural component of habitat; and

iv. seep and vent communities comprised of invertebrate and microbial species found nowhere else (i.e. endemic).

Examples of topographical, hydrophysical or geological features, including fragile geological structures, that potentially support the species groups or communities, referred to above:

i. submerged edges and slopes (e.g. corals and sponges);

ii. summits and flanks of seamounts, guyots, banks, knolls, and hills (e.g. corals, sponges, xenophyphores);

iii. canyons and trenches (e.g. burrowed clay outcrops, corals);

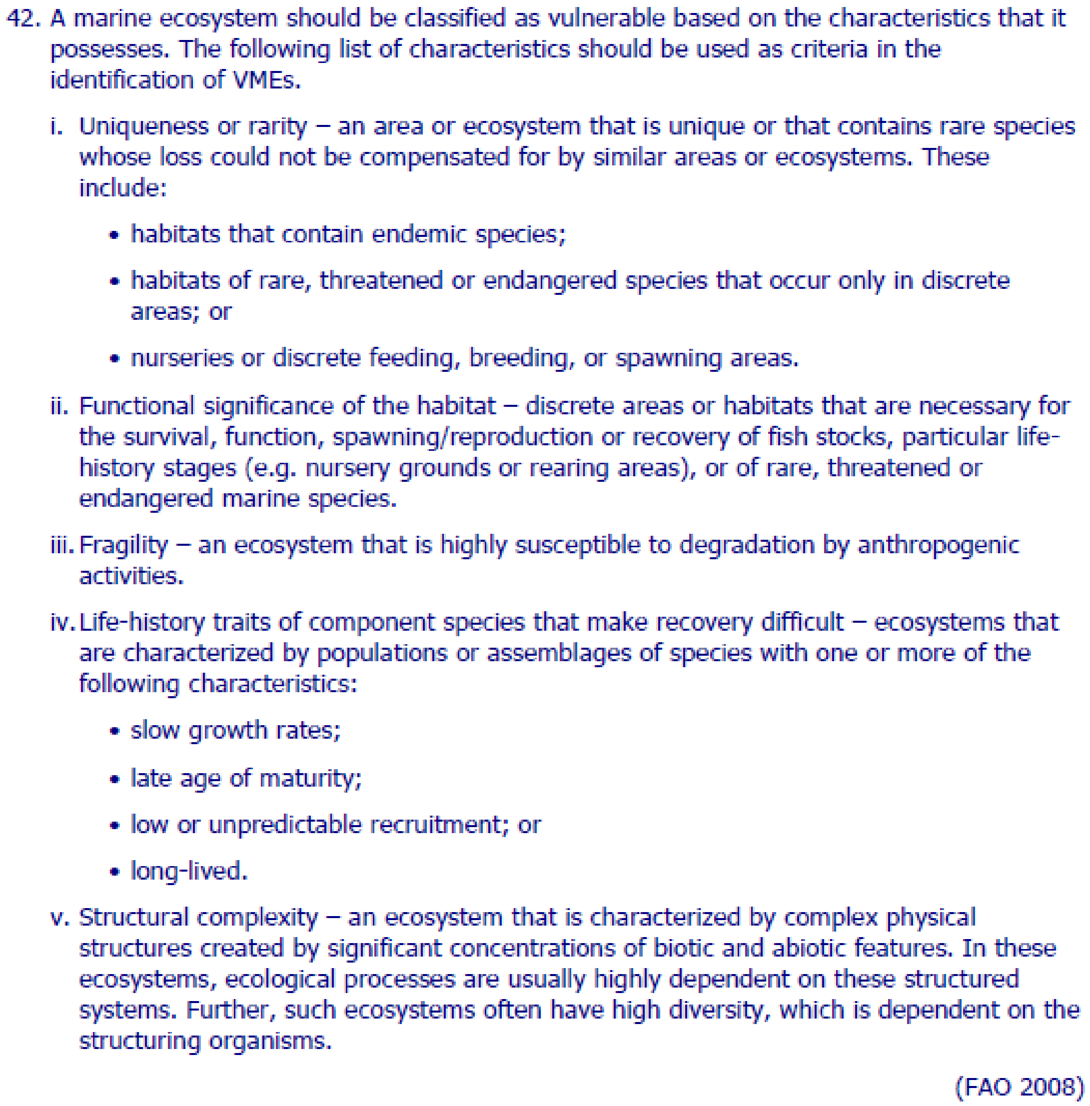
iv. hydrothermal vents (e.g. microbial communities and endemic invertebrates); and

v. cold seeps (e.g. mud volcanoes for microbes, hard substrates for sessile invertebrates).

(FAO 2008)

Appendix 2 – Criteria for identification of VMEs

Characteristics which should be used as criteria in the definition of vulnerable marine ecosystems according to the FAO guidelines (as quoted in the SPRFMO Bottom Fishing Impact Assessment Standard – SPRFMO 2009):



42. A marine ecosystem should be classified as vulnerable based on the characteristics that it possesses. The following list of characteristics should be used as criteria in the identification of VMEs.

    i. Uniqueness or rarity – an area or ecosystem that is unique or that contains rare species whose loss could not be compensated for by similar areas or ecosystems. These include:

        - habitats that contain endemic species;
        - habitats of rare, threatened or endangered species that occur only in discrete areas; or
        - nurseries or discrete feeding, breeding, or spawning areas.

    ii. Functional significance of the habitat – discrete areas or habitats that are necessary for the survival, function, spawning/reproduction or recovery of fish stocks, particular life-history stages (e.g. nursery grounds or rearing areas), or of rare, threatened or endangered marine species.

    iii. Fragility – an ecosystem that is highly susceptible to degradation by anthropogenic activities.

    iv. Life-history traits of component species that make recovery difficult – ecosystems that are characterized by populations or assemblages of species with one or more of the following characteristics:

        - slow growth rates;
        - late age of maturity;
        - low or unpredictable recruitment; or
        - long-lived.

    v. Structural complexity – an ecosystem that is characterized by complex physical structures created by significant concentrations of biotic and abiotic features. In these ecosystems, ecological processes are usually highly dependent on these structured systems. Further, such ecosystems often have high diversity, which is dependent on the structuring organisms.

(FAO 2008)

Appendix 3 – Vulnerability of invertebrates to physical disturbance

Reproduction of Table 1 from CCAMLR (2009)

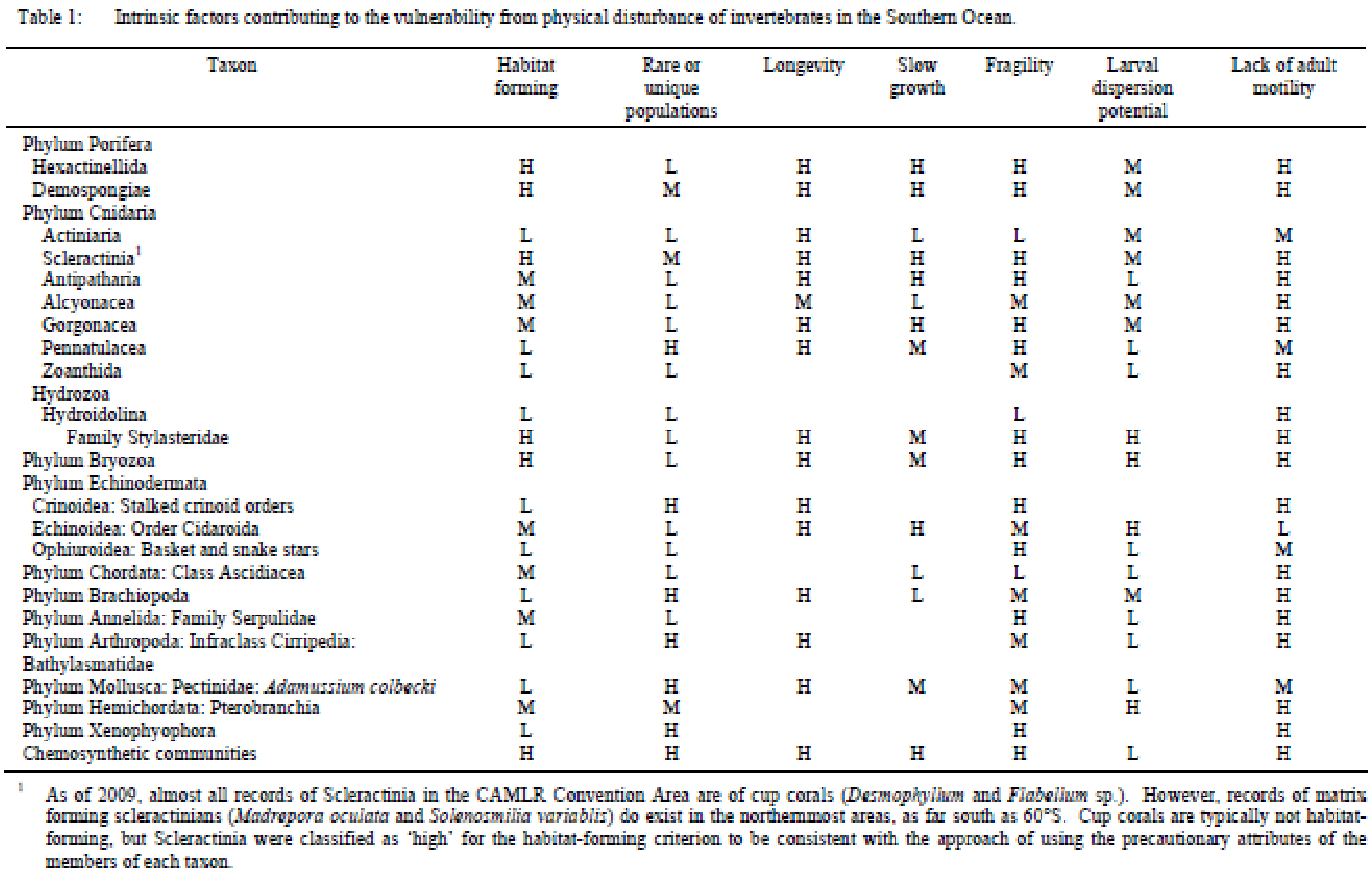


Table 1: Intrinsic factors contributing to the vulnerability from physical disturbance of invertebrates in the Southern Ocean.

Taxon	Habitat forming	Rare or unique populations	Longevity	Slow growth	Fragility	Larval dispersion potential	Lack of adult motility
Phylum Porifera							
Hexactinellida	H	L	H	H	H	M	H
Demospongiae	H	M	H	H	H	M	H
Phylum Cnidaria							
Actiniaria	L	L	H	L	L	M	M
Scleractinia[1]	H	M	H	H	H	M	H
Antipatharia	M	L	H	H	H	L	H
Alcyonacea	M	L	M	L	M	M	H
Gorgonacea	M	L	H	H	H	M	H
Pennatulacea	L	H	H	M	H	L	M
Zoanthida	L	L			M	L	H
Hydrozoa							
Hydroidolina	L	L			L		H
Family Stylasteridae	H	L	H	M	H	H	H
Phylum Bryozoa	H	L	H	M	H	H	H
Phylum Echinodermata							
Crinoidea: Stalked crinoid orders	L	H	H		H		H
Echinoidea: Order Cidaroida	M	L	H	H	M	H	L
Ophiuroidea: Basket and snake stars	L	L			H	L	M
Phylum Chordata: Class Ascidiacea	M	L		L	L	L	H
Phylum Brachiopoda	L	H	H	L	M	M	H
Phylum Annelida: Family Serpulidae	M	L			H	L	H
Phylum Arthropoda: Infraclass Cirripedia: Bathylasmatidae	L	H	H		M	L	H
Phylum Mollusca: Pectinidae: *Adamussium colbecki*	L	H	H	M	M	L	M
Phylum Hemichordata: Pterobranchia	M	M			M	H	H
Phylum Xenophyophora	L	H			H		H
Chemosynthetic communities	H	H	H	H	H	L	H

[1] As of 2009, almost all records of Scleractinia in the CAMLR Convention Area are of cup corals (*Desmophyllum* and *Flabellum* sp.). However, records of matrix forming scleractinians (*Madrepora oculata* and *Solenosmilia variablis*) do exist in the northernmost areas, as far south as 60°S. Cup corals are typically not habitat-forming, but Scleractinia were classified as 'high' for the habitat-forming criterion to be consistent with the approach of using the precautionary attributes of the members of each taxon.

Appendix 4 – What constitutes significant bycatch of a VME?

Reproduced from Rogers et al. (2008) – pg 26 & 27:

“Practical guidelines have been drawn from observations of the quantities of by-catch that may be associated with the existence of VMEs on the seabed from different types of fishing gear[11,12] *as well as the authors’ own experience of how key species that comprise VMEs are distributed and their size and shape. These guidelines will have to be tailored to regional requirements or through the application of adaptive management strategies, altered in response to new or specific data related to an area. They are included here solely as an indication of the sorts of factors that should be considered when RFMOs or management agencies discuss how to define a significant encounter with a VME in their area of jurisdiction.”*

Corals	**Sponges or other habitat-forming epifauna**
A single haul constituting >5kg of stony coral or coral Rubble, or >2kg of black corals or octocorals or more than 2 coral colonies	A single haul constituting >5kg of sponge or other habitat-forming epifauna
Two or more consecutive hauls containing > 2kg each of live corals on the same trawl track or setting area for fishing gear or where consecutive trawling tracks or sets intersect	Two or more consecutive hauls containing >5kg sponges or other habitat-forming Epifauna on the same trawl track or setting area for fishing gear or where consecutive trawling tracks or sets intersect.
>4 encounters of corals >2kg within an area (1km^2) within one year. >4 corals per 1000 hooks in a long line fishery within one year within an area (10 km^2).	>10 encounters of >2kg sponges or other habitat forming epifauna in an area (1 km^2) within one year.
>15% of hauls of any gear within an area (10- 100 km^2) containing corals.	>15% of hauls of any gear within an area (10- 100 km^2) containing sponges or other habitat-forming epifaunal taxa.

Appendix 5 – Decision-support diagram for managing VMEs

Reproduction of Figure 1 from Auster et al. (2010)

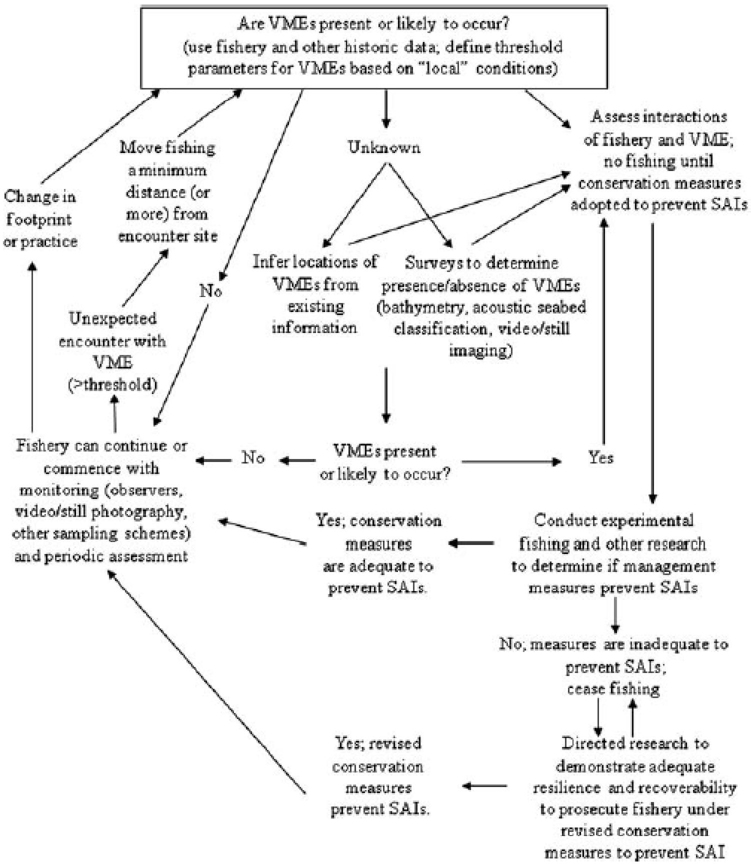
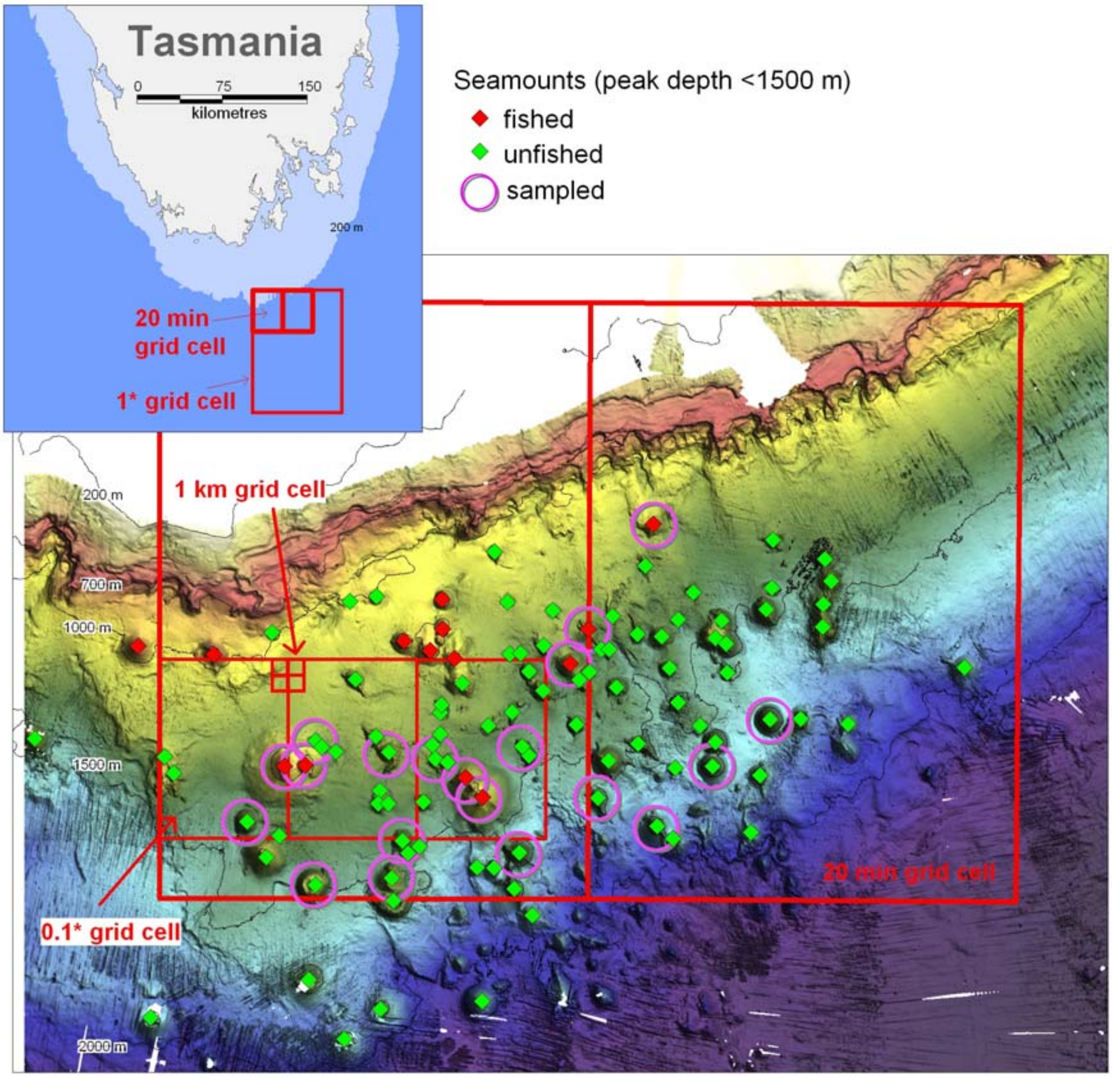


Figure 1. Decision-support diagram for managing vulnerable marine ecosystems based on FAO guidelines (modified from FAO, 2008).

Appendix 6 – Tasmanian Seamounts — illustrating the relevance of spatial scales to the BFIA process

An illustration of spatial scales relevant to BFIA using a well-studied fishery area encompassing a cluster of small conical seamounts south of Tasmania. The grid cell sizes are 1º (the finest scale at which some data layers are available at global scales); 20' (SPRFMO footprint standard); 0.1º (scale of fishing effort distribution mapped in this BFIA); and 1 km (the scale of fishing effort mapping typical in Australian domestic fisheries, the scale mapped by scientific observers in CCAMLR, and the scale suited to understand the fine scale impacts of fishing on individual features). Multi-beam swath image (20 m resolution) shaded by depth with main contours shown at left-hand side of image. Individual seamounts with peak depths of <1500 m flagged with fishing history and presence of scientific sampling.



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