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Australian Government
Australian Fisheries Management Authority

Ecological Risk Assessment for Effects of Fishing

REPORT FOR THE DEMERSAL LONGLINE SUBFISHERY OF THE HEARD AND MCDONALD ISLANDS FISHERY

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This fishery Ecologic Risk Assessment report should be cited as:

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Notes to this document:
This fishery ERA report contains figures and tables with numbers that correspond to the full methodology document for the ERAEF method:

> Hobday, A. J., A. Smith, H. Webb, R. Daley, S. Wayte, C. Bulman, J. Dowdney, A. Williams, M. Sporcic, J. Dambacher, M. Fuller, T. Walker (2007). Ecological Risk Assessment for the Effects of Fishing: Methodology. Report R04/1072 for the Australian Fisheries Management Authority, Canberra.

Thus, table and figure numbers within the fishery ERA report are not sequential as not all are relevant to the fishery ERA report results.

Additional details on the rationale and the background to the methods development are contained in the ERAEF Final Report:

> Smith, A., A. Hobday, H. Webb, R. Daley, S. Wayte, C. Bulman, J. Dowdney, A. Williams, M. Sporcic, J. Dambacher, M. Fuller, D. Furlani, T. Walker. (2007). Ecological Risk Assessment for the Effects of Fishing: Final Report R04/1072 for the Australian Fisheries Management Authority, Canberra.

Executive Summary

This assessment of the ecological impacts of the Heard and McDonald Islands Demersal Longline Fishery was undertaken using the ERAEF method version 9.2. ERAEF stands for "Ecological Risk Assessment for Effect of Fishing", and was developed jointly by CSIRO Marine and Atmospheric Research, and the Australian Fisheries Management Authority. ERAEF provides a hierarchical framework for a comprehensive assessment of the ecological risks arising from fishing, with impacts assessed against five ecological components – target species; by-product and by-catch species; threatened, endangered and protected (TEP) species; habitats; and (ecological) communities.

ERAEF proceeds through four stages of analysis: scoping; an expert judgement based Level 1 analysis (SICA – Scale Intensity Consequence Analysis); an empirically based Level 2 analysis (PSA – Productivity Susceptibility Analysis); and a model based Level 3 analysis. This hierarchical approach provides a cost-efficient way of screening hazards, with increasing time and attention paid only to those hazards that are not eliminated at lower levels in the analysis. Risk management responses may be identified at any level in the analysis.

Application of the ERAEF methods to a fishery can be thought of as a set of screening or prioritization steps that work towards a full quantitative ecological risk assessment. At the start of the process, all components are assumed to be at high risk. Each step, or Level, potentially screens out issues that are of low concern. The Scoping stage screens out activities that do not occur in the fishery. Level 1 screens out activities that are judged to have low impact, and potentially screens out whole ecological components as well. Level 2 is a screening or prioritization process for individual species, habitats and communities at risk from direct impacts of fishing. The Level 2 methods do not provide absolute measures of risk. Instead they combine information on productivity and exposure to fishing to assess potential risk – the term used at Level 2 is risk. Because of the precautionary approach to uncertainty, there will be more false positives than false negatives at Level 2, and the list of high risk species or habitats should not be interpreted as all being at high risk from fishing. Level 2 is a screening process to identify species or habitats that require further investigation. Some of these may require only a little further investigation to identify them as a false positive; for some of them managers and industry may decide to implement a management response; others will require further analysis using Level 3 methods, which do assess absolute levels of risk.

This assessment of the Heard and McDonald Islands Demersal Longline Fishery includes the following:

- Scoping
- Level 1 results for all components
- Level 2 results for the three species components, and for habitats

Fishery Description

Gear:	Demersal longline (autoline)
Area:	Heard and McDonald Islands Fishery
Depth range:	800- 1000m
Fleet size:	1-2 vessels
Effort:	Approximately 1,500,000 hooks per year *
Landings:	636 t in 2005
Discard rate:	Quota species 0 %; non-quota species ~15% in 2005
Main target species:	Patagonian toothfish
Management:	Quota management system for 2 species/stocks and 6 bycatch species/groups
Observer program:	observer program operating since beginning of fishery in 1997

Ecological Units Assessed

Target species:	1
Byproduct species:	17
Bycatch (Discard) Species:	1
TEP species:	84
Habitats:	NA
Communities:	9

Level 1 Results

Habitats for this fishery were not assessed using most recent ERAEF methodology due to unavailability of habitat data. A study of benthic habitats is currently being undertaken and future work proposed for this region, by the AAD.

Risk scores ranged from 1 - 4 across all 32 hazards (fishing activities) considered and four ecological components assessed. A number of hazards were eliminated at Level 1 (risk scores 1 or 2). Two hazards were given further consideration. Those hazards had risk scores of $\geq$3:

- Fishing (direct impact with capture on target species, byproduct/bycatch species and community components)

- Translocation of species (impact on target species, byproduct/bycatch species and community components)

The external hazard, 'other fisheries', had risk scores of $\geq$3 for all components.

One ecological component was eliminated at Level 1: TEP. It is important to note that the worst case scenario considered for TEP species was the impact of capture fishing on black-browed albatross. This bird species has the smallest population size for any in the region – around 1,200. However, it is almost certain that an annual catch of 1% (12 birds per year) would not prevent this fishery from meeting its main objective for TEP species - ensure TEP species do not further approach extinction of become extinct. The

fishery currently has measures in place which would result in closure of the sub-fishery before ten birds were caught in a year. In addition, there are no records of birds being captured during deployment of the gear. Only three birds have been caught in the history of the sub-fishery.

The remaining three components examined had consequence (risk) score ≥3 for at least one activity.

Capture fishing risks to target and byproduct/discards were evaluated at level 2 PSA.

The risks associated with frozen bait are assessed by AQUIS.

Level 2 Results

Species
A total of 19 species were examined at level two. Of the 19 species assessed, expert overrides were used only on one species. Of the 13 species were initially scored at high risk, four of these species had more than three missing attributes, and are likely to be false positive results. One of the high risk species was the target species which is under comprehensive management plans. This leaves seven species of genuine concern and three species of whiptails at medium risk and not of greatest concern. The species at highest risk in this sub-fishery are sleeper sharks and skates. There has been a study of sleeper sharks in the Southern Ocean but it does not include yield estimates. There have limited studies of skates in the region. A maximum allowable catch is in place for skates but it is not clear that this catch level is sustainable. Skates are extraordinarily vulnerable (Musick, *et al*., 2000) and are considered one of the most threatened groups of all marine species worldwide. There have been local and near extinctions overseas (Dulvy *et al*., 2000; Stevens *et al.*, 2000).

Habitats
Habitats for this fishery are not currently assessed using most recent ERAEF methodology due to unavailability of habitat data.

Communities
The community component was not assessed at Level 2 for this sub-fishery, but should be considered in future assessments when the methods to do this are fully developed.

Summary
To date the principle ecological concern for the automatic-longline sub-fishery around Heard Island has been has been TEP species and birds in particular. This ERAEF assessment indicates these concerns have been largely allayed by mitigation measures. Observer data has demonstrated these measures have been effective. In the absence of any annual catches that exceed ten birds, the bird issue is now largely one of ensuring compliance with these measures.

Conversely skates are regularly caught in significant numbers. There are genuine concerns for skates worldwide because of their low productivity and a high proportion of endemic species. Fishers report that skates can be released alive and this is considered best practice. However, tagging studies suggest that post capture survivorship of skates is much lower than toothfish. In addition, there has been no analysis of observer data to ensure that the best practice of releasing skates by cutting the snood to prevent jaw injury has been followed.

Managing identified risks

Using the results of the ecological risk assessment, the next steps for each fishery will be to consider and implement appropriate management responses to address these risks. To ensure a consistent process for responding to the ERA outcomes, AFMA has developed an Ecological Risk Management (ERM) framework.

TABLE OF CONTENTS

Fishery ERA reports to be completed

List of Summary documents

List of Scoping documents

List of Level 1 (SICA) documents

List of Level 2 (PSA) documents

List of figures

List of tables

1. Overview

Ecological Risk Assessment for the Effects of Fishing (ERAEF) Framework

The Hierarchical Approach

The Ecological Risk Assessment for the Effects of Fishing (ERAEF) framework involves a hierarchical approach that moves from a comprehensive but largely qualitative analysis of risk at Level 1, through a more focused and semi-quantitative approach at Level 2, to a highly focused and fully quantitative "model-based" approach at Level 3 (**Figure 1**). This approach is efficient because many potential risks are screened out at Level 1, so that the more intensive and quantitative analyses at Level 2 (and ultimately at Level 3) are limited to a subset of the higher risk activities associated with fishing. It also leads to rapid identification of high-risk activities, which in turn can lead to immediate remedial action (risk management response). The ERAEF approach is also precautionary, in the sense that risks will be scored high in the absence of information, evidence or logical argument to the contrary.

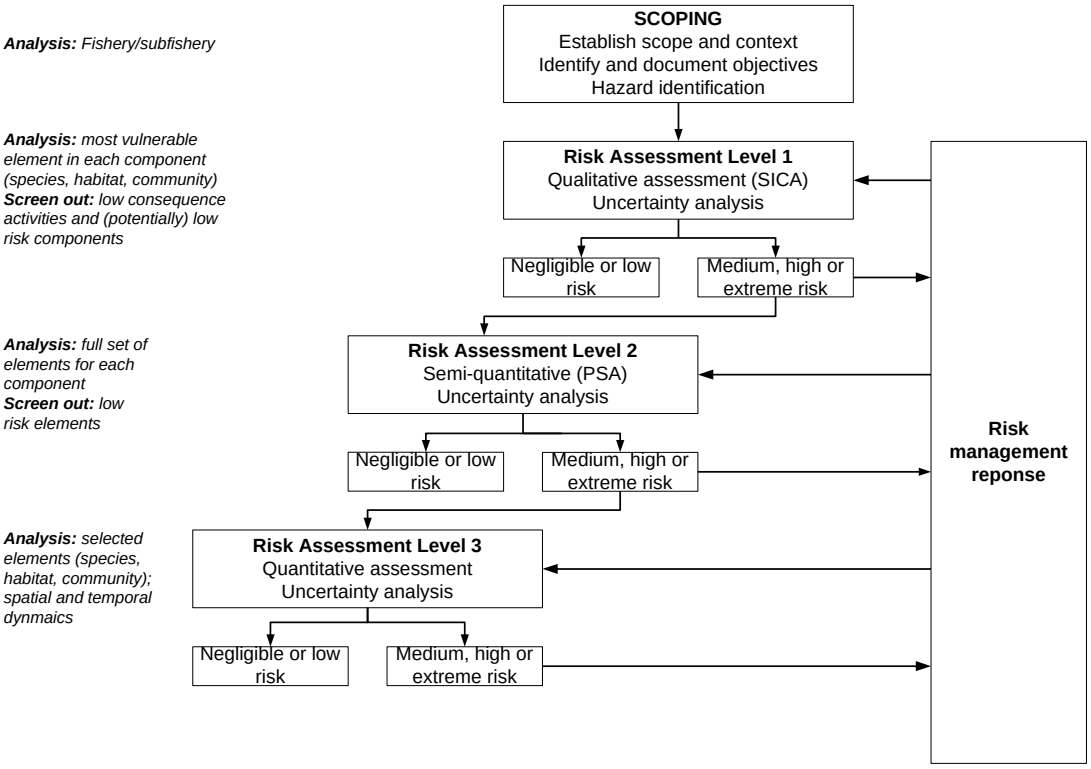


Figure 1. Overview of ERAEF showing focus of analysis for each level at the left in italics.

Conceptual Model

The approach makes use of a general conceptual model of how fishing impacts on ecological systems, which is used as the basis for the risk assessment evaluations at each level of analysis (Levels 1-3). For the ERAEF approach, five general ecological

components are evaluated, corresponding to five areas of focus in evaluating impacts of fishing for strategic assessment under EPBC legislation. The five *components* are:

- Target species
- By-product and by-catch species
- Threatened, endangered and protected species (TEP species)
- Habitats
- Ecological communities

This conceptual model (**Figure 2**) progresses from *fishery characteristics* of the fishery or sub-fishery, → *fishing activities* associated with fishing and *external activities*, which may impact the five ecological components (target, byproduct and bycatch species, TEP species, habitats, and communities); → *effects of fishing and external activities* which are the direct impacts of fishing and external activities; → *natural processes and resources* that are affected by the impacts of fishing and external activities; → *sub-components* which are affected by impacts to natural processes and resources; → *components*, which are affected by impacts to the sub-components. Impacts to the sub-components and components in turn affect achievement of management objectives.

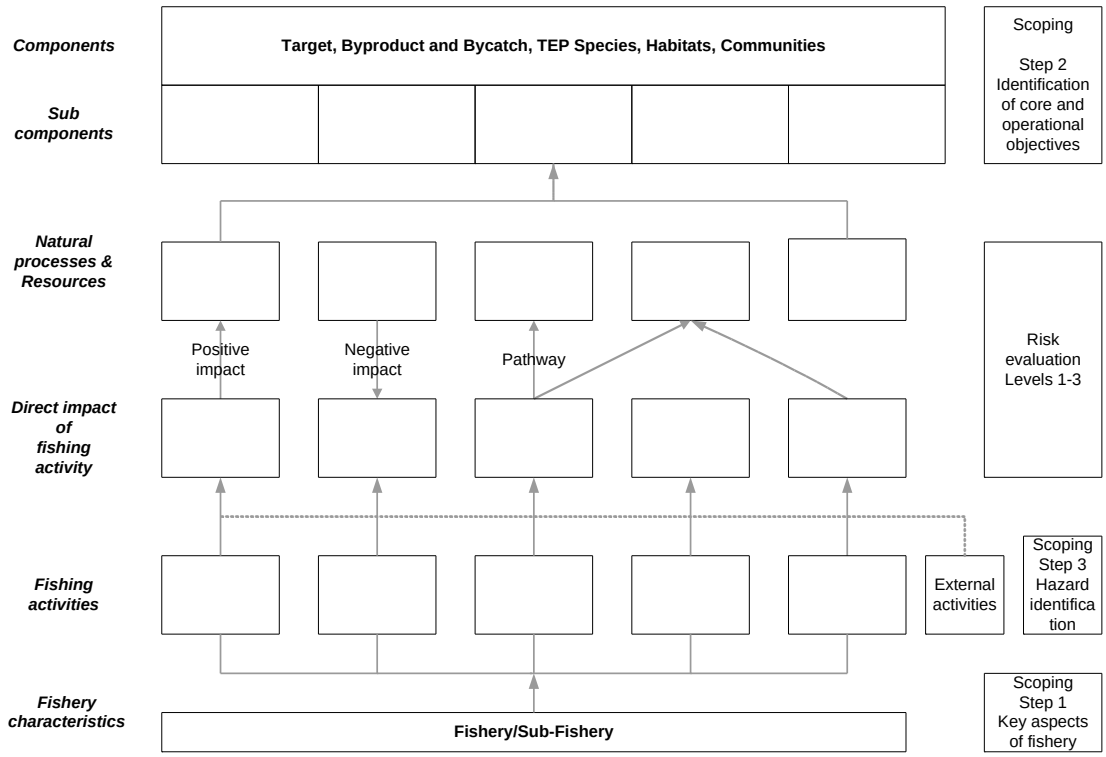


Figure 2. Generic conceptual model used in ERAEF.

The external activities that may impact the fishery objectives are also identified at the Scoping stage and evaluated at Level 1. This provides information on the additional impacts on the ecological components being evaluated, even though management of the external activities is outside the scope of management for that fishery.

The assessment of risk at each level takes into account current management strategies and arrangements. A crucial process in the risk assessment framework is to document the rationale behind assessments and decisions at each step in the analysis. The decision to proceed to subsequent levels depends on

- Estimated risk at the previous level
- Availability of data to proceed to the next level
- Management response (e.g. if the risk is high but immediate changes to management regulations or fishing practices will reduce the risk, then analysis at the next level may be unnecessary).

A full description of the ERAEF method is provided in the methodology document (Hobday et al 2007). This fishery report contains figures and tables with numbers that correspond to this methodology document. Thus, table and figure numbers within this fishery ERAEF report are not sequential, as not all figures and tables are relevant to the fishery risk assessment results.

ERAEF stakeholder engagement process

A recognized part of conventional risk assessment is the involvement of stakeholders involved in the activities being assessed. Stakeholders can make an important contribution by providing expert judgment, fishery-specific and ecological knowledge, and process and outcome ownership. The ERAEF method also relies on stakeholder involvement at each stage in the process, as outlined below. Stakeholder interactions are recorded.

Scoping

In the first instance, scoping is based on review of existing documents and information, with much of it collected and completed to a draft stage prior to full stakeholder involvement. This provides all the stakeholders with information on the relevant background issues. Three key outputs are required from the scoping, each requiring stakeholder input.

1. Identification of units of analysis (species, habitats and communities) potentially impacted by fishery activities (section 2.2.2; Scoping Documents S2A, S2B and S2C).
2. Selection of objectives (section 2.2.3; Scoping Document S3) is a challenging part of the assessment, because these are often poorly defined, particularly with regard to the habitat and communities components. Stakeholder involvement is necessary to agree on the set of objectives that the risks will be evaluated against. A set of preliminary objectives relevant to the sub-components is selected by the drafting authors, and then presented to the stakeholders for modification. An agreed set of objectives is then used in the Level 1 SICA analysis. The agreement of the fishery management advisory body (e.g. the MAC, which contains representatives from industry, management, science, policy and conservation) is considered to represent agreement by the stakeholders at large.
3. Selection of activities (hazards) (section 2.2.4; Scoping Document S4) that occur in the sub-fishery is made using a checklist of potential activities provided. The checklist was developed following extensive review, and allows repeatability between fisheries. Additional activities raised by the stakeholders can be

included in this checklist (and would feed back into the original checklist). The background information and consultation with the stakeholders is used to finalize the set of activities. Many activities will be self-evident (e.g. fishing, which obviously occurs), but for others, expert or anecdotal evidence may be required.

Level 1. SICA (Scale, Intensity, Consequence Analysis)

The SICA analysis evaluates the risk to ecological components resulting from the stakeholder-agreed set of activities. Evaluation of the temporal and spatial scale, intensity, sub-component, unit of analysis, and credible scenario (consequence for a sub-component) can be undertaken in a workshop situation, or prepared ahead by the draft fishery ERA report author and debated at the stakeholder meeting. Because of the number of activities (up to 24) in each of five components (resulting in up to 120 SICA elements), preparation before involving the full set of stakeholders may allow time and attention to be focused on the uncertain or controversial or high risk elements. The rationale for each SICA element must be documented and this may represent a challenge in the workshop situation. Documenting the rationale ahead of time for the straw-man scenarios is crucial to allow the workshop debate to focus on the right portions of the logical progression that resulted in the consequence score.

SICA elements are scored on a scale of 1 to 6 (negligible to extreme) using a "plausible worst case" approach (see ERAEF Methods Document for details). Level 1 analysis potentially result in the elimination of activities (hazards) and in some cases whole components. Any SICA element that scores 2 or less is documented, but not considered further for analysis or management response.

Level 2. PSA (Productivity Susceptibility Analysis)

The semi-quantitative nature of this analysis tier should reduce but not eliminate the need for stakeholder involvement. In particular, transparency about the assessment will lead to greater confidence in the results. The components that were identified to be at moderate or greater risk (SICA score > 2) at Level 1 are examined at Level 2. The units of analysis at Level 2 are the agreed set of species, habitat types or communities in each component identified during the scoping stage. A comprehensive set of attributes that are proxies for productivity and susceptibility have been identified during the ERAEF project. Where information is missing, the default assumption is that risk will be set high. Details of the PSA method are described in the accompanying ERAEF Methods Document. Stakeholders can provide input and suggestions on appropriate attributes, including novel ones, for evaluating risk in the specific fishery. The attribute values for many of the units (e.g. age at maturity, depth range, mean trophic level) can be obtained from published literature and other resources (e.g. scientific experts) without full stakeholder involvement. This is a consultation of the published scientific literature. Further stakeholder input is required when the preliminary gathering of attribute values is completed. In particular, where information is missing, expert opinion can be used to derive the most reasonable conservative estimate. For example, if the species attribute values for annual fecundity have been categorized as low, medium and high on the set [<5, 5-500, >500], estimates for species with no data can still be made. Estimated fecundity of a species such as a broadcast-spawning fish with unknown fecundity, is still likely greater than the cut-off for the high fecundity categorization (>500). Susceptibility attribute estimates, such as "fraction alive when landed", can also be

made based on input from experts such as scientific observers. The final PSA is completed by scientists because access to computing resources, databases, and programming skills is required. Feedback to stakeholders regarding comments received during the preliminary PSA consultations is considered crucial. The final results are then presented to the stakeholder group before decisions regarding Level 3 are made. The stakeholder group may also decide on priorities for analysis at Level 3.

Level 3

This stage of the risk assessment is fully-quantitative and relies on in-depth scientific studies on the units identified as at medium or greater risk in the Level 2 PSA. It will be both time and data-intensive. Individual stakeholders are engaged as required in a more intensive and directed fashion. Results are presented to the stakeholder group and feedback incorporated, but live modification is not considered likely.

Conclusion and final risk assessment report

The conclusion of the stakeholder consultation process will result in a final risk assessment report for the individual fishery according to the ERAEF methods. It is envisaged that the completed assessment will be adopted by the fishery management group and used by AFMA for a range of management purposes, including addressing the requirements of the EPBC Act as evaluated by Department of the Environment and Heritage.

Subsequent risk assessment iterations for a fishery

The frequency at which each fishery must revise and update the risk assessment is not fully prescribed. As new information arises or management changes occur, the risks can be re-evaluated, and documented as before. The fishery management group or AFMA may take ownership of this process, or scientific consultants may be engaged. In any case the ERAEF should again be based on the input of the full set of stakeholders and reviewed by independent experts familiar with the process.

Each fishery ERA report will be revised at least every four years or as required by Strategic Assessment. However, to ensure that actions in the intervening period do not unduly increase ecological risk, each year certain criteria will be considered. At the end of each year, the following trigger questions should be considered by the MAC for each sub-fishery.

- Has there been a change in the spatial distribution of effort of more than 50% compared to the average distribution over the previous four years?
- Has there been a change in effort in the fishery of more than 50% compared to the four year average (e.g. number of boats in the fishery)?
- Has there been an expansion of a new gear type or configuration such that a new sub-fishery might be defined?

▪ Responses to these questions should be tabled at the relevant fishery MAC each year and appear on the MAC calendar and work program. If the answer to any of these trigger questions is yes, then the sub-fishery should be re-evaluated.

2. Results

The focus of analysis is the fishery as identified by the responsible management authority. The assessment area is defined by the fishery management jurisdiction within the AFZ. The fishery may also be divided into sub-fisheries on the basis of fishing method and/or spatial coverage. These sub-fisheries should be clearly identified and described during the scoping stage. Portions of the scoping and analysis at Level 1 and beyond, is specific to a particular sub-fishery. The fishery is a group of people carrying out certain activities as defined under a management plan. Depending on the jurisdiction, the fishery/sub-fishery may include any combination of commercial, recreational, and/or indigenous fishers.

2.1 Stakeholder engagement

2.1 Summary Document SD1. Summary of stakeholder involvement for fishery

Heard and McDonald Islands Demersal Longline Fishery

	Type of stakeholder interaction	Date of stakeholder interaction	Composition of stakeholder group (names or roles)	Summary of outcome
Scoping	Phone calls and email	July-October	Bob Stanley, AFMA logbook manager. Geoff Tuck, CSIRO	Provided information for scoping stage of fishery ERA report
	Meeting. MSC Icefish review committee general meeting at IASOS	October 27, 2003	MSC Committee, various IASOS staff and students	ERA methods discussed. Agreement to provide some information to the MSC group if request received.
	Email and phone calls	April 20-26, 2004	Campbell Davies led a small group reviewing fishery ERA report	Draft reviewed by AAD scientists. Comments on out dated information and suggestions for additional information made. Experts were identified for additional input. Dick Williams (general expertise) Andrew Constable (general expertise) Tim Lamb (observers) Esmee van Wick (fish by-catch) Graham Robertson and Barbara Wienecke (Sea bird bycatch mitigation) Nick Gales (Marine mammal ecology and fishery interactions)
	Meeting, SAFAG	April 28, 2004	See minutes of meeting	e.g. April 24, feedback on preferred objectives was provided Hazards agreed on.
Level 2 (PSA)	Email and face-to-face	April 2004	Bruce Deagle and AWRU at UTas	Provided some taxa data for diving depths for birds and seals for use in PSA
		May 2006	AAD	Draft species lists reviewed
Level 1 and 2	Stakeholder meeting	27 June 2006	AAD, Industry reps, AFMA	ERA methods and results presented. New composition of group and assessment team and methodology, resulted in necessity to revisit initial steps in process-AFMA to clarify. Level 2 results not discussed. CSIRO to amend Level 1 and Level 2 where appropriate.

2.2 Scoping

The aim in the Scoping stage is to develop a profile of the fishery being assessed. This provides information needed to complete Levels 1 and 2 and at stakeholder meetings. The focus of analysis is the fishery, which may be divided into sub-fisheries on the basis of fishing method and/or spatial coverage. Scoping involves six steps:

Step 1 Documenting the general fishery characteristics
Step 2 Generating "unit of analysis" lists (species, habitat types, communities)
Step 3 Selection of objectives
Step 4 Hazard identification
Step 5 Bibliography
Step 6 Decision rules to move to Level 1

2.2.1 General Fishery Characteristics (Step 1).

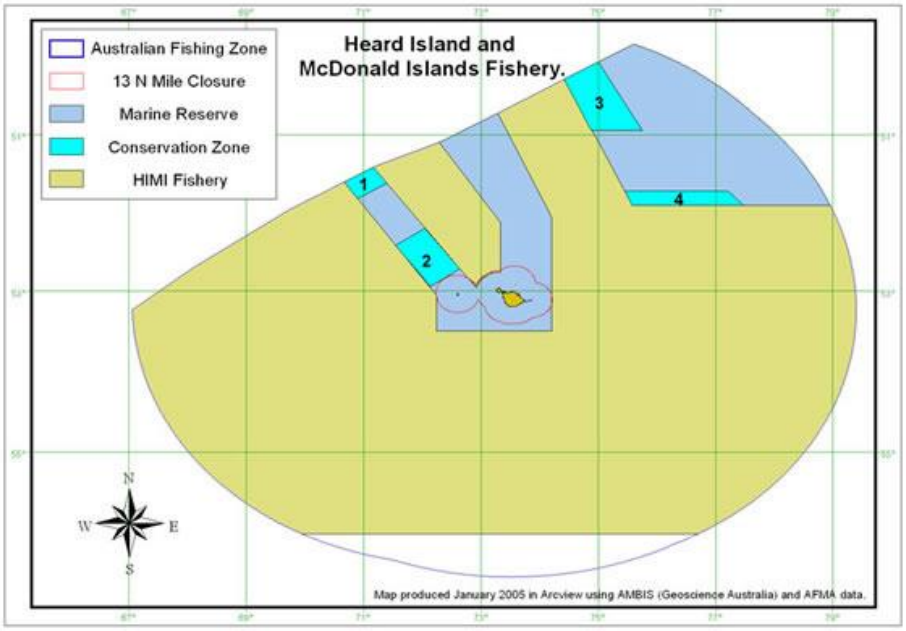
The information used to complete this step may come from a range of documents such as the Fishery's Management Plan, Assessment Reports, Bycatch Action Plans, and any other relevant background documents. The level and range of information available will vary. Some fisheries/sub-fisheries will have a range of reliable information, whereas others may have limited information.

Scoping Document S1 General Fishery Characteristics

Sub-fishery Name: Demersal longline
Fishery Name: Heard and McDonald Islands Fishery
Date of assessment: June 2006

General Fishery Characteristics	
Fishery Name	Heard Island and McDonald Islands (HIMI) Fisheries *(CCAMLR Statistical Division 58.5.2)*
Sub-fisheries	There are currently four sub-fisheries based on fishing methods, the first of which could be considered as two sub-fisheries because two species are targetted: 1. **Demersal otter board trawling** for *Dissostichus eleginoides* Patagonian toothfish and *Champsocephalus gunnari* Mackerel icefish. 2. **Mid-water trawling** for *C. gunnari* Mackerel icefish. This method is considered experimental, and has had limited application over the past few years. 3. **Demersal longlining** for *D. eleginoides* Patagonian toothfish began in May 2003 season under scientific permits. 4. **Pot and trap fishing.** An experimental trap fishery for Patagonian toothfish began in 2005. These methods may significantly reduce seabird and marine mammal interactions that are common issues with longline fisheries although not in the HIMI fishery to date. The advantage of pots and traps over trawling is that they lessen the impact on the benthic habitats. It is thought that these methods could access a different age group of toothfish stocks, as they are capable of being used over the rough bottom that trawling cannot access. The impact of trap fishing on bycatch species would need to be evaluated.
Sub-fisheries assessed	This assessment only considers demersal longlining for *Dissostichus eleginoides* Patagonian toothfish.
Start date/history	Fishing activity in the region had been sparse until recently. There are records of Soviet and Polish vessels fishing both *Dissostichus eleginoides* Patagonian toothfish and *Champsocephalus gunnari* Mackerel icefish in the region in the 1970s and some research

	surveys were conducted by AAD in the early 1990s before the establishment of the EEZs of Australia and France. The Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR) came into force in 1982, as part of the Antarctic Treaty System, with the aim of regulating exploitation rather than outright protection. CCAMLR was established at a time when commercial interests in krill were growing rapidly; it began to be truly effective as a management regime in 1991 when the first catch limits were set. From the outset CCAMLR was based on the principle that management of fisheries should include not just the target species but also dependent and associated species and their ecological relationships. Commercial fishing for *D. eleginoides* and *C. gunnari* by Australian operators commenced in March 1997 using demersal and midwater trawls in accordance with CCAMLR Conservation Measure 110/XV. Subsequently, licensed Australian vessels have attempted to take the TAC set by CCAMLR each year but due to fluctuations in abundances, they have not always caught it (Williams *et al.* 2002). Longlining for *D. eleginoides* began in May 2003. *D. eleginoides* has recently been targeted at a number of locations in the subantarctic. The fishery has attracted unauthorised operators from several countries that are working outside the regulatory framework. Illegal, unregulated or unreported (IUU) fishing is of concern because it has the potential to undermine attempts to manage fish stocks. In 1999, CCAMLR adopted a catch documentation scheme which will help prevent illegally caught fish entering the markets of CCAMLR nations. IUU fishing is also a concern because it may involve the use of fishing techniques that can cause the death of non-target species as by-catch. In particular, albatrosses are taken inadvertently by long-line fishing. CCAMLR has introduced a Conservation Measure to reduce the incidence of seabird mortality during long-lining. The Australian Fisheries Management Authority limits the fishery around Heard and Macquarie Islands to trawling to minimise the impacts on seabirds. The Australian Antarctic Division has recently established the Antarctic Marine Living Resources program to provide the scientific basis for ecologically sustainable management of Southern Ocean fisheries. (Source: http://www.afma.gov.au/fisheries)
Geographic extent of fishery	The fishery operates in sub-Antarctic waters adjacent to Heard Island and the McDonald Islands. Heard Island and McDonald Islands (HIMI) are external territories of Australia located in the Southern Indian Ocean about 4,000 km south-west of Perth. The islands lie south of the Polar Front. The Islands are listed on the Register of the National Estate as the only unmodified example of a sub-Antarctic island ecosystem. In addition, the Islands and the 12 nautical mile territorial sea around them are on the World Heritage List and form part of the Heard Island Wilderness Reserve that is managed by the Australian Antarctic Division (AAD) and is closed to fishing. In recognition of the Islands' importance, fishing is prohibited within 13 nautical miles of the Islands, providing a buffer zone of one nautical mile. The fishery extends from 13 nautical miles offshore to the edge of the 200 nautical mile Australian Economic Exclusive Zone (EEZ) around the Islands and is managed by the Australian Fisheries Management Authority. The fishery lies in CCAMLR Statistical Division 58.5.2.

	 (Source: http://www.afma.gov.au/fisheries/antarctic/himi/default.htm)
Regions or Zones within the fishery	The HIMI Fishery for Patagonian toothfish is divided into 3 main fishing grounds A, B and C that will not be identified further by AFMA to retain confidentiality of the licensed operators of the fishery. The grounds are on the Heard Island plateau between 450 m and 700 m deep (Williams *et al.* 2002). The longline fishery operates in the deeper water between 1000 and 1200m and catches larger fish than the trawl fishery
Fishing season	The fishing season for 2005/6 is from 1 May to 31 August 2006 with extension to 30 September 2006 for vessels fully complying with Conservation Measure 25-02 in the previous season. Limited to catch of 3 seabirds per vessel in a season.
Target species and stock status	**Patagonian toothfish (*Dissostichus eleginoides*)** The Patagonian toothfish (*Dissostichus eleginoides*) is widely distributed throughout large areas of the Antarctic oceans. It is a demersal (found at or near the sea bottom) species found at depths up to 2,500 metres, although it is reported to be pelagic (living at or near the ocean surface) throughout some periods of its life (eggs to young juveniles). Patagonian toothfish occur throughout the Plateau from shallow depths to 1800m. Younger fish, less than 600mmTL, occur in less than 500m and as they grow they move deeper into depths to 800m, where they can become locally abundant. Older fish move into depths>1000m where they are caught by longline mainly between 1000 and 1200m The largest fish are assumed to be in depths >1200m. Stock status of uncertain. In addition, illegal foreign fishing occurs in some locations within the Australian commercial HIMI fishery. Illegal fishing therefore primarily threatens the fish targeted by the licensed fishery. Genetic studies have shown that populations at HIMI are distinct from Macquarie Island and South Georgia but that there is no distinction between those at Heard, McDonald, Kerguelen, Crozet or Marion/Prince Edward Islands. Tagging studies (Williams et al. 2002) suggests that a metapopulation exists in the Indian ocean sector. (Source: FSA 2004 SC-CAMLR-XXIII/4 Item No5)
Bait Collection and usage	Frozen squid is imported under licence from AQIS. AQIS has strict regulations to minimize the risk of introduction of disease.
Current entitlements	Only 1 longliner participates in the HIMI Fishery. Any boat with a minimum quota of 25.5% of the Statutory Fishing Rights (SFR) can participate. (Source: AFMA Annual Report 2001-2002; MSC 2006)

Current and recent TACs, quota trends by method

The TAC for toothfish is across all methods.

Year	Patagonian toothfish
2002/3	2879
2003/4	2873
2004/5	2787
2005/6	2584

The TACs for bycatch currently in place for Division 58.5.2 (the CCAMLR code for the region including HIMI) for 2005-2006 are:

Species	TAC (tonnes)
Channichthys rhinoceratus Unicorn icefish	150
Lepidonotothen squamifrons Grey rockcod	80
Skates and rays*	120
Macrourus spp.	360
Other species	50

*For skates and rays if the bycatch in the longline fishery reaches 60 tonnes a review will be triggered.

(Source: CCAMLR 2005/6 Schedule of Conservation Measures; SAFAG 2005; AFMA HIMIF TAC D4 2005)

Current and recent fishery effort trends by method

Year	Thousand hooks*
2002/3	642
2003/4	1598
2004/5	1591

(Source: CCAMLR Statistical Bulletin no 18 , May 2006)

Current and recent fishery catch trends by method

Total catch of toothfish by longline fishery

Year	Longline	IUU
2002/3	270	1512
2003/4	552	637
2004/5	636	0-265

(Source: AFMA)

Total catches of bycatch species recorded by CCAMLR by all methods.

	Channichthys rhinoceratus Unicorn icefish	*Lepidonotothen squamifrons* Grey rockcod	Skates and rays	*Macrourus* spp.	Sharks	Other fish species
2002/3	(-) 20.9	(0.5) 0.42	(8.8) 40.8	(2.5) 4.4	(1.5) 0.001	(.035) 0.6
2003/4	(-) 13.5	(-) 2.9	(45) 69.1	(31.5) 44.7	(-) 0.01	(1.1) 2.0
2004/5	(-) 34.5	(-) 2.5	(67) 78.7	(47.1) 69.7	(1.7) 0.52	(0.93) 3.3

Data in () are unofficial estimates from AAD database.

(Source: CCAMLR Statistical Bulletin no 18 , May 2006; Fishery Report TOP 2005)

Current and recent value of fishery ($)

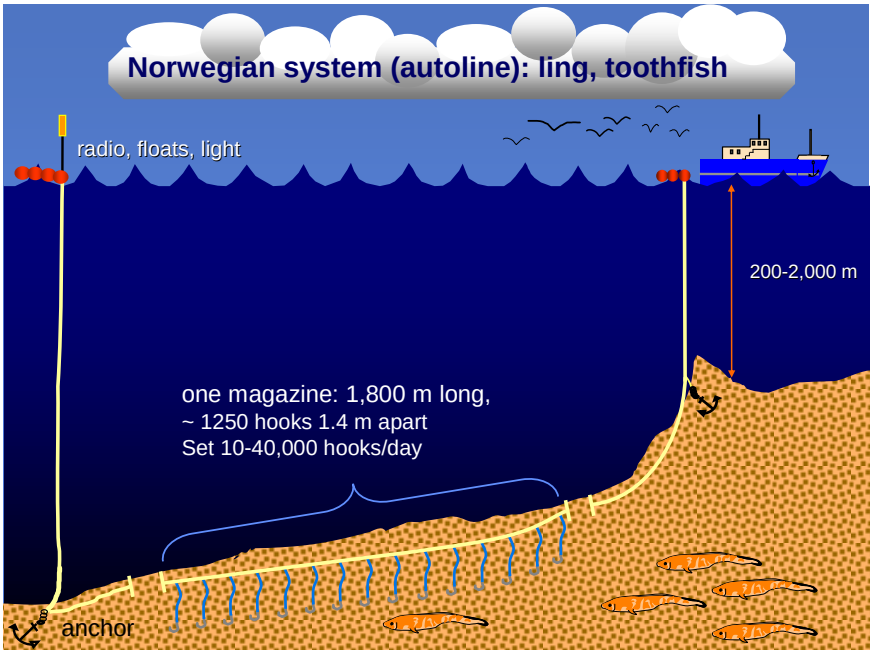
Patagonian toothfish

$27.4 million (estimated assuming to be ex-vessel at $10/kg). Actual values unavailable as AFMA is unable to release this information to maintain operator confidentiality. 96/97 $20 million, 97/98 $36 million, 98/99 $36 million, 99/00 $30 million, 00/01 $30 million (estimated). Note: value assumed to be ex-vessel.

	Source: AFMA
Relationship with other fisheries	The Antarctic Fisheries are both managed within the context of the Australian Government's policy position within CCAMLR. Accordingly the fishery is more stringently than CCAMLR regulations. CCAMLR is the International Convention for the Conservation of Antarctic Marine Living Resources and Australia is one of the 24 member nations. CCAMLR is charged with ensuring the conservation and sustainable use of Antarctic living marine resources, with the exception of whales (ICRW) and seals (CCS). **IUU** Illegal fishing has been a concern in the Toothfish fishery but not the icefish fishery. IUU targets the northern and central part of the Kerguelen Plateau and the north-eastern part of the HIMI AFZ**.** Australia is committed to combating illegal fishing in the EEZ around HIMI, and the region is the focus of growing national and international efforts to combat illegal fishing. A voluntary International Plan of Action for Illegal, Unreported and Unregulated (IUU) Fishing has been developed through the Food and Agriculture Organisation of the United Nations, within the framework of the Code of Conduct for Responsible Fisheries, and further measures may be adopted by the Commission for the Conservation of Antarctic Marine Living Resources. (Source: http://ccamlr.org) **Longline fisheries of other nations** Longlining is the principal method in the French EEZ around the Îles Kerguelen for Patagonian toothfish, adjacent to the HIMI fishery. Since 2000/2001 catches of Patagonian toothfish have varied between 5312 t and 5838 t and those of skates and rays between 119 and 856 t. Longline fishing is thought to have less impact on benthic habitats than bottom trawling, although it may have greater impacts on the bycatch of some non-target species, such as skates (Rajiformes) and rat-tails (*Macrourus* spp.), as well as bycatch of seabirds and mammals. However no birds or mammals were caught in the longline fishery in 2002/3 or 2003/4 seasons.
Gear	
Fishing gear and methods	Demersal longlining principally uses the autoline system. The gear has a main-line containing several thousand short, evenly spaced branch-lines or snoods, each with a terminal baited hook. Each snood is attached via collar to the main-line to allow rotation around the main –line and swivel. The snoods are between 1-2 m apart typically 1300mm. The lines are stored in "magazines" being a line 1000-1200m long, with 950-1200 ready-baited hooks. Several "magazines" can be joined together. Setting the line usually done by drawing one end of the line from the hauling room at the end of the boat. The other end is attached to a marker flag, beacon and buoys which are deployed. Heavy grapnel anchors attached to the line several hundred meters below the buoys cause the line to submerge to the ocean floor. The anchors stabilise one end of the line, the boats steams away, paying out the line which is automatically baited as it passes though the baiting machine. Weights or buoys are attached at intervals along the line. Another set of anchors stabilises the end. The lines are left for 24 hrs to attract toothfish. The vessel retrieves the lines by drawing the lines back onto the vessel. (Source: Assessment Report New and Exploratory Fisheries in the CCAMLR Region , June 2005; Threat Abatement Plan 2005)
Fishing gear restrictions	A range of restrictions are prescribed under Conservation Measures (see Regulations) which include the weighting of lines, coloured (blue) snoods, paired streamer lines, use of thawed baits and a limited season for longline operations.
Selectivity of gear and fishing methods	The gear selects for larger Patagonian toothfish. It also has a greater catch rate of skates and rays. Trigger limits on the catches of skates and rays are in place so that if half the annual TAC of those species are taken in the longline fishery a review is undertaken.
Spatial gear zone set	Deeper water off the Eastern Trough and Heard Plateau.

<table>
<tr><td>Depth range gear set</td><td>Gear is deployed between 1000 and 1200m.</td></tr>
<tr><td>How gear set</td><td>Demersal longlines are set horizontally on the ocean floor. They can be many kilometres long and carry thousands of hooks. Baited hooks are attached to the longline by short lines called snoods that hang off the mainline. Demersal longlines are anchored to the sea floor.

Auto longlining is another type of longlining - it is basically demersal longlining except that some of the functions (for example baiting the hook) are automated

Indicative longline configuration (Graham Robertson, AAD)
(Source: AFMA)</td></tr>
<tr><td>Area of gear impact per set or shot</td><td>Longlining occurs over an area of about 13,000 sq. km. The major area on the southern slope of the Eastern Trough is about 10,000 sq. km</td></tr>
<tr><td>Capacity of gear</td><td></td></tr>
<tr><td>Effort per annum all boats</td><td><table>
<tr><td>Year</td><td>Thousand hooks*</td></tr>
<tr><td>2002/3</td><td>642</td></tr>
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<tr><td>2004/5</td><td>1591</td></tr>
</table>
(Source: CCAMLR Statistical Bulletin no 18 , May 2006)</td></tr>
<tr><td>Lost gear and ghost fishing</td><td>Lost gear occurs rarely and operators are required to attempt to retrieve it. Operators also recover illegal fishing gear, some of which may have drifted into the region. No gear reported lost during 2004/5.
(Source: Assessment Report 2003; SAFAG 23, May 2005, SAFAG 2005, Nov 2005)</td></tr>
<tr><td colspan="2">Issues</td></tr>
<tr><td>Target species issues</td><td>Major uncertainties concerning Patagonian toothfish (Dissostichus eleginoides):
1. biological aspects including lifespan, age at maturity, location of spawning grounds,
2. distribution of stocks,
3. stock size,
4. genetic transfer between stocks, emigration/immigration rates between stocks,</td></tr>
</table>

	5. stock independence at Heard Island (Williams *et al.* 2002). The possibility that the stocks at Kerguelen and HIMI are not as assumed independent from each other or either/both constitute part of a straddling stock with the High Seas fishery managed by CCAMLR in Statistical Division 58.5.2., 6. dependence of other predators on Patagonian toothfish as prey items. (Source: EA Assessment 2002)
Byproduct and bycatch issues and interactions	Bycatch or byproduct is not considered a major issue in Antarctic fisheries. There is close to 100% observer coverage on all trips to the regions, which has resulted in accurate catch and bycatch reporting. This allows for most hauls to be observed, and the monitoring of catch taken. Most of the non-target fishes are retained for milling into meal which is dumped on return to port and is thus classified as byproduct in the terms of this assessment even though not sold. The data collection to date indicates that in the HIMI Fishery the average total bycatch and byproduct from all areas and irrespective of target species over the period 1996/97 to 2002/03 was 1.16% of the total catch by weight (WG-FSA-03/73). The range was between 0.85% and 2.77% (1997). For 2003/4 and 2004/5, the average bycatch has been about 0.04%. The major bycatch species are skates and rays, and macrourids**.** (Source: CCAMLR Document WG-FSA-03/73; Bycatch Action Plan 2003; CCAMLR Statistical Bulletin no18 , May 2006; http://www.ccamlr.org/pu/e/pubs/sa/abs03.pdf) **Major uncertainties concerning other deepwater species, such as Unicorn Icefish, Grey Rockcod, and elasmobranchs:** 1. biological aspects including lifespan, age at maturity, location of spawning grounds, 2. distribution of stocks, 3. stock size, 4. dependence of other predators on these deepwater species as prey items.
TEP issues and interactions	Interactions causing injury or death to seabirds and marine mammals have been extremely low to date in Antarctic trawl operations, and SAFAG's assessment is that the current fishing operations do not pose a significant threat to seabird or marine mammal populations. If the number of reported incidents of seabird or marine mammals increases substantially, AFMA will review mechanisms to reduce the level of interactions. AFMA is continuing to investigate appropriate assessment methods for these species. **Marine mammals** Currently the low number of reported incidents involving death or serious injury to marine mammals is a positive factor in the fishery. For example: in the Antarctic fisheries only two seal fatalities were recorded in a 3 year period (Wienecke and Robertson 2002). However, if the number of reported incidents of marine mammal interactions increases substantially, AFMA will review mechanisms to reduce the level of interactions. AFMA is continuing to investigate appropriate assessment methods for these species. Observers will continue to monitor seal activities from the vessel, through their environmental observations. A review of management arrangements may be undertaken if such interactions were to substantially increase. **Seabirds-general** No seabirds were hooked by longlining although 3 were entangled during hauling. Currently the low number of reported incidents involving death or serious injury to seabirds is a positive factor favouring the fishery. For example: in the Antarctic fisheries only nine seabird fatalities were recorded in a 3-year period (Wienecke and Robertson 2002). However, if the number of reported incidents of seabird interactions increases substantially, AFMA will review mechanisms to reduce the level of interactions. AFMA is continuing to investigate appropriate assessment methods for these species. To reduce the incentive for seabirds to congregate around vessels, operators are required to minimize lighting on the vessel and discharge of waste products, including offal (waste products from fish processing) or unwanted dead fish is prohibited.

	Longline fishing is currently listed as a key threatening process for seabirds under the Endangered Species Protection Act 1992. Under this Act, a Threat Abatement Plan (TAP) for the Incidental Catch of Seabirds During Oceanic Longline Fishing Operations has been developed for fisheries around mainland Australia. CCAMLR Conservation Measures 24-02 and 25-02 specifically provide for longlining mitigation measures to minimise incidental mortality of seabirds from longlining operations. **Penguins** Interactions between penguins and the trawl gear are not seen as serious concerns (Wienecke and Robertson 2002). However, there is concern for the potential impact on penguin species of the Mackerel icefish fishery at Heard Island. Three species of penguins (King, Gentoo and Macaroni) are known to take *C. gunnari* as prey items. King penguins in particular take significant amounts (17% by weight of total diet) at the end of a 4-5 month fasting period. The birds are raising chicks at this time and the scarcity of other prey items increases the importance of Mackerel icefish as prey items during this period. However, the data has only been collected for one year (1992) and may not be applicable in all years (Moore *et al.* 1998).
Habitat issues and interactions	**Habitat Protection** A Commonwealth Marine Protected Area has been established in the HIMI region. There is already a sizeable area set aside in the HIMI Fishery where no fishing can occur (within 13 nautical miles of the Islands). The protected zone is discussed in the section 'Regions or Zones within the Fishery'. (Source:http://www.afma.gov.au/information/publications/fishery/baps/default.htm)
Community issues and interactions	No specific issues identified. However, the importance of the Antarctic community is recognised by the CCAMLR approach to ecosystem-based management. AFMA has recognised and incorporated this approach in their management strategies for the HIMI fishery. In addition, the management of the HIMI islands as Wilderness Reserves by the AAD; the prohibition on fishing within 13 nautical miles of the islands; the establishment of the HIMI Marine Reserve in 2002 and the continued monitoring of top predators both in terms of diet, reproductive rates and overall abundance are seen as key actions in the preservation of community ecosystems. The information available on each species will be reviewed annually by the Antarctic Fishery Assessment Group (SAFAG) and CCAMLR with the aim of continuing to develop specific bycatch limits based on population assessments. This review will incorporate data from the monitoring program including observer data and shot-by-shot logbook information recorded by industry, and will include information learned from fisheries in other parts of the world (e.g. sleeper sharks). AFMA, in conjunction with SAFAG, monitored the tag and release of sleeper sharks, investigated the use of new monitoring technologies and conducted a risk assessment for sleeper sharks. This was completed by AAD and submitted to SAFAG in 2002 and CCAMLR in 2003 (see CCAMLR document WG-FSA-03/6). A tagging program for skates began in 2001. Preliminary results indicated that recaptures of tagged *B. eatonii* was about 2%, lower than that of *D. eleginoides* (10%) (van Wijk and Williams 2003: CCAMLR Document WG-FSA-03/73). Also, estimates of growth rates indicated that the species was likely to be a slow-growing and long-lived one.
Discarding	AFMA requires that no offal is to be discarded and bycatch is mealed where possible and discarded on land, to avoid possible provisioning effects.
Management: planned and those implemented	
Management Objectives	The objectives of *Heard Island and McDonald Islands Management Plan for 2002* are: 1. to manage the Fishery efficiently and cost effectively for the Commonwealth,

	2. to ensure that the exploitation of the resources of the Fishery and the carrying on of any related activities are conducted in a manner consistent with the principles of ecologically sustainable development and the exercise of the precautionary principle, and in particular, the need to have regard to the impact of fishing activities on non-target species and the long-term sustainability of the marine environment, 3. to maximise economic efficiency in the exploitation of the resources of the Fishery, 4. to ensure AFMA's accountability to the fishing industry and to the Australian community in management of the resources of the Fishery, 5. to reach Government targets for the recovery of the costs of AFMA in relation to the Fishery, 6. to ensure, through proper conservation and management, that the living resources of the Australian Fishing Zone (AFZ) are not endangered by over-exploitation, 7. to achieve the best use of the living resources of the AFZ, and 8. to ensure that conservation and management measures in the Fishery implement Australia's obligations under international agreements that deal with fish stocks, and other relevant international agreements. (Source: AFMA Annual Report 2001-2002)
Fishery management plan	The HIMI fishery was first managed under the HIMI Exploratory Fishery Interim Management Policy November 1996 to August 1997. This was replaced by the HIMI Management Policy 1998 to 2000, which was extended to November 2001. Now the fishery is managed under the HIMI Fishery Management Plan 2002 and a supporting framework of regulations, permit conditions and directions. The HIMI fishery falls within the area covered by CCAMLR and is therefore subject to the Conservation Measures set by CCAMLR. Australia's minimum international obligations under CCAMLR are to manage the fishery in accordance with those measures but AFMA may impose additional ones. However these are not stated in the Management Plan. The HIMI Management Plan was assessed under the Environmental Protection and Biodiversity Act 1999. (Source: MSC Assessment Report HIMI Mackerel Icefish 2006)
Input controls	HIMI Fisheries is managed under a system of input and output controls designed to manage catches of the target and non-target species. Input controls are: • a limit of three boats through a SRF quota system where operators must have a minimum holding of 25.5% of quota to access the fishery • move-on provisions for bycatch species under Conservation Measure 33-02 (2005)(see Regulations) (Source: CCAMLR 2005/6 Schedule of Conservation Measures; MSC Assessment Report HIMI Mackerel Icefish 2006)
Output controls	Output controls are: • annual review and setting of total allowable catches: (TAC) 2005/2006 for Patagonian toothfish is 2584 tonnes (Conservation Measure 41-08 2005). • catch limits of bycatch species: fishing shall cease if by-catch of any species in either targetted fishery reaches its limit as specified in Conservation Measure 33-02 (Conservation Measure 41-08 and 42-02) • if 50% of catch limit is reached for any non-target species, AFMA will review operating practices with SFR holders • carry-over provision for Patagonian toothfish-any over-catch will be carried into subsequent year and deducted from operators' quota at a rate of 2 for 1. (Source: CCAMLR 2005/6 Schedule of Conservation Measures; MSC Assessment Report HIMI Mackerel Icefish 2006)
Technical measures	See Regulations CCAMLR 2005/6 Schedule of Conservation Measures
Regulations	Australia, through its work in CCAMLR, has undertaken assessments on potentially commercial bycatch species (i.e. grey rockcod (*Lepidonotothen squamifrons*) and unicorn icefish (*Channichthys rhinoceratus)*) based on the results of random stratified

trawl surveys. Based on these assessments, TACs have been set even though they are presently non-target species. CCAMLR has also agreed to apply a general precautionary catch limit for other non-target species for which no assessment has been undertaken. Some of these species are not caught by longlining however skates and rays are a particular issue for this fishery.

Generally, under Conservation Measure 33-02 (2005) the following regulations apply:

- There will be no directed fishery for any other species other than Patagonian toothfish and Mackerel icefish in Division 58.5.2 in 2005/6 fishing year.

- The TACs for bycatch currently in place for Division 58.5.2 for 2005/2006 are:

Species	TAC (tonnes)
Channichthys rhinoceratus Unicorn icefish	150
Grey rockcod *Lepidonotothen squamifrons*	80
Skates and rays	120
Macrourus spp.	360
Other species	50

- If, in the course of a directed fishery, the bycatch in any one haul of *Channichthys rhinoceratus*, *Lepidonotothen squamifrons*, *Macrourus* species, *Somniosus* species or skates and rays is equal to or greater than two tonnes, the fishing vessel shall not fish using that method of fishing at any point within five nautical miles of the location where the bycatch exceeded two tonnes for a period of at least five days.

- If in the course of a directed fishery, the bycatch in any one haul of any other by-catch species for which bycatch limitations apply is equal to or greater than one tonne, the fishing vessel shall not fish using that method of fishing at any point within five nautical miles of the location where the bycatch exceeded two tonnes for a period of at least five days.

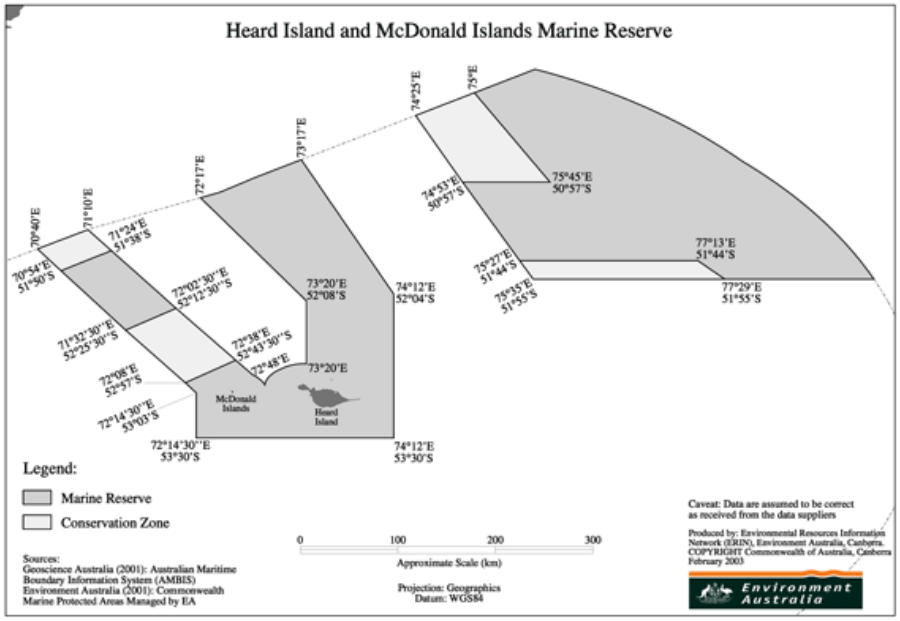
Under Conservation Measure 24-02
A range of protocols for prescription of longline weighting to mitigate seabird interactions.

Under Conservation Measure 25-02
Protocol for minimisation of the incidental mortality of seabirds in the course of longlining in the Convention area which prescribes that:

- Hooklines should sink beyond the reach of birds as soon as possible after deployment
- Integrated weights on autolines should be used
- Spanish method of setting should release weights before line tension occurs
- Longlines are to be set at night only (now amended to include daytime setting)
- Dumping of offal is prohibited while setting lines
- Vessels unable to retain offal on board or discharge on opposite side of setting will not be allowed to operate in the area
- Streamer lines shall be deployed to deter birds
- A device to discourage birds from accessing baits during hauling shall be employed
- Birds captured alive should be released alive and wherever possible hooks removed without jeopardy to the bird.
- Other variations may be tested if appropriate observers are onboard.

(Source: CCAMLR 2005/6 Schedule of Conservation Measures)

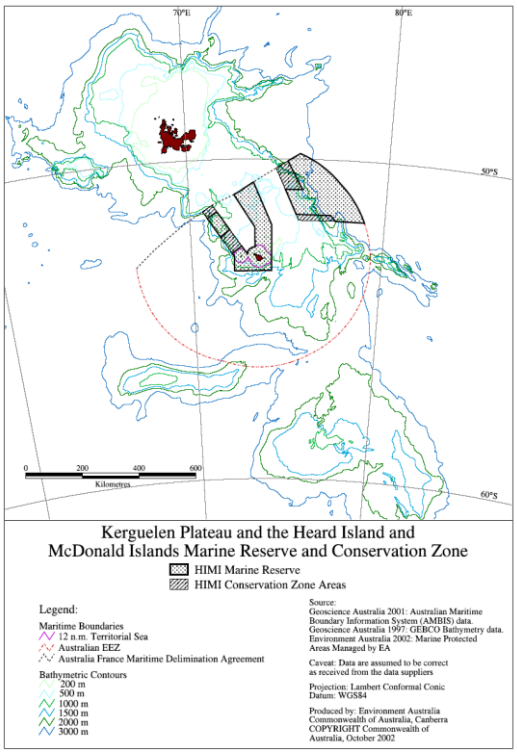
Initiatives and strategies	The objective of the ***Antarctic Fisheries Bycatch Action Plan 2003*** is: To ensure that the impacts of the fishery's bycatch on the ecosystem are sustainable and consistent with legislative requirements. Six strategies have been developed to achieve this objective: 1 Develop and review non-target species catch limits to ensure catches are within sustainable limits 2 Minimise the bycatch of non-target species, including sharks , skates and rays, 3 Evaluate any fishing impacts on seabirds and marine mammals 4 Develop mitigation measures to minimise seabird and marine mammal catches in the longline fishery 5 Develop mitigation measures to minimise seabird and marine mammal interaction in the trawl fishery 6 Assess the benthic/ecological impacts of fishing on habitats. (Source: AFMA Antarctic Fisheries Bycatch Action Plan 2003). Other significant programs that are applicable to the HIMI fishery are the **Threat Abatement Plan (TAP) for the Incidental Catch of Seabirds During Oceanic Longline Fishing Operations** and the **Recovery Plan for Albatrosses and Giant Petrels**. The **Catch Documentation Scheme** was established in 2001 by CCAMLR to track catches of toothfish sold in participating countries. It is used to estimate IUU catch. In addition to the previous controls and regulations, further conditions accompany the statutory fishing rights: Boat eligibility Personal consumption and jellymeat (in the toothfish fishery) VMS requirements Boat marking Transhipping and carrying Product labelling Notification requirements CCAMLR inspection Carriage of observers Data collection officers Safety assessment Contingency arrangements for breakdown of the meal plant and disposal of fish meal (Source: MSC Assessment Report HIMI Mackerel Icefish 2006) **Heard Island and McDonald Islands Marine Reserve** In October 2002 the Heard Island and McDonald Islands (HIMI) Marine Reserve was declared under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act).



(Source: http://www.deh.gov.au/coasts/mpa/heard/maps/index.html)

The Heard Island and McDonald Islands (HIMI) Marine Reserve is located in Australia's remote subantarctic waters, approximately 4000 kilometres south-west of the Australian mainland and 1000 kilometres north of Antarctica. It covers an area of approximately 65,000 square kilometres or 6.5 million hectares, and includes Heard Island and the McDonald Islands, the surrounding 12 nautical mile territorial sea, plus an extended marine area (including the seabed and subsoil to a depth of 1000 metres) which extends in parts to the 200 nautical mile Exclusive Economic Zone (EEZ) boundary. Details of boundaries can be found at:

(Source: http://www.heardisland.aq/protection/marine_reserve/reserve_boundary.html).



(Source: http://aadc-maps.aad.gov.au/aadc/mapcat/maps_on_lineage.cfm?map_lineage_id=1&format=table)

	Classified as an IUCN Category 1a Strict nature reserve managed primarily for scientific research or environmental monitoring, the Reserve comprises the world's largest fully protected marine Reserve. The purposes for declaring the Marine Reserve, as outlined in the Marine Reserve Proposal, are to: a. protect conservation values of Heard Island and McDonald Islands, the territorial sea and the adjacent Exclusive Economic Zone (HIMI EEZ) including: • the World Heritage and cultural values of the Territory of Heard Island and McDonald Islands • the unique features of the benthic and pelagic environments • representative portions of the different marine habitat types • marine areas used by land-based marine predators for local foraging activities b. provide an effective conservation framework which will contribute to the integrated and ecologically sustainable management of the HIMI region as a whole c. provide a scientific reference area for the study of ecosystem function within the HIMI region d. add representative examples of the HIMI EEZ to the National Representative System of Marine Protect Areas. (Source: http://www.heardisland.aq/protection/marine_reserve/index.html) *Management of the HIMI Marine Reserve* Administration of the HIMI Marine Reserve is the responsibility of the Australian Antarctic Division. The EPBC Act requires that management must be based on IUCN category Ia reserve management principles, and be not inconsistent with Australian World Heritage management principles. The Management Plan for the HIMI Marine Reserve was enacted in 2005 and addresses a broad range of management issues. It includes a similarly broad range of measures to address these issues, such as from the cleaning of clothing and gear to prevent unwanted 'alien' species, to where and how visitors can go to the toilet. The new management plan replaces the previous Heard Island Wilderness Reserve Management Plan (PDF) in force for the HIMI Territory since 1996 under the Environment Protection and Management Ordinance 1987. (Source: http://www.heardisland.aq/protection/management_plan/index.html)
Enabling processes	There are detailed management plans for Patagonian toothfish and Mackerel icefish. Catches and landings are monitored by logbooks and observer data. Stock assessments on target and some non-target species are conducted annual by SAFAG. The By-catch Action Plan is reviewed biannually and outcomes are reported against performance indicators.
Other initiatives or agreements	The declaration and ongoing management of the Heard Island and McDonald Islands (HIMI) Marine Reserve contributes to the implementation of several international conservation agreements, including: World Heritage Convention Ramsar Convention Bonn Convention China/Australia Migratory Birds Agreement Japan/Australia Migratory Birds Agreement Australia/France Treaty on Maritime Cooperation Convention on Biological Diversity Agreement on the Conservation of Albatrosses and Petrels Convention on the Conservation of Antarctic Marine Living Resources International Convention for the Prevention of Pollution from Ships (MARPOL) Convention on the International Trade in Endangered Species International Convention for the Regulation of Whaling United Nations Convention on the Law of the Sea

	(Source: http://www.heardisland.aq/protection/legislation/International_Agreements.html#CCAMLR)
Data	
Logbook data	All Australian operators are required to complete electronic catch and effort logbooks with total coverage. Data verified through observer program and catch documentation scheme. Currently there are 4 logbooks: C1v2006 CCAMLR Fine-scale Catch and Effort Data for Trawl Fisheries C2v2006 CCAMLR Fine-scale Catch and Effort Data for Longline Fisheries C5v2006 CCAMLR Fine-scale Catch and Effort Data for Pot Fisheries TACv2006 CCAMLR 5 day, 10 day or monthly Catch and Effort Report ANT05 (Antarctic Waters Catch Details Log) for trawl and ANT02 for Vessel and gear details. CCAMLR publish catch statistics for all Antarctic fisheries in their jurisdiction annually in the Statistical Bulletin series.
Observer data	There is 100% observer coverage during all fishing activities. All wildlife interactions are also monitored. Observer data are maintained by AAD and a copy held by AFMA.
Other data	The most recent surveys were conducted by AAD. They conducted a random-stratified survey in June 2005 to survey juvenile Patagonian toothfish (Constable *et al.* 2005a) and Mackerel icefish (daytime only) (Constable *et al.* 2005b) on the Heard Island Plateau and Shell Bank to 1000m. The purpose of the surveys was to provide information to CCAMLR for short-term stock assessments. It also assessed the sensitivity of the assessment to a number of other factors such as growth parameters, effect of excluding older cohorts, risk of adult fish and revised mortality rates. (Source: WG_FAS_05/30&39, http://www.afma.gov.au/fisheries/antarctic/himi/publications/default.htm#fap)

2.2.2 Unit of Analysis Lists (Step 2)

The units of analysis for the sub-fishery are listed by component:

- Species Components (target, byproduct/discards and TEP components). [Scoping document S2A Species]
- Habitat Component: habitat types. [Scoping document S2B Habitats]
- Community Component: community types. [Scoping document S2C Communities]

Scoping Document S2A Species

Each species identified during the scoping is added to the ERAEF database used to run the Level 2 analyses. A CAAB code (Code for Australian Aquatic Biota) is required to input the information. The CAAB codes for each species may be found at http://www.marine.csiro.au/caab/

Target species *Heard and McDonald Islands Demersal Longline Fishery*
List the target species of the sub- fishery. This list is obtained by reviewing all available fishery literature, including logbooks, observer reports and discussions with stakeholders. Target species are as agreed by the fishery.

Species Number	Taxa	Family name	Scientific name	Common Name	CAAB code
765	Teleost	Nototheniidae	*Dissostichus eleginoides*	Patagonian toothfish	37404792

Byproduct species *Heard and McDonald Islands Demersal Longline Fishery*

Byproduct refers to any part of the catch which is kept or sold by the fisher but which is not a target species. This list is obtained by reviewing all available fishery literature, including logbooks, observer reports and discussions with stakeholders.

Species Number	Taxa	Family name	Scientific name	Common name	CAAB code
302	Chondrichthyan	Rajidae	*Bathyraja irrasa*	Skate	
304	Chondrichthyan	Rajidae	*Bathyraja murrayi*	Skate	
1480	Chondrichthyan	Rajidae	*Bathyraja eatonii*	Skate	37031750
1481	Chondrichthyan	Rajidae	*Bathyraja maccaini*	Skate	37031751
1482	Chondrichthyan	Rajidae	*Raja georgiana*	Skate	37031753
826	Chondrichthyan	Squalidae	*Etmopterus granulosus*	Southern lantern shark	37020021
2787	Invertebrate	Asteroidea	*Asteroidea*	Starfish	26200000
2783	Invertebrate	Octopodidae	*Octopodidae*	Octopus	22630000
1981	Invertebrate		*Porifera - undifferentiated*	Sponges	10000000
2777	Invertebrate		*Gastropoda*	Snail	22200000
336	Teleost	Macrouridae	*Macrourus carinatus*	Whiptail ; bigeye grenadier	37232036
1479	Teleost	Macrouridae	*Macrourus whitsoni*	[A whiptail]	37232753
2845	Teleost	Macrouridae	*Macrourus holotrachys*		
275	Teleost	Moridae	*Antimora rostrata*	Morid cod	37224008
1462	Teleost	Moridae	*Lepidion sp.*	Morid cod	
1461	Teleost	Muraenolepididae	*Muraenolepis sp.*	Moray cod (undifferentiated)	
2866	Teleost	Nototheniidae	*Notothenia squamifrons*	Grey rock cod	37404793

Discard (Bycatch) species *Heard and McDonald Islands Demersal Longline Fishery*

Bycatch as defined in the Commonwealth Policy on Fisheries Bycatch 2000 refers to:

- that part of a fisher's catch which is returned to the sea either because it has no commercial value or because regulations preclude it being retained; and
- that part of the 'catch' that does not reach the deck but is affected by interaction with the fishing gear

However, in the ERAEF method, the part of the target or byproduct catch that is discarded is included in the assessment of the target or byproduct species. The list of bycatch species is obtained by reviewing all available fishery literature, including logbooks, observer reports and discussions with stakeholders.

Species Number	Taxa	Family name	Scientific name	Common Name	CAAB code
257	Chondrichthyan	Squalidae	*Somniosus antarcticus*	Sleeper shark	37020036

TEP species *Heard and McDonald Islands Demersal Longline Fishery*
TEP species are those species listed as Threatened, Endangered or Protected under the EPBC Act.

TEP species are often poorly listed by fisheries due to low frequency of direct interaction. Both direct (capture) and indirect (e.g. food source captured) interaction are considered in the ERAEF approach. A list of TEP species has been generated for each fishery and is included in the PSA workbook species list. This list has been generated using the DEH Search Tool from DEH home page *http://www.deh.gov.au/*

For each fishery, the list of TEP species is compiled by reviewing all available fishery literature. Species considered to have potential to interact with fishery (based on geographic range & proven/perceived susceptibility to the fishing gear/methods and examples from other similar fisheries across the globe) should also be included.

Species Number	Taxa	Family name	Scientific name	Common name	CAAB code
1437	Marine bird	Chionididae	*Chionis minor nasicornis/minor*	Black-faced sheathbill	40126001
1032	Marine bird	Diomedeidae	*Thalassarche bulleri*	Buller's albatross	40040001
1034	Marine bird	Diomedeidae	*Thalassarche chlororhynchos*	Yellow-nosed albatross, atlantic yellow-	40040003
1035	Marine bird	Diomedeidae	*Thalassarche chrysostoma*	Grey-headed albatross	40040004
753	Marine bird	Diomedeidae	*Diomedea epomophora*	Southern royal albatross	40040005
451	Marine bird	Diomedeidae	*Diomedea exulans*	Wandering albatross	40040006
1085	Marine bird	Diomedeidae	*Thalassarche melanophrys*	Black-browed albatross	40040007
1008	Marine bird	Diomedeidae	*Phoebetria fusca*	Sooty albatross	40040008
1009	Marine bird	Diomedeidae	*Phoebetria palpebrata*	Light-mantled albatross	40040009
799	Marine bird	Diomedeidae	*Diomedea sanfordi*	Northern royal albatross	40040012
1031	Marine bird	Diomedeidae	*Thalassarche carteri*	Indian yellow-nosed albatross	40040014
1428	Marine bird	Diomedeidae	*Diomedea amsterdamensis*	Amsterdam albatross	40040018
1695	Marine bird	Fregatidae	*Fregata spp.*	Frigate birds	40050000
917	Marine bird	Hydrobatidae	*Fregetta tropica*	Black-bellied storm-petrel	40042002
555	Marine bird	Hydrobatidae	*Garrodia nereis*	Grey-backed storm petrel	40042003
556	Marine bird	Hydrobatidae	*Oceanites oceanicus*	Wilson's storm petrel (subantarctic)	40042004
1696	Marine bird	Laridae	*Catharacta spp.*	Skuas	40128000
325	Marine bird	Laridae	*Catharacta skua*	Great skua	40128005

Species Number	Taxa	Family name	Scientific name	Common name	CAAB code
973	Marine bird	Laridae	*Larus dominicanus*	Kelp gull	40128012
1023	Marine bird	Laridae	*Sterna paradisaea*	Arctic tern	40128032
292	Marine bird	Laridae	*Sterna vittata*	Antarctic tern (nz)	40128035
589	Marine bird	Laridae	*Catharacta lonnbergi lonnbergi*	Subantarctic skua (southern)	
1474	Marine bird	Phalacrocoracidae	*Phalacrocorax nivalis*	Heard island cormorant	
1690	Marine bird	Procellariidae	*Pachyptila spp.*	Prions	40041000
595	Marine bird	Procellariidae	*Daption capense*	Cape petrel	40041003
314	Marine bird	Procellariidae	*Fulmarus glacialoides*	Southern fulmar	40041004
939	Marine bird	Procellariidae	*Halobaena caerulea*	Blue petrel	40041005
1052	Marine bird	Procellariidae	*Lugensa brevirostris*	Kerguelen petrel	40041006
73	Marine bird	Procellariidae	*Macronectes giganteus*	Southern giant-petrel	40041007
981	Marine bird	Procellariidae	*Macronectes halli*	Northern giant-petrel	40041008
1532	Marine bird	Procellariidae	*Pachyptila crassirostris*	Fulmar prion	40041010
488	Marine bird	Procellariidae	*Pachyptila desolata*	Antarctic prion	40041011
1430	Marine bird	Procellariidae	*Pagodroma nivea*	Snow petrel	40041015
492	Marine bird	Procellariidae	*Pelecanoides georgicus*	South georgian diving petrel	40041016
1006	Marine bird	Procellariidae	*Pelecanoides urinatrix*	Common diving-petrel	40041017
1041	Marine bird	Procellariidae	*Procellaria aequinoctialis*	White-chinned petrel	40041018
494	Marine bird	Procellariidae	*Procellaria cinerea*	Grey petrel	40041019
504	Marine bird	Procellariidae	*Pterodroma lessoni*	White-headed petrel	40041029
1047	Marine bird	Procellariidae	*Pterodroma macroptera*	Great-winged petrel	40041031
1048	Marine bird	Procellariidae	*Pterodroma mollis*	Soft-plumaged petrel	40041032
1057	Marine bird	Procellariidae	*Puffinus griseus*	Sooty shearwater	40041042
1060	Marine bird	Procellariidae	*Puffinus tenuirostris*	Short-tailed shearwater	40041047
553	Marine bird	Procellariidae	*Thalassoica antarctica*	Antarctic petrel	40041048
1475	Marine bird	Scolopacidae	*Tringa nebularia*	Greenshank	
1427	Marine bird	Spheniscidae	*Aptenodytes forsteri*	Emperor penguin	40001001
785	Marine bird	Spheniscidae	*Aptenodytes patagonicus*	King penguin	40001002
787	Marine bird	Spheniscidae	*Eudyptes chrysocome*	Rockhopper penguin	40001003
1426	Marine bird	Spheniscidae	*Eudyptes chrysolophus*	Macaroni penguin	40001004

Species Number	Taxa	Family name	Scientific name	Common name	CAAB code
1513	Marine bird	Spheniscidae	*Pygoscelis adeliae*	Adelie penguin	40001009
1511	Marine bird	Spheniscidae	*Pygoscelis antarctica*	Chinstrap penguin	40001010
819	Marine bird	Spheniscidae	*Pygoscelis papua*	Gentoo penguin	40001011
1670	Marine bird		*Leucocarbo atriceps nivalis*	Imperial shag (Heard Island)	
896	Marine mammal	Balaenidae	*Eubalaena australis*	Southern right whale	41110001
1439	Marine mammal	Balaenidae	*Balaenoptera bonaerensis*	Antarctic minke whale	41112007
256	Marine mammal	Balaenopteridae	*Balaenoptera acutorostrata*	Minke whale	41112001
261	Marine mammal	Balaenopteridae	*Balaenoptera borealis*	Sei whale	41112002
265	Marine mammal	Balaenopteridae	*Balaenoptera musculus*	Blue whale	41112004
268	Marine mammal	Balaenopteridae	*Balaenoptera physalus*	Fin whale	41112005
984	Marine mammal	Balaenopteridae	*Megaptera novaeangliae*	Humpback whale	41112006
935	Marine mammal	Delphinidae	*Globicephala melas*	Long-finned pilot whale	41116004
937	Marine mammal	Delphinidae	*Grampus griseus*	Risso's dolphin	41116005
832	Marine mammal	Delphinidae	*Lagenorhynchus cruciger*	Hourglass dolphin	41116007
971	Marine mammal	Delphinidae	*Lagenorhynchus obscurus*	Dusky dolphin	41116008
61	Marine mammal	Delphinidae	*Lissodelphis peronii*	Southern right whale dolphin	41116009
1002	Marine mammal	Delphinidae	*Orcinus orca*	Killer whale	41116011
1091	Marine mammal	Delphinidae	*Tursiops truncatus*	Bottlenose dolphin	41116019
293	Marine mammal	Otariidae	*Arctocephalus gazella*	Antarctic fur seal	41131002
263	Marine mammal	Otariidae	*Arctocephalus tropicalis*	Subantarctic fur seal	41131004
295	Marine mammal	Phocidae	*Hydrurga leptonyx*	Leopard seal	41136001
296	Marine mammal	Phocidae	*Leptonychotes weddelli*	Weddell seal	41136002
297	Marine mammal	Phocidae	*Lobodon carcinophagus*	Crabeater seal	41136003
993	Marine mammal	Phocidae	*Mirounga leonina*	Elephant seal	41136004
1441	Marine mammal	Phocidae	*Ommatophoca rossii*	Ross seal	41136005
833	Marine mammal	Phocoenidae	*Australophocoena dioptrica*	Spectacled porpoise	41117001
968	Marine mammal	Physeteridae	*Kogia breviceps*	Pygmy sperm whale	41119001
969	Marine mammal	Physeteridae	*Kogia simus*	Dwarf sperm whale	41119002
1036	Marine mammal	Physeteridae	*Physeter catodon*	Sperm whale	41119003
269	Marine mammal	Ziphiidae	*Berardius arnuxii*	Arnoux's beaked whale	41120001

Species Number	Taxa	Family name	Scientific name	Common name	CAAB code
959	Marine mammal	Ziphiidae	*Hyperoodon planifrons*	Southern bottlenose whale	41120002
988	Marine mammal	Ziphiidae	*Mesoplodon grayi*	Gray's beaked whale	41120007
989	Marine mammal	Ziphiidae	*Mesoplodon hectori*	Hector's beaked whale	41120008
990	Marine mammal	Ziphiidae	*Mesoplodon layardii*	Strap-toothed beaked whale	41120009
1098	Marine mammal	Ziphiidae	*Ziphius cavirostris*	Cuvier's beaked whale	41120012

Scoping Document S2B1 & 2. Habitats

Not assessed.

Scoping Document S2C1. Demersal Communities

In ERAEF, communities are defined as the set of species assemblages that occupy the large scale provinces and biomes identified from national bioregionalisation studies. The biota includes mobile fauna, both vertebrate and invertebrate, but excludes sessile organisms such as corals that are largely structural and are used to identify benthic habitats. The same community lists are used for all fisheries, with those selected as relevant for a particular fishery being identified on the basis of spatial overlap with effort in the fishery. The spatial boundaries for demersal communities are based on IMCRA boundaries for the shelf, and on slope bioregionalisation for the slope (IMCRA 1998; Last *et al*. 2005). The spatial boundaries for the pelagic communities are based on pelagic bioregionalisation and on oceanography (Condie *et al*. 2003; Lyne and Hayes 2004). Fishery and region specific modifications to these boundaries are described in detail in Hobday *et al*. (2007) and briefly outlined in the footnotes to the community Tables below.

Demersal communities in which fishing activity occurs the HIMI Longline fishery (x). Shaded cells indicate all communities within the province.

Demersal community	Cape	North Eastern Transition	North Eastern	Central Eastern Transition	Central Eastern	South Eastern Transition	Central Bass	Tasmanian	Western Tas Transition	Southern	South Western Transition	Central Western	Central Western Transition	North Western	North Western Transition	Timor	Timor Transition	Heard & McDonald Is	Macquarie Is
Inner Shelf 0 – 110m [1,2]																			
Outer Shelf 110 – 250m [1,2,]																			
Upper Slope 250 – 565m [3]																			
Mid–Upper Slope 565 – 820m[3]																			
Mid Slope 820 – 1100m[3]																			
Lower slope/ Abyssal > 1100m[6]																		x x	
Reef 0 -110m[7, 8]																			
Reef 110-250m[8]																			
Seamount 0 – 110m																			
Seamount 110- 250m																			
Seamount 250 – 565m																			
Seamount 565 – 820m																			
Seamount 820 – 1100m																			
Seamount 1100 – 3000m																			
Plateau 0 – 110m																			
Plateau 110- 250m[4]																		x x	
Plateau 250 – 565m[4]																			
Plateau 565 – 820m[5]																		x	
Plateau 820 – 1100m[5]																		x	

[1] Four inner shelf communities occur in the Timor Transition (Arafura, Groote, Cape York and Gulf of Carpentaria) and three inner shelf communities occur in the Southern (Eyre, Eucla and South West Coast). At Macquarie Is: [2]inner & outer shelves (0-250m), and [3]upper and midslope communities combined (250-1000m). At Heard/McDonald Is: [4]outer and upper slope plateau communities combined to form four communities: Shell Bank, inner and outer Heard Plateau (100-500m) and Western Banks (200-500m), [5]mid and upper plateau communities combined into 3 trough (Western, North Eastern and South Eastern), southern slope and North Eastern plateau communities (500-1000m), and [6] 3 groups at Heard Is: Deep Shell Bank (>1000m), Southern and North East Lower slope/abyssal, [7]Great Barrier Reef in the North Eastern Province and Transition and [8] Rowley Shoals in North Western Transition.

Scoping Document S2C2. Pelagic Communities

Pelagic communities that overlie the demersal communities in which fishing activity occurs in the HIMI Longline fishery (x).

Pelagic community	North-eastern	Eastern	Southern	Western	Northern	North-western	Heard and McDonald Is[2]	Macquarie Is
Coastal pelagic 0-200m[1,2]								
Oceanic (1) 0 – 600m								
Oceanic (2) >600m								
Seamount oceanic (1) 0 – 600m								
Seamount oceanic (2) 600–3000m								
Oceanic (1) 0 – 200m								
Oceanic (2) 200-600m								
Oceanic (3) >600m								
Seamount oceanic (1) 0 – 200m								
Seamount oceanic (2) 200 – 600m								
Seamount oceanic (3) 600–3000m								
Oceanic (1) 0-400m								
Oceanic (2) >400m								
Oceanic (1) 0-800m								
Oceanic (2) >800m								
Plateau (1) 0-600m								
Plateau (2) >600m								
Heard Plateau 0-1000m[3]							x	
Oceanic (1) 0-1000m							x	
Oceanic (2) >1000m							x	
Oceanic (1) 0-1600m								
Oceanic (2) >1600m								

Shaded cells indicate all communities that exist in the province. [1] Northern Province has five coastal pelagic zones (NWS, Bonaparte, Arafura, Gulf and East Cape York) and Southern Province has two zones (Tas, GAB). [2] At Macquarie Is: coastal pelagic zone to 250m. [3] At Heard and McDonald Is: coastal pelagic zone broadened to cover entire plateau to maximum of 1000m.

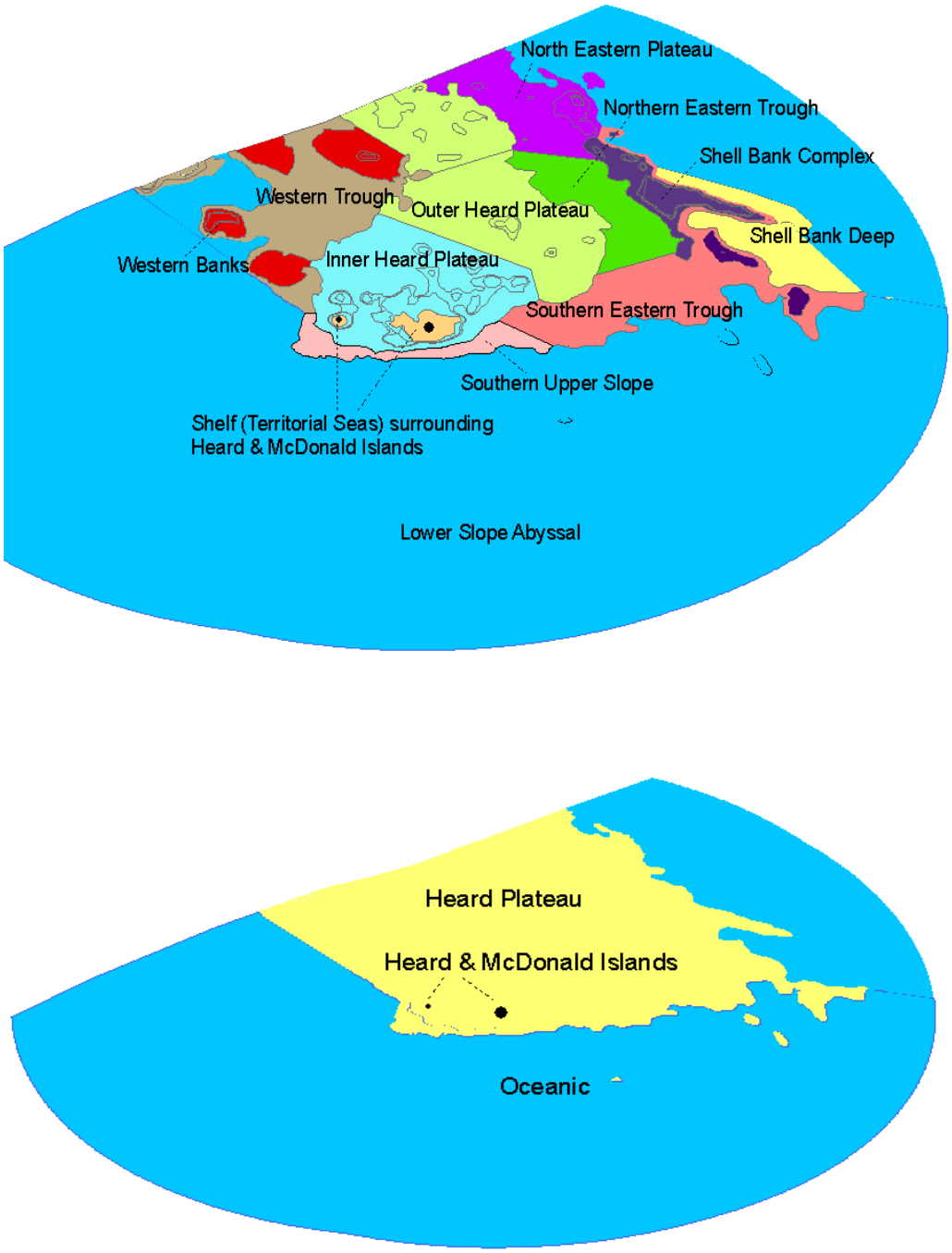


Fig S1. (a) Demersal and (b) pelagic communities in the Heard and McDonald Islands Fisheries.

2.2.3 Identification of Objectives for Components and Sub-components (Step 3)

Objectives are identified for each sub-fishery for the five ecological components (target, bycatch/byproduct, TEP, habitats, and communities) and sub-components, and are clearly documented. It is important to identify objectives that managers, the fishing industry, and other stakeholders can agree on, and that scientists can quantify and assess. The criteria for selecting ecological operational objectives for risk assessment are that they:

- be biologically relevant;
- have an unambiguous operational definition;
- be accessible to prediction and measurement; and
- that the quantities they relate to be exposed to the hazards.

For fisheries that have completed ESD reports, use can be made of the operational objectives stated in those reports.

Each 'operational objective' is matched to example indicators. **Scoping Document S3** provides suggested examples of operational objectives and indicators. Where operational objectives are already agreed for a fishery (Existing Management Objectives), those should be used (e.g. Strategic Assessment Reports). The objectives need not be exactly specified, with regard to numbers or fractions of removal/impact, but should indicate that an impact in the sub-component is of concern/interest to the sub-fishery. The rationale for including or discarding an operational objective is a crucial part of the table and must explain why the particular objective has or has not been selected for in the (sub) fishery. Only the operational objectives selected for inclusion in the (sub)fishery are used for Level 1 analysis (**Level 1 SICA Document L1.1**).

Scoping Document S3 Components and Sub-components Identification of Objectives

(Note: Operational objectives that are eliminated are shaded out)

Component	Core Objective	Sub-component	Example Operational Objectives	Example Indicators	Rationale
	"What is the general goal?"	*As shown in sub-component model diagrams at the beginning of this section.*	*"What you are specifically trying to achieve"*	*"What you are going to use to measure performance"*	*Rationale flagged as 'EMO' where Existing Management Objective in place, or 'AMO' where there is an existing AFMA Management Objective in place for other Commonwealth fisheries (assumed that squid fishery will fall into line).*

Component	Core Objective	Sub-component	Example Operational Objectives	Example Indicators	Rationale
Target Species	Avoid recruitment failure of the target species Avoid negative consequences for species or population sub-components	1. Population size	1.1 No trend in biomass 1.2 Maintain biomass above a specified level 1.3 Maintain catch at specified level 1.4 Species do not approach extinction or become extinct	Biomass, numbers, density, CPUE, yield	1.1 Target species managed to maintain biomass above set levels 1.2 EMO and AMO – maintain ecologically viable stock levels 1.3 TACs for each species set by biological reference points based on EMO. Catch levels vary yearly as determined by the TACs. 1.4 Covered by 1.2
		2. Geographic range	2.1 Geographic range of the population, in terms of size and continuity does not change outside acceptable bounds	Presence of population across the Southern Ocean	2.1 Individual stocks assumed to be isolated and therefore independent. The stocks at HIMI, Kerguelen and in the High seas (CCAMLR Statistical Division 58.5.2) are possibly interdependent.
		3. Genetic structure	3.1 Genetic diversity does not change outside acceptable bounds	Frequency of genotypes in the population, effective population size (N_e), number of spawning units	3.1 Not currently monitored. No reference levels established. Mitochondrial DNA work has shown that separate stocks are found in the Macquarie, Heard, and South Georgia regions.
		4. Age/size/sex structure	4.1 Age/size/sex structure does not change outside acceptable bounds (e.g. more than X% from reference structure)	Biomass, numbers or relative proportion in age/size/sex classes Biomass of spawners Mean size, sex ratio	4.1 Covered in general by 1.2 EMO and AMO. The size range of Patagonian toothfish suggests that the fishery is not targeting recruitment or spawning grounds.

Component	Core Objective	Sub-component	Example Operational Objectives	Example Indicators	Rationale
		5. Reproductive Capacity	5.1 Fecundity of the population does not change outside acceptable bounds (e.g. more than X% of reference population fecundity) 2 Recruitment to the population does not change outside acceptable bounds	Egg production of population Abundance of recruits	5.1 Covered by 1.2 EMO and AMO. Reproductive capacity in terms of egg production may be easier to monitor via changes in Age/size/sex structure. 5.2 Covered by 1.2 EMO and AMO. May be easier to monitor via changes in Age/size/sex structure in the fishery. For Mackerel icefish move on provisions exist when a haul contains more than 100 kg of Mackerel icefish where more than 10 % are smaller than 240 mm total length. The vessel must not fish within 5 nm of that site for at least 5 days.
		6. Behaviour /Movement	6.1 Behaviour and movement patterns of the population do not change outside acceptable bounds	Presence of population across space, movement patterns within the population (e.g. attraction to bait, lights)	6.1 Covered by 1.2 EMO and AMO. Links between the HIMI, Kerguelen and Crozet stocks Has been investigated by DNA and tagging studies.

Component	Core Objective	Sub-component	Example Operational Objectives	Example Indicators	Rationale
Byproduct and Bycatch	Avoid recruitment failure of the byproduct and bycatch species Avoid negative consequences for species or population sub-components	1. Population size	1.1 No trend in biomass 1.2 Species do not approach extinction or become extinct 1.3 Maintain biomass above a specified level 1.4 Maintain catch at specified level	Biomass, numbers, density, CPUE, yield	1.1 Objective too general and covered by 1.2 and 1.3 1.2 Covered by EMO and AMO that ensures the fishery does not threaten bycatch species. 1.3 EMO/AMO – Annual reviews of all information on bycatch species with the aim of developing species specific bycatch limits. Use of 'move on provisions' to limit exploitation of bycatch stocks in localised areas. 1.4Maintaining bycatch/byproduct levels not a specific objective. The protection of bycatch by TACs based on precautionary principles is the preferred method. "Move on provisions" are enforced if bycatch exceeds set limits.
		2. Geographic range	2.1 Geographic range of the population, in terms of size and continuity does not change outside acceptable bounds	Presence of population across space	2.1 Not currently monitored. No specific management objective based on the geographic range of bycatch/byproduct species.
		3. Genetic structure	3.1 Genetic diversity does not change outside acceptable bounds	Frequency of genotypes in the population, effective population size (N_e), number of spawning units	3.1 Not currently monitored. No reference levels established. No specific management objective based on the genetic structure of bycatch species.

Component	Core Objective	Sub-component	Example Operational Objectives	Example Indicators	Rationale
		4. Age/size/sex structure	4.1 Age/size/sex structure does not change outside acceptable bounds (e.g. more than X% from reference structure)	Biomass, numbers or relative proportion in age/size/sex classes Biomass of spawners Mean size, sex ratio	4.1 EMO – move on provisions require that if bycatch in any one haul exceeds set limits (2 tonnes grey rockcod and unicorn icefish, 1 tonne all other species) then the vessel must not use that fishing method within 5 nm of that site for at least 5 days..
		5 Reproductive Capacity	5.1 Fecundity of the population does not change outside acceptable bounds (e.g. more than X% of reference population fecundity) Recruitment to the population does not change outside acceptable bounds	Egg production of population Abundance of recruits	5.1 Beyond the generality of the EMO "Fishing is conducted in a manner that does not threaten stocks of byproduct / bycatch species", reproductive capacity is not currently measured for bycatch/byproduct species and is largely covered by other objectives.
		6. Behaviour /Movement	6.1 Behaviour and movement patterns of the population do not change outside acceptable bounds	Presence of population across space, movement patterns within the population (e.g. attraction to bait, lights)	6.1 Trawling does not appear to attract bycatch species or alter their behaviour and movement patterns, resulting in the attraction of species to fishing grounds.

Component	Core Objective	Sub-component	Example Operational Objectives	Example Indicators	Rationale
TEP species	Avoid recruitment failure of TEP species Avoid negative consequences for TEP species or population sub-components Avoid negative impacts on the population from fishing	1. Population size	1.1 Species do not further approach extinction or become extinct 1.2 No trend in biomass 1.3 Maintain biomass above a specified level 1.4 Maintain catch at specified level	Biomass, numbers, density, CPUE, yield	1.1 EMO - The fishery is conducted in a manner that avoids mortality of, or injuries to, endangered, threatened or protected species (EA Assessment 2002). 1.2 A positive trend in biomass is desirable for TEP species. 1.3 Maintenance of TEP biomass above specified levels not currently a fishery operational objective. 1.4 The above EMO states '..must avoid mortality/injury to TEPs'.
		2. Geographic range	2.1 Geographic range of the population, in terms of size and continuity does not change outside acceptable bounds	Presence of population across space, i.e. the Southern Ocean.	2.1 Change in geographic range of TEP species may have serious consequences e.g. population fragmentation and/or forcing species into sub-optimal areas.
		3. Genetic structure	3.1 Genetic diversity does not change outside acceptable bounds	Frequency of genotypes in the population, effective population size (N_e), number of spawning units	3.1 Because population size of TEP species is often small, TEPs are sensitive to loss of genetic diversity. Genetic monitoring may be an effective approach to measure possible fishery impacts.

Component	Core Objective	Sub-component	Example Operational Objectives	Example Indicators	Rationale
		4. Age/size/sex structure	4.1 Age/size/sex structure does not change outside acceptable bounds (e.g. more than X% from reference structure)	Biomass, numbers or relative proportion in age/size/sex classes Biomass of spawners Mean size, sex ratio	4.1 Monitoring the age/size/sex structure of TEP populations may be a useful management tool allowing the identification of possible fishery impacts and that cross-section of the population most at risk.
		5. Reproductive Capacity	5.1 Fecundity of the population does not change outside acceptable bounds (e.g. more than X% of reference population fecundity) Recruitment to the population does not change outside acceptable bounds	Egg production of population Abundance of recruits	5.1 The reproductive capacity of TEP species is of concern to the HIMI Fishery because potential fishery induced changes in reproductive ability (e.g. reduction in prey items may critically affect seabird brooding success) may have immediate impact on the population size of TEP species.

Component	Core Objective	Sub-component	Example Operational Objectives	Example Indicators	Rationale
		6. Behaviour /Movement	6.1 Behaviour and movement patterns of the population do not change outside acceptable bounds	Presence of population across space, movement patterns within the population (e.g. attraction to bait, lights)	6.1 Trawling operations may attract TEP species and alter behaviour and movement patterns, resulting in the habituation of TEP species to fishing vessels The overall effect may be to prevent juveniles from learning to fend for themselves therefore increasing the animals' reliance on fishing vessels. Subsequently this could substantially increase the risk of injury/mortality by collision, entrapment or entanglement with a vessel or fishing gear.
		7. Interactions with fishery	7.1 Survival after interactions is maximised 7.2 Interactions do not affect the viability of the population or its ability to recover	Survival rate of species after interactions Number of interactions, biomass or numbers in population	7.1, 7.2, EMO – The fishery is conducted in a manner that avoids mortality of, or injuries to, endangered, threatened or protected species. Includes the prohibition on discarding offal (bycatch, fish processing waste, unwanted dead fish), gear restrictions and reduced lighting levels to minimise interactions and attraction of the vessel to TEP species. (EA Assessment 2002)

Component	Core Objective	Sub-component	Example Operational Objectives	Example Indicators	Rationale
Habitats	Avoid negative impacts on the quality of the environment Avoid reduction in the amount and quality of habitat	1. Water quality	1.1 Water quality does not change outside acceptable bounds	Water chemistry, noise levels, debris levels, turbidity levels, pollutant concentrations, light pollution from artificial light	1.1 EMO control the discharge or discarding of waste (fish offal and poultry products and brassicas) and limit lighting on the vessels. MARPOL regulations prohibit discharge of oils, discarding of plastics.
		2. Air quality	2.1 Air quality does not change outside acceptable bounds	Air chemistry, noise levels, visual pollution, pollutant concentrations, light pollution from artificial light	2.1 Not currently perceived as an important habitat sub-component, trawling operations not believed to strongly influence air quality.
		3. Substrate quality	3.1 Sediment quality does not change outside acceptable bounds	Sediment chemistry, stability, particle size, debris, pollutant concentrations	3.1 EMO – The fishery is conducted, in a manner that minimises the impact of fishing operations on benthic habitat Controls on bobbin and disc size requirements to minimise benthic impacts (EA Assessment 2002). The current MPA and conservation areas reserve large areas of the known habitat types from fishing disturbance.

Component	Core Objective	Sub-component	Example Operational Objectives	Example Indicators	Rationale
		4. Habitat types	4.1 Relative abundance of habitat types does not vary outside acceptable bounds	Extent and area of habitat types, % cover, spatial pattern, landscape scale	4.1 Trawling activities may result in changes to the local habitat types in the fishing grounds. The current MPA and conservation areas reserve large areas of the known habitat types from fishing disturbance.
		5. Habitat structure and function	5.1 Size, shape and condition of habitat types does not vary outside acceptable bounds	Size structure, species composition and morphology of biotic habitats	5.1 Trawling activities may result in local disruption to pelagic and benthic processes.
Communities	Avoid negative impacts on the composition/function/distribution/structure of the community	1. Species composition	1.1 Species composition of communities does not vary outside acceptable bounds	Species presence/absence, species numbers or biomass (relative or absolute) Richness Diversity indices Evenness indices	1.1 EMO – The fishery is conducted, in a manner that minimises the impact of fishing operations on the ecosystem generally. Preliminary assessments of benthic impacts by AFMA have been based on AAD trawl data and quantitative monitoring of benthic bycatch. AFMA have further planned research for benthic impacts through their 5 year Strategic Research Plan (EA Assessment 2002).

Component	Core Objective	Sub-component	Example Operational Objectives	Example Indicators	Rationale
		2. Functional group composition	2.1 Functional group composition does not change outside acceptable bounds	Number of functional groups, species per functional group (e.g. autotrophs, filter feeders, herbivores, omnivores, carnivores)	2.1 The presence/abundance of 'functional group' members may fluctuate widely, however in terms of maintenance of ecosystem processes it is important that the aggregate effect of a functional group is maintained.
		3. Distribution of the community	3.1 Community range does not vary outside acceptable bounds	Geographic range of the community, continuity of range, patchiness	3.1 Demersal Longlining operations have unknown impacts on the benthos in the fishing grounds. AFMA have planned further research on benthic impacts to clarify this issue. The current MPA and conservation areas reserve large areas of the known habitat types from fishing disturbance.
		4. Trophic/size structure	4.1 Community size spectra/trophic structure does not vary outside acceptable bounds	Size spectra of the community Number of octaves, Biomass/number in each size class Mean trophic level Number of trophic levels	4.1 Trawling activities for target species have the potential to remove a significant component of the predator functional group. Increased abundance of the prey groups may then allow shifts in relative abundance of higher trophic level organisms.
		5. Bio- and geo-chemical cycles	5.1 Cycles do not vary outside acceptable bounds	Indicators of cycles, salinity, carbon, nitrogen, phosphorus flux	5.1 Trawling operations not perceived to have a detectable effect on bio and geochemical cycles.

2.2.4 Hazard Identification (Step 4)

Hazards are the activities undertaken in the process of fishing, and any external activities, which have the potential to lead to harm.

The effects of fishery/sub-fishery specific hazards are identified under the following categories:

- capture
- direct impact without capture
- addition/movement of biological material
- addition of non biological material
- disturbance of physical processes
- external hazards

These fishing and external activities are scored on a presence/absence basis for each fishery/sub-fishery. An activity is scored as a zero if it does not occur and as a one if it does occur. The rationale for the scoring is also documented in detail and must include if/how the activity occurs and how the hazard may impact on organisms/habitat.

Scoping Document S4. Hazard Identification Scoring Sheet

This table is completed once for each sub-fishery. **Table 4** provides a set of examples of fishing activities for the effects of fishing to be used as a guide to assist in scoring the hazards.
Sub-fishery Name: Demersal longline
Fishery Name: Heard and McDonald Islands Fishery
Date of assessment: June 2006

Direct impact of Fishing	Fishing Activity	Score (0/1)	Documentation of Rationale
Capture	Bait collection	0	Frozen imported bait used
	Fishing	1	
	Incidental behaviour	0	No ports, no landings, no recreational fishing recorded.
Direct impact without capture	Bait collection	0	Frozen imported bait used
	Fishing	1	Species escaping hooks after capture
	Incidental behaviour	0	
	Gear loss	1	Loss of lines up to 5600m, hooks , floats , weights , buoys and ropes reported.
	Anchoring/ mooring	0	Not recorded.
	Navigation/steaming	1	
Addition/ movement of biological material	Translocation of species (boat launching, reballasting)	1	Translocation of species via ballast water or as hull or organisms fouling sea water piping systems is a potential risk. Disease from baits a possibility.
	On board processing	0	Fish processed on board but all unwanted bycatch is ground and stored as fishmeal onboard vessel.
	Discarding catch	0	Ground and stored as fishmeal. May only be discharged in emergency and then under strict conditions.
	Stock enhancement	0	
	Provisioning	1	Bait is used. Some lost while gear is deployed without capturing fish.
	Organic waste disposal	1	Sewage disposal not covered by regulations? Disposal of certain food scraps, brassicas and poultry products prohibited, other food scraps disposed of according to MARPOL regulations.
Addition of non-biological material	Debris	1	MARPOL regulations enforced. Vessel operators have installed signs to remind/educate crew members with regard to proper processes.
	Chemical pollution	1	Regulated by MARPOL
	Exhaust	1	Types of fuels being burnt e.g.: MDO (marine diesel oils) vs HFO (heavy fuel oil)
	Gear loss	1	Gear loss occurs and some not retrieved therefore likely to impact benthic habitats, ghost fishing
	Navigation/ steaming	1	Navigation/steaming introduces noise to environment. Depth sounders/ acoustic net positioning systems have potential to disturb marine species.

Direct impact of Fishing	Fishing Activity	Score (0/1)	Documentation of Rationale
	Activity/ presence on water	1	Presence of vessel introduces noise/stimuli to environment. Birds attracted to presence of vessel.
Disturb physical processes	Bait collection	0	Frozen imported bait used
	Fishing	1	Demersal longlines contact the bottom, may disrupt on recovery
	Boat launching	0	Vessels operate from established ports.
	Anchoring/ mooring	0	No records of vessels anchoring in sub-Antarctic AFZ.
	Navigation/ steaming	1	Wake mixing of surface waters does occur.
External Hazards (specify the particular example within each activity area)	Other capture fishery methods	1	IUU fishing vessels using longlines. Area too remote for indigenous or recreational fishers.
	Aquaculture	0	None
	Coastal development	0	None
	Other extractive activities	0	None known.
	Other non-extractive activities	0	None known.
	Other anthropogenic activities	1	Tourist shipping and landings by tourists

Table 4. Examples of fishing activities (Modified from Fletcher et al. 2002).

Direct Impact of Fishing	Fishing Activity	Examples of Activities Include
Capture		Activities that result in the capture or removal of organisms. This includes cryptic mortality due to organisms being caught but dropping out prior to the gear's retrieval (i.e. They are caught but not landed)
	Bait collection	Capture of organisms due to bait gear deployment, retrieval and bait fishing. This includes organisms caught but not landed.
	Fishing	Capture of organisms due to gear deployment, retrieval and actual fishing. This includes organisms caught but not landed.
	Incidental behaviour	Capture of organisms due to crew behaviour incidental to primary fishing activities, possible in the crew's down time; e.g. crew may line or spear fish while anchored, or perform other harvesting activities, including any land-based harvesting that occurs when crew are camping in their down time.
Direct impact, without capture		This includes any activities that may result in direct impacts (damage or mortality) to organisms without actual capture.
	Bait collection	Direct impacts (damage or mortality) to organisms due to interactions (excluding capture) with bait gear during deployment, retrieval and bait fishing. This includes: damage/mortality to organisms through contact with the gear that doesn't result in capture, e.g. Damage/mortality to benthic species by gear moving over them, organisms that hit nets but aren't caught.
	Fishing	Direct impacts (damage or mortality) to organisms due to interactions (excluding capture) with fishing gear during deployment, retrieval and fishing. This includes: damage/mortality to organisms through contact with the gear that doesn't result in capture, e.g. Damage/mortality to benthic species by gear moving over them, organisms that hit nets but are not caught.
	Incidental behaviour	Direct impacts (damage or mortality) without capture, to organisms due to behaviour incidental to primary fishing activities, possibly in the crew's down time; e.g. the use of firearms on scavenging species, damage/mortality to organisms through contact with the gear that the crew use to fish during their down time. This does not include impacts on predator species of removing their prey through fishing.
	Gear loss	Direct impacts (damage or mortality), without capture on organisms due to gear that has been lost from the fishing boat. This includes damage/mortality to species when the lost gear contacts them or if species swallow the lost gear.
	Anchoring/ mooring	Direct impact (damage or mortality) that occurs and when anchoring or mooring. This includes damage/mortality due to physical contact of the anchor, chain or rope with organisms, e.g. An anchor damaging live coral.
	Navigation/ steaming	Direct impact (damage or mortality) without capture may occur while vessels are navigating or steaming. This includes collisions with marine organisms or birds.
Addition/ movement of biological material		Any activities that result in the addition or movement of biological material to the ecosystem of the fishery.
	Translocation of species (boat	The translocation and introduction of species to the area of the fishery, through transportation of any life stage. This transport can occur through movement on boat hulls or in ballast water as boats move throughout the fishery or from outside areas into the fishery.

Direct Impact of Fishing	Fishing Activity	Examples of Activities Include
	movements, reballasting)	
	On board processing	The discarding of unwanted sections of target after on board processing introduces or moves biological material, e.g. heading and gutting, retaining fins but discarding trunks.
	Discarding catch	The discarding of unwanted organisms from the catch can introduce or move biological material. This includes individuals of target and byproduct species due to damage (e.g. shark or marine mammal predation), size, high grading and catch limits. Also includes discarding of all non-retained bycatch species. This also includes discarding of catch resulting from incidental fishing by the crew. The discards could be alive or dead.
	Stock enhancement	The addition of larvae, juveniles or adults to the fishery or ecosystem to increase the stock or catches.
	Provisioning	The use of bait or berley in the fishery.
	Organic waste disposal	The disposal of organic wastes (e.g. food scraps, sewage) from the boats.
Addition of non-biological material		Any activities that result in non-biological material being added to the ecosystem of the fishery, this includes physical debris, chemicals (in the air and water), lost gear, noise and visual stimuli.
	Debris	Non-biological material may be introduced in the form of debris from fishing vessels or mother ships. This includes debris from the fishing process: e.g. cardboard thrown over from bait boxes, straps and netting bags lost. Debris from non-fishing activities can also contribute to this e.g. Crew rubbish – discarding or food scraps, plastics or other rubbish. Discarding at sea is regulated by MARPOL, which forbids the discarding of plastics.
	Chemical pollution	Chemicals can be introduced to water, sediment and atmosphere through: oil spills, detergents other cleaning agents, any chemicals used during processing or fishing activities.
	Exhaust	Exhaust can be introduced to the atmosphere and water through operation of fishing vessels
	Gear loss	The loss of gear will result in the addition of non-biological material, this includes hooks, line, sinkers, nets, otter boards, light sticks, buoys etc.
	Navigation /steaming	The navigation and steaming of vessels will introduce noise and visual stimuli into the environment. Boat collisions and/or sinking of vessels. Echo-sounding may introduce noise that may disrupt some species (e.g. whales, orange roughy)
	Activity /presence on water	The activity or presence of fishing vessels on the water will noise and visual stimuli into the environment.
Disturb physical processes		Any activities that will disturb physical processes, particularly processes related to water movement or sediment and hard substrate (e.g. boulders, rocky reef) processes.
	Bait collection	Bait collection may disturb physical processes if the gear contacts seafloor-disturbing sediment, or if the gear disrupts water flow patterns.

Direct Impact of Fishing	Fishing Activity	Examples of Activities Include
	Fishing	Fishing activities may disturb physical processes if the gear contacts seafloor-disturbing sediment, or if the gear disrupts water flow patterns.
	Boat launching	Boat launching may disturb physical processes, particularly in the intertidal regions, if dredging is required, or the boats are dragged across substrate. This would also include foreshore impacts where fishers drive along beaches to reach fishing locations and launch boats. Impacts of boat launching that occurs within established marinas are outside the scope of this assessment.
	Anchoring /mooring	Anchoring/mooring may affect the physical processes in the area that anchors and anchor chains contact the seafloor.
	Navigation /steaming	Navigation /steaming may affect the physical processes on the benthos and the pelagic by turbulent action of propellers or wake formation.
External hazards		Any outside activities that will result in an impact on the component in the same location and period that the fishery operates. The particular activity as well as the mechanism for external hazards should be specified.
	Other capture fishery methods	Take or habitat impact by other commercial, indigenous or recreational fisheries operating in the same region as the fishery under examination
	Aquaculture	Capture of feed species for aquaculture. Impacts of cages on the benthos in the region
	Coastal development	Sewage discharge, ocean dumping, agricultural runoff
	Other extractive activities	Oil and gas pipelines, drilling, seismic activity
	Other non-extractive activities	Defence, shipping lanes, dumping of munitions, submarine cables
	Other anthropogenic activities	Recreational activities, such as scuba diving leading to coral damage, power boats colliding with whales, dugongs, turtles. Shipping, oil spills

2.2.5 Bibliography (Step 5)

All references used in the scoping assessment are included in the References section.

Key documents can be found on the AFMA web page at www.afma.gov.au and include the following:

- Assessment Report
- Management Plan
- Management Regulations
- Management Plan and Regulation Guidelines
- AFMA At a glance web page http://www.afma.gov.au/fisheries/etbf/at_a_glance.php
- Bycatch Action Plans
- Data Summary Reports (logbook and observer)

Other publications that may provided information include

- BRS Fishery Status Reports
- Strategic Plans

2.2.6 Decision rules to move to Level 1(Step 6)

Any hazards that are identified at Step 4 Hazard Identification as occurring in the fishery are carried forward for analysis at Level 1.

In this case, 15 out of 26 possible internal activities were identified as occurring in this fishery. Two out of 6 external activities were identified. Thus, a total of 17 activity-component scenarios will be considered at Level 1. This results in 85 total scenarios (of 160 possible) to be developed and evaluated using the unit lists (species, habitats, communities).

2.3 Level 1 Scale, Intensity and Consequence Analysis (SICA)

Level 1 aims to identify which hazards lead to a significant impact on any species, habitat or community. Analysis at Level 1 is for whole components (target; bycatch and byproduct; TEP species; habitat; and communities), not individual sub-components. Since Level 1 is used mainly as a rapid screening tool, a "worst case" approach is used to ensure that elements screened out as low risk (either activities or components) are genuinely low risk. Analysis at Level 1 for each component is accomplished by considering the most vulnerable sub-component and the most vulnerable unit of analysis (e.g. most vulnerable species, habitat type or community). This is known as credible scenario evaluation (Richard Stocklosa e-systems Pty Ltd (March 2003) Review of CSIRO Risk Assessment Methodology: ecological risk assessment for the effects of fishing) in conventional risk assessment. In addition, where judgments about risk are uncertain, the highest level of risk that is still regarded as plausible is chosen. For this reason, the measures of risk produced at Level 1 cannot be regarded as absolute.

At Level 1 each fishery/sub-fishery is assessed using a scale, intensity and consequence analysis (SICA). SICA is applied to the component as a whole by choosing the most vulnerable sub-component (linked to an operational objective) and most vulnerable unit of analysis. The rationale for these choices must be documented in detail. These steps are outlined below. Scale, intensity, and consequence analysis (SICA) consists of thirteen steps. The first ten steps are performed for each activity and component, and correspond to the columns of the SICA table. The final three steps summarise the results for each component.

Step1: Record the hazard identification score (absence (0) presence (1) scores) identified at step 3 at the scoping level (Scoping Document S3) onto the SICA table
Step 2: Score spatial scale of the activity
Step 3: Score temporal scale of the activity
Step 4: Choose the sub-component most likely to be affected by activity
Step 5: Choose the most vulnerable unit of analysis for the component e.g. species, habitat type or community assemblage
Step 6: Select the most appropriate operational objective
Step 7: Score the intensity of the activity for that sub-component
Step 8: Score the consequence resulting from the intensity for that sub component
Step 9: Record confidence/uncertainty for the consequence scores
Step 10. Document rationale for each of the above steps

Step 11. Summary of SICA results
Step 12. Evaluation/discussion of Level 1
Step 13. Components to be examined at Level 2

2.3.1 Record the hazard identification score (absence (0) presence (1) scores) identified at step 3 in the scoping level onto the SICA Document (Step 1)

Record the hazard identification score absence (0) presence (1) identified at Step 3 at the scoping level onto the SICA sheet. A separate sheet will be required for each

component (target, bycatch and byproduct, and TEP species, habitat, and communities). Only those activities that scored a 1 (presence) will be analysed at Level 1

2.3.2 Score spatial scale of activity (Step 2)

The greatest spatial extent must be used for determining the spatial scale score for each identified hazard. For example, if fishing (e.g. capture by longline) takes place within an area of 200 nm by 300 nm, then the spatial scale is scored as 4. The score is then recorded onto the SICA Document and the rationale documented.

Spatial scale score of activity

<1 nm:	1-10 nm:	10-100 nm:	100-500 nm:	500-1000 nm:	>1000 nm:
1	2	3	4	5	6

Maps and graphs may be used to supplement the information (e.g. sketches of the distribution of the activity relative to the distribution of the component) and additional notes describing the nature of the activity should be provided. The spatial scale score at Step 2 is not used directly, but the analysis is used in making judgments about level of intensity at Step 7. Obviously, two activities can score the same with regard to spatial scale, but the intensity of each can differ vastly. The reasons for the score are recorded in the rationale column of the SICA spreadsheet.

2.3.3 Score temporal scale of activity (Step 3)

The highest frequency must be used for determining the temporal scale score for each identified hazard. If the fishing activity occurs daily, the temporal scale is scored as 6. If oil spillage occurs about once per year, then the temporal scale of that hazard scores a 3. The score is then recorded onto the SICA Document and the rationale documented.

Temporal scale score of activity

Decadal (1 day every 10 years or so)	Every several years (1 day every several years)	Annual (1-100 days per year)	Quarterly (100-200 days per year)	Weekly (200-300 days per year)	Daily (300-365 days per year)
1	2	3	4	5	6

It may be more logical for some activities to consider the aggregate number of days that an activity occurs. For example, if the activity “fishing” was undertaken by 10 boats during the same 150 days of the year, the score is 3. If the same 10 boats each spend 30 non-overlapping days fishing, the temporal scale of the activity is a sum of 300 days, indicating that a score of 6 is appropriate. In the case where the activity occurs over many days, but only every 10 years, the number of days by the number of years in the cycle is used to determine the score. For example, 100 days of an activity every 10 years averages to 10 days every year, so that a score of 3 is appropriate.

The temporal scale score at Step 3 is not used directly, but the analysis is used in making judgments about level of intensity at Step 7. Obviously, two activities can score the same with regard to temporal scale, but the intensity of each can differ vastly. The reasons for the score are recorded in the rationale column.

2.3.4 Choose the sub-component most likely to be affected by activity (Step 4)

The most vulnerable sub-component must be used for analysis of each identified hazard. This selection must be made on the basis of expected highest potential risk for each 'direct impact of fishing' and 'fishing activity' combination, and recorded in the 'sub-component' column of the SICA Document. The justification is recorded in the rationale column.

2.3.5 Choose the unit of analysis most likely to be affected by activity and to have highest consequence score (Step 5)

The most vulnerable 'unit of analysis' (i.e. most vulnerable species, habitat type or community) must be used for analysis of each identified hazard. The species, habitats, or communities (depending on which component is being analysed) are selected from **Scoping Document S2 (A – C)**. This selection must be made on the basis of expected highest potential risk for each 'direct impact of fishing' and 'fishing activity' combination, and recorded in the 'unit of analysis' column of the SICA Document. The justification is recorded in the rationale column.

2.3.6 Select the most appropriate operational objective (Step 6)

To provide linkage between the SICA consequence score and the management objectives, the most appropriate operational objective for each sub-component is chosen. The most relevant operational objective code from **Scoping Document S3** is recorded in the 'operational objective' column in the SICA document. Note that SICA can only be performed on operational objectives agreed as important for the (sub) fishery during scoping and contained in **Scoping Document S3**. If the SICA process identifies reasons to include sub-components or operational objectives that were previously not included/eliminated then these sub-components or operational objectives must be re-instated.

2.3.7 Score the intensity of the activity for the component (Step 7)

The score for intensity of an activity considers the direct impacts in line with the categories shown in the conceptual model (**Figure 2**) (capture, direct impact without capture, addition/movement of biological material, addition of non-biological material, disturbance to physical processes, external hazards). The intensity of the activity is judged based on the scale of the activity, its nature and extent. Activities are scored as per intensity scores below.

Intensity score of activity (Modified from Fletcher et al. 2002)

Level	Score	Description
Negligible	1	remote likelihood of detection at any spatial or temporal scale
Minor	2	occurs rarely or in few restricted locations and detectability even at these scales is rare
Moderate	3	moderate at broader spatial scale, or severe but local
Major	4	severe and occurs reasonably often at broad spatial scale
Severe	5	occasional but very severe and localized or less severe but widespread and frequent
Catastrophic	6	local to regional severity or continual and widespread

This score is then recorded on the **Level 1 (SICA) Document** and the rationale documented.

2.3.8 Score the consequence of intensity for that component (Step 8)

The consequence of the activity is a measure of the likelihood of not achieving the operational objective for the selected sub-component and unit of analysis. It considers the flow on effects of the direct impacts from Step 7 for the relevant indicator (e.g. decline in biomass below the selected threshold due to direct capture). Activities are scored as per consequence scores below. A more detailed description of the consequences at each level for each component (target, bycatch and byproduct, TEP species, habitats, and communities) is provided as a guide for scoring the consequences of the activities in the description of consequences table (see **Table 5** Appendix B).

Consequence score for ERAEF activities (Modified from Fletcher et al. 2002).

Level	Score	Description
Negligible	1	Impact unlikely to be detectable at the scale of the stock/habitat/community
Minor	2	Minimal impact on stock/habitat/community structure or dynamics
Moderate	3	Maximum impact that still meets an objective (e.g. sustainable level of impact such as full exploitation rate for a target species).
Major	4	Wider and longer term impacts (e.g. long-term decline in CPUE)
Severe	5	Very serious impacts now occurring, with relatively long time period likely to be needed to restore to an acceptable level (e.g. serious decline in spawning biomass limiting population increase).
Intolerable	6	Widespread and permanent/irreversible damage or loss will occur-unlikely to ever be fixed (e.g. extinction)

The score should be based on existing information and/or the expertise of the risk assessment group. The rationale for assigning each consequence score must be documented. The conceptual model may be used to link impact to consequence by showing the pathway that was considered. In the absence of agreement or information, the highest score (worst case scenario) considered plausible is applied to the activity.

2.3.9 Record confidence/uncertainty for the consequence scores (Step 9)

The information used at this level is qualitative and each step is based on expert (fishers, managers, conservationists, scientists) judgment. The confidence rating for the consequence score is rated as 1 (low confidence) or 2 (high confidence) for the activity/component. The score is recorded on the SICA Document and the rationale documented. The confidence will reflect the levels of uncertainty for each score at steps 2, 3, 7 and 8.

Description of Confidence scores for Consequences. The confidence score appropriate to the rationale is used, and documented on the SICA Document.

Confidence	Score	Rationale for the confidence score
Low	1	Data exists, but is considered poor or conflicting No data exists Disagreement between experts
High	2	Data exists and is considered sound Consensus between experts Consequence is constrained by logical consideration

2.3.10 Document rationale for each of the above steps (Step 10)

The rationale forms a logical pathway to the consequence score. It is provided for each choice at each step of the SICA analysis.

2.3.1 Level 1 (SICA) Documents

SICA steps 1-10. Tables of descriptions of consequences for each component and each sub component provide a guide for scoring the level of consequence (see Appendix C)

L1.1 - Target Species Component

Direct impact of fishing	Fishing activity	Presence (1) Absence (0)	Spatial scale of Hazard (1-6)	Temporal scale of	Sub-component	Unit of analysis	Operational objective	Intensity Score (1-6)	Consequence Score	Confidence Score (1-2)	Rationale
Capture	Bait collection	0									
	Fishing	1	3	3	Age/Size/Sex structure	Patagonian toothfish	4.1	3	3	2	Longlining occurs over an area of about 13,000sq km, the major area is about 10,000sq km.=>season is restricted to about 5 months=>larger Patagonian toothfish selected by this method and age/sex/size structure most likely to be affected although reproductive capacity could be reduced if these fish are a significant proportion of breeding population =>intensity moderate, catch and effort doubled in first year of fishery but has been stable for the past 2 years => consequence moderate -TAC limits catch to within sustainable levels so impact on population dynamics sustainable and recruitment not affected however caution is necessary while uncertainty about location and size of spawning populations exists => confidence high, observer data and logbooks
	Incidental behaviour	0									
Direct impact without capture	Bait collection	0									
	Fishing	1	3	3	Population Size	Patagonian toothfish	1.1	2	1	2	Population size most likely to be affected if escaped fish have reduced survival=>intensity minor => consequence negligible escaped fish have good survival given success of tagging studies and detection of impact unlikely => confidence high ,observer data and logbooks

Direct impact of fishing	Fishing activity	Presence (1) Absence (0)	Spatial scale of Hazard (1-6)	Temporal scale of Hazard (1-6)	Sub-component	Unit of analysis	Operational objective (2.1)	Intensity Score (1-6)	Consequence Score (1-6)	Confidence Score (1-2)	Rationale
	Incidental behaviour	0									
	Gear loss	1	3	3	Population Size	Patagonian toothfish	1.1	1	1	2	Gear loss occurs rarely => intensity negligible and even so, baits disappear rapidly so ghost fishing unlikely and any gear would tend to ball up thus no risk of entanglement to fish => therefore consequence negligible => confidence high, observer reports all lost gear
	Anchoring/ mooring	0									
	Navigation/ steaming	1	3	3	Behaviour/movement	Patagonian toothfish	6.1	1	1	2	One vessel on grounds and species are deepwater species below 400m therefore cannot collide with vessel => intensity negligible =>consequence negligible =>confidence high, logic
Addition/ movement of biological material	Translocation of species	1	3	3	Population size	Patagonian toothfish	1.1	2	3	1	Frozen bait used therefore a risk of introducing disease from other areas=>intensity minor as detectability would be rare=> consequence moderate because the impact on target species could be at least detectable if not severe and outbreaks have occurred with major consequences elsewhere. However there has been no detectable impact from this activity and the likelihood of this event is low, . AQIS strictly regulate and licence importation of bait to eliminate the risk of introduction of disease via bait => confidence low no data
	On board processing	0									
	Discarding catch	0									
	Stock enhancement	0									
	Provisioning	0									

Direct impact of fishing	Fishing activity	Presence (1) Absence (0)	Spatial scale of Hazard (1-6)	Temporal scale of Hazard (1-6)	Sub-component	Unit of analysis	Operational objective (6.1)	Intensity Score (1-6)	Consequence Score (1-6)	Confidence Score (1-2)	Rationale
	Organic waste disposal	1	3	3	Behaviour/movement	Patagonian toothfish	6.1	1	1	2	Vessels do not dispose of any plastic rubbish, or poultry products and comply strictly with MARPOL regulations therefore organic waste discharge could only be accidental; target species depths>400m therefore cannot alter behaviour of fish => intensity negligible =>consequence negligible =>confidence high, 100% observer coverage, compliance to regulations
Addition of non-biological material	Debris	1	3	3	Population size	Patagonian toothfish	1.1	1	1	2	Vessels do not dispose of any plastic rubbish, or poultry products and comply strictly with MARPOL regulations; accidental loss of rubbish overboard might occur rarely => intensity negligible=>consequence negligible=>confidence high, 100% observer coverage, compliance to regulations
	Chemical pollution	1	3	2	Population size	Patagonian toothfish	1.1	1	1	2	Vessels comply strictly with MARPOL regulations; few chemicals used at sea and any chemical pollution unlikely to reach target species depths>400m. Oil spill from collision or grounding but unlikely due to only 1 vessel in area usually => intensity negligible=>consequence negligible=>confidence high, 100% observer coverage, compliance to regulations
	Exhaust	1	3	3	Population size	Patagonian toothfish	1.1	1	1	2	Exhaust from vessel daily but dispersed and would have no effect on demersal fish =>intensity negligible=>consequence negligible=>confidence high, logical
	Gear loss	1	3	3	Population size	Patagonian toothfish	1.1	1	1	1	Gear loss occurs rarely and all reasonable attempts to retrieve gear are made and possibility of altering behaviour from lost gear is unlikely to be detectable=>intensity negligible =>consequence negligible unlikely to detect => confidence low , no data on risk to target species
	Navigation/ steaming	1	3	3	Behaviour/movement	Patagonian toothfish	6.1	1	1	2	Limited vessels operating in area therefore noise and stimuli from navigation /steaming , collision , echo sounding minimal =>intensity negligible=>consequence negligible as fish are deepwater species=>confidence high, logical

Direct impact of fishing	Fishing activity	Presence (1) Absence (0)	Spatial scale of Hazard (1-6)	Temporal scale of Hazard (1-6)	Sub-component	Unit of analysis	Operational objective (2.1)	Intensity Score (1-6)	Consequence Score (1-6)	Confidence Score (1-2)	Rationale
	Activity/ presence on water	1	3	3	Behaviour/movement	Patagonian toothfish	6.1	1	1	2	Limited vessels operating in area therefore noise and stimuli but target species >400m and unlikely to be affected=>intensity negligible=>consequence negligible=>confidence high, logical
Disturb physical processes	Bait collection	0									
	Fishing	1	3	3	Behaviour/movement	Patagonian toothfish	6.1	1	1	1	Lines are weighted internally therefore area of impact very small unless intensity of activity increases and might affect behaviour/movement of target species=>intensity negligible=>consequence negligible=>confidence low, no data
	Boat launching	0									
	Anchoring/ mooring	0									
	Navigation/ steaming	1	3	3	Behaviour/movement	Patagonian toothfish	6.1	1	1	2	Limited vessels operating and disturbance of water column would be undetectable against oceanic processes =>intensity negligible=>consequence negligible=>confidence high, logical
External Impacts (specify the particular example within each activity area)	Other fisheries	1	6	4	Population size	Patagonian toothfish	1.1	3	4	1	Demersal trawling occurs nearby and on the same stock but at higher effort and over longer season therefore might have a moderate impact. Occasional scientific surveys take fish but would have minimal impact. Foreign legal longlining and IUU longlining adjacent to our EEZ has large impacts on the toothfish stock at HIMI if stocks are considered to be the same =>intensity moderate=>consequence major if IUU is impacting the same straddling stock =>confidence low as stock structure and reproduction dynamics uncertain
	Aquaculture	0									
	Coastal development	0									

Direct impact of fishing	Fishing activity	Presence (1) Absence (0)	Spatial scale of Hazard (1-6)	Temporal scale of Hazard (1-6)	Sub-component	Unit of analysis	Operational objective (6.1)	Intensity Score (1-6)	Consequence Score (1-6)	Confidence Score (1-2)	Rationale
	Other extractive activities	0									
	Other non extractive activities	0		0							
	Other anthropogenic activities	1	3	3	Behaviour/movement	Patagonian toothfish	6.1	1	1	2	Tourist/shipping occurs to Heard Island but unlikely to occur on fishing grounds and to affect deepwater species=>intensity negligible=>consequence negligible=>confidence high

L1.2 - Byproduct and Bycatch Component

Direct impact of fishing	Fishing activity	Presence (1) Absence (0)	Spatial scale of Hazard (1-3)	Temporal scale of Hazard (1-3)	Sub-component	Unit of analysis	Operational objective (S2.1)	Intensity Score (1-6)	Consequence Score (1-6)	Confidence Score (1-2)	Rationale
Capture	Bait collection	0	0	0							
	Fishing	1	3	3	Population size	Skates and rays	1.1	3	3	2	Longlining occurs over an area of about 13,000sq km, major area of about 10,000sq km.=>season is restricted to about 5 months=>skates and rays chosen as most vulnerable species because of their known low productivity; comprise about 2% of non-target catch but a further 6% are released; susceptibility to capture is higher than trawl gear and population status is unknown therefore TACS of 120 tonnes overall is set and trigger limit of 60 tonnes will instigate investigation => intensity moderate as catch and effort increasing => consequence moderate as impacts probably detectable => confidence high ,observer data and logbooks
	Incidental behaviour	0	0	0							
Direct impact without capture	Bait collection	0	0	0							
	Fishing	1	3	3	Population size	Skates and rays	1.1	3	2	2	Most skates and rays are released from line at water level therefore reducing post-capture mortality => intensity moderate => consequence minor - tagging studies suggest a lower survival than toothfish however rate of bycatch released is small - only 6% of total catch => confidence high, observer data and logbooks
	Incidental behaviour	0	0	0							

Direct impact of fishing	Fishing activity	Presence (1) Absence (0)	Spatial scale of Hazard (1-3)	Temporal scale of Hazard (1-3)	Sub-component	Unit of analysis	Operational objective (S2.1)	Intensity Score (1-6)	Consequence Score (1-6)	Confidence Score (1-2)	Rationale
	Gear loss	1	3	3	Population size	Skates and rays	1.1	1	1	1	Gear loss occurs rarely => intensity negligible and even so, baits disappear rapidly so ghost fishing unlikely and any gear would tend to ball up thus no risk of entanglement to fish => therefore consequence negligible => confidence high, observer reports all lost gear
	Anchoring/ mooring	0	0	0							
	Navigation/ steaming	1	3	3	Behaviour/movement	Skates and rays	6.1	1	1	2	Limited vessels on grounds and species are deepwater species below 400m therefore unlikely to collide=> intensity negligible=>consequence negligible=>confidence high, logic
Addition/ movement of biological material	Translocation of species	1	3	3	Population size	Skates and rays	1.1	2	3	1	Frozen bait used therefore a risk of introducing disease from other areas => intensity minor as detectability would be rare => consequence moderate because the impact on target species could be at least detectable if not severe and outbreaks have occurred with major consequences elsewhere. However there has been no detectable impact from this activity and the likelihood of this event is low. AQIS strictly regulate and licence importation of bait to eliminate the risk of introduction of disease via bait => confidence low, no data
	On board processing	0	0	0							
	Discarding catch	0	0	0							
	Stock enhancement	0	0	0							
	Provisioning	0	0	0							

Direct impact of fishing	Fishing activity	Presence (1) Absence (0)	Spatial scale of Hazard (1-3)	Temporal scale of Hazard (1-3)	Sub-component	Unit of analysis	Operational objective (S2.1)	Intensity Score (1-6)	Consequence Score (1-6)	Confidence Score (1-2)	Rationale
	Organic waste disposal	1	3	3	Population size	Skates and rays	1.1	1	1	2	Vessels do not dispose of any plastic rubbish, or poultry products and comply strictly with MARPOL regulations therefore organic waste discharge could only be accidental; target species depths>400m therefore cannot alter behaviour of fish => intensity negligible =>consequence negligible =>confidence high, 100% observer coverage, compliance to regulations
Addition of non-biological material	Debris	1	3	3	Population Size	Skates and rays	1.1	1	1	2	Vessels do not dispose of any plastic rubbish, or poultry products and comply strictly with MARPOL regulations; accidental loss of rubbish overboard might occur rarely => intensity negligible=>consequence negligible=>confidence high, 100% observer coverage, compliance to regulations
	Chemical pollution	1	3	2	Population size	Skates and rays	1.1	1	1	2	Vessels comply strictly with MARPOL regulations; few chemicals used at sea and any chemical pollution unlikely to reach target species depths>400m. Oil spill from collision or grounding but unlikely due to only 1 vessel in area usually => intensity negligible=>consequence negligible=>confidence high, 100% observer coverage, compliance to regulations
	Exhaust	1	3	3	Population size	Skates and rays	1.1	1	1	2	Exhaust from vessel daily but dispersed and would have no effect on demersal fish =>intensity negligible=>consequence negligible=>confidence high, logical
	Gear loss	1	3	3	Behaviour/movement	Skates and rays	6.1	1	1	1	Gear loss occurs rarely and all reasonable attempts to retrieve gear are made and possibility of altering behaviour from lost gear is unlikely to be detectable=>intensity negligible =>consequence negligible unlikely to detect => confidence low , no data on risk to target species

Direct impact of fishing	Fishing activity	Presence (1) Absence (0)	Spatial scale of Hazard (1-6)	Temporal scale of Hazard (1-6)	Sub-component	Unit of analysis	Operational objective (S2.1)	Intensity Score (1-6)	Consequence Score (1-6)	Confidence Score (1-2)	Rationale
	Navigation/ steaming	1	3	3	Behaviour/movement	Skates and rays	6.1	1	1	2	Limited vessels operating in area therefore noise and stimuli from navigation /steaming , collision , echo sounding minimal =>intensity negligible=>consequence negligible as fish are deepwater species=>confidence high, logical
	Activity/ presence on water	1	3	3	Behaviour/movement	Skates and rays	6.1	1	1	2	Limited vessels operating in area therefore noise and stimuli but species are deepwater and unlikely to be affected=>intensity negligible=>consequence negligible=>confidence high, logical
Disturb physical processes	Bait collection	0	0	0							
	Fishing	1	3	3	Behaviour/movement	Skates and rays	6.1	1	1	1	Lines are weighted internally therefore area of impact very small unless intensity of activity increases and might affect behaviour/movement of skates and rays=>intensity negligible=>consequence negligible=>confidence low, no data
	Boat launching	0	0	0							
	Anchoring/ mooring	0	0	0							
	Navigation/ steaming	1	3	3	Behaviour/movement	Skates and rays	6.1	1	1	2	Limited vessels operating and disturbance of water column would be undetectable against oceanic processes =>intensity negligible=>consequence negligible=>confidence high, logical
External Impacts (specify the particular example within each activity area)	Other fisheries	1	6	4	Population size	Skates and rays	1.1	3	3	1	Demersal trawling occurs nearby but at higher effort and over longer season therefore might have a moderate impact on skates and rays. Occasional scientific surveys take fish but would have minimal impact =>intensity moderate =>consequence moderate =>confidence low as stock structure and reproduction dynamics of skates and rays uncertain
	Aquaculture	0	0	0							

Direct impact of fishing	Fishing activity	Presence (1) Absence (0)	Spatial scale of Hazard (1-3)	Temporal scale of Hazard (1-3)	Sub-component	Unit of analysis	Operational objective (S2.1)	Intensity Score (1-6)	Consequence Score (1-6)	Confidence Score (1-2)	Rationale
	Coastal development	0	0	0							
	Other extractive activities	0	0	0							
	Other non extractive activities	0	0	0							
	Other anthropogenic activities	1	3	3	Behaviour/movement	Skates and rays	6.1	1	1	2	Tourist/shipping occurs to Heard Island but unlikely to occur on fishing grounds and to affect deepwater species=>intensity negligible=>consequence negligible=>confidence high

L1.3 - TEP Species Component

Direct impact of fishing	Fishing activity	Presence (1) Absence (0)	Spatial scale of Hazard (1-3)	Temporal scale of Hazard (1-3)	Sub-component	Unit of analysis	Operational objective (2.1)	Intensity Score (1-6)	Consequence Score (1-6)	Confidence Score (1-2)	Rationale
Capture	Bait collection	0	0	0							
	Fishing	1	3	3	Population size	Southern Giant Petrel *Macronectes giganteus,* Black-browed Albatross *Thalassarche melanophrys*	1.1	1	1	2	Longlining occurs over an area of about 13000sq km, major area of about 10000sq km=> season is about 5 months=> Southern Giant Petrel population has declined globally and at Heard Island by about 50% since 1950s and is listed as vulnerable; much of the decline over last 20 years attributed to fishing activities esp. longlining. Breeding populations of Black browed albatross about 600 pairs; birds seen regularly on fishing grounds and => population size could be impacted by fishing as longline operations in adjacent French EEZ and high seas and globally have high rates of mortality on seabirds however within AFZ mitigating measures are strictly implemented =>intensity negligible as no seabirds have been taken on longline operations =>consequence negligible =>confidence high, 100% observer coverage and all records of wildlife interactions are reported.
	Incidental behaviour	0	0	0							
Direct impact without capture	Bait collection	0	0	0							
	Fishing	1	3	3	Population size	Southern Giant Petrel *Macronectes giganteus,* Black-browed Albatross *Thalassarche melanophrys*	1.1	1	1	2	Birds might interact with gear as it is being deployed or hauled however mitigating measures are strictly implemented =>intensity negligible as no seabirds have been taken or injured during longline operations =>consequence negligible =>confidence high, 100% observer coverage and all records of wildlife interactions are reported.
	Incidental behaviour	0	0	0							

Direct impact of fishing	Fishing activity	Presence (1) Absence (0)	Spatial scale of Hazard (1-3)	Temporal scale of Hazard (1-3)	Sub-component	Unit of analysis	Operational objective (3.1)	Intensity Score (1-6)	Consequence Score (1-6)	Confidence Score (1-2)	Rationale
	Gear loss	1	3	3	Population size	Southern Giant Petrel *Macronectes giganteus,* Black-browed Albatross *Thalassarche melanophrys*	1.1	1	1	2	Gear loss occurs rarely and demersal gear unable to interact with birds=> intensity negligible => consequence negligible => confidence high, 100% observer coverage reports all lost gear
	Anchoring/ mooring	0	0	0							
	Navigation/steaming	1	3	3	Population size	Southern Giant Petrel *Macronectes giganteus,* Black-browed Albatross *Thalassarche melanophrys*	1.1	1	1	2	Birds occasionally collide with vessel during operations however mitigating measures are strictly implemented such as minimising lights=> intensity negligible as no Giant Petrels or Albatross have been taken or injured by colliding with vessel => consequence negligible=>confidence high, 100% observer coverage and all records of wildlife interactions are reported.
Addition/ movement of biological material	Translocation of species	1	3	3	Population size	Southern Giant Petrel *Macronectes giganteus,* Black-browed Albatross *Thalassarche melanophrys*	1.1	1	1	2	Birds unable to take bait from lines due to strict regulations on setting gear with weighted lines to minimise seabird attraction =>intensity negligible as no birds have been reported taking bait =>consequence negligible => confidence high, 100% observer coverage
	On board processing	0	0	0							
	Discarding catch	0	0	0							
	Stock enhancement	0	0	0							
	Provisioning	0	0	0							

Direct impact of fishing	Fishing activity	Presence (1) Absence (0)	Spatial scale of Hazard (1-3)	Temporal scale of Hazard (1-3)	Sub-component	Unit of analysis	Operational objective (6.1)	Intensity Score (1-6)	Consequence Score (1-6)	Confidence Score (1-2)	Rationale
	Organic waste disposal	1	3	3	Behaviour/movement	Southern Giant Petrel *Macronectes giganteus,* Black-browed Albatross *Thalassarche melanophrys*	6.1	1	2	2	Vessels do not dispose of any plastic rubbish, or poultry products and comply strictly with MARPOL regulations therefore organic waste discharge could only be accidental; target species depths>400m therefore cannot alter behaviour of fish => intensity negligible =>consequence negligible =>confidence high, 100% observer coverage, compliance to regulations
Addition of non-biological material	Debris	1	3	3	Population Size	Southern Giant Petrel *Macronectes giganteus,* Black-browed Albatross *Thalassarche melanophrys*	1.1	1	2	2	Vessels do not dispose of any plastic rubbish, or poultry products and comply strictly with MARPOL regulations; accidental loss of rubbish overboard might occur rarely => intensity negligible=>consequence negligible=>confidence high, 100% observer coverage, compliance to regulations
	Chemical pollution	1	3	2	Population Size	Southern Giant Petrel *Macronectes giganteus,* Black-browed Albatross *Thalassarche melanophrys*	1.1	1	1	2	Vessels comply strictly with MARPOL regulations; few chemicals used at sea and any chemical pollution unlikely to reach target species depths>400m. Oil spill from collision or grounding but unlikely due to only 1 vessel in area usually => intensity negligible=>consequence negligible=>confidence high, 100% observer coverage, compliance to regulations
	Exhaust	1	3	3	Behaviour/movement	Southern Giant Petrel *Macronectes giganteus,* Black-browed Albatross *Thalassarche melanophrys*	6.1	1	1	2	Exhaust from vessel daily but dispersed and would have no effect on demersal fish =>intensity negligible=>consequence negligible=>confidence high, logical

Direct impact of fishing	Fishing activity	Presence (1) Absence (0)	Spatial scale of Hazard (1-3)	Temporal scale of Hazard (1-3)	Sub-component	Unit of analysis	Operational objective (3.1)	Intensity Score (1-6)	Consequence Score (1-6)	Confidence Score (1-2)	Rationale
	Gear loss	1	3	3	Population Size	Southern Giant Petrel *Macronectes giganteus,* Black-browed Albatross *Thalassarche melanophrys*	1.1	1	1	1	Gear loss occurs rarely. Gear lost on bottom not encountered by birds =>intensity negligible =>consequence negligible unlikely to detect => confidence high , 100% observer coverage
	Navigation/ steaming	1	3	3	Behaviour/movement	Southern Giant Petrel *Macronectes giganteus,* Black-browed Albatross *Thalassarche melanophrys*	1.1	1	2	2	Limited vessels operating in area therefore noise and stimuli from navigation /steaming , collision , echo sounding minimal => intensity negligible=>consequence minor as birds may be attracted or repelled temporarily but not persistent change=>confidence high, logical
	Activity/ presence on water	1	3	3	Behaviour/movement	Southern Giant Petrel *Macronectes giganteus,* Black-browed Albatross *Thalassarche melanophrys*	6.1	1	2	2	Limited vessels operating in area therefore noise and stimuli but target species >400m and unlikely to be affected=>intensity negligible=>consequence minor as birds may be attracted or repelled temporarily but not persistent change=>confidence high, logical
Disturb physical processes	Bait collection	0	0	0							
	Fishing	1	3	3	Behaviour/movement	Elephant Seal *Mirounga leonina,*	6.1	1	1	1	Gear is weighted and might affect benthic physical processes but area of impact small unless intensity of activity increases; lines and float might affect water column causing disruption to foraging area of Elephant Seals which are know to occur in areas of longline fishing =>intensity negligible=>consequence negligible=>confidence low, no data
	Boat launching	0	0	0							
	Anchoring/ mooring	0	0	0							

Direct impact of fishing	Fishing activity	Presence (1) Absence (0)	Spatial scale of Hazard (1-3)	Temporal scale of Hazard (1-3)	Sub-component	Unit of analysis	Operational objective (3.1)	Intensity Score (1-6)	Consequence Score (1-6)	Confidence Score (1-2)	Rationale
	Navigation/steaming	1	3	3	Behaviour/movement	Southern Giant Petrel *Macronectes giganteus*	6.1	1	1	2	Limited vessels operating and disturbance of water column would be undetectable against oceanic processes unlikely to affect birds on surface=>intensity negligible=>consequence negligible=>confidence high logical
External Impacts (specify the particular example within each activity area)	Other fisheries	1	6	4	Population size	Southern Giant Petrel *Macronectes giganteus,* Black-browed Albatross *Thalassarche melanophrys*	1.1	3	4	2	Demersal trawling occurs nearby at higher effort and over longer season and some birds have being killed during trawling operations but minimal impact. Foreign legal longlining and IUU longlining adjacent to our EEZ kill 10, 000 birds per year which is likely to impact all bird populations around HIMI =>intensity moderate=>consequence major -declines in bird populations globally has been attributed to longlining fishing operations => confidence high, widespread agreement
	Aquaculture	0	0	0							
	Coastal development	0	0	0							
	Other extractive activities	0	0	0							
	Other non-extractive activities	0	0	0							
	Other anthropogenic activities	1	3	3	Population size	Southern Giant Petrel *Macronectes giganteus,* Black-browed Albatross *Thalassarche melanophrys*	6.1	1	1	2	Tourist/shipping occurs to Heard Island but unlikely to occur on fishing grounds and to affect deepwater species=>intensity negligible=>consequence negligible=>confidence high,

L1.4 - Habitat Component -not assessed.

L1.5 - Community Component

Direct impact of fishing	Fishing Activity	Presence (1) Absence (0)	Spatial scale of Hazard (1-6)	Temporal scale of Hazard (1-6)	Sub-component	Unit of analysis	Operational objective (S2.1)	Intensity Score (1-6)	Consequence Score (1-6)	Confidence Score (1-2)	Rationale
Capture	Bait collection	0	0	0							
	Fishing	1	3	3	Species composition	Southern Eastern Trough 500-1000m	1.1	3	3	1	Longlining occurs over an area of about 13000sq km, major area of about 10000sq km in the South Eastern Trough community=>season is restricted to about 5 months species => composition of community likely to be affected by removal of target and bycatch species => Intensity moderate => Consequence rated as moderate as detectable changes in community composition of less than 10% probable=> Confidence was recorded as low; no current data available.
	Incidental behaviour	0	0	0							
Direct impact without capture	Bait collection	0	0	0							
	Fishing	1	3	3	Species composition	Southern Eastern Trough 500-1000m	1.1	2	2	1	Composition of community likely to be affected by release of bycatch species and uncertain post-capture survival => Intensity minor=> Consequence rated as minor as unlikely to detect changes up to 5% => Confidence low; no current data available.
	Incidental behaviour	0	0	0							
	Gear loss	1	3	3	Species composition	Southern Eastern Trough 500-1000m	1.1	1	1	1	Gear loss occurs rarely => intensity negligible => consequence negligible => confidence high, observer reports all lost gear
	Anchoring/ mooring	0	0	0							

Direct impact of fishing	Fishing Activity	Presence (1) Absence (0)	Spatial scale of Hazard (1-6)	Temporal scale of Hazard (1-6)	Sub-component	Unit of analysis	Operational objective (S2.1)	Intensity Score (1-6)	Consequence Score (1-6)	Confidence Score (1-2)	Rationale
	Navigation/ steaming	1	3	3	Species composition	Heard Plateau 0-1000m pelagic	1.1	2	1	2	Limited vessels on grounds. Pelagic species unlikely to collide=> intensity minor, some birds are occasionally reported to run into ships=>consequence negligible=>confidence high 100% observer coverage, no collisions reported
Addition/ movement of biological material	Translocation of species	1	3	3	Species composition	Southern Eastern Trough 500-1000m	1.1	1	3	1	Frozen bait used therefore a risk of introducing disease from other areas => intensity negligible as translocation not reported => consequences moderate as disease outbreaks could have severe local impacts, community composition could be altered up to 10% => confidence low no data or evidence outbreaks have occurred
	On board processing	0	0	0							
	Discarding catch	0	0	0							
	Stock enhancement	0	0	0							
	Provisioning	0	0	0							
	Organic waste disposal	1	3	3	Distribution of community	Heard Plateau 0-1000m pelagic	3.1	1	1	2	Vessels do not dispose of any plastic rubbish, or poultry products and comply strictly with MARPOL regulations therefore organic waste discharge could only be accidental; likely to affect distribution of species in pelagic communities => intensity negligible=>consequence negligible=>confidence high
Addition of non-biological material	Debris	1	3	3	Species composition	Heard Plateau 0-1000m pelagic	1.1	1	1	2	Vessels do not dispose of any plastic rubbish, or poultry products and comply strictly with MARPOL regulations; accidental loss of rubbish overboard might occur rarely => intensity negligible=>consequence negligible=>confidence high, observer coverage

Direct impact of fishing	Fishing Activity	Presence (1) Absence (0)	Spatial scale of Hazard (1-6)	Temporal scale of Hazard (1-6)	Sub-component	Unit of analysis	Operational objective (S2.1)	Intensity Score (1-6)	Consequence Score (1-6)	Confidence Score (1-2)	Rationale
	Chemical pollution	1	3	2	Species composition	Heard Plateau 0-1000m pelagic	1.1	2	1	2	All vessels comply with MARPOL regulations; few chemicals used at sea and any chemical pollution would disperse/dilute relatively quickly. Detergents might be discharged but would be minimal and diluted. Oil spill from collision of vessels but unlikely due to only 1 vessel in longlining area usually => intensity minor=>consequence negligible=>confidence high, compliance with regulations
	Exhaust	1	3	3	Distribution of community	Heard Plateau 0-1000m pelagic	3.1	1	1	2	Exhaust from vessel daily but dispersed and might affect distribution of community member briefly =>intensity negligible=>consequence negligible=>confidence high logical
	Gear loss	1	3	3	Distribution of community	Southern Eastern Trough 500-1000m	3.1	1	1	1	Gear loss occurs rarely and all reasonable attempts to retrieve gear are made and possibility of altering distribution of community members from lost gear is unlikely to be detectable=>intensity negligible =>consequence negligible unlikely to detect => confidence low , no data on risk to target species
	Navigation/ steaming	1	3	3	Distribution of community	Heard Plateau 0-1000m pelagic	3.1	1	1	1	Limited vessels operating in area therefore noise and stimuli from navigation /steaming , collision , echo sounding minimal but might affect large marine mammals in the area temporarily=>intensity negligible=>consequence negligible unlikely to detect any variations in distribution =>confidence low
	Activity/ presence on water	1	3	3	Distribution of community	Heard Plateau 0-1000m pelagic	3.1	1	1	2	Limited vessels operating in area therefore noise and stimuli might attract/repel species and affect distribution of pelagic community temporarily=>intensity negligible=>consequence negligible unlikely to detect any variations in distribution =>confidence high, logic
	Bait collection	0	0	0							

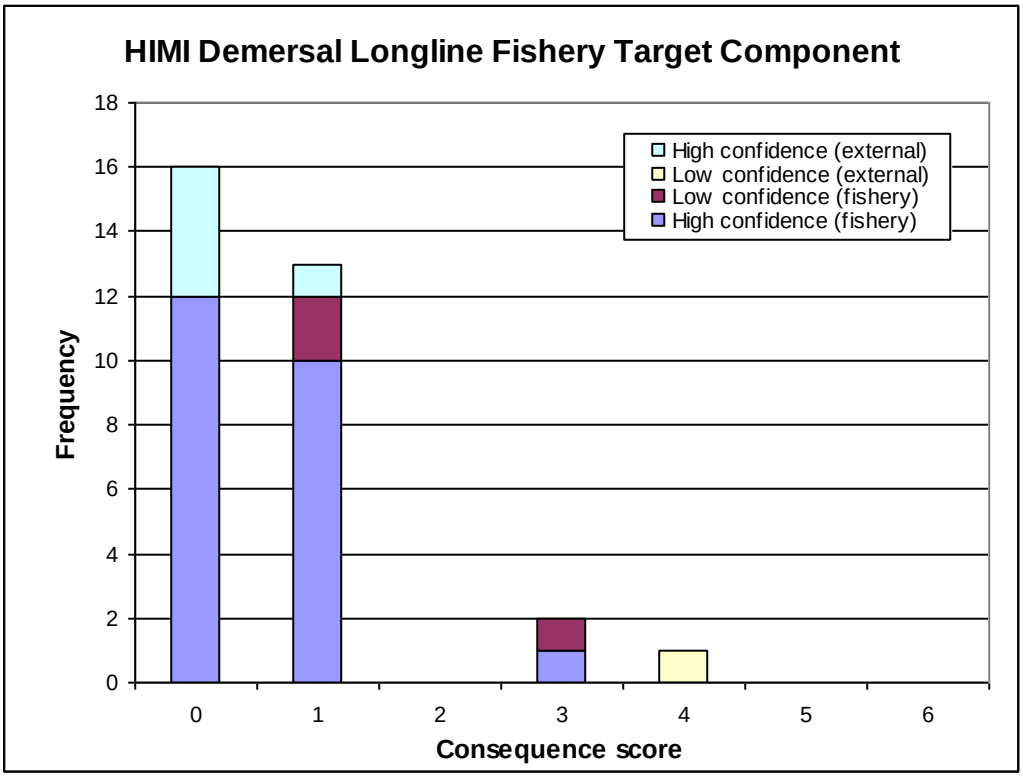
Direct impact of fishing	Fishing Activity	Presence (1) Absence (0)	Spatial scale of Hazard (1-6)	Temporal scale of Hazard (1-6)	Sub-component	Unit of analysis	Operational objective (S2.1)	Intensity Score (1-6)	Consequence Score (1-6)	Confidence Score (1-2)	Rationale
Disturb physical processes	Fishing	1	3	3	Distribution of community	Southern Eastern Trough 500-1000m	3.1	1	1	1	Gear is weighted but area of impact on sea floor small unless intensity of activity increases. and might affect distribution of community =>intensity negligible as gear loss is rare=>consequence negligible unlikely to detect variation=>confidence low, no data
	Boat launching	0	0	0							
	Anchoring/ mooring	0	0	0							
	Navigation/steaming	1	3	3	Distribution of community	Heard Plateau 0-1000m pelagic	3.1	1	1	2	Limited vessels operating and disturbance of water column would be undetectable against oceanic processes =>intensity negligible=>consequence negligible=>confidence high, logic
External Impacts (specify the particular example within each activity area)	Other fisheries: e.g. HIMI demersal trawl; IUU longline fishing	1	6	4	Species composition	Southern Eastern Trough 500-1000m	1.1	3	3	1	Demersal trawling occurs in adjacent areas at higher effort and over longer season, IUU longlining may also have severe impact on large predator populations around HIMI =>intensity moderate=>consequence moderate as TACs in domestic fishing limits the impact on population sizes => confidence low as stock structures and sizes uncertain.
	Aquaculture	0	0	0							
	Coastal development	0	0	0							
	Other extractive activities	0	0	0							
	Other non extractive activities	0	0	0							
	Other anthropogenic activities	1	3	3	Distribution of community	Heard Plateau 0-1000m pelagic	3.1	1	1	2	Tourist/shipping occurs to Heard Island but unlikely to occur on fishing grounds and to affect deepwater species=>intensity negligible=>consequence negligible=>confidence high

2.3.11 Summary of SICA results

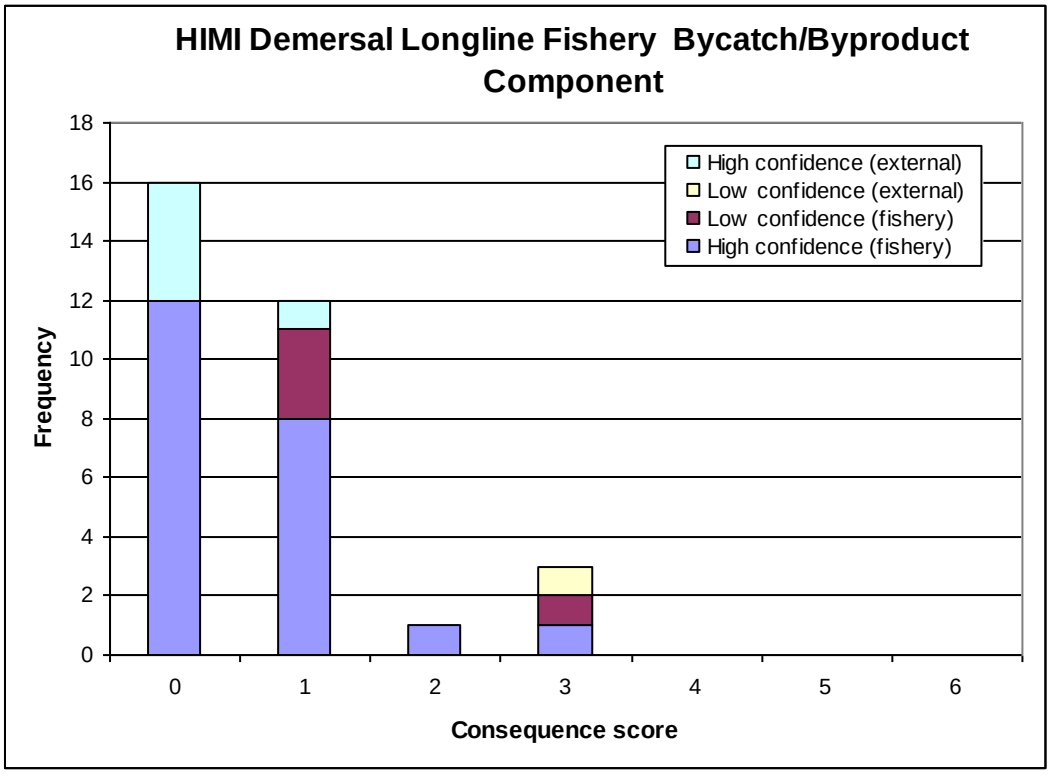
The report provides a summary table (**Level 1 (SICA) Document L1.6**) of consequence scores for all activity/component combinations and a table showing those that scored 3 or above for consequence, and differentiating those that did so with high confidence (in bold).

Level 1 (SICA) Document L1.6. Summary table of consequence scores for all activity/component combinations.

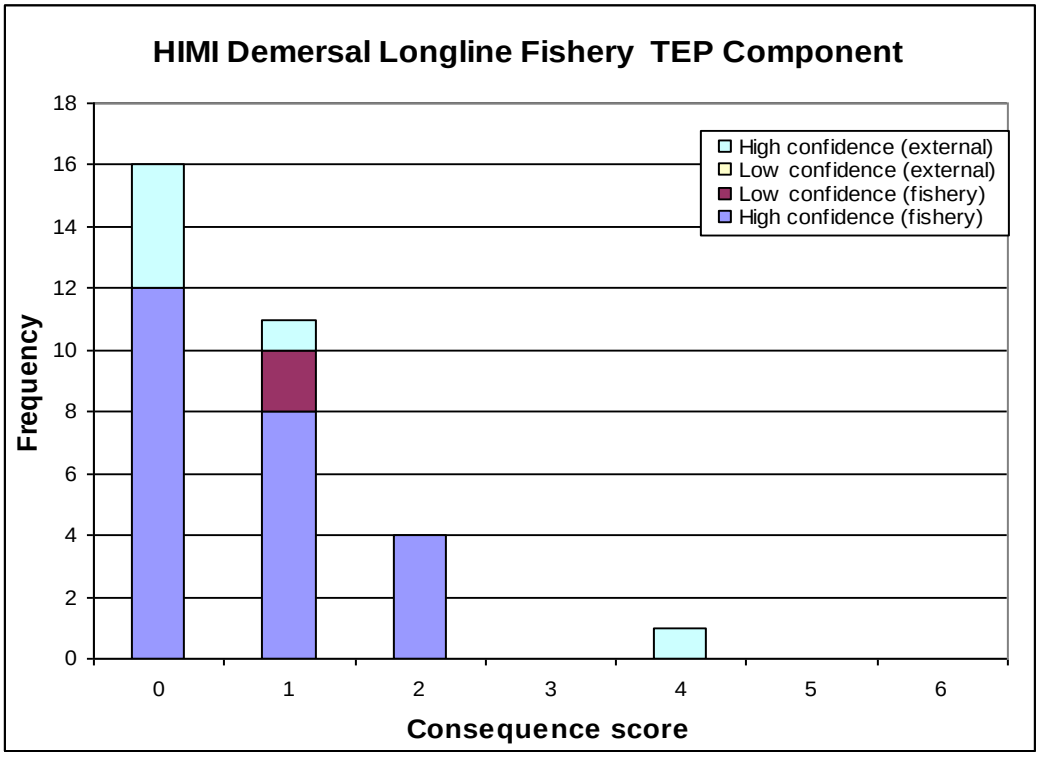
Direct impact	Activity	Target species	Byproduct and bycatch species	TEP species	Communities
Capture	Bait collection	0	0	0	0
	Fishing	3	3	1	3
	Incidental behaviour	0	0	0	0
Direct impact without capture	Bait collection	0	0	0	0
	Fishing	1	2	1	2
	Incidental behaviour	0	0	0	0
	Gear loss	1	1	1	1
	Anchoring/ mooring	0	0	0	0
	Navigation/ steaming	1	1	1	1
Addition/ movement of biological material	Translocation of species	3	3	1	3
	On board processing	0	0	0	0
	Discarding catch	0	0	0	0
	Stock enhancement	0	0	0	0
	Provisioning	0	0	0	0
	Organic waste disposal	1	1	2	1
Addition of non-biological material	Debris	1	1	2	1
	Chemical pollution	1	1	1	1
	Exhaust	1	1	1	1
	Gear loss	1	1	1	1
	Navigation/ steaming	1	1	2	1
	Activity/ presence on water	1	1	2	1
Disturb physical processes	Bait collection	0	0	0	0
	Fishing	1	1	1	1
	Boat launching	0	0	0	0
	Anchoring/ mooring	0	0	0	0
	Navigation/steaming	1	1	1	1
External hazards (specify the particular example within each activity area)	Other fisheries	4	3	4	3
	Aquaculture	0	0	0	0
	Coastal development	0	0	0	0
	Other extractive activities	0	0	0	0
	Other non extractive activities	0	0	0	0
	Other anthropogenic activities	1	1	1	1



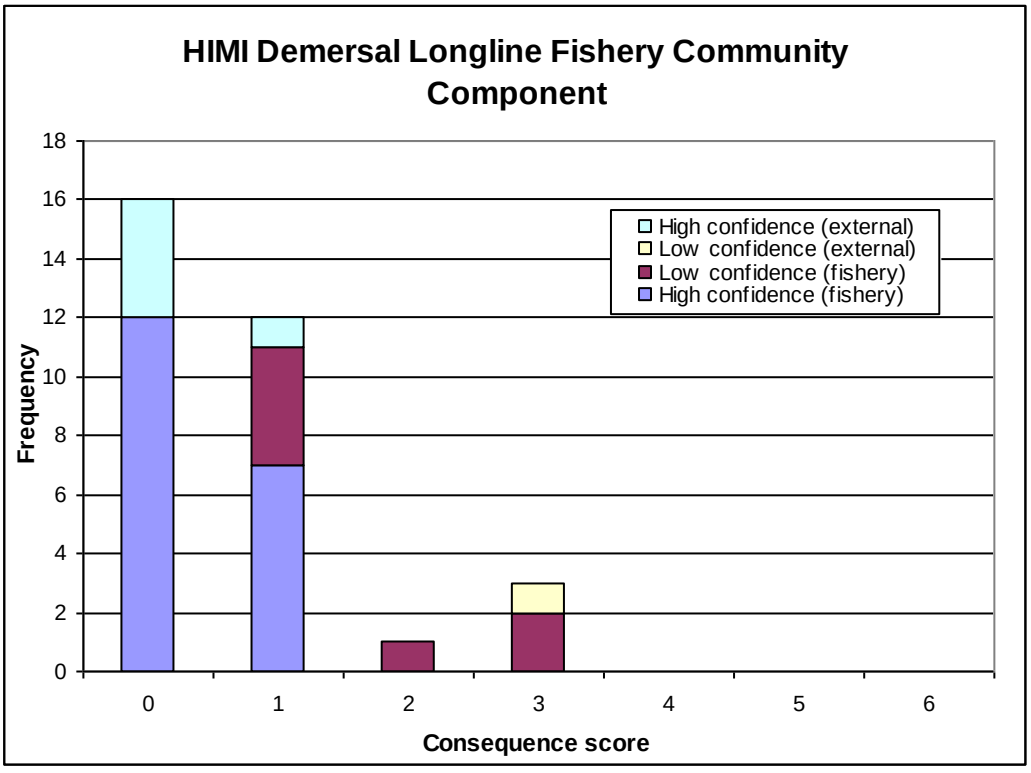
Target species: Frequency of consequence score differentiated between high and low confidence.



Byproduct and bycatch species: Frequency of consequence score differentiated between high and low confidence



TEP species: Frequency of consequence score differentiated between high and low confidence



Communities: Frequency of consequence score differentiated between high and low confidence

2.3.12 Evaluation/discussion of Level 1

Four ecological units were assessed. One ecological component was eliminated at the end of Level 1 – TEP species. The remaining three components – Target species, byproduct/discard species and communities had (consequence (risk) score ≥3 for at least one activity.

Risk scores were between 1 and 4 across all 32 hazards (fishing activities). A number of hazards were eliminated at Level 1 (risk scores 1 or 2). Those hazards that were not eliminated (risk scores of ≥3) were:

- Fishing (direct impact with capture on target species, byproduct/bycatch species and community components)

- Translocation of species (impact on target species, byproduct/bycatch species and community components)

Risks rated as major (risk scores 4) were all related external hazard "other fisheries" for the target and TEP species components assessed. No higher impacts (risk score ≥5) were scored.

Risks from fishing was assessed to be moderate for the target species Patagonian toothfish, as targeting larger fish species may remove a significant proportion of the spawning stock. However, since the fishery operates with strict quotas catches are limited to sustainable levels. The risk from fishing was assessed to be major for skates and rays byproduct/bycatch species, since these species are more susceptible to capture using longlines compared to trawl gear and the population status is unknown. The confidence of these consequence scores was low, since data is unavailable.

Risks from species translocation were assessed to be moderate for the target and byproduct/bycatch and for the south eastern trough community species as imported frozen bait may introduce disease from other areas and alter population sizes of the species. This risk was assessed to be potentially moderate as the risk of disease could have serious impacts on the species and community; however bait is imported under licence from AQIS which requires strict regulations to eliminate the risk of importing disease.

Significant risk scores (≥3) were also obtained for the external hazard "other fisheries in the region" for the four ecological components assessed. In particular, demersal trawling and foreign legal and IUU long-lining may impact Patagonian toothfish (target species component) and TEP species particularly, and the bycatch/byproduct species and the south-eastern trough community (community component).

2.3.13 Components to be examined at Level 2

As a result of the preliminary SICA analysis, the components that are to be examined at Level 2 are those with any consequence scores of 3 or above. These components are:

- Target
- Bycatch/byproduct species

- Communities

The SICA has removed some components from further analysis, as these are judged to be impacted with low consequence by the set of activities considered. Those components excluded are

- TEP

2.4 Level 2 Productivity and Susceptibility Analysis (PSA)

When the risk of an activity at Level 1 (SICA) on a component is moderate or higher and no planned management interventions that would remove this risk are identified, an assessment is required at Level 2. The PSA approach is a method of assessment which allows all units within any of the ecological components to be effectively and comprehensively screened for risk. The units of analysis are the complete set of species habitats or communities identified at the scoping stage. The PSA results in sections 2.4.2 and 2.4.3 of this report measure risk only from direct impacts of fishing, which in all assessments to date, has been the hazard with the greatest risks identified at Level 1. Future iterations of the methodology will include PSAs modified to measure the risk due to other activities, such as gear loss.

The PSA approach is based on the assumption that the risk to an ecological component will depend on two characteristics of the component units: (1) the extent of the impact due to the fishing activity, which will be determined by the susceptibility of the unit to the fishing activities (Susceptibility) and (2) the productivity of the unit (Productivity), which will determine the rate at which the unit can recover after potential depletion or damage by the fishing. It is important to note that the PSA analysis essentially measures potential for risk hereafter noted as 'risk'. A measure of absolute risk requires some direct measure of abundance or mortality rate for the unit in question, and this information is generally lacking at Level 2.

The PSA approach examines attributes of each unit that contribute to or reflect its productivity or susceptibility to provide a relative measure of risk to the unit. The following section describes how this approach is applied to the different components in the analysis. Full details of the methods are described in Hobday et al. (2007).

Species

The following Table outlines the seven attributes that are averaged to measure productivity, and the four aspects that are multiplied to measure susceptibility for all the species components.

	Attribute
Productivity	Average age at maturity
	Average size at maturity
	Average maximum age
	Average maximum size
	Fecundity
	Reproductive strategy
	Trophic level
Susceptibility	Availability considers overlap of fishing effort with a species distribution
	Encounterability considers the likelihood that a species will encounter fishing gear that is deployed within the geographic range of that species (based on two attributes: adult habitat and bathymetry)
	Selectivity considers the potential of the gear to capture or retain species
	Post capture mortality considers the condition and subsequent survival of a species that is captured and released (or discarded)

The productivity attributes for each species are based on data from the literature or from data sources such as FishBase. The four aspects of susceptibility are calculated in the following way:

Availability considers overlap of effort with species distribution. For species without distribution maps, availability is scored based on broad geographic distribution (global, southern hemisphere, Australian endemic). Where more detailed distribution maps are available (e.g. from BIOREG data or DEH protected species maps), availability is scored as the overlap between fishing effort and the portion of the species range that lies within the broader geographical spread of the fishery. Overrides can occur where direct data from independent observer programs are available.

Encounterability is the likelihood that a species will encounter fishing gear deployed within its range. Encounterability is scored using habitat information from FishBase, modified by bathymetric information. Higher risk corresponds to the gear being deployed at the core depth range of the species. Overrides are based on mitigation measures and fishery independent observer data.

For species that do encounter gear, **selectivity** is a measure of the likelihood that the species will be caught by the gear. Factors affecting selectivity will be gear and species dependent, but body size in relation to gear size is an important attribute for this aspect. Overrides can be based on body shape, swimming speed and independent observer data.

For species that are caught by the gear, **post capture mortality** measures the survival probability of the species. Obviously, for species that are retained, survival will be zero. Species that are discarded may or may not survive. This aspect is mainly scored using independent filed observations or expert knowledge.

Overall susceptibility scores for species are a product of the four aspects outlined above. This means that susceptibility scores will be substantially reduced if any one of the four aspects is considered to be low risk. However the default assumption in the absence of verifiable supporting data is that all aspects are high risk.

Habitats

Similar to species, PSA methods for habitats are based around a set of attributes that measure productivity and susceptibility. Productivity attributes include speed of regeneration of fauna, and likelihood of natural disturbance. The susceptibility attributes for habitats are described in the following Table.

Aspect	Attribute	Concept	Rationale
Susceptibility			
Availability	General depth range (Biome)	Spatial overlap of subfishery with habitat defined at biomic scale	Habitat occurs within the management area
Encounterability	Depth zone and feature type	Habitat encountered at the depth and	Fishing takes place where habitat occurs

Aspect	Attribute	Concept	Rationale
		location at which fishing activity occurs	
	Ruggedness (fractal dimension of substratum and seabed slope)	Relief, rugosity, hardness and seabed slope influence accessibility to different sub-fisheries	Rugged substratum is less accessible to mobile gears. Steeply sloping seabed is less accessible to mobile gears
	Level of disturbance	Gear footprint and intensity of encounters	Degree of impact is determined by the frequency and intensity of encounters (inc. size, weight and mobility of individual gears)
Selectivity	Removability/ mortality of fauna/ flora	Removal/ mortality of structure forming epifauna/ flora (inc. bioturbating infauna)	Erect, large, rugose, inflexible, delicate epifauna and flora, and large or delicate and shallow burrowing infauna (at depths impacted by mobile gears) are preferentially removed or damaged.
	Areal extent	How much of each habitat is present	Effective degree of impact greater in rarer habitats: rarer habitats may maintain rarer species.
	Removability of substratum	Certain size classes can be removed	Intermediate sized clasts (~6 cm to 3 m) that form attachment sites for sessile fauna can be permanently removed
	Substratum hardness	Composition of substrata	Harder substratum is intrinsically more resistant
	Seabed slope	Mobility of substrata once dislodged; generally higher levels of structural fauna	Gravity or latent energy transfer assists movement of habitat structures, e.g. turbidity flows, larger clasts. Greater density of filter feeding animals found where currents move up and down slopes.
Productivity			
Productivity	Regeneration of fauna	Accumulation/ recovery of fauna	Fauna have different intrinsic growth and reproductive rates which are also variable in different conditions of temperature, nutrients, productivity.
	Natural disturbance	Level of natural disturbance affects intrinsic ability to recover	Frequently disturbed communities adapted to recover from disturbance

Communities

PSA methods for communities are still under development. Consequently, it has not yet been possible to undertake level 2 risk analyses for communities.

During the Level 2 assessment, each unit of analysis within each ecological component (species or habitat) is scored for risk based on attributes for productivity and susceptibility, and the results are plotted as shown in Figure 13.

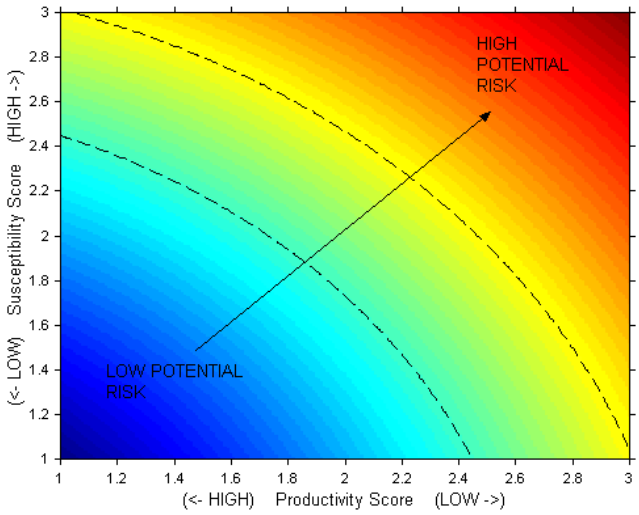


Figure 13. The axes on which risk to the ecological units is plotted. The *x*-axis includes attributes that influence the productivity of a unit, or its ability to recover after impact from fishing. The *y*-axis includes attributes that influence the susceptibility of the unit to impacts from fishing. The combination of susceptibility and productivity determines the relative risk to a unit, i.e. units with high susceptibility and low productivity are at highest risk, while units with low susceptibility and high productivity are at lowest risk. The contour lines divide regions of equal risk and group units of similar risk levels.

There are seven steps for the PSA undertaken for each component brought forward from Level 1 analysis.

Step 1	Identify the units excluded from analysis and document the reason for exclusion
Step 2	Score units for productivity
Step 3	Score units for susceptibility
Step 4	Plot individual units of analysis onto a PSA Plot
Step 5	Ranking of overall risk to each unit
Step 6	Evaluation of the PSA analysis
Step 7	Decision rules to move from Level 2 to Level 3

2.4.1 Units excluded from analysis and document the reason for exclusion (Step 1)

Species lists for PSA analysis are derived from recent observer data where possible or, for fisheries with no observer programs, from logbook and scientific data. In some logbook data, there may only be family level identifications. Where possible these are resolved to species level by cross-checking with alternative data sources and discussion with experts. In cases where this is not possible (mainly invertebrates) the analysis may be based on family average data.

ERA species id	Taxa name	Scientific name	CAAB code	Family name	Common name	Role	Reason for removal
982	Teleost	Macruronus novaezelandiae	37227001	Merluciidae	Blue grenadier		Temperate species out of range
1366	Teleost	Ophidiidae	37228901	Ophidiidae	Cusk eel		Undifferentiated taxon
1451	Chondrichthyan	Bathyraja spp.		Rajidae	Skate		Undifferentiated taxon
1453	Chondrichthyan	Rajiformes		Rajidae	Skate		Undifferentiated taxon
1466	Teleost	Macrourus sp.		Macrouridae	Whiptail		Undifferentiated taxon
1467	Teleost	Macrouridae		Macrouridae	Whiptail		Undifferentiated taxon
1486	Teleost	Dissostichus mawsoni	37404795	Nototheniidae	[An icefish]		Antarctic distribution
1508	Teleost	Muraenolepis microps	37223751	Muraenolepididae	[An eelcod]		Synonym for Muraenolepis sp.
2769	Not Allocated	not entered					Undifferentiated taxon
2949	Not Allocated	Ophiuroidea					Undifferentiated taxon
2992	Not Allocated	Unlisted non-fish species					Undifferentiated taxon
1360	Chondrichthyan	Etmopterus sp.	37020097	Squalidae	Lantern shark	BP	Undifferentiated taxon
1663	Chondrichthyan	Bathyraja sp. (false maccaini)		Rajidae	Skate	BP	Taxonomic problems

2.4.2 and 2.4.3 Level 2 PSA (steps 2 and 3)

Summary of Species PSA results

The results in the Tables below provide details of the PSA assessments for each species, separated by role in the fishery, and by taxa where appropriate. These assessments are limited to direct impacts from fishing, and the operational objective is to avoid over-exploitation due to fishing, either as over-fishing or becoming over-fished. The risk scores and categories (high, medium or low) reflect potential rather than actual risk using the Level 2 (PSA) method. No account is taken of the level of catch, the size of the population, or the likely exploitation rate for species assessed at Level 2. To assess actual risk for any species requires a Level 3 assessment which does account for these factors. However the spatial overlap of the fishery with a species range considers recent effort distributions at Level 2, whereas the entire jurisdictional range of the fishery is considered at Level 1.

The PSA analyses do not fully take account of management actions already in place in the fishery that may mitigate for high risk species. Some management actions or strategies, however, can be accounted for in the analysis where they exist. These include spatial management that limits the range of the fishery (affecting availability), gear limits that affect the size of animals that are captured (selectivity), and handling practices that may affect the survival of species after capture (post capture mortality). Management strategies that are not reflected in the PSA scores include limits to fishing effort, use of catch limits (such as TACs), and some other controls such as seasonal closures.

It should be noted that the PSA method is likely to generate more false positives for high risk (species assessed to be high risk when they are actually low risk) than false negatives (species assessed to be low risk when they are actually high risk). This is due to the precautionary approach to uncertainty adopted in the PSA method, whereby attributes are set at high risk levels in the absence of information. It also arises from the nature of the PSA method assessing potential rather than actual risk, as discussed above. Thus some species will be assessed at high risk because they have low productivity and are exposed to the fishery, even though they are rarely if ever caught and are relatively abundant.

In the PSA Tables below, the “Comments” column is used to provide information on one or more of the following aspects of the analysis for each species: use of overrides to alter susceptibility scores (for example based on use of observer data, or taking account of specific management measures or mitigation); data or information sources or limitations; and information that supports the overall scores. The use of over-rides is explained more fully in Hobday et al (2007).

The PSA Tables also report on “missing information” (the number of attributes with missing data that therefore score at the highest risk level by default). There are seven attributes used to score productivity and four aspects (availability, encounterability, selectivity and post capture mortality) used to score susceptibility (though encounterability is the average of two attributes). An attribute or aspect is scored as missing if there are no data available to score it, and it has defaulted to high risk for this reason. For some species, attributes may be scored on information from related species

or other supplementary information, and even though this information is indirect and less reliable than if species specific information was available, this is not scored as a missing attribute.

There are differences between analyses for TEP species and the other species components. In particular, target, by-product and by-catch species are included on the basis that they are known to be caught by the fishery (in some cases only very rarely). However TEP species are included in the analysis on the basis that they occur in the area of the fishery, whether or not there has ever been an interaction with the fishery recorded. For this reason there may be a higher proportion of false positives for high vulnerability for TEP species, unless there is a robust observer program that can verify that species do not interact with the gear.

Observer data and observer expert knowledge are important sources of information in the PSA analyses, particularly for the bycatch and TEP components. The level of observer data for this fishery is regarded as high. There has been 100% observer coverage since the beginning of the fishery. Observer data are maintained by AAD and a copy held by AFMA (see Scoping Document S1 General Fishery Characteristics).

Level 2 PSA results. A summary of the species considered at Level 2 is presented below, and is sorted by role in the fishery, by taxa, and by the overall risk score (high(>3.18), medium(2.64-3.18), low(<2.64)), together with categorisation of risk (refer to section 2.4.8).

Target species *HIMI Demersal Longline Fishery*

ERA species ID	Scientific Name	Common Name	Total logbook catch (kg) 2002-05	Missing > 3 attributes (Y/N)	Number of missing productivity attributes (out of 7)	Number of missing susceptibility attributes (out of 5)	Productivity (additive) 1- low risk, 3 - high risk	Susceptibility (mult) 1- low risk, 3 - high risk	2D risk value (P&S) 1.41- low risk, 4.24 - high risk	Susceptibility override used?	PSA risk category	High/Med risk category (Refer 2.4.8)	Comments
Teleost													
765	Dissostichus eleginoides	Patagonian toothfish	1081477	N	0	0	1.86	3.00	3.53	N	High		

Byproduct species *HIMI Demersal Longline Fishery*

ERA species ID	Scientific Name	Common name	Total logbook catch (kg) 2002-05	Missing > 3 attributes (Y/N)	Number of missing productivity attributes (out of 7)	Number of missing susceptibility attributes (out of 5)	Productivity (additive) 1- low risk, 3 - high risk	Susceptibility (mult) 1- low risk, 3 - high risk	2D risk value (P&S) 1.41- low risk, 4.24 - high risk	Susceptibility override used?	PSA risk category	High/Med risk category (Refer 2.4.8)	Comments
Chondrichthyan													
1480	Bathyraja eatonii	[a skate]	504	N	0	0	2.43	3.00	3.86	N	High	Spatial uncertainty	
302	Bathyraja irrasa	skate	28737	N	0	0	2.43	3.00	3.86	N	High	Spatial uncertainty	
1481	Bathyraja maccaini	[a skate]	0	N	0	1	2.43	3.00	3.86	N	High	Spatial uncertainty	
304	Bathyraja murrayi	skate	30	N	0	0	2.29	3.00	3.77	N	High	Spatial uncertainty	
1482	Raja georgiana	[a skate]	0	N	0	0	2.14	3.00	3.69	N	High	Spatial uncertainty	
826	Etmopterus granulosus	southern lantern shark	4	N	0	0	2.43	2.33	3.37	N	High	Spatial uncertainty	
Invertebrate													
2787	Asteroidea	starfish	1953	Y	7	3	3.00	3.00	4.24	N	High	Missing data	
2783	Octopodidae	octopus	15	Y	7	3	3.00	3.00	4.24	N	High	Missing data	
1981	Porifera - undifferentiated	sponges	0	Y	7	3	3.00	3.00	4.24	N	High	Missing data	
2777	Gastropoda	snail	0	Y	7	3	3.00	3.00	4.24	N	High	Missing data	
Teleost													
1462	Lepidion sp.	morid cod	0	N	2	0	1.71	3.00	3.46	N	High	Spatial uncertainty	

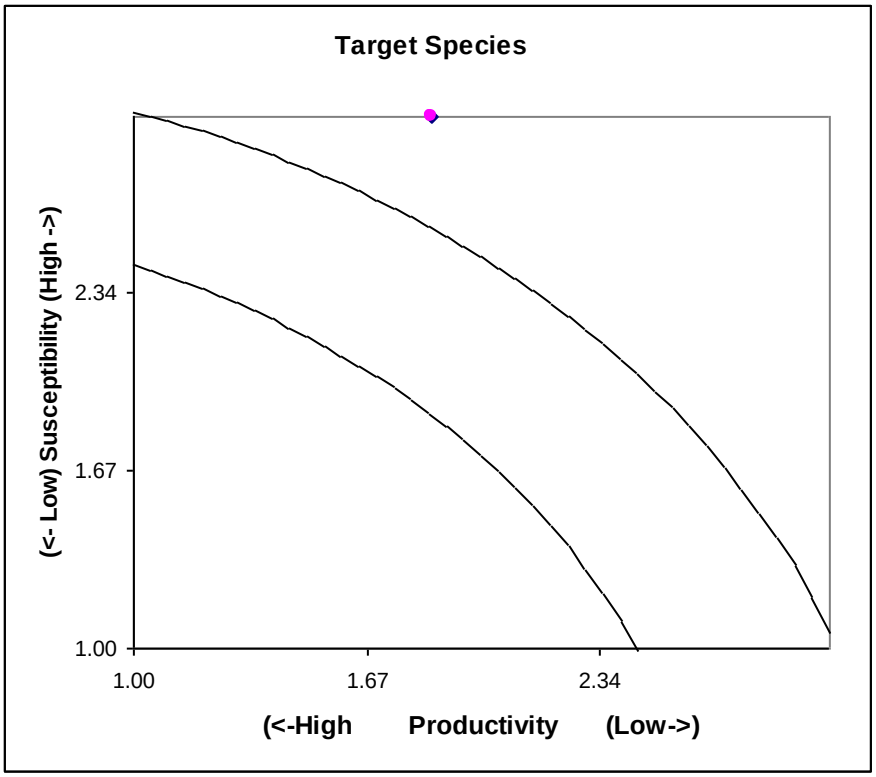
ERA species ID	Scientific Name	Common name	Total logbook catch (kg) 2002-05	Missing > 3 attributes (Y/N)	Number of missing productivity attributes (out of 7)	Number of missing susceptibility attributes (out of 5)	Productivity (additive) 1- low risk, 3 - high risk	Susceptibility (mult) 1- low risk, 3 - high risk	2D risk value (P&S) 1.41- low risk, 4.24 - high risk	Susceptibility override used?	PSA risk category	High/Med risk category (Refer 2.4.8)	Comments
2845	Macrourus holotrachys		30910	N	1	0	2.14	2.33	3.17	N	Med	Spatial uncertainty	
1479	Macrourus whitsoni	[a whiptail]	2370	N	0	0	2.00	2.33	3.07	N	Med	Spatial uncertainty	
336	Macrourus carinatus	whiptail ; Bigeye grenadier	4125	N	0	0	1.86	2.33	2.98	N	Med	Spatial uncertainty	
275	Antimora rostrata	morid cod	1969	N	1	0	1.71	1.67	2.39	N	Low		
1461	Muraenolepis sp.	Moray cod (undifferentiated)	0	N	2	0	1.71	1.67	2.39	N	Low		
768	Lepidonotothen squamifrons	Grey rockcod ; an icefish	0	N	0	1	1.43	1.89	2.37	N	Low		

Discard species *HIMI Demersal Longline Fishery*

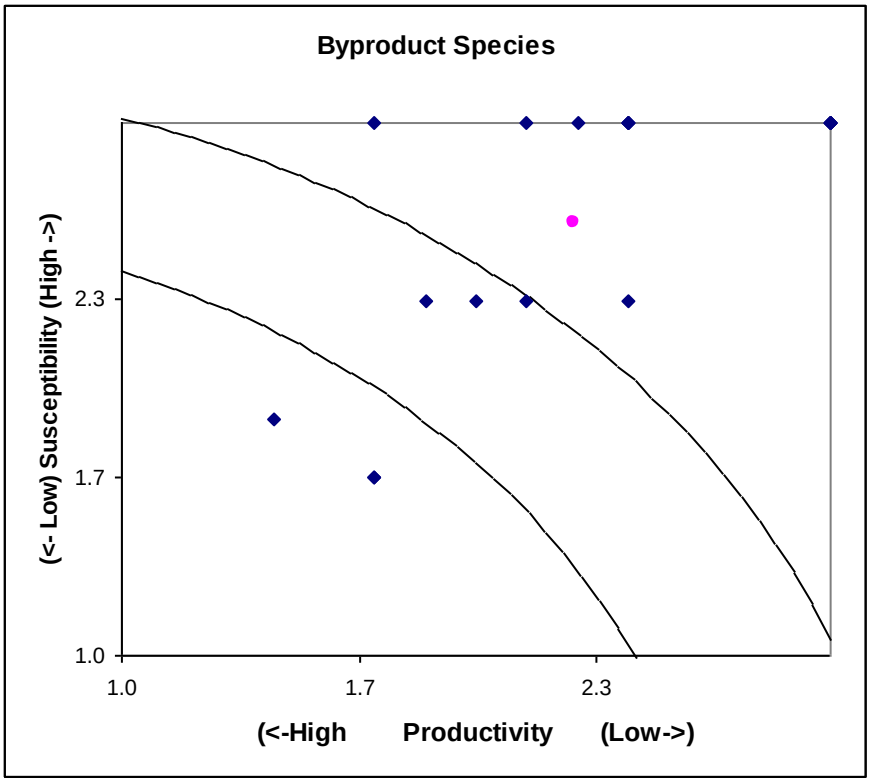
ERA species ID	Scientific Name	Common Name	Total logbook catch (kg) 2002-05	Missing > 3 attributes (Y/N)	Number of missing productivity attributes (out of 7)	Number of missing susceptibility attributes (out of 5)	Productivity (additive) 1- low risk, 3 - high risk	Susceptibility (mult) 1- low risk, 3 - high risk	2D risk value (P&S) 1.41- low risk, 4.24 - high risk	Susceptibility override used?	PSA risk category	High/Med risk category (Refer 2.4.8)	Comments
Chondrichthyan													
257	Somniosus antarcticus	Sleeper shark; Southern Sleeper Shark	3180	N	0	0	2.57	3.00	3.95	Y	High	Spatial uncertainty	Expert override: override applied to availability - increased from 1 to 3 because restricted to Southern Ocean (Scott 1976;Yano, Stevens and Compagno 2004).

2.4.4 PSA Plot for individual units of analysis (Step 4)

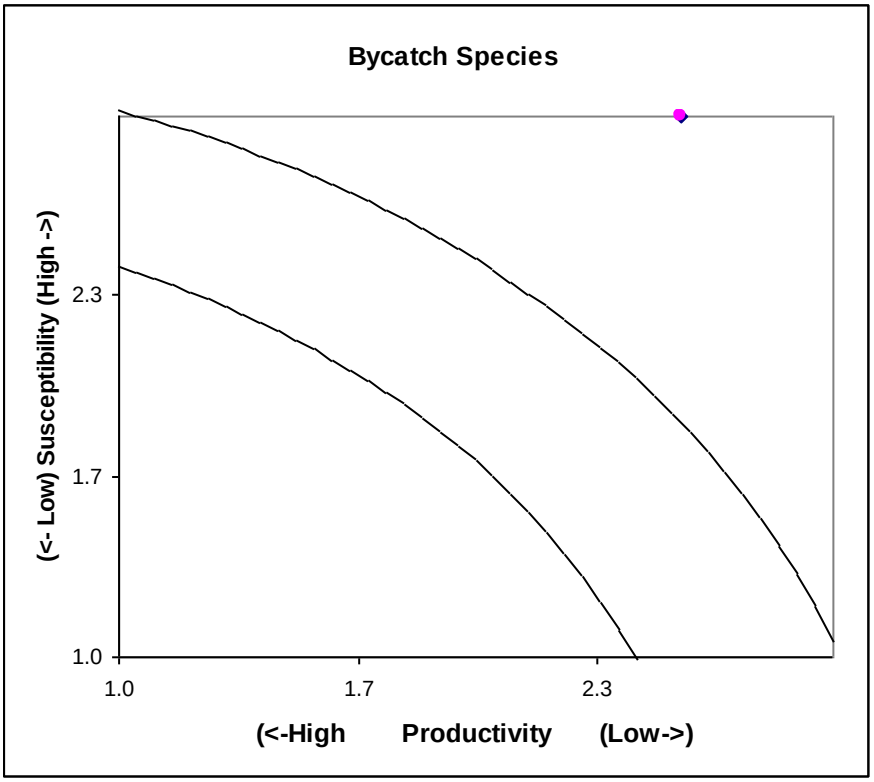
The average productivity and susceptibility scores for each unit of analysis (e.g. for each species) are then used to place the individual units of analysis on 2D plots (as below). The relative position of the units on the plot will determine relative risk at the unit level as per PSA plot below. The overall risk value for a unit is the Euclidean distance from the origin of the graph. Units that fall in the upper third of the PSA plots are deemed to be at high risk. Units with a PSA score in the middle are at medium risk, while units in the lower third are at low risk with regard to the productivity and susceptibility attributes. The divisions between these risk categories are based on dividing the area of the PSA plots into equal thirds. If all productivity and susceptibility scores (scale 1-3) are assumed to be equally likely, then 1/3rd of the Euclidean overall risk values will be greater than 3.18 (high risk), 1/3rd will be between 3.18 and 2.64 (medium risk), and 1/3rd will be lower than 2.64 (low risk).



PSA plot for target species



PSA plot for byproduct species



PSA plot for bycatch/discards species

The overall risk value for each unit is the Euclidean distance from the origin to the location of the species on the PSA plot. The units are then divided into three risk

categories, high, medium and low, according to the risk values (**Figure 17)**. The cut-offs for each category are thirds of the total distribution of all possible risk values (**Figure 17)**.

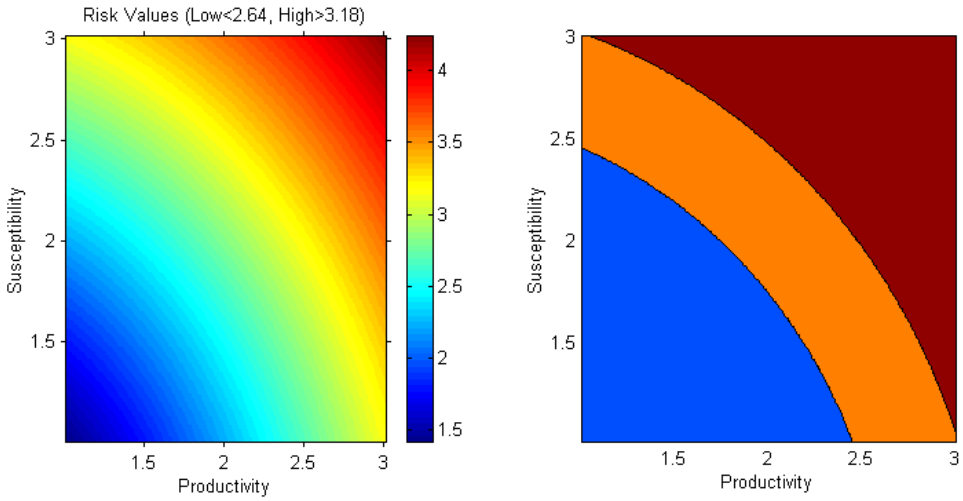


Figure 17. Overall risk values in the PSA plot. Left panel. Colour map of the distribution of the euclidean overall risk values. Right panel. The PSA plot contoured to show the low risk (blue), medium risk (orange) and high risk (red) value.

The PSA output allows identification and prioritization (via ranking the overall risk scores) of the units (e.g. species, habitat types, communities) at greatest risk to fishing activities. This prioritization means units with the lowest inherent productivity or highest susceptibility, which can only sustain the lowest level of impact, can be examined in detail. The overall risk to an individual unit will depend on the level of impact as well its productivity and susceptibility.

2.4.5 Uncertainty analysis ranking of overall risk (Step 5)

The final PSA result for a species is obtained by ranking overall risk value resulting from scoring the productivity and susceptibility attributes. Uncertainty in the PSA results can arise when there is imprecise, incorrect or missing data, where an average for a higher taxonomic unit was used (e.g. average genera value for species units), or because an inappropriate attribute was included. The number of missing attributes, and hence conservative scores, is tallied for each unit of analysis. Units with missing scores will have a more conservative overall risk value than those species with fewer missing attributes, as the highest score for the attribute is used in the absence of data. Gathering the information to allow the attribute to be scored may reduce the overall risk value. Identification of high-risk units with missing attribute information should translate into prioritisation of additional research (an alternative strategy).

A second measure of uncertainty is due to the selection of the attributes. The influence of particular attributes on the final result for a unit of analysis (e.g. a habitat unit) can be quantified with an uncertainty analysis, using a Monte Carlo resampling technique. A set of productivity and susceptibility scores for each unit is calculated by removing one of the productivity or susceptibility attributes at a time, until all attribute combinations have been used. The variation (standard deviation) in the productivity and susceptibility scores is a measure of the uncertainty in the overall PSA score. If the uncertainty

analysis shows that the unit would be treated differently with regard to risk, it should be the subject of more study.

The validity of the ranking can also be examined by comparing the results with those from other data sources or modelling approaches that have already been undertaken in specific fisheries. For example, the PSA results of the individual species (target, byproduct and bycatch and TEP) can be compared against catch rates for any species or against completed stock assessments. These comparisons will show whether the PSA ranking agrees with these other sources of information or more rigorous approaches.

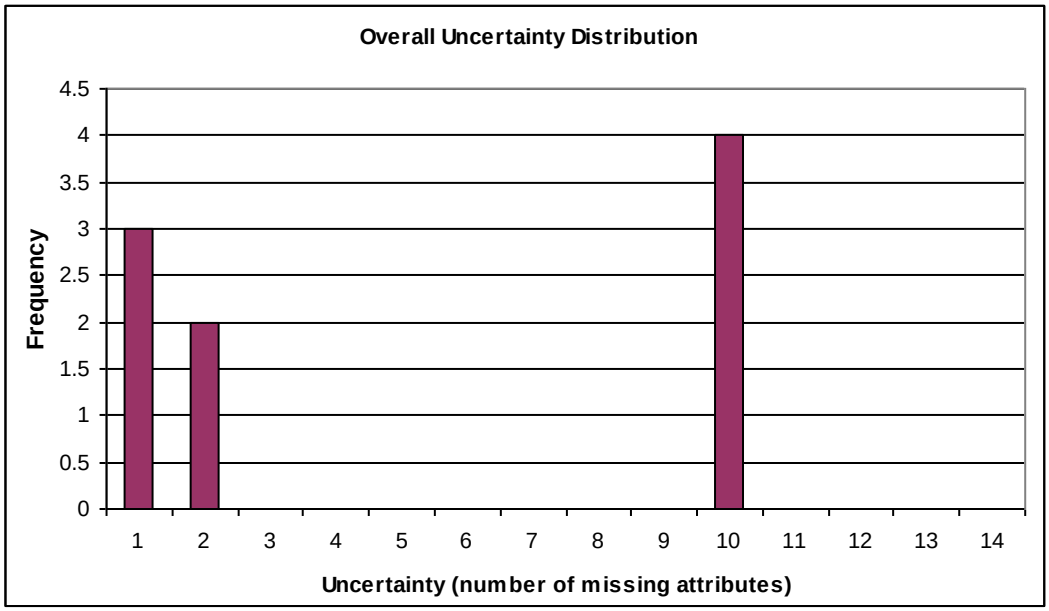
Availability of information

The ability to score each species based on information on each attribute varied between the attributes (as per summary below). With regard to the productivity attributes, reproductive strategy was missing in 37% of species, and so the most conservative score was used, while information on average size at maturity could be found or calculated for 79% of units. For the susceptibility attributes, bathymetry overlap was missing in 26% of species, and so the most conservative score was used. The current method of scoring the availability and post-capture mortality attributes provides a value for each attribute for each species – some of these are based on good information, whereas others are merely sensible default values.

Summary of the success of obtaining information on the set of productivity and susceptibility attributes for the species. Where information on an attribute was missing the highest score was used in the PSA.

Productivity Attributes	**Average age at maturity**	**Average max age**	**Fecundity**	**Average max size**	**Average size at maturity**	**Repro-ductive strategy**	**Trophic level**
Total species scores for attribute	15	13	12	15	15	12	15
n species scores with attribute unknown, (conservative score used)	4	6	7	6	4	8	4
% unknown information	21	32	37	21	21	37	21
Susceptibility Attributes	**Availability**	**Encounterability**		**Selectivity**	**PCM**		
		Bathymetry overlap	**Habitat**				
Total species scores for attribute	19	14	15	15	19		
n species scores with attribute unknown, (conservative score used)	0	5	4	4	0		
% unknown information	0	26	21	21	0		

Each species considered in the analysis had information for an average of 5.21 (74%) productivity attributes and 4.3 (86%) susceptibility attributes. This meant that, on average, conservative scores were used for less than 80% of the attributes for a single species. Species had missing information for between 0 and 10 of the combined 12 productivity and susceptibility attributes.



Species: Overall uncertainty distribution - frequency of missing information for the combined productivity and susceptibility attributes

Correlation between attributes

Species component:

The attributes selected for productivity were often strongly correlated (as per correlation matrix below for productivity). The strongest productivity attribute correlation was between maximum size and reproductive strategy. This is why the attributes for productivity are averaged, as they are all in turn correlated with the intrinsic rate of increase (see *ERAEF: Methodology* document for more details). In contrast the susceptibility attributes were less correlated, which is to be expected as they measure independent aspects of this dimension, and are multiplied to obtain the overall susceptibility score. The susceptibility correlation could not be calculated between the Availability and any other aspect, because there was no variation in the Availability score.

Correlation matrix for the species productivity attributes. The correlation (r) is based on the scores within each attribute pair. Results from PSA workbook ranking graphs worksheet.

	Age at maturity	Max age	Fecundity	Max size	Min size at maturity	Reproductive strategy	Trophic level
Age at maturity	X						
Max age	0.19	X					
Fecundity	0.27	0.16	X				
Max size	0.37	0.29	0.06	X			
Min size at maturity	0.68	0.28	0.31	0.74	X		
Reproductive strategy	0.59	0.34	0.36	0.63	0.71	X	
Trophic level	0.56	0.46	0.35	0.51	0.61	0.61	X

Correlation matrix for the four species susceptibility attributes. The correlation (r) is based on the scores within each attribute pair. Results from PSA workbook ranking graphs worksheet.

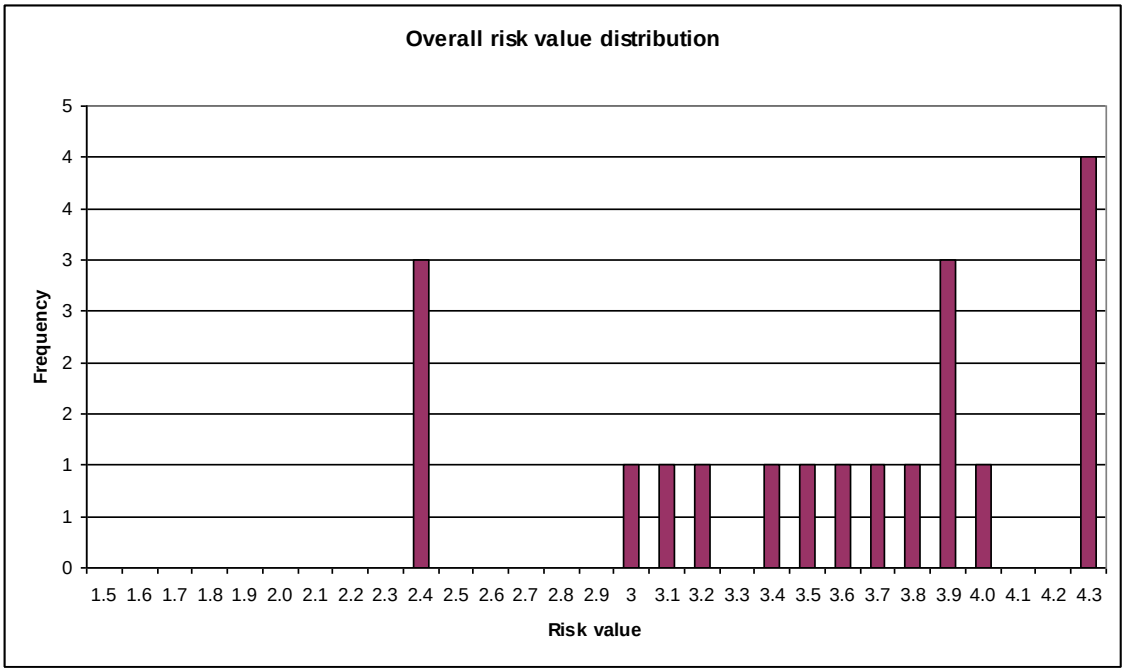
	Availability	Encounterability	Selectivity	Post-capture mortality
Availability	X			
Encounterability	-0.15	X		
Selectivity	0.26	-0.06	X	
Post-capture mortality	-	-	-	X

Productivity and susceptibility values for Species

The average productivity score for all species was 2.27 ± 0.1 (mean ± SD of scores calculated using n-1 attributes) and the mean susceptibility score was 2.65 (as per summary of average productivity and susceptibility scores as below). Individual scores are shown above in *Summary of PSA results*. The small variation in the average of the boot-strapped values (using n-1 attributes), indicates the productivity and susceptibility scores are robust to elimination of a single attribute. Information for a single attribute does not have a disproportionately large effect on the productivity and susceptibility scores. Information was missing for an average of 2 attributes out of 12 possible for each species.

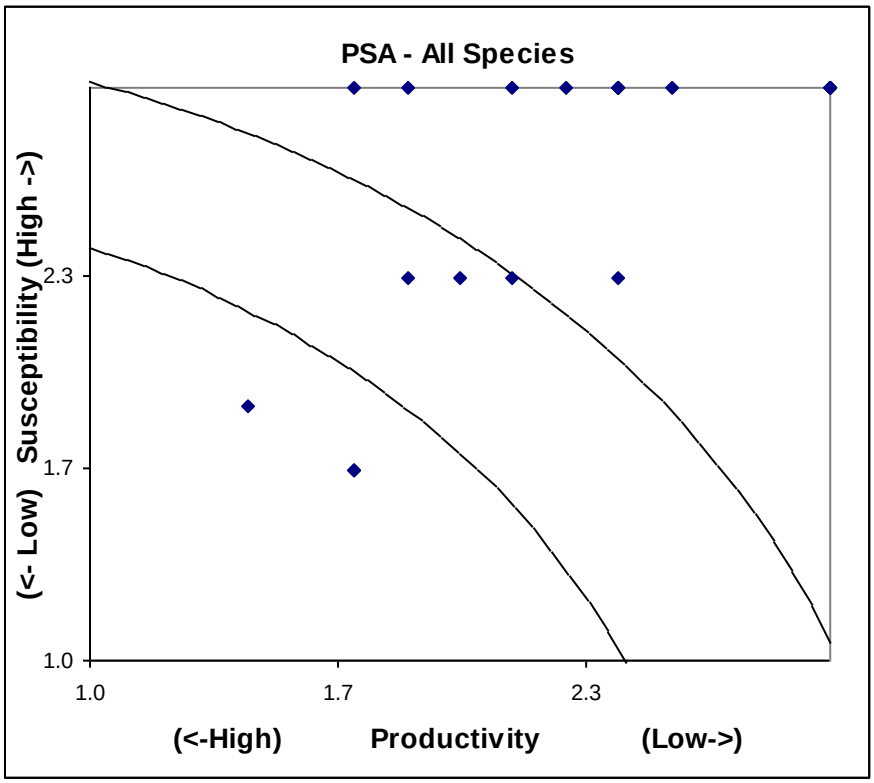
Overall Risk Values for Species

The overall risk values (Euclidean distance on the PSA plot) could fall between 1 and 4.24 (scores of 1&1 and 3&3 for both productivity and susceptibility respectively). The mean observed overall risk score was 3.51, with a range of 2.39 – 4.24**.** The actual values for each species are shown in *Summary of PSA results* (above). A total of 13 species (68%) were classed as high risk, 3 (16%) were in the medium risk category, and 3 (16%) were classed as low risk**.**



Frequency distribution of the overall risk values generated for the 19 species in the HIMI demersal longline fishery PSA.

The distribution of the overall risk values of all species is shown on the PSA plot below. The species are distributed in the upper right of the plot, indicating that most species in the fishery are at high risk.



PSA plot for all species in the HIMI demersal longline fishery. Species in the upper right of the plot are at highest risk

The number of attributes with missing information is of particular interest, because the conservative scoring means these units may be scored at higher risk than if all the information was known. This relationship between the overall risk score and the number of missing attributes shows that an increase in the number of missing attributes (and hence conservative scores used) results in a skew to higher risk values. This suggests that as information becomes available on those attributes, the risk values may decline for some units.

2.4.6 Evaluation of the PSA results (Step 6)

Species Components:

Overall
A total of 36 species were considered. Of these, 17 species were eliminated from the species list because they were synonyms or had insufficient taxonomic resolutions. A total of 19 species including one target, one discard, and 17 byproduct species were considered at level 2. TEP species were eliminated at the end of Leve1 1. Of the 19 species assessed, expert overrides were used only on one species. Of the 13 species were initially scored at high risk, four of these species had more than three missing attributes, and are likely to be false positive results.

The average number of missing for byproduct species was 2.61 out of a possible 12. This largely reflects the remoteness of the Antarctic region, where there have been fewer studies of the bio-geography, taxonomy and biology of demersal fishes and invertebrates, compared to the Australian continental EEZ.

Of the 13 evaluated as high risk, one species is a discarded deepwater dogfish and one is the target species. The remaining species are a mixture of invertebrates, teleosts, and chondrichthyans. The invertebrates are potentially false positive results due to missing attribute data but the most of the chondrichthyans and some of the teleosts are of genuine concern.

Summary of average productivity, susceptibility and overall risk scores.

Component	Measure	
All species	Number of species	19
	Average of productivity total	2.27
	Average of susceptibility total	2.66
	Average of overall risk value (2D)	3.51
	Average number of missing attributes	2.47
Target species	Number of species	1
	Average of productivity total	1.86
	Average of susceptibility total	3
	Average of overall risk value (2D)	3.53
	Average number of missing attributes	0
Byproduct species	Number of species	17
	Average of productivity total	2.28
	Average of susceptibility total	2.64
	Average of overall risk value (2D)	3.51
	Average number of missing attributes	2.61
Bycatch species	Number of species	1
	Average of productivity total	2.57
	Average of susceptibility total	3
	Average of overall risk value (2D)	3.95
	Average number of missing attributes	0

PSA risk categories for each species component

Risk Category	High	Medium	Low	Total
Target species	1			1
Byproduct species	11	3	3	17
Bycatch species	1			1
Total	13	3	3	19

PSA risk categories for each taxon

Risk Category	High	Medium	Low	Total
Chondrichthyan	7			7
Invertebrate	4			4
Teleost	2	3	3	8
Total	13	3	3	19

Discussion

Target species

The single target species was classified as high risk. The species is managed and has detailed assessments.

Byproduct species

Of the 17 byproduct species, 11 are classified as high risk, 3 as medium risk and 3 as low risk.

The large number of high risk scores was influenced by missing information. However some species need further consideration. These species include skates, whiptails and benthic invertebrates.

Skates are considered among the most threatened marine vertebrates worldwide (Dulvy 2000). Observer data suggests about 108 tonnes of skate (including skates not identified to species level) have been caught by longlining in the HIMI fishery over the assessment period (2002-5). Tagging studies suggest post capture mortality is high and that migration rates are low.

Three species of whiptails have been caught in significant quantities, a total of 37.4 tonnes over the last four years
Macrourus carinatus
Macrourus whitsoni
Macrourus holotrachys
Of these, *M. holotrachys* has been caught in the greatest quantities – 31 t over the last five years. This species is restricted to the Southern Ocean. It is a relatively long-lived species, living to 52 years but matures early (12 years) and has high fecundity (15,000).

The main benthic invertebrates reported in observer data are ‘starfish’ – 2 t over the last five years.

Bycatch species

There was only one bycatch species considered: sleeper shark. The sleeper shark is a poorly known deepwater dogfish. Other species of deepwater dogfish have annual fecundity of less than 1. Studies of other deepwater dogfishes as well as, blue sharks and white sharks suggest post release mortality is around 50%. There are no yield estimates for sleeper sharks.

2.4.7 Decision rules to move from Level 2 to Level 3 (Step 7)

For the PSA overall risk values, units that fall in the upper third (risk value > 3.18) and middle third (2.64 < risk value < 3.18) of the PSA plots are deemed to be at high and medium risk respectively. These need to be the focus of further work, either through implementing a management response to address the risk to the vulnerable species or by further examination for risk within the particular ecological component at Level 3. Units at low risk, in the lower third (risk value <2.64), will be deemed not at risk from the sub-fishery and the assessment is concluded for these units.

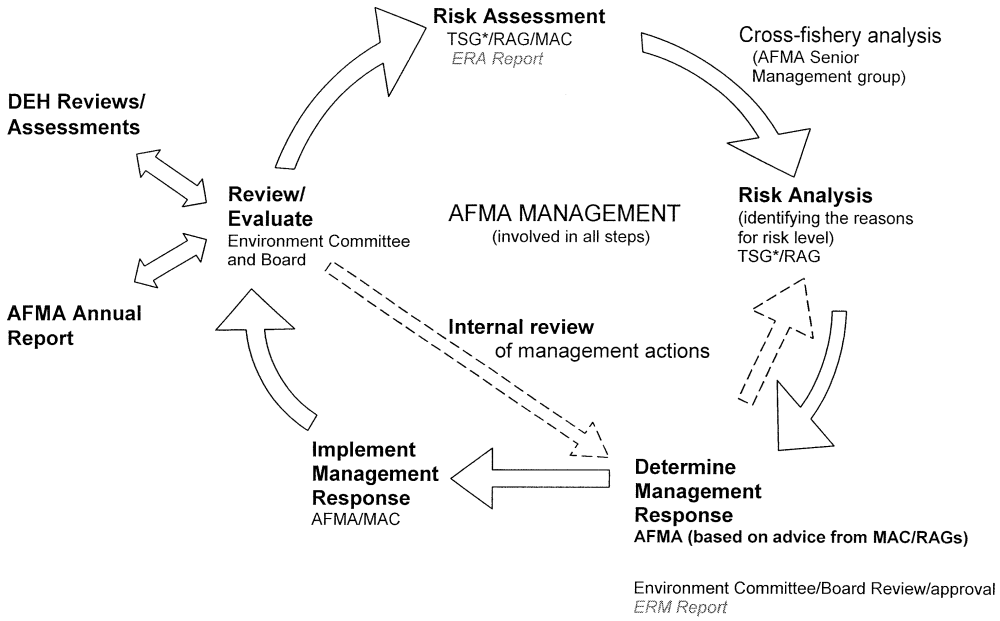
For example, if in a Level 2 analysis of habitat types, two of seven habitat types were determined to have risk from the sub-fishery, only those two habitat types would be considered at Level 3.

The output from the Level 2 analysis will result in four options:

- The risk of fishing on a unit of analysis within a component (e.g. single species or habitat type) is not high, the rationale is documented, and the impact of the fishing activity on this unit need not be assessed at a higher level unless management or the fishery changes.
- The risk of fishing on a unit is high but management strategies are introduced rapidly that will reduce this risk, this unit need not be assessed further unless the management or the fishery changes.
- The risk of fishing on a unit is high but there is additional information that can be used to determine if Level 3 or even a new management action is required. This information should be sought before action is taken
- The risk of fishing on a unit is high and there are no planned management interventions that would remove this risk, therefore the reasons are documented and the assessment moves to Level 3.

At level 2 analysis, a fishery can decide to further investigate the risk of fishing to the species via a level 3 assessment or implement a management response to mitigate the risk. To ensure all fisheries follow a consistent process in responding to the results of the risk assessment, AFMA has developed an ecological risk management framework. The framework (see Figure x below) makes use of the existing AFMA management structures to enable the ERAs to become a part of normal fisheries management, including the involvement of fisheries consultative committees. A separate document, the ERM report, will be developed that outlines the reasons why species are at high risk and what actions the fishery will implement to respond to the risks.

Figure x: Ecological Risk Management Framework



*TSG – Technical Support Group - currently provided by CSIRO.

2.4.8 High/Medium risk categorisation (Step 8)

Following the Level 2 PSA scoring of target, bycatch and byproduct, and TEP species, the high and medium risk species have been divided into five categories that highlight potential reasons for the higher risk scores. These categories should also help identify areas of uncertainty and assist decisions regarding possible management responses for these species. The categories are independent and species are allocated to each category in the order the categories are presented below. Thus, while in principle a species could qualify for both Category 1 and 2, it will only appear in Category 1 because that was scored first. The five categories are programmed into the PSA excel spreadsheets for each fishery according to the following algorithms:

- **Category 1: Missing data** (*>3 missing attributes in either Productivity or Susceptibility estimation)*. Rationale: A total of more than 3 missing attributes (out of 12 possible) could lead to a change in risk score if the information became known. This is because where information is missing for an attribute, that attribute is automatically scored as high risk. The choice of 3 attributes was identified using sensitivity analysis.
- **Category 2**: **Spatial overlap**
    - **2A. Widely distributed** *(More than 80% of the full range of a species is outside the jurisdictional boundary of the fishery)*. Rationale: These species may have refuge outside the fishery.
    - **2B. Low overlap** *(<20% overlap between effort and the species distribution inside the fishery).* Refers to the preferred Availability attribute used to

calculate Susceptibility. Rationale: This cutoff (20%) has no strong rationale, other than being a low percentage overlap. Additional work to determine what threshold might be applicable is required. However, the categories are to be used as a guide for management, and additional effort to decide on cutoffs may be misplaced if the categories are just used as a guide. A similar analysis could be undertaken for the encounterability and selectivity attributes, but there is more information available for availability (overlap) for most species and overlap may be more informative about risk. A subtle change in fishing practice could modify encounterability or selectivity, while to change availability requires a major change in fleet location, which will be easier to detect.

- **Category 3**: **Low (susceptibility) attribute score** (*One of the susceptibility attribute scores = 1).* Rationale: These species may be scored high risk based on productivity risk alone, even if their susceptibility is very low.
- **Category 4**: **Spatial uncertainty** (*No detailed distributional dat*a *available*) Availability was calculated using less reliable mapping data or distributional categories: Global/Southern Hemisphere/Australia, with stock likelihood overrides where necessary. Rationale: the absence of fine scale catch and species distribution data (e.g. TEP species) means that the substitute attribute (precautionary) was used. Spatial data should be sought.
- **Category 5 Other**: *risk score not affected by 1-4 considered above*

Categorisation results - High risk species

Detailed species by species results of the categorisation are presented for medium and high risk species in the Tables in section 2.4.2 of this report. The following is a brief summary of the results for species classified as high risk from the PSA analyses.

In this fishery of the 13 species classified as high risk, 4 had missing information for more than 3 attributes and the remaining 9 had uncertain spatial distribution information.
Note: Table below from PSA spreadsheet.

High risk Category	Description	Total
Category 1	High risk - Missing data for more that 3 attributes	4
Category 2A	High risk - Widely distributed outside fishery	0
Category 2B	High risk - Low overlap inside fishery	0
Category 3	High risk - One susceptibility attribute scored low	0
Category 4	High risk – Spatial uncertainty	9
Other	High risk -other	0
	Total High	13

It is important to stress that this categorization does not imply a down-grading of risk. It is intended as a tool to focus subsequent discussions on risk treatment and identify needs for further data. Sensitivity analysis to the particular cutoffs has not been undertaken in a formal sense, and may not be required, as these categories are intended as guides to focus further consideration of the high risk species. These categories may also indicate the presence of false positives in the high risk species category, but only further analysis or data can determine this.

2.5 Level 3

Elements of Level 3 assessment have already occurred for the high risk target species. Annual stock assessments are carried out for the target species, as well as ongoing monitoring of bycatch/byproduct species. The results of these assessments confirm the result obtained in the ERAEF approach, this species is at high risk.

Skates – need review, recent paper by Dulvy et al. (2000)

Sleeper sharks – Recent paper by Stevens et al.

3. General discussion and research implications

The HIMI Automatic longline fishery target Patagonian toothfish around Heard and McDonald Islands in the sub-Antarctic about 4,000 km SW of Perth. Fishing occurs across three main fishing grounds with confidential locations. The fishing method uses automatically baited long-lines with integral weighted lines. The lines are set in deeper water (1,000 – 1,200 m) and catch larger fish than the trawl fishery. Potentially the line method could have a greater impact on the breeding stock of the target species than the trawl fishery. The target species is under a comprehensive management plan.

In the past, the principal ecological concern for longline fisheries in the sub-Antarctic has been incidental capture of birds. A number of mitigation measures are in place in the sub-fishery to protect birds. Observer data provides strong evidence that these measures have been effective.

The fishery takes a significant bycatch of whiptails, sleeper sharks and skates, and the impacts of the fishery on them, particularly skates, need further consideration.

3.1 Level 1

Habitats were not examined.

The main hazards identified at level 1 were capture fishing, translocation of disease and external impacts from foreign-legal and IUU fishing

Capture fishing had moderate impacts for the target species component and byproduct species component with skates highlighted as the worst case scenario for byproduct species. These species impacts are likely to result in moderate impacts on communities.

The worst case scenario considered for TEP species was the impact of capture fishing on black-browed albatross. This bird species has the smallest population size for any in the region – around 1,200. However, it is almost certain that an annual catch of 1% (12 birds per year) would not prevent this fishery from meeting its main objective for TEP species - ensure TEP species do not further approach extinction of become extinct. The fishery currently has measures in place which would result in closure of the sub-fishery before ten birds were caught in a year. In addition, there are no records of birds being captured during deployment of the gear. Only three birds have been caught in the history of the sub-fishery. The TEP component was eliminated at the end of level 1. Capture fishing was evaluated at level 2 PSA.

The risks associated with frozen bait are assessed by AQIS.

3.2 Level 2

Level 1 analyses suggested two species components were at moderate risk from fishing - target and byproduct/discard species. This assessment was largely confirmed by the Level 2 analyses.

Of the 19 species assessed, 13 were found to be at high risk, with 12 of these in the by-product and by-catch categories.

Habitats were not assessed.

3.2.1 Species at risk

The target species were assessed to be at potentially high risk, because of its high susceptibility to capture. This species is currently managed under a precautionary quota management system based on detailed quantitative stock assessments (Level 3 analyses see CCAMLR WG-FSA October, 2006).

Overall, of the list of 16 species rated as high or medium risk from the PSA analyses, the authors consider that 10 non-target species need further evaluation or management response. This expert judgment is based on taxonomy/identification, distribution, stock structure, and movements, and overlap with the demersal trawl fishery.

Species	*Risk Category*
• *Bathyraja irrasa*	Spatial uncertainty
• *B. eatonii*	Spatial uncertainty
• *B. murrayi*	Spatial uncertainty
• *B. maccaini*	Spatial uncertainty
• *B. georgiana*	Spatial uncertainty
• *Etmopterus granulosus*	Spatial uncertainty
• *Somniosus antarcticus*	Spatial uncertainty
• *Macrourus carinatus* (medium risk)	Spatial uncertainty
• *M. holotrachys* (medium risk)	Spatial uncertainty
• *M. whitsoni*(medium risk)	Spatial uncertainty

Four invertebrates were evaluated as high risk but these species are likely to be false positives due to missing data. The main benthic invertebrates reported in observer data are ‘starfish’ (Asteroidea) with only 2 t over the last five years. Of the four, only sponges are long lived and the annual average catch of sponges reported in observer data is less than 1 kg. Demersal longlining is unlikely to present a serious risk to these species.

Six of the high risk byproduct species are chondrichthyans. Of these five are skate species of genuine concern. *Bathyraja irrasa* and *B. eatonii* are caught in high to medium quantities and therefore present a real risk. The other species of *Bathyraja* have been rarely caught or not recorded during the period of assessment however there were a further 88 t of unidentified *Bathyraja* caught. Skates are considered among the most threatened marine vertebrates worldwide (Dulvy et al. 2000). It is considered good practice among operators to cut the snoods and avoid breaking the jaw of captured skates. Observers are present on vessels and could monitor compliance with this desirable practice. However, when tagged skates are released their survival rate is much lower than toothfish (Tim Lamb AAD personal communication). The maximum annual catch limit for skates is 60 t but the biological basis for this catch level is unclear and should be justified.

The other chondrichthyan byproduct species at risk is the lantern shark Etmopterus granulosus. While it is abundant on the Cascade Plateau, it has been infrequently caught at Heard Island.

The only bycatch species is also a high risk chondrichthyan. . Sleeper sharks have had a level 3 assessment however they were assumed to be another species with a worldwide distribution resulting in a low risk. Yano, Stevens and Compagno (2004) have since described this species as *S. antarcticus* whose distribution is restricted to the southern hemisphere. The sleeper shark is released alive where possible however, the long term survival rate of released sleeper sharks is unknown and therefore we consider that this species is at real risk.

Only one teleost is a high risk byproduct species. It is a morid cod which is unresolved taxonomically and therefore has missing attributes particularly spatial data resulting in a probable false positive. It is has rarely been recorded therefore we would consider it unlikely to be at risk. However, three macrourids which are caught in significant numbers are considered to be medium risk. While they are considered to have higher fecundity (around 15,000 eggs) than the chondrichthyan species, they have missing spatial data contributing to that risk. They are also caught in reasonable quantities in the demersal trawl fishery and are managed by a TAC.

Residual risk

As discussed elsewhere in this report (Section 1), the ERAEF methods are both hierarchically structured and precautionary. The Level 1 (SICA) analyses are used to identify potential hazards associated with fishing and which broad components of the ecological system they apply to. The Level 2 (PSA) analyses consider the direct impacts of fishing on individual species and habitats (rather than whole components), but the large numbers of species that need to be assessed and the nature of the information available for most species in the PSA analyses limits these analyses in several important respects. These include that some existing management measures are not directly accounted for, and that no direct account is taken of the level of mortality associated with fishing. Both these factors are taken into account in the ERAEF framework at Level 3, but the analyses reported here stop at Level 2. This means that the risk levels for species must be regarded as identifying potential rather than actual risk, and due to the precautionary assumptions made in the PSA analyses, there will be a tendency to overestimate absolute levels of risk from fishing.

In moving from ERA to ERM, AFMA will focus scarce resources on the highest priority species and habitats (those likely to be most at risk from fishing). To that end, and because Level 3 analyses are not yet available for most species, AFMA (with input from CSIRO and other stakeholders) has developed guidelines to assess “residual risk” for those species identified as being at high potential risk based on the PSA analyses. The residual risk guidelines will be applied on a species by species basis, and include consideration of existing management measures not currently accounted for in the PSA analyses, as well as additional information about the levels of direct mortality. These guidelines will also provide a transparent process for including more precise or missing information into the PSA analysis as it becomes available.

CSIRO and AFMA will continue to work together to include the broad set of management arrangements in Level 2 analyses, and these methods will be incorporated in future developments of the ERAEF framework. CSIRO has also undertaken some preliminary Level 3 analyses for bycatch species for several fisheries, and these or similar methods will also form part of the overall ERAEF framework into the future.

3.2.2 Habitats at risk

Habitats for this fishery are not currently assessed using most recent ERAEF methodology due to unavailability of habitat data.

3.2.3 Community assemblages at risk

The community component was not assessed at Level 2 for this sub-fishery, but should be considered in future assessments when the methods to do this are fully developed.

3.3 Key Uncertainties / Recommendations for Research and Monitoring

Specific recommendations arising from this assessment include:

- Maintain existing mitigation measures for seabirds and maintain the current high level of observer coverage to ensure compliance
- It is recommended that the sub-fishery considers development of a strategy for skates and sleeper sharks which may include:
    - Collect and compile observer data to determine the proportion of skates released by cutting the snood to minimise jaw damage
    - Study the long term survivorship of skates and sleeper sharks released after capture
    - Collect reproductive and ageing data for skates and sleeper sharks to evaluate their productivity
    - Develop yield estimates for skates and sleeper sharks.

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Glossary of Terms

Assemblage	A subset of the species in the community that can be easily recognized and studied. For example, the set of sharks and rays in a community is the Chondrichthyan assemblage.
Attribute	A general term for a set of properties relating to the productivity or susceptibility of a particular unit of analysis.
Bycatch species	A non-target species captured in a fishery, usually of low value and often discarded (see also Byproduct).
Byproduct species	A non-target species captured in a fishery, but it may have value to the fisher and be retained for sale.
Community	A complete set of interacting species.
Component	A major area of relevance to fisheries with regard to ecological risk assessment (e.g. target species, bycatch and byproduct species, threatened and endangered species, habitats, and communities).
Component model	A conceptual description of the impacts of fishing activities (hazards) on components and sub-components, linked through the processes and resources that determine the level of a component.
Consequence	The effect of an activity on achieving the operational objective for a sub-component.
Core objective	The overall aim of management for a component.
End point	A term used in risk assessment to denote the object of the assessment; equivalent to component or sub-component in ERAEF
Ecosystem	The spatially explicit association of abiotic and biotic elements within which there is a flow of resources, such as nutrients, biomass or energy (Crooks, 2002).
External factor	Factors other than fishing that affect achievement of operational objectives for components and sub-components.
Fishery method	A technique or set of equipment used to harvest fish in a fishery (e.g. long-lining, purse-seining, trawling).
Fishery	A related set of fish harvesting activities regulated by an authority (e.g. South-East Trawl Fishery).
Habitat	The place where fauna or flora complete all or a portion of their life cycle.
Hazard identification	The identification of activities (hazards) that may impact the components of interest.
Indicator	Used to monitor the effect of an activity on a sub-component. An indicator is something that can be measured, such as biomass or abundance.
Likelihood	The chance that a sub-component will be affected by an activity.

Operational objective	A measurable objective for a component or sub-component (typically expressed as “the level of X does not fall outside acceptable bounds”)
Precautionary approach	The approach whereby, if there is uncertainty about the outcome of an action, the benefit of the doubt should be given to the biological entity (such as species, habitat or community).
PSA	Productivity-Susceptibility Analysis. Used at Level 2 in the ERAEF methodology.
Scoping	A general step in an ERA or the first step in the ERAEF involving the identification of the fishery history, management, methods, scope and activities.
SICA	Scale, Impact, Consequence Analysis. Used at Level 1 in the ERAEF methodology.
Sub-component	A more detailed aspect of a component. For example, within the target species component, the sub-components include the population size, geographic range, and the age/size/sex structure.
Sub-fishery	A subdivision of the fishery on the basis of the gear or areal extent of the fishery. Ecological risk is assessed separately for each sub-fishery within a fishery.
Sustainability	Ability to be maintained indefinitely
Target species	A species or group of species whose capture is the goal of a fishery, sub-fishery, or fishing operation.
Trophic position	Location of an individual organism or species within a food web.
Unit of analysis	The entities for which attributes are scored in the Level 2 analysis. For example, the units of analysis for the Target Species component are individual “species”, while for Habitats, they are “biotypes”, and for Communities the units are “assemblages”.

Appendix A: General summary of stakeholder feedback

Date	Format received	Comment from stakeholder	Action/explanation
		No comments received	

Appendix B: PSA results summary of stakeholder discussions

Level 2 (PSA) Document L2.1. Summary table of stakeholder discussion regarding PSA results. No species were discussed at the Sub-Antarctic Fisheries meeting on 27 June 2006 at AFMA, Canberra.

Taxa name	Scientific name	Common name	Role in fishery	PSA risk ranking (H/M/L)	Comments from meeting, and follow-up	Action	Outcome	Possible management response
					e.g. Distribution queried- core depth is mostly shallower than fishery	*Changed depth dsn*	*Reduced risk from high to medium*	
					e.g. extra size information provided by fishers	*Max size added*	*Reduced risk from high to medium*	
					e.g. Confusion re species identification	*none*	*none*	*Improve species identification*
					e.g. more common on outer shelf. Does occur in range of fishery according to literature.	*none*	*none*	*Check depths at which caught in adjacent fishery*

Appendix C: SICA consequence scores for ecological components

Table C1. Target Species. Description of consequences for each component and each sub-component. Use table as a guide for scoring the level of consequence for target species (Modified from Fletcher et al. 2002).

Sub-component	Score/level					
	1 Negligible	**2 Minor**	**3 Moderate**	**4 Major**	**5 Severe**	**6 Intolerable**
Population size	**1. Population size** Insignificant change to population size/growth rate (r). Unlikely to be detectable against background variability for this population.	**1. Population size** Possible detectable change in size/growth rate (r) but minimal impact on population size and none on dynamics.	**1. Population size** Full exploitation rate but long-term recruitment dynamics not adversely damaged.	**1. Population size** Affecting recruitment state of stocks and/or their capacity to increase	**1. Population size** Likely to cause local extinctions if continued in longer term	**1. Population size** Local extinctions are imminent/immediate
Geographic range	**2. Geographic range** No detectable change in geographic range. Unlikely to be detectable against background variability for this population.	**2. Geographic range** Possible detectable change in geographic range but minimal impact on population range and none on dynamics, change in geographic range up to 5 % of original.	**2. Geographic range** Change in geographic range up to 10 % of original.	**2. Geographic range** Change in geographic range up to 25 % of original.	**2. Geographic range** Change in geographic range up to 50 % of original.	**2. Geographic range** Change in geographic range > 50 % of original.
Genetic structure	**3. Genetic structure** No detectable change in genetic structure. Unlikely to be detectable against background variability for this population.	**3. Genetic structure** Possible detectable change in genetic structure. Any change in frequency of genotypes, effective population size or number of spawning units up to 5%.	**3. Genetic structure** Change in frequency of genotypes, effective population size or number of spawning units up to 10%.	**3. Genetic structure** Change in frequency of genotypes, effective population size or number of spawning units up to 25%.	**3. Genetic structure** Change in frequency of genotypes, effective population size or number of spawning units, change up to 50%.	**3. Genetic structure** Change in frequency of genotypes, effective population size or number of spawning units > 50%.

Sub-component	Score/level					
	1 Negligible	2 Minor	3 Moderate	4 Major	5 Severe	6 Intolerable
Age/size/sex structure	**4. Age/size/sex structure** No detectable change in age/size/sex structure. Unlikely to be detectable against background variability for this population.	**4. Age/size/sex structure** Possible detectable change in age/size/sex structure but minimal impact on population dynamics.	**4. Age/size/sex structure** Impact on population dynamics at maximum sustainable level, long-term recruitment dynamics not adversely affected.	**4. Age/size/sex structure** Long-term recruitment dynamics adversely affected. Time to recover to original structure up to 5 generations free from impact.	**4. Age/size/sex structure** Long-term recruitment dynamics adversely affected. Time to recover to original structure up to 10 generations free from impact.	**4. Age/size/sex structure** Long-term recruitment dynamics adversely affected. Time to recover to original structure > 100 generations free from impact.
Reproductive capacity	**5. Reproductive capacity** No detectable change in reproductive capacity. Unlikely to be detectable against background variability for this population.	**5. Reproductive capacity** Possible detectable change in reproductive capacity but minimal impact on population dynamics.	**5. Reproductive capacity** Impact on population dynamics at maximum sustainable level, long-term recruitment dynamics not adversely affected.	**5. Reproductive capacity** Change in reproductive capacity adversely affecting long-term recruitment dynamics. Time to recovery up to 5 generations free from impact.	**5. Reproductive capacity** Change in reproductive capacity adversely affecting long-term recruitment dynamics. Time to recovery up to 10 generations free from impact.	**5. Reproductive capacity** Change in reproductive capacity adversely affecting long-term recruitment dynamics. Time to recovery > 100 generations free from impact.
Behaviour/movement	**6. Behaviour/ movement** No detectable change in behaviour/ movement. Unlikely to be detectable against background variability for this population. Time taken to recover to pre-disturbed state on the scale of hours.	**6. Behaviour/ movement** Possible detectable change in behaviour/ movement but minimal impact on population dynamics. Time to return to original behaviour/ movement on the	**6. Behaviour/ movement** Detectable change in behaviour/ movement with the potential for some impact on population dynamics. Time to return to original behaviour/ movement on the	**6. Behaviour/ movement** Change in behaviour/ movement with impacts on population dynamics. Time to return to original behaviour/ movement on the scale of months to years.	**6. Behaviour/ movement** Change in behaviour/ movement with impacts on population dynamics. Time to return to original behaviour/ movement on the	**6. Behaviour/ movement** Change to behaviour/ movement. Population does not return to original behaviour/ movement.

Sub-component	Score/level					
	1 Negligible	2 Minor	3 Moderate	4 Major	5 Severe	6 Intolerable
		scale of days to weeks.	scale of weeks to months.		scale of years to decades.	

Table C2. Bycatch and Byproduct species. Description of consequences for each component and each sub-component. Use table as a guide for scoring the level of consequence for bycatch/byproduct species (Modified from Fletcher et al. 2002).

Sub-component	Score/level					
	1 Negligible	**2 Minor**	**3 Moderate**	**4 Major**	**5 Severe**	**6 Intolerable**
Population size	**1. Population size** Insignificant change to population size/growth rate (r). Unlikely to be detectable against background variability for this population.	**1. Population size** Possible detectable change in size/growth rate (r) but minimal impact on population size and none on dynamics.	**1. Population size** No information is available on the relative area or susceptibility to capture/ impact or on the risk of life history traits of this type of species Susceptibility to capture is suspected to be less than 50% and species do not have vulnerable life history traits. For species with vulnerable life history traits to stay in this category susceptibility to capture must be less than 25%.	**1. Population size** Relative state of capture/susceptibility suspected/known to be greater than 50% and species should be examined explicitly.	**1. Population size** Likely to cause local extinctions if continued in longer term	**1. Population size** Local extinctions are imminent/immediate
Geographic range	**2. Geographic range** No detectable change in geographic range. Unlikely to be detectable against background	**2. Geographic range** Possible detectable change in geographic range but minimal impact on population range and none on dynamics, change in	**2. Geographic range** Change in geographic range up to 10 % of original.	**2. Geographic range** Change in geographic range up to 25 % of original.	**2. Geographic range** Change in geographic range up to 50 % of original.	**2. Geographic range** Change in geographic range > 50 % of original.

Sub-component	Score/level					
	1 Negligible	2 Minor	3 Moderate	4 Major	5 Severe	6 Intolerable
	variability for this population.	geographic range up to 5 % of original.				
Genetic structure	**3. Genetic structure** No detectable change in genetic structure. Unlikely to be detectable against background variability for this population.	**3. Genetic structure** Possible detectable change in genetic structure. Any change in frequency of genotypes, effective population size or number of spawning units up to 5%.	**3. Genetic structure** Detectable change in genetic structure. Change in frequency of genotypes, effective population size or number of spawning units up to 10%.	**3. Genetic structure** Change in frequency of genotypes, effective population size or number of spawning units up to 25%.	**3. Genetic structure** Change in frequency of genotypes, effective population size or number of spawning units up to 50%.	**3. Genetic structure** Change in frequency of genotypes, effective population size or number of spawning units > 50%.
Age/size/sex structure	**4. Age/size/sex structure** No detectable change in age/size/sex structure. Unlikely to be detectable against background variability for this population.	**4. Age/size/sex structure** Possible detectable change in age/size/sex structure but minimal impact on population dynamics.	**4. Age/size/sex structure** Detectable change in age/size/sex structure. Impact on population dynamics at maximum sustainable level, long-term recruitment dynamics not adversely damaged.	**4. Age/size/sex structure** Long-term recruitment dynamics adversely affected. Time to recover to original structure up to 5 generations free from impact.	**4. Age/size/sex structure** Long-term recruitment dynamics adversely affected. Time to recover to original structure up to 10 generations free from impact.	**4. Age/size/sex structure** Long-term recruitment dynamics adversely affected. Time to recover to original structure > 100 generations free from impact.
Reproductive capacity	**5. Reproductive capacity** No detectable change in reproductive capacity. Unlikely to be detectable against background	**5. Reproductive capacity** Possible detectable change in reproductive capacity but minimal impact on population dynamics.	**5. Reproductive capacity** Detectable change in reproductive capacity, impact on population dynamics at maximum sustainable level, long-term	**5. Reproductive capacity** Change in reproductive capacity adversely affecting long-term recruitment dynamics. Time to recovery up to 5	**5. Reproductive capacity** Change in reproductive capacity adversely affecting long-term recruitment dynamics. Time to recovery up to 10	**5. Reproductive capacity** Change in reproductive capacity adversely affecting long-term recruitment dynamics. Time to recovery > 100 generations free from impact.

Sub-component	Score/level					
	1 Negligible	2 Minor	3 Moderate	4 Major	5 Severe	6 Intolerable
	variability for this population.		recruitment dynamics not adversely damaged.	generations free from impact.	generations free from impact.	
Behaviour/movement	**6. Behaviour/ movement** No detectable change in behaviour/ movement. Unlikely to be detectable against background variability for this population. Time taken to recover to pre-disturbed state on the scale of hours.	**6. Behaviour/ movement** Possible detectable change in behaviour/ movement but minimal impact on population dynamics. Time to return to original behaviour/ movement on the scale of days to weeks.	**6. Behaviour/ movement** Detectable change in behaviour/ movement with the potential for some impact on population dynamics. Time to return to original behaviour/ movement on the scale of weeks to months.	**6. Behaviour/ movement** Change in behaviour/ movement with impacts on population dynamics. Time to return to original behaviour/ movement on the scale of months to years	**6. Behaviour/ movement** Change in behaviour/ movement with impacts on population dynamics. Time to return to original behaviour/ movement on the scale of years to decades.	**6. Behaviour/ movement** Change to behaviour/ movement. Population does not return to original behaviour/ movement.

Table C3. TEP species. Description of consequences for each component and each sub-component. Use table as a guide for scoring the level of consequence for TEP species (Modified from Fletcher et al. 2002).

Sub-component	Score/level					
	1 Negligible	**2 Minor**	**3 Moderate**	**4 Major**	**5 Severe**	**6 Intolerable**
Population size	**1. Population size** Almost none are killed.	**1. Population size** Insignificant change to population size/growth rate (r). Unlikely to be detectable against background variability for this population.	**1. Population size**. State of reduction on the rate of increase are at the maximum acceptable level. Possible detectable change in size/ growth rate (r) but minimal impact on population size and none on dynamics of TEP species.	**1. Population size** Affecting recruitment state of stocks or their capacity to increase.	**1. Population size** Local extinctions are imminent/immediate	**1. Population size** Global extinctions are imminent/immediate
Geographic range	**2. Geographic range** No interactions leading to impact on geographic range.	**2. Geographic range** No detectable change in geographic range. Unlikely to be detectable against background variability for this population.	**2. Geographic range** Possible detectable change in geographic range but minimal impact on population range and none on dynamics. Change in geographic range up to 5 % of original.	**2. Geographic range** Change in geographic range up to 10% of original.	**2. Geographic range** Change in geographic range up to 25% of original.	**2. Geographic range** Change in geographic range up to 25% of original.
Genetic structure	**3. Genetic structure** No interactions leading to impact on genetic structure.	**3. Genetic structure** No detectable change in genetic structure. Unlikely to be detectable against background variability for this population.	**3. Genetic structure** Possible detectable change in genetic structure but minimal impact at population level. Any change in frequency of	**3. Genetic structure** Moderate change in genetic structure. Change in frequency of genotypes, effective population size or number of	**3. Genetic structure** Change in frequency of genotypes, effective population size or number of spawning units up to 25%.	**3. Genetic structure** Change in frequency of genotypes, effective population size or number of spawning units up to 25%.

Sub-component	Score/level					
	1 Negligible	2 Minor	3 Moderate	4 Major	5 Severe	6 Intolerable
			genotypes, effective population size or number of spawning units up to 5%.	spawning units up to 10%.		
Age/size/sex structure	**4. Age/size/sex structure** No interactions leading to change in age/size/sex structure.	**4. Age/size/sex structure** No detectable change in age/size/sex structure. Unlikely to be detectable against background variability for this population.	**4. Age/size/sex structure** Possible detectable change in age/size/sex structure but minimal impact on population dynamics.	**4. Age/size/sex structure** Detectable change in age/size/sex structure. Impact on population dynamics at maximum sustainable level, long-term recruitment dynamics not adversely damaged.	**4. Age/size/sex structure** Severe change in age/size/sex structure. Impact adversely affecting population dynamics. Time to recover to original structure up to 5 generations free from impact	**4. Age/size/sex structure** Impact adversely affecting population dynamics. Time to recover to original structure > 10 generations free from impact
Reproductive capacity	**5. Reproductive capacity** No interactions resulting in change to reproductive capacity.	**5. Reproductive capacity** No detectable change in reproductive capacity. Unlikely to be detectable against background variability for this population.	**5. Reproductive capacity** Possible detectable change in reproductive capacity but minimal impact on population dynamics.	**5. Reproductive capacity** Detectable change in reproductive capacity, impact on population dynamics at maximum sustainable level, long-term recruitment dynamics not adversely damaged.	**5. Reproductive capacity** Change in reproductive capacity, impact adversely affecting recruitment dynamics. Time to recover to original structure up to 5 generations free from impact	**5. Reproductive capacity** Change in reproductive capacity, impact adversely affecting recruitment dynamics. Time to recover to original structure > 10 generations free from impact
Behaviour/movement	**6. Behaviour/ movement** No interactions resulting in change	**6. Behaviour/ movement** No detectable change in behaviour/ movement. Time to	**6. Behaviour/ movement** Possible detectable change in behaviour/ movement but	**6. Behaviour/ movement** Detectable change in behaviour/ movement with the	**6. Behaviour/ movement** Change in behaviour/ movement, impact adversely affecting	**6. Behaviour/ movement** Change in behaviour/ movement. Impact adversely affecting

Sub-component	Score/level					
	1 Negligible	**2 Minor**	**3 Moderate**	**4 Major**	**5 Severe**	**6 Intolerable**
	to behaviour/ movement.	return to original behaviour/ movement on the scale of hours.	minimal impact on population dynamics. Time to return to original behaviour/ movement on the scale of days to weeks	potential for some impact on population dynamics. Time to return to original behaviour/ movement on the scale of weeks to months	population dynamics. Time to return to original behaviour/ movement on the scale of months to years.	population dynamics. Time to return to original behaviour/ movement on the scale of years to decades.
Interaction with fishery	**7. Interactions with fishery** No interactions with fishery.	**7. Interactions with fishery** Few interactions and involving up to 5% of population.	**7. Interactions with fishery** Moderate level of interactions with fishery involving up to10 % of population.	**7. Interactions with fishery** Major interactions with fishery, interactions and involving up to 25% of population.	**7. Interactions with fishery** Frequent interactions involving ~ 50% of population.	**7. Interactions with fishery** Frequent interactions involving the entire known population negatively affecting the viability of the population.

Table C4. Habitats. Description of consequences for each component and each sub-component. Use table as a guide for scoring the level of consequence for habitats. Note that for sub-components Habitat types and Habitat structure and function, time to recover from impact scales differ from substrate, water and air. Rationale: structural elements operate on greater timeframes to return to pre-disturbance states (Modified from Fletcher et al. 2002).

Sub-component	Score/level					
	1 Negligible	**2 Minor**	**3 Moderate**	**4 Major**	**5 Severe**	**6 Intolerable**
Substrate quality	**1. Substrate quality** Reduction in the productivity (similar to the intrinsic rate of increase for species) on the substrate from the activity is unlikely to be detectable. Time taken to recover to pre-disturbed state on the scale of hours.	**1. Substrate quality** Detectable impact on substrate quality. At small spatial scale time taken to recover to pre-disturbed state on the scale of days to weeks, at larger spatial scales recovery time of hours to days.	**1. Substrate quality** More widespread effects on the dynamics of substrate quality but the state are still considered acceptable given the percent area affected, the types of impact occurring and the recovery capacity of the substrate. For impacts on non-fragile substrates this may be for up to 50% of habitat affected, but for more fragile habitats, e.g. reef substrate, to stay in this category the % area affected needs to be smaller up to 25%.	**1. Substrate quality** The level of reduction of internal dynamics of habitats may be larger than is sensible to ensure that the habitat will not be able to recover adequately, or it will cause strong downstream effects from loss of function. Time to recover from local impact on the scale of months to years, at larger spatial scales recovery time of weeks to months.	**1. Substrate quality** Severe impact on substrate quality with 50 - 90% of the habitat affected or removed by the activity which may seriously endanger its long-term survival and result in changes to ecosystem function. Recovery period measured in years to decades.	**1. Substrate quality** The dynamics of the entire habitat is in danger of being changed in a major way, or > 90% of habitat destroyed.
Water quality	**2. Water quality** No direct impact on water quality. Impact unlikely to be detectable. Time taken to recover to	**2. Water quality** Detectable impact on water quality. Time to recover from local impact on the scale of days to weeks, at	**2. Water quality** Moderate impact on water quality. Time to recover from local impact on the scale of weeks to months,	**2. Water quality** Time to recover from local impact on the scale of months to years, at larger spatial scales	**2. Water quality** Impact on water quality with 50 - 90% of the habitat affected or removed by the activity which	**2. Water quality** The dynamics of the entire habitat is in danger of being changed in a major

Sub-component	Score/level					
	1 Negligible	**2 Minor**	**3 Moderate**	**4 Major**	**5 Severe**	**6 Intolerable**
	pre-disturbed state on the scale of hours.	larger spatial scales recovery time of hours to days.	at larger spatial scales recovery time of days to weeks.	recovery time of weeks to months.	may seriously endanger its long-term survival and result in changes to ecosystem function. Recovery period measured in years to decades.	way, or > 90% of habitat destroyed.
Air quality	**3. Air quality** No direct impact on air quality. Impact unlikely to be detectable. Time taken to recover to pre-disturbed state on the scale of hours.	**3. Air quality** Detectable impact on air quality. Time to recover from local impact on the scale of days to weeks, at larger spatial scales recovery time of hours to days.	**3. Air quality** Detectable impact on air quality. Time to recover from local impact on the scale of weeks to months, at larger spatial scales recovery time of days to weeks.	**3. Air quality** Time to recover from local impact on the scale of months to years, at larger spatial scales recovery time of weeks to months.	**3. Air quality** Impact on air quality with 50 - 90% of the habitat affected or removed by the activity .which may seriously endanger its long-term survival and result in changes to ecosystem function. Recovery period measured in years to decades.	**3. Air quality** The dynamics of the entire habitat is in danger of being changed in a major way, or > 90% of habitat destroyed.
Habitat types	**4. Habitat types** No direct impact on habitat types. Impact unlikely to be detectable. Time taken to recover to pre-disturbed state on the scale of hours to days.	**4. Habitat types** Detectable impact on distribution of habitat types. Time to recover from local impact on the scale of days to weeks, at larger spatial scales recovery time of days to months.	**4. Habitat types** Impact reduces distribution of habitat types. Time to recover from local impact on the scale of weeks to months, at larger spatial scales recovery time of months to < one year.	**4. Habitat types** The reduction of habitat type areal extent may threaten ability to recover adequately, or cause strong downstream effects in habitat distribution and extent. Time to recover from impact on the scale of > one	**4. Habitat types** Impact on relative abundance of habitat types resulting in severe changes to ecosystem function. Recovery period likely to be > decadal	**4. Habitat types** The dynamics of the entire habitat is in danger of being changed in a catastrophic way. The distribution of habitat types has been shifted away from original spatial pattern. If reversible, will require a long-

Sub-component	Score/level					
	1 Negligible	**2 Minor**	**3 Moderate**	**4 Major**	**5 Severe**	**6 Intolerable**
				year to < decadal timeframes.		term recovery period, on the scale of decades to centuries.
Habitat structure and function	**5. Habitat structure and function** No detectable change to the internal dynamics of habitat or populations of species making up the habitat. Time taken to recover to pre-disturbed state on the scale of hours to days.	**5. Habitat structure and function** Detectable impact on habitat structure and function. Time to recover from impact on the scale of days to months, regardless of spatial scale	**5. Habitat structure and function** Impact reduces habitat structure and function. For impacts on non-fragile habitat structure this may be for up to 50% of habitat affected, but for more fragile habitats, to stay in this category the % area affected needs to be smaller up to 20%. Time to recover from local impact on the scale of months to < one year, at larger spatial scales recovery time of months to < one year.	**5. Habitat structure and function** The level of reduction of internal dynamics of habitat may threaten ability to recover adequately, or it will cause strong downstream effects from loss of function. For impacts on non-fragile habitats this may be for up to 50% of habitat affected, but for more fragile habitats, to stay in this category the % area affected up to 25%. Time to recover from impact on the scale of > one year to < decadal timeframes.	**5. Habitat structure and function** Impact on habitat function resulting from severe changes to internal dynamics of habitats. Time to recover from impact likely to be > decadal.	**5. Habitat structure and function** The dynamics of the entire habitat is in danger of being changed in a catastrophic way which may not be reversible. Habitat losses occur. Some elements may remain but will require a long-term recovery period, on the scale of decades to centuries.

Table C5. Communities. Description of consequences for each component and each sub-component. Use table as a guide for scoring the level of consequence for communities (Modified from Fletcher et al. 2002).

Sub-component	Score/level					
	1 Negligible	**2 Minor**	**3 Moderate**	**4 Major**	**5 Severe**	**6 Intolerable**
Species composition	1. Species composition Interactions may be occurring which affect the internal dynamics of communities leading to change in species composition not detectable against natural variation.	1. Species composition Impacted species do not play a keystone role – only minor changes in relative abundance of other constituents. Changes of species composition up to 5%.	1. Species composition Detectable changes to the community species composition without a major change in function (no loss of function). Changes to species composition up to 10%.	1. Species composition Major changes to the community species composition (~25%) (involving keystone species) with major change in function. Ecosystem function altered measurably and some function or components are locally missing/declining/increasing outside of historical range and/or allowed/facilitated new species to appear. Recovery period measured in years.	1. Species composition Change to ecosystem structure and function. Ecosystem dynamics currently shifting as different species appear in fishery. Recovery period measured in years to decades.	1. Species composition Total collapse of ecosystem processes. Long-term recovery period required, on the scale of decades to centuries
Functional group composition	2. Functional group composition Interactions which affect the internal dynamics of communities leading to change in functional group composition not detectable against natural variation.	2. Functional group composition Minor changes in relative abundance of community constituents up to 5%.	2. Functional group composition Changes in relative abundance of community constituents, up to 10% chance of flipping to an alternate state/ trophic cascade.	2. Functional group composition Ecosystem function altered measurably and some functional groups are locally missing/declining/increasing outside of historical range and/or allowed/facilitated new species to appear. Recovery period measured in months to years.	2. Functional group composition Ecosystem dynamics currently shifting, some functional groups are missing and new species/groups are now appearing in the fishery. Recovery period measured in years to decades.	2. Functional group composition Ecosystem function catastrophically altered with total collapse of ecosystem processes. Recovery period measured in decades to centuries.
Distribution of the community	3. Distribution of the community	3. Distribution of the community	3. Distribution of the community	3. Distribution of the community	3. Distribution of the community	3. Distribution of the community

Sub-component	Score/level					
	1 Negligible	2 Minor	3 Moderate	4 Major	5 Severe	6 Intolerable
	Interactions which affect the distribution of communities unlikely to be detectable against natural variation.	Possible detectable change in geographic range of communities but minimal impact on community dynamics change in geographic range up to 5 % of original.	Detectable change in geographic range of communities with some impact on community dynamics Change in geographic range up to 10 % of original.	Geographic range of communities, ecosystem function altered measurably and some functional groups are locally missing/declining/increasing outside of historical range. Change in geographic range for up to 25 % of the species. Recovery period measured in months to years.	Change in geographic range of communities, ecosystem function altered and some functional groups are currently missing and new groups are present. Change in geographic range for up to 50 % of species including keystone species. Recovery period measured in years to decades.	Change in geographic range of communities, ecosystem function collapsed. Change in geographic range for >90% of species including keystone species. Recovery period measured in decades to centuries.
Trophic/size structure	4. Trophic/size structure Interactions which affect the internal dynamics unlikely to be detectable against natural variation.	4. Trophic/size structure Change in mean trophic level, biomass/ number in each size class up to 5%.	4. Trophic/size structure Changes in mean trophic level, biomass/ number in each size class up to 10%.	4. Trophic/size structure Changes in mean trophic level. Ecosystem function altered measurably and some function or components are locally missing/declining/increasing outside of historical range and/or allowed/facilitated new species to appear. Recovery period measured in years to decades.	4. Trophic/size structure Changes in mean trophic level. Ecosystem function severely altered and some function or components are missing and new groups present. Recovery period measured in years to decades.	4. Trophic/size structure Ecosystem function catastrophically altered as a result of changes in mean trophic level, total collapse of ecosystem processes. Recovery period measured in decades to centuries.
Bio-geochemical cycles	5. Bio- and geochemical cycles	5. Bio- and geochemical cycles	5. Bio- and geochemical cycles	5. Bio- and geochemical cycles	5. Bio- and geochemical cycles	5. Bio- and geochemical cycles

Sub-component	Score/level					
	1 Negligible	**2 Minor**	**3 Moderate**	**4 Major**	**5 Severe**	**6 Intolerable**
	Interactions which affect bio- & geochemical cycling unlikely to be detectable against natural variation.	Only minor changes in relative abundance of other constituents leading to minimal changes to bio- & geochemical cycling up to 5%.	Changes in relative abundance of other constituents leading to minimal changes to bio- & geochemical cycling, up to 10%.	Changes in relative abundance of constituents leading to major changes to bio- & geochemical cycling, up to 25%.	Changes in relative abundance of constituents leading to Severe changes to bio- & geochemical cycling. Recovery period measured in years to decades.	Ecosystem function catastrophically altered as a result of community changes affecting bio- and geo- chemical cycles, total collapse of ecosystem processes. Recovery period measured in decades to centuries.