R04/1072 | 28/06/2007

Australian Government
Australian Fisheries Management Authority

Ecological Risk Assessment for Effects of Fishing

REPORT FOR THE MIDWATER TRAWL SUB-FISHERY OF THE HEARD AND MCDONALD ISLANDS FISHERY

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This fishery ERA report should be cited as:

Bulman, C., Daley, R., Sporcic, M., Fuller, M., Stevenson, D., and Hobday, A., (2007). Ecological Risk Assessment for the Effects of Fishing: Report for the Midwater Trawl Sub-fishery of the Heard and McDonald Islands Fishery. Report for the Australian Fisheries Management Authority, Canberra.

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<u>Notes to this document:</u>

This fishery ERA report document 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 Midwater Trawl 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 Midwater Trawl Fishery includes the following:

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

Fishery Description

Gear: Midwater trawl (90 mm for Mackerel icefish)
Area: Heard and McDonald Islands Midwater Trawl Fishery
Depth range: 180-270m water column depth
Fleet size: 1 vessel
Effort: Approximately 100 shots per year
Landings: 709 t in 2004/5
Discard rate: Quota species 92%; non-quota species 8% (2002-5)
Main target species: Mackerel icefish
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:	2
By-product species:	21
Bycatch Species:	3
TEP species:	80
Habitats:	NA
Communities:	2

Level 1 Results

No ecological components were eliminated at Level 1 (consequence (risk) score ≥3 for at least one activity).

Risk scores were between 1-3 across all 32 hazards (fishing activities) and four ecological components assessed. A number of hazards (fishing activities) were eliminated at Level 1 (risk scores 1 or 2). Those hazards included (risk scores of ≥3) were:

- Fishing (direct impact with and without capture on all components)

External hazards from other fisheries also scored moderately for target and byproduct species. No risks were rated as major (=4), severe (=5) or intolerable (=6).

Habitats for this fishery are not currently assessed using most recent ERAEF methodology due to unavailability of habitat data. AAD is currently conducting a study of benthic habitats and future work proposed for this region.

Level 2 Results

Species
A total of 106 species were subsequently considered at level 2 of which expert overrides were used in 82. Of the 10 high risk species assessed at level 2, 7 were likely to be false positives because of missing attribute data or poor distribution data. The target species, icefish, which has a comprehensive management plan and annual stock assessments, represented only a medium risk. It has been accredited by MSC and presents no serious ecological concern. Of the non-target species, porbeagles are considered most at risk due largely to a combination of its pelagic habit making it more susceptible to midwater fishing method and its low productivity. Of the TEP species, the Black browed albatross represented a high risk due to its capture in the fishery. Other birds including some that that have been captured such as white-chinned petrels present as medium risk species. No further seabird mortality has occurred and the voluntary precautions taken by the operator and the mitigation measures in already adhered to appear to have been successful so far. However, the new mitigation measures have only been in place for a short period.

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

The midwater trawl fishery for icefish is well-managed and highly regulated, therefore presenting no real concern for the target species. The operators prosecute the fishery with a high level compliance and have shown integrity by self-imposing precautions to reduce threat to TEP species. The major concern that needs further monitoring and investigation is the impact on porbeagles and seabirds, particularly if effort in the fishery increases.

Two ecological issues are highlighted from this ERAEF assessment of the mid-water trawl sub-fishery at Heard and McDonald Island. Firstly and most importantly there is a need for continued monitoring of seabird interactions to ensure mandatory and recently introduced voluntary mitigation measures are effective in maintaining seabird mortality at sustainable levels.

Secondly there is a need to monitor catches of porbeagle shark (currently around 7 tonnes over the last five years) and ensure these catches are sustainable.

A further consideration is the potential for mid-water trawl gear to interact with beaked whales and dolphins. Such interactions have occurred in domestic mid-water trawl fisheries around the Australian continent. However, there are no records of interactions with cetaceans in the sub-fishery.

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.

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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.

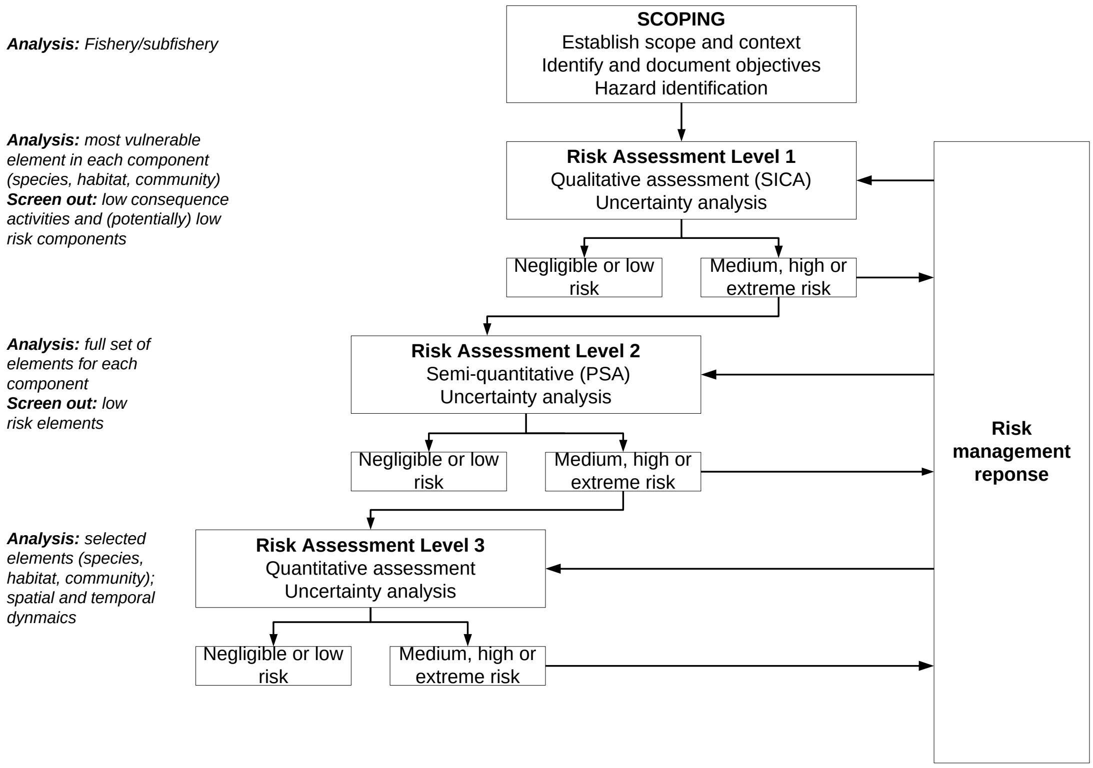


Figure 1. Overview of ERAEF showing focus of analysis for each level at the left in italics.

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.

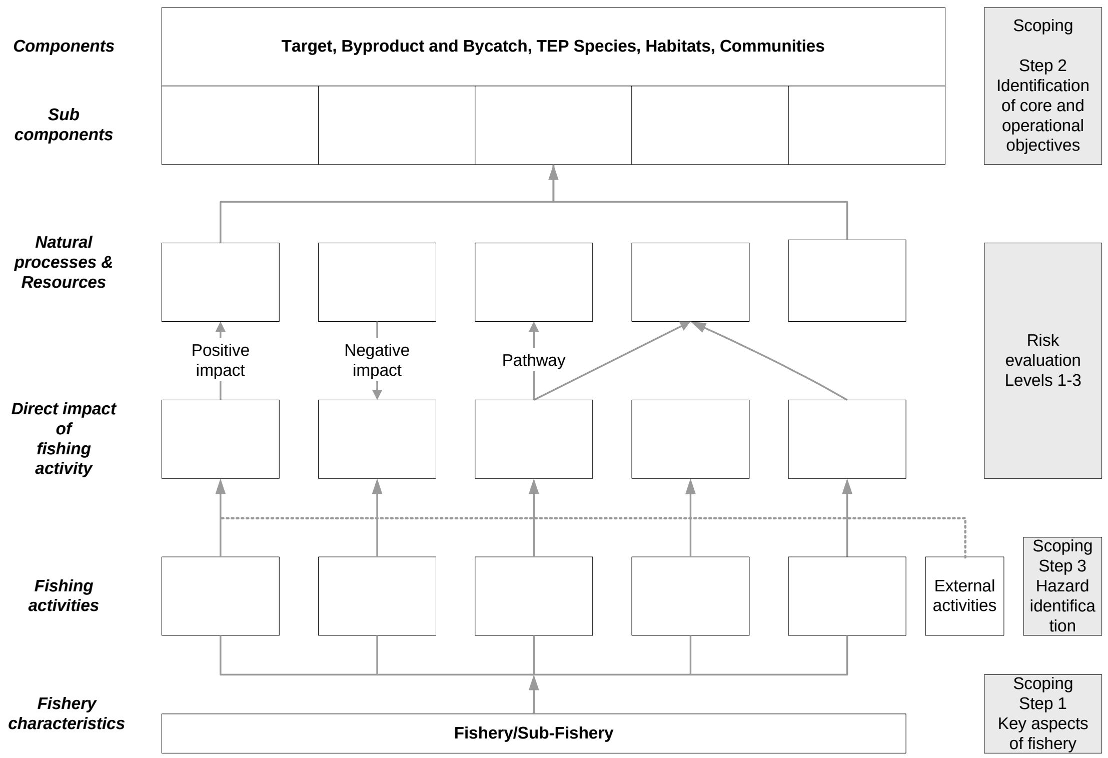


Figure 2. Generic conceptual model used in ERAEF.

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 2006). 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 Midwater Trawl Fishery

Fishery ERA report stage	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
Scoping	Emails and meeting	May, June 2006	AAD	Draft scoping and species lists reviewed
Level 1 and 2	Stakeholder meeting	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

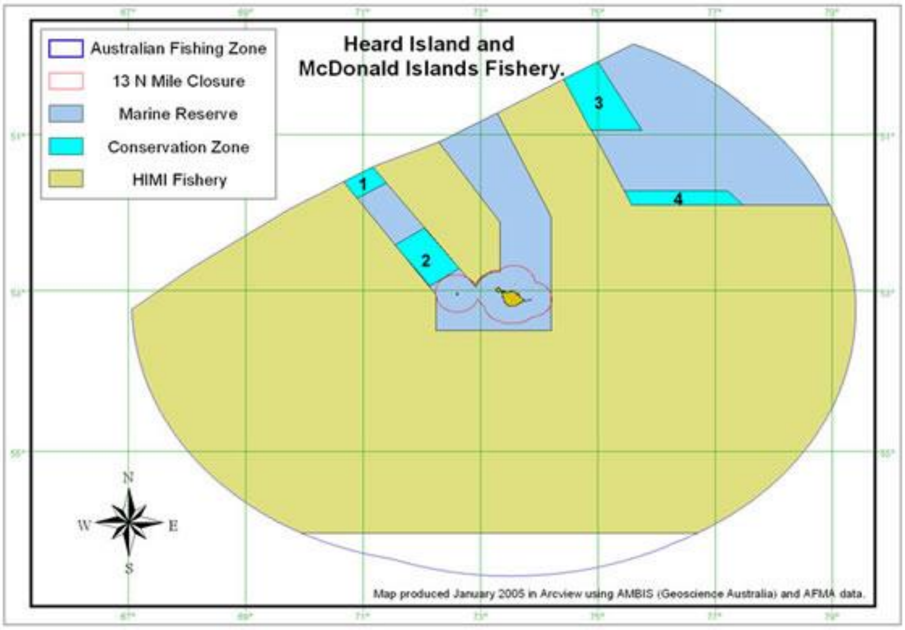
2.2.1 General Fishery Characteristics (Step 1).

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

Fishery Name: Fishery Name: Heard and McDonald Island Midwater trawl
Date of assessment: April 2004 (updated 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 midwater trawling for *Champsocephalus gunnari* Mackerel icefish. NB Patagonian toothfish are caught incidentally but are not targetted.
Start date/history	Fishing activity in the region had been sparse until recently. There are records of Soviet and Polish vessels fishing *Champsocephalus gunnari* Mackerel icefish in the region in the 1970s and some research surveys were conducted by AAD in the early 1990s.

	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 Measures 109/XV and 110/XV (1996) respectively(now CM 41-08 and 42-02). 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 the icefish limit (Williams *et al.* 2002). (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	Icefish are fished on the shallower parts of the plateau particularly on the southeast slope and Gunnari Ridge (Meyer *et al*. 2000). Until 1998 they were also abundant on Shell Bank (Williams *et al* 2002) but this area has been closed since then due to concern that it was not able to sustain a fishery and the potential for overlap between the icefish fishery and the foraging activities of icefish predators (Meyer *et al.* 2000).

Fishing season	The fishing season for *Champsocephalus gunnari* Mackerel icefish is from 1 December to 30 November each year.
Target species and stock status	**Mackerel icefish (*Champsocephalus gunnari*)** Mackerel icefish (*Champsocephalus gunnari*) is found in the Atlantic and Indian sectors of the Southern Ocean. In the Atlantic, it has been found at Bouvet Island and at all the islands of the Scotia Arc (South Georgia, South Sandwich, South Orkney, and South Shetland Islands) as well as the northern part of the Antarctic Peninsula. In the Indian Ocean sector, it is found on the northern part of the Kerguelen Plateau and banks between Iles Kerguelen and Heard Island. There it is confined to waters less than 500m, but usually occurs shallower than 300m (Williams *et al.* 2002). Icefish are abundant on the shallower parts of the plateau particularly on the southeast part, Gunnari Ridge (Meyer *et al*. 2000) and until 1998 was abundant on Shell Bank (Williams *et al* 2002). They are rarely found on the other shallow banks in contrast to the reports of the early 1970s where catches were made on Pike, Aurora and Shell Banks, and other parts of the Plateau (Williams *et al.* 2002). Older juveniles and adults form large aggregations predominantly in the demersal (found at or near the sea bottom) or mid-water range of the water column. The HIMI region is the only area where Mackerel icefish are targeted in the AFZ. Stock size for the Plateau and Gunnari Ridge in 2004, was estimated to be about 24000 tonnes (2005 Fishery Report: *C. gunnari* Heard Island (Division 58.5.2).
Bait Collection and usage	n/a
Current entitlements	A limit of three boats participates in the HIMI Fishery. Any boat with a minimum quota of 25.5% of the Statutory Fishing Rights (SFR) can participate. 1 longliner has operated since the 2002/3 season. AFMA Annual Report 2001-2002; MSC 2006
Current and recent TACs, quota trends by method	The TACs for target species in Division 58.5.2 (the CCAMLR code for the region including HIMI) do not specify separate TACs for each method. The total TACs for target species and across all methods are:

Year	Agreed TAC (Tonnes)	
	Patagonian toothfish	Mackerel icefish
2000/1	2995	1150
2001/2	2815	885
2002/3	2879	2980
2003/4	2873	292
2004/5	2787	1864
2005/6	2584	1210

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

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

Current and recent fishery effort trends by method	Midwater trawl shots* Year | No. midwater shots 2000/1 | - 2001/2 | 422 2002/3 | 106 2003/4 | 9 2004/5 | 137 *derived from AAD database. (Source: unofficial data from AAD database).

Midwater trawl shots*

Year	No. midwater shots
2000/1	-
2001/2	422
2002/3	106
2003/4	9
2004/5	137

*derived from AAD database.

(Source: unofficial data from AAD database).

Current and recent fishery catch trends by method

Midwater trawl catches of target species (tonnes)*

Year	Mackerel icefish	Patagonian toothfish
2001/2	259 (865)	80
2002/3	41(2345)	0.2
2003/4	1 (78)	-
2004/5	709 (1851)	0.02

*derived from AAD database. Data in () are CCAMLR total icefish catches (demersal and midwater).

Midwater trawl catches of byproduct species (tonnes)*

Year	*Channichthys rhinoceratus* Unicorn icefish	*Lepidonotothen squamifrons* Grey rockcod	Skates and rays	*Macrourus* spp.	Sharks	Other fish species
2001/2	0.1 (2.9)	0.08 (0.55)	0.08 (0)	0.3 (0)	1.2 (0)	>0.001 (0.2)
2002/3	0.8 (20.9)	0.005 (0.42)	0.3 (40.8)	>0.001 (4.4)	0 (0.001)	>0.001 (0.6)
2003/4	0.03 (13.5)	0 (2.9)	>0.001 (69.1)	0 (44.7)	0 (0.01)	0 (2.0)
2004/5	1.2 (34.5)	>0.001 (2.5)	0.1 (78.7)	0 (69.7)	1.9 (0.52)	>0.001 (3.3)

*derived from AAD database. Data in () are CCAMLR total species catches (demersal and midwater).

(Source: unofficial estimates from AAD database; CCAMLR Statistical Bulletin no18 , May 2006)

Current and recent value of fishery ($)

Icefish
$3.6 million (estimated using to be ex-vessel at $2 kg). Accurate estimates unavailable to maintain operator confidentiality AFMA is unable to release this information.

(Source: AFMA)

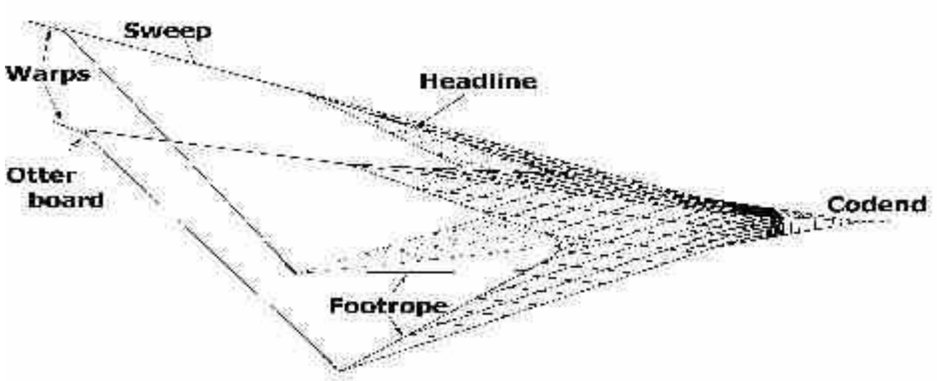
Relationship with other fisheries

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).

Demersal trawling occurs on the fishing grounds targeting both icefish and Patagonian toothfish.

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.

(Source: http://ccamlr.org)

	Longline fishery Demersal longlining for Patagonian toothfish began in 2002/3. Longlining operations generally occur on the deeper slope where larger fish occur and does not impact icefish.
Gear	
Fishing gear and methods	When mid-water trawling, a net similar to, but typically larger than, a demersal trawl is towed in the mid-water column the net is spread horizontally and vertically like that of the demersal trawler. However, it does not have the same ground gear as it is not designed to touch the seafloor. Mid-water trawl nets are also equipped with electronic units to allow monitoring of the net in the water column. Mid-water trawling in the Fishery occurs at depths of around 350 metres. Like demersal trawling, mid-water trawling relies on the herding of fish inward toward the mouth of the net where they are scooped up and are ultimately trapped in the codend. No other net specifications available.  Mid water trawling (Hampidjan net makers) (Source: AFMA)
Fishing gear restrictions	Trawl nets are limited to a 90mm minimum when targeting mackerel icefish to enable juvenile fish to escape.
Selectivity of gear and fishing methods	Trawl nets for mackerel icefish have minimum mesh size of 90mm. Midwater trawling generally targets the target species often resulting in little or no bycatch.
Spatial gear zone set	Midwater trawling is conducted on the upper Heard Plateau.
Depth range gear set	When targeting Icefish, gear is deployed between 180-270m, bottom depth between 350-400m.
How gear set	Nets are set in mid-water column 100-200m above bottom.
Area of gear impact per set or shot	Not applicable
Capacity of gear	Catches are monitored to maximum capacity of 15 tonnes.

<table>
<tr><td>Effort per annum all boats</td><td>The effort in the midwater trawl fishery is very low and declining largely due to the experimental nature of the fishery. The number of midwater trawl shots varies seasonally due to the fluctuation in availability of icefish, but generally appears to have declined.

<table>
<tr><th>Year</th><th>No midwater hauls</th><th>Midwater hauls as % of all trawl hauls</th></tr>
<tr><td>2002</td><td>422</td><td>6.5%</td></tr>
<tr><td>2003</td><td>106</td><td>1.1%</td></tr>
<tr><td>2004</td><td>9</td><td>0.1%</td></tr>
<tr><td>2005</td><td>137</td><td>2.2%</td></tr>
</table>
(Source: Unofficial estimates from AAD database)</td></tr>
<tr><td>Lost gear and ghost fishing</td><td>No gear reported lost during midwater operations.
(Source: Environment Australia 2002; SAFAG 23, May 2005)</td></tr>
<tr><td colspan="2">Issues</td></tr>
<tr><td>Target species issues</td><td>Major uncertainties concerning Mackerel icefish (Champsocephalus gunnari):
1. biological aspects including lifespan, age at maturity, location of spawning grounds (although these are the best known of the set listed here),
2. distribution of stocks,
3. stock size,
4. dependence of other predators on Mackerel icefish as prey items (Moore et al. 1998).</td></tr>
<tr><td>Byproduct and bycatch issues and interactions</td><td>The HIMI Fishery is conducted in a manner that poses only limited risk to bycatch species, protected species and the broader marine ecosystem. Whilst current bycatch levels are low by weight there is some uncertainty as to the impacts of the fishery on bycatch species, in particular sleeper sharks, skates and rays, and benthic communities. Environment Australia (EA) considers that the management arrangements in place are sufficiently precautionary and work is ongoing to further minimise the overall risk to bycatch species. Interaction with protected species is minimal and there are some measures in place to minimise the impact of trawling on benthic communities and the marine environment. The combination of management arrangements, data gathering and proposed research provides confidence in the fishery's ability to maintain low bycatch levels and minimise interaction with protected species and the ecosystem.

(Source: Environment Australia 2002)
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 no 18 , May 2006; http://www.ccamlr.org/pu/e/pubs/sa/abs03.pdf)</td></tr>
<tr><td>TEP issues and interactions</td><td>Interactions causing injury or death to seabirds and marine mammals have been extremely low to date in Antarctic trawl operations, and SAFAG's assessment was that the current fishing operations do not pose a significant threat to seabird or marine mammal populations.
CCAMLR Conservation Measure 25-03 specifically sets out mitigation measures to minimise incidental mortality of seabirds and marine mammals from trawling however there are no limits on seabird mortality yet.

Marine mammals</td></tr>
</table>

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.
In the HIMI fishery the current operators have adopted a code of conduct for minimisation of seal interactions, the code includes the following measures:

- winch must not be stopped when shooting net and bridles. If the winch is stopped the net must be recovered and checked for seals
- the net must be checked for gilled fish and all fish removed prior to the shot
- net deployment not to occur from one hour before civil twilight until one hour after civil twilight

Seabirds-general
The low number of reported incidents involving death or serious injury to seabirds from interaction with trawl gear is a positive factor favouring the fishery. However a recent escalation of fatalities in 2005: 13 birds were killed in the 2004/5 season of which 12 were killed in midwater trawling operations. Seven of these were Black-browed albatrosses, of which there are 600 pairs breeding on Heard Is. The operator immediately, and voluntarily, employed measures to eliminate further risk such as only midwater trawling at night. AFMA will review mechanisms to reduce the level of interactions. AFMA is continuing to investigate appropriate assessment methods for these species. A proposal to mitigate or eliminate seabird bycatch by Robertson et al. (2005) was presented at SARAG 25 for discussion at CCAMLR XXI.
To reduce the incentive for seabirds to congregate around vessels, AFMA will maintain the minimisation of lighting on the vessel and the prohibition on discharge of waste products, including offal (waste products from fish processing) or unwanted dead fish.

Fatalities of seabirds from trawling.

	1/12/1997-30/11/2004		1/12/2004-10/5/2005	
Seabird spp.	Icefish	Toothfish	Icefish	Toothfish
Black-browed Albatrosses	2	nil	7	nil
Southern giant petrels	1	nil		
White-chinned petrels	4	1	5	1
Cape petrels	1	6		
Antarctic prions	nil	2		

(Source: SARAG 26, May 2006; Robertson et al. 2005)

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 (EA Assessment 2002). 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	**Benthic damage by trawl gear** The impacts of demersal and mid-water trawl fishing on habitats have to date not been assessed in detail for the Antarctic fisheries. Mid-water trawling is though to have less impact on habitats than demersal trawling since they do not touch the bottom. Midwater trawling occurs infrequently and is considered largely experimental **Habitat Protection** A Commonwealth Marine Protected Area has been established in the Macquarie Island region and 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 described in the section ‘‘Initiatives and Strategies’. 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 12 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. A specific allowance is made for predator needs by adopting a limit reference point for the fishery of not less than 75% median escapement of the spawning biomass over a two year projection. However, this assumes that the biomass is known and that it does not fall below a sustainable level. 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 with the possible use of Potential Biological Removal levels. 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) In April 2006 the HIMI Mackerel Icefish Fishery was certified by the Marine Stewardship Council.
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) • mesh-size is restricted to greater than 120 mm for Patagonian toothfish fishery and greater than 90mm for Mackerel icefish fishery (Conservation Measures 22-02 (1984) and 22-03 (1990)) • other bottom gear restrictions. (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) and for Mackerel icefish is 1210 tonnes (Conservation Measure 42-02 (2005)) • Move –on provisions if, in hauls larger than 100 kg of icefish, more than 10% of the fish are less than legal limits (240mm) (Conservation Measure 42-02)) • 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, AAFMA will review operating practices with SFR holders • carry-over provision for Patagonian toothfish-any overcatch 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)

<table>
<tr><td>Technical measures</td><td>Mesh size
Under AFMA requirements the mesh-size of the trawl nets used must not be less than 90 mm for targeting mackerel icefish.
(Source: CCAMLR 2005/6 Schedule of Conservation Measures)</td></tr>
<tr><td>Regulations</td><td>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.

Under Conservation Measure 25-03 (2005) the following regulations apply:

The use of net monitor cables on vessels in the Convention area is prohibited.
Vessels operating in the Convention area should at all times arrange the location and level of lighting so as to minimise illumination directed out from the vessel consistent with the safe operation of the vessel.
Discharge of offal shall be prohibited during shooting and hauling of gear.
Nets should be cleaned prior to shooting to remove items that might attract birds
Vessels should adopt shooting and hauling procedures to minimise the time the net is lying on the surface of the water with the meshes slack. Net maintenance should not be carried out with the net in the water.
Vessels are encouraged to develop gear configurations that will minimise the chance of birds encountering the parts of the net to which they are most vulnerable.

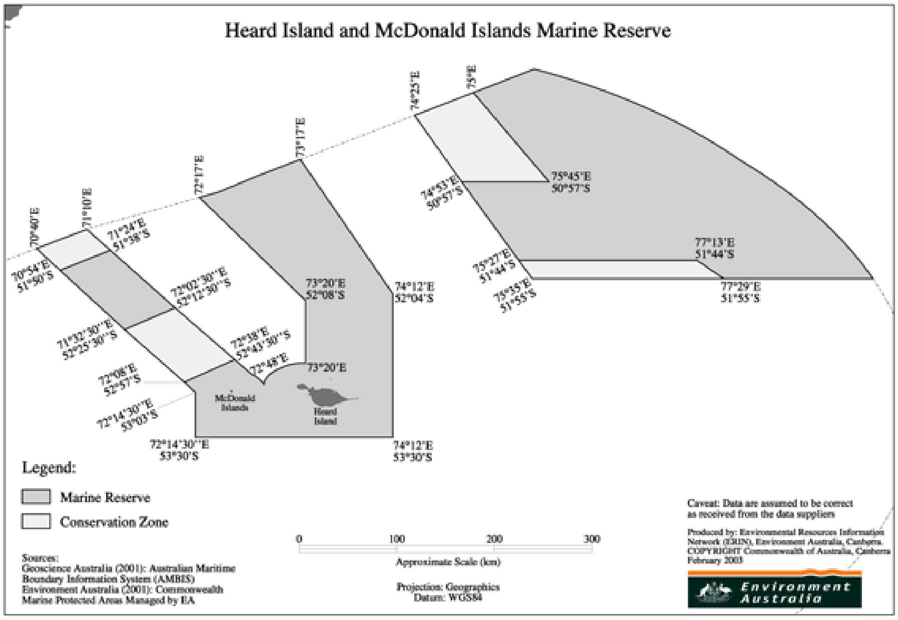
Under Conservation Measure 33-02 (2005) the following regulations apply:

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:
<table>
<tr><td>Species</td><td>TAC (tonnes)</td></tr>
<tr><td>Channichthys rhinoceratus Unicorn icefish</td><td>150</td></tr>
<tr><td>Grey rockcod Lepidonotothen squamifrons</td><td>80</td></tr>
<tr><td>Skates and rays</td><td>120</td></tr>
<tr><td>Macrourus spp.</td><td>360</td></tr>
<tr><td>Other species</td><td>50</td></tr>
</table>
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 42-02 (2005)

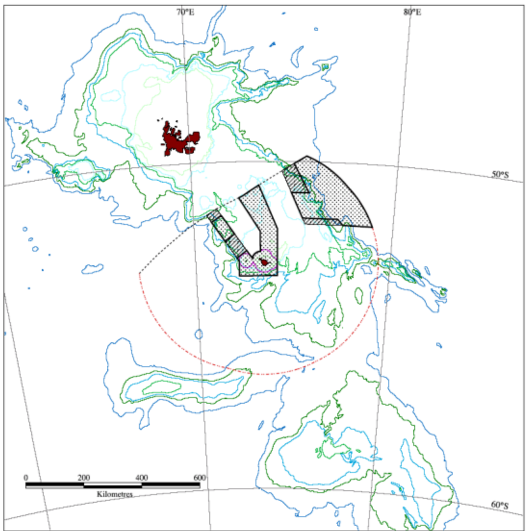
In any one haul where 100 kg or more of Mackerel icefish are caught and juvenile (less than 240 mm total length) Mackerel icefish constitute 10% or greater of the catch by number, the vessel is not allowed to use that fishing method within 5 nm of that site for at least 5 days
</td></tr>
</table>

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



Kerguelen Plateau and the Heard Island and McDonald Islands Marine Reserve and Conservation Zone

	(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. adds 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 Midwater Trawl 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. NB Patagonian toothfish are not targetted by this fishery but are caught incidentally and are therefore included

Species Number	Taxa	Family name	Scientific name	Common Name	CAAB code
765	Teleost	Nototheniidae	*Dissostichus eleginoides*	Patagonian toothfish	37404792
1390	Teleost	Channichthyidae	*Champsocephalus gunnari*	Mackerel icefish	37407791

<u>Byproduct species *Heard and McDonald Islands Midwater Trawl Fishery*</u>

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
826	Chondrichthyan	Squalidae	*Etmopterus granulosus*	southern lantern shark	37020021
1480	Chondrichthyan	Rajidae	*Bathyraja eatonii*	[a skate]	37031750
1481	Chondrichthyan	Rajidae	*Bathyraja maccaini*	[a skate]	37031751
1482	Chondrichthyan	Rajidae	*Raja georgiana*	[a skate]	37031753
302	Chondrichthyan	Rajidae	*Bathyraja irrasa*	skate	
304	Chondrichthyan	Rajidae	*Bathyraja murrayi*	skate	
2787	Invertebrate	Asteroidea	*Asteroidea*		26200000
2805	Teleost	Bathylagidae	*Bathylagus sp.*		37098800
536	Teleost	Macrouridae	*Cynomacrurus piriei*	rattail/whiptail/grenadier	37232054
537	Teleost	Melamphaidae	*Poromitra crassiceps*	bigscale	37251004
644	Teleost	Lampridae	*Lampris immaculatus*	Southern moonfish	37268002
768	Teleost	Nototheniidae	*Lepidonotothen squamifrons*	Grey rockcod ; an icefish	37404793
770	Teleost	Channichthyidae	*Channichthys rhinoceratus*	Unicorn icefish	37407792
1493	Teleost	Achiropsettidae	*Mancopsetta maculata*	[a southern flounder]	37460076
2863	Teleost	Nototheniidae	*Notothenia (Gobionotothen) acuta*		
2867	Teleost	Nototheniidae	*Notothenia (Notothenia) rossii rossii*		
2868	Teleost	Nototheniidae	*Nototheniops mizops*		
1459	Teleost	Myctophidae	*Myctophidae indet*	lanternfish	
1461	Teleost	Muraenolepididae	*Muraenolepis sp.*	Moray cod (undifferentiated)	
1466	Teleost	Macrouridae	*Macrourus sp.*	whiptail	
2845	Teleost	Macrouridae	*Macrourus holotrachys*		

<u>Bycatch species *Heard and McDonald Islands Midwater Trawl Fishery*</u>

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
972	Chondrichthyan	Lamnidae	*Lamna nasus*	Porbeagle shark	37010004
257	Chondrichthyan	Squalidae	*Somniosus antarcticus*	Sleeper shark; Southern Sleeper Shark	37020036
1981	Invertebrate		*Porifera - undifferentiated*	sponges	10000000

<u>TEP species *Heard and McDonald Islands Midwater Trawl Fishery*</u>

List the TEP species that occur in the area of the sub-fishery. Highlight species that are known to interact directly with the 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
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
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
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
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

Species Number	Taxa	Family name	Scientific name	Common Name	CAAB code
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
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
1695	Marine bird	Fregatidae	*Fregata spp.*	frigate birds	40050000
1437	Marine bird	Chionididae	*Chionis minor nasicornis/minor*	Black-faced sheathbill	40126001
1696	Marine bird	Laridae	*Catharacta spp.*	Skuas	40128000
325	Marine bird	Laridae	*Catharacta skua*	Great Skua	40128005
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)	
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

Species Number	Taxa	Family name	Scientific name	Common Name	CAAB code
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
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 undertaken in this assessment.

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 Midwater trawl 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]																			
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																			

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
Plateau 0 – 110m																			
Plateau 110- 250m[4]																		x	
Plateau 250 – 565m[4]																			
Plateau 565 – 820m[5]																			
Plateau 820 – 1100m[5]																			

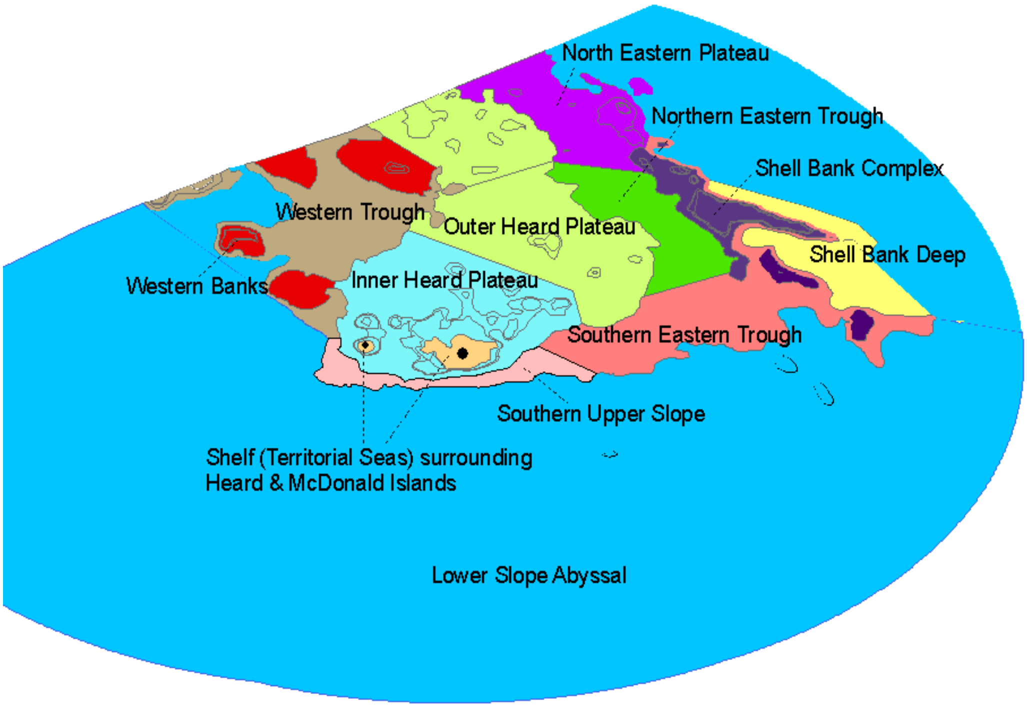
[1] Four inner shelf communities occur in the Timor Transition (Arafura, Groote, Cape York and Gulf of Carpentaria) and three inner shelf communities occur in the Southern (Eyre, Eucla and South West Coast). At Macquarie Is: [2]inner & outer shelves (0-250m), and [3]upper and midslope communities combined (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.

Document S2C2. Pelagic Communities

Pelagic communities that overlie the demersal communities in which fishing activity occurs in the HIMI Midwater trawl fishery (x). Shaded cells indicate all communities that exist in the province.

Pelagic community	Northeastern	Eastern	Southern	Western	Northern	Northwestern	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								
Oceanic (2) >1000m								
Oceanic (1) 0-1600m								
Oceanic (2) >1600m								

[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.



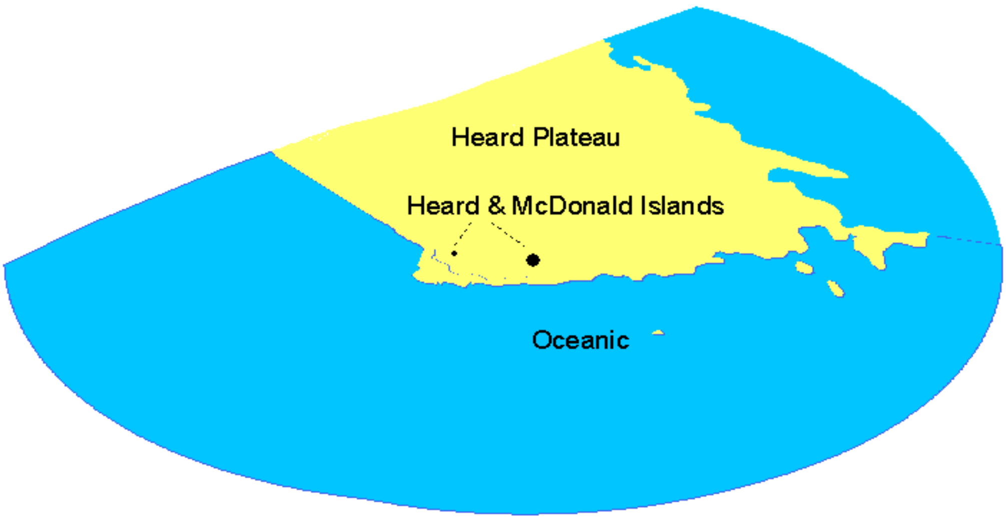


Fig S1. (a) Demersal and (b) pelagic communities in the Heard and McDonald Islands Fisheries.

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. However the possible links between the HIMI, Kerguelen and Crozet stocks and their respective degree of independence from each other require further investigation

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 Midwater trawling operations are expected to have little impact on the benthos in the fishing grounds however large capacity nets could remove considerable amounts of fish altering the distribution of community species. 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.

Component	Core Objective	Sub-component	Example Operational Objectives	Example Indicators	Rationale
		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.

Fishery Name: Heard and McDonald Island Fishery
Sub-fishery Name: Midwater trawl
Date completed: Updated June 2006

Direct impact of Fishing	Fishing Activity	Score (0/1)	Documentation of Rationale
Capture	Bait collection	0	Trawl fishery no baits used.
	Fishing	1	Capture of organisms due to gear deployment, retrieval and actual fishing. This includes organisms caught but not landed.
	Incidental behaviour	0	No ports, no landings, no recreational fishing recorded.
Direct impact without capture	Bait collection	0	Trawl fishery no baits used.
	Fishing	1	Damage to benthos and habitat, fish escaping net.
	Incidental behaviour	0	
	Gear loss	0	
	Anchoring/ mooring	0	Not recorded.
	Navigation/steaming	1	Collisions with marine organisms or birds without death.
Addition/ movement of biological material	Translocation of species (boat launching, re-ballasting)	1	No bait fishing but translocation of species via ballast water or as hull or organisms fouling sea water piping systems is a potential risk.
	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	0	No bait or berley used in fishery
	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	0	
	Navigation/ steaming	1	Navigation/steaming introduce 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	Trawl fishery no baits used.
	Fishing	1	Water column disturbed by nets
	Boat launching	0	Vessels operate from established ports.
	Anchoring/ mooring	0	No records of vessels anchoring in sub-Antarctic AFZ.
	Navigation/ steaming	1	Due to depth benthos unlikely to be affected. 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. Longline fisheries for toothfish. 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, re-ballasting)	
	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 have 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, 12 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 14 activity-component scenarios will be considered at Level 1. This results in 54 total scenarios (of 160 possible) to be developed and evaluated using the unit lists (species and 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** below).

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 Table above)

L1.1 - Target Species Component

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
Bait collection										
Fishing	1	3	3	Population size	Mackerel icefish	1.2	2	3	2	Midwater trawling occurs in a small area on the southern Heard Plateau (~30nm x 30nm). Fishing occurs less than 100 days per year. Population size most likely to be affected before other sub-components. Behaviour/movement unlikely to be immediately affected as long as fishing efforts remain concentrated at specific grounds. Mackerel Icefish principle target of pelagic trawls. =>intensity minor because occurring irregularly in localised area =>Consequence moderate because proportion of total catch due to midwater trawling has risen in past year although overall very variable due to variability in recruitment; TAC levels being annually reviewed and adjusted to maintain fishery =>Confidence high due data collection by observers and research conducted in the fishery to date.
Incidental behaviour	0									
Bait collection	0									
Fishing	1	3	3	Population size	Mackerel icefish	1.2	2	2	2	Population size of icefish most likely to be affected before other sub-components if fish escaping from net have reduced survival rates however mesh sizes prescribed to allow 75% escapement to ensure stock maintenance and food supply for foraging birds =>intensity minor because occurring irregularly in localised area =>Consequence minor overall catches very variable due to variability in recruitment; TAC levels being annually reviewed and adjusted to maintain fishery and 75 % escapement prescription =>Confidence high 100% observer coverage and research conducted in the fishery to date.

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
Incidental behaviour	0									
Gear loss	0									
Anchoring/ mooring	0									
Navigation/ steaming	1	3	3	Population size	Mackerel icefish	1.2	1	1	2	Navigation/steaming occur less than 100 days per year. Population size mot likely to be affected by collision of fish with vessel =>Intensity negligible depth of icefish preclude collision with vessel =>consequence negligible =>Confidence high logic would indicate minimal impact.
Translocation of species	1	3	3	Population size	Mackerel icefish	1.2	1	2	1	Translocation of species could occur via ballast, hull fouling. Population size most likely to be affected before major changes in geographic range or genetic structure =>intensity negligible because the likelihood of temperate water species surviving and establishing as a threat to Mackerel icefish in sub-Antarctic waters is considered negligible =>However consequence scored as minor due to the potential for the spread of fish-borne disease =>Confidence low due absence of data on susceptibility of Mackerel icefish to fish-borne diseases.
On board processing	0									
Discarding catch	0									
Stock enhancement	0									
Provisioning	0									
Organic waste disposal	1	3	3	Behaviour/moveme nt	Mackerel icefish	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 and unlikely to alter behaviour of fish =>intensity negligible =>consequence negligible =>confidence high, 100% observer coverage, compliance to regulations

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
Debris	1	3	3	Population Size	Mackerel icefish	1.2	1	1	2	The limited number of vessels in the fishery coupled with MARPOL regulations restricting the deliberate disposal of debris and the installation of signs/notices in the accommodation to remind/educate the crew as to their legal obligations for disposal of debris. =>All are seen to reduce the intensity for debris disposal, therefore scored as negligible. =>Provided deliberate disposal of debris does not occur, the consequences of accidental disposal are seen as negligible. =>Confidence is high 100% observer coverage and the regulations limit debris being deliberately thrown overboard.
Chemical pollution	1	3	3	Population size	Mackerel icefish	1.2	2	2	2	Chemical pollution may only occur accidentally and rarely. The limited number of vessels in the fishery coupled with MARPOL regulations restricting the deliberate disposal of chemical pollutants and the installation of signs/notices in the accommodation to remind/educate the crew as to their legal obligations for disposal of chemical pollutants. =>All are seen to reduce the intensity for chemical pollutants disposal, therefore scored as minor. =>Provided deliberate disposal of chemicals does not occur, the consequences of accidental disposal to target species are seen as minor. =>Confidence is high as the regulations limit chemicals being deliberately dumped at sea.
Exhaust	1	3	3	Population size	Mackerel icefish	1.2	1	1	2	Fishing therefore exhaust emissions occurs less than 100 days per year =>intensity and consequence are both scored as negligible. The limited number of vessels in the fishery coupled with the depth at which target species are found makes it highly unlikely that exhaust gas emissions will have an affect on the target species. Further weather conditions in the region are frequently extreme, rapidly dispersing exhaust emissions. =>Confidence is high due to depth of water column separating target species from emissions.
Gear loss	0	0	0							
Navigation/ steaming	1	3	3	Behaviour/moveme nt	Mackerel icefish	6.1	1	1	2	Navigation/steaming introduces noise from engines and sounders electronic equipment which may affect behaviour of fish =>Intensity negligible due to the limited number of vessels in the fishery =>Consequence is also seen as negligible, as only a small area is affected and target species mobility and depth locations seen as mitigating factors =>Confidence high, logic
Activity/ presence on water	1	3	3	Behaviour/moveme nt	Mackerel icefish	6.1	1	1	2	Behaviour of Mackerel icefish could be affected by presence of vessel by attraction or repulsion =>Intensity negligible due to the limited number of vessels in the fishery. =>Consequence is also seen as negligible as only a small area is affected temporarily and target species mobility and depth locations seen as mitigating factors. =>Confidence high, logic

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
Bait collection	0									
Fishing	1	3	3	Behaviour/moveme nt	Mackerel icefish	6.1	1	1	2	Mackerel icefish as a mid-water/pelagic species most likely to be affected by disturbance of water column. =>Intensity negligible as disturbance to the water column is a frequent event in the Southern Ocean. =>Consequence is negligible. Only a small area is affected. Separating trawl disturbance from the effects of wind mixing in the Southern Ocean would not be possible =>Confidence recorded as high due to constraints imposed by logical consideration.
Boat launching	0									
Anchoring/ mooring	0									
Navigation/ steaming	1	3	3	Behaviour/moveme nt	Mackerel icefish	6.1	1	1	2	Mackerel icefish chosen as mid-water/pelagic species most likely to be affected by wake mixing =>Intensity negligible due to the limited number of vessels in the fishery and disturbance to the water column is a frequent event in the Southern Ocean.=>Consequence negligible, as only a small area is affected, and unable to detect against natural variation =>Confidence high, logic.
Other fisheries; Demersal	1	3	3	Population size	Mackerel icefish	1.2	3	3	2	Demersal trawling catches icefish in larger numbers than midwater trawling =>intensity moderate =>Consequence moderate as TACs limit catches to sustainable level of impact =>Confidence was recorded as high, 100% observer coverage, logbooks
Aquaculture	0									
Coastal development	0									
Other extractive activities	0									
Other non extractive activities	0									

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
Other anthropogenic activities	1	3	3	Behaviour/moveme nt	Mackerel icefish	6.1	2	1	2	Research and tourism and the passage of research/tourist vessels. Mackerel icefish chosen as mid-water/pelagic species more likely to be affected than a demersal species. =>Intensity minor due to the limited number of vessels/visits/groups per year. =>Consequence is seen as negligible, as only a small area is affected and target species mobility and depth locations seen as mitigating factors. =>Confidence was recorded as high due to data regarding numbers and activities indicate target species not at risk.

L1.2 - Byproduct and Bycatch 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	Population size	Porbeagle *Lamna nasus*	1.3	2	3	2	Midwater trawling occurs in a small area on the southern Heard Plateau (~30nm x 30nm). Fishing occurs less than 100 days per year. Population size most likely to be affected before other sub-components as productivity of porbeagle considered much lower than other bycatch species =>intensity minor because occurring irregularly in localised area. =>Consequence rated as moderate as bycatch levels being monitored and annually reviewed =>Confidence high due data collection by observers and research conducted in the fishery to date.
	Incidental behaviour	0	0	0							
Direct impact without capture	Bait collection	0	0	0							
	Fishing	1	3	3	Population size	Porbeagle *Lamna nasus*	1.3	2	2	2	Population size most likely to be affected before other sub-components by post-capture survival being affected ->intensity minor because fishing occurring irregularly in localised area and bycatch low. =>Consequence minor =>Confidence high due data collection by observers and bycatch levels being monitored and annually reviewed.
	Incidental behaviour	0	0	0							
	Gear loss	0	0	0							
	Anchoring/ mooring	0	0	0							
	Navigation/ steaming	1	3	3	Behaviour/movement	Porbeagle *Lamna nasus*	6.1	1	1	2	Population size could be affected by collision with vessel =>Intensity rated as negligible as thought unlikely to occur =>Consequence also scored as negligible =>Confidence high. Logical constraints would suggest impact is minimal.

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
Addition/ movement of biological material	Translocation of species	1	3	3	Population size	Porbeagle *Lamna nasus*	1.3	1	2	1	Translocation of species could occur via ballast, hull fouling. Population size most likely to be affected before major changes in geographic range or genetic structure =>Intensity negligible because the likelihood of temperate water species surviving and establishing as a threat to fish in sub-Antarctic waters is considered negligible =>However consequence scored as minor due to the potential for the spread of fish-borne disease =>Confidence low due absence of data on susceptibility of species to fish-borne diseases.
	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	Behaviour/movement	Porbeagle *Lamna nasus*	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 and unlikely to alter behaviour of fish =>intensity negligible =>consequence negligible =>confidence high, 100% observer coverage, compliance to regulations. The ban on disposal of bycatch waste/fish meal viewed as mitigating factor.
Addition of non-biological material	Debris	1	3	3	Population Size	Porbeagle *Lamna nasus*	1.3	1	1	2	Disposal of debris may occur accidentally rarely =>Intensity scored as negligible. The limited number of vessels in the fishery coupled with MARPOL regulations restricting the deliberate disposal of debris, the installation of signs/notices in the accommodation to remind/educate the crew as to their legal obligations for disposal of debris are all seen to reduce the intensity for debris disposal. =>Provided deliberate disposal of debris does not occur, the consequences of accidental disposal are seen as negligible. =>Confidence is high as the regulations limit debris being deliberately thrown overboard. Accidental

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
											loss of material overboard is seen as minor and not sufficient to affect the fishery.
	Chemical pollution	1	3	3	Population size	Porbeagle *Lamna nasus*	1.3	2	2	2	Chemical pollution may only occur accidentally and rarely. The limited number of vessels in the fishery coupled with MARPOL regulations restricting the deliberate disposal of chemical pollutants and the installation of signs/notices in the accommodation to remind/educate the crew as to their legal obligations for disposal of chemical pollutants. =>All are seen to reduce the intensity for chemical pollutants disposal, therefore scored as minor. =>Provided deliberate disposal of chemicals does not occur, the consequences of accidental disposal to target species are seen as minor. =>Confidence is high as the regulations limit chemicals being deliberately dumped at sea.
	Exhaust	1	3	3	Population size	Porbeagle *Lamna nasus*	1.3	1	1	2	Fishing therefore exhaust emissions occurs less than 100 days per year =>intensity and consequence are both scored as negligible. The limited number of vessels in the fishery coupled with the depth at which target species are found makes it highly unlikely that exhaust gas emissions will have an affect on the target species. Further weather conditions in the region are frequently extreme, rapidly dispersing exhaust emissions. =>Confidence is high due to depth of water column separating target species from emissions.
	Gear loss	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	Behaviour/movement	Porbeagle *Lamna nasus*	6.1	1	1	2	Navigation/steaming introduces noise from engines and sounders electronic equipment which may affect behaviour of fish =>Intensity negligible due to the limited number of vessels in the fishery =>Consequence is also seen as negligible, as only a small area is affected and target species mobility and depth locations seen as mitigating factors =>Confidence high, logic
	Activity/ presence on water	1	3	3	Behaviour/movement	Porbeagle *Lamna nasus*	6.1	1	1	2	Behaviour of porbeagle could be affected by presence of vessel by attraction or repulsion =>Intensity negligible due to the limited number of vessels in the fishery. =>Consequence is also seen as negligible as only a small area is affected temporarily and target species mobility and depth locations seen as mitigating factors. =>Confidence high, logic
Disturb physical processes	Bait collection	0	0	0							
	Fishing	1	3	3	Behaviour/movement	Porbeagle *Lamna nasus*	6.1	1	1	2	Porbeagle may be affected by mixing effects of water through nets =>Intensity negligible as disturbance to the water column is a frequent event in the Southern Ocean. =>Consequence is negligible. Only a small area is affected. Separating trawl disturbance from the effects of wind mixing in the Southern Ocean would not be possible. =>Confidence recorded as high due to constraints imposed by logical consideration.
	Boat launching	0	0	0							
	Anchoring/ mooring	0	0	0							
	Navigation/ steaming	1	3	3	Behaviour/movement	Porbeagle *Lamna nasus*	6.1	1	1	2	=>Intensity negligible as disturbance to the water column is a frequent event in the Southern Ocean. =>Consequence is negligible. Only a small area is affected. Separating wake mixing from the effects of wind mixing in the Southern Ocean would not be possible. =>Confidence recorded as high due to constraints imposed by logical consideration.

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
External Impacts (specify the particular example within each activity area)	Other fisheries	1	3	3	Population size	Porbeagle *Lamna nasus*	1.3	3	3	2	Some demersal trawling in similar areas to midwater trawling and also adjacent might also capture porbeagles. =>Intensity rated as moderate =>Consequence is moderate as TACs are applied =>Confidence was recorded as high, 100% observer coverage and logbook
	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	Behaviour/movement	Porbeagle *Lamna nasus*	6.1	2	1	2	Research and tourism and the passage of research/tourist vessels. =>Intensity minor due to the limited number of vessels/visits/groups per year. =>Consequence is seen as negligible as only a small area is affected and porbeagle mobility and midwater habit seen as mitigating factors. =>Confidence was recorded as high due to data regarding numbers and activities.

L1.3 - TEP Species 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	Population size	Black-browed Albatross *Thalassarche melanophrys*	1.1	2	3	2	Midwater trawling occurs in a small area on the southern Heard Plateau (~30nm x 30nm). Fishing occurs less than 100 days per year. Population size of Black browed albatross most likely to be affected before other sub-components because only 600 pairs breed on Heard Is. Of 12 seabirds killed in midwater trawling operations in 2005 season, 7 were Black-browed Albatross therefore about 1% mortality due to interaction. 5 white - chinned Petrels which are abundant were also killed =>intensity minor because midwater trawling occurring irregularly in localised area=>Consequence moderate as population size is small .However voluntary mitigation measures such as setting at night & cleaning decks and nets of fish together with mitigation measures already complied with, have prevented further incidents =>Confidence high due data collection by observers and research conducted in the fishery to date.
	Incidental behaviour	0	0	0							
Direct impact without capture	Bait collection	0	0	0							
	Fishing	1	3	3	Population size	Black-browed Albatross *Thalassarche melanophrys*	1.1	2	2	2	Mitigating factors including reduced lighting bans on net-sonde cables, removal of protruding wires and now night setting of trawls is applied. Population size most likely to be affected before other sub-components as albatross numbers are low. =>intensity minor because trawling occurring irregularly in localised area. =>Consequence minor as the mortality of birds appear to be unaltered. Voluntary mitigation measures by vessel operator such as setting at night has prevented further incidents=>Confidence high due data collection by observers and research conducted in the fishery to date.

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
	Incidental behaviour	0	0	0							
	Gear loss	0	0	0							
	Anchoring/ mooring	0	0	0							
	Navigation/steaming	1	3	3	Population size	Black-browed Albatross *Thalassarche melanophrys*	1.1	2	2	2	Mitigating factors including reduced lighting bans on net-sonde cables, removal of protruding wires and now night setting of trawls are applied. Population size most likely to be affected before other sub-components as albatross numbers are low. Seabirds have flown into vessels or fishing gear by accident 3 prions collided with vessel observed in 2004 however no albatross reported killed by collision. =>Intensity scored as minor =>consequence score as minor =>Confidence high due data collection by observers and research conducted in the fishery to date.
Addition/ movement of biological material	Translocation of species	1	3	3	Population size	Black-browed Albatross *Thalassarche melanophrys*	1.1	1	2	1	Translocation of species could occur via ballast, hull fouling. Population size most likely to be affected before major changes in geographic range or genetic structure =>intensity negligible because the likelihood of temperate water species surviving and establishing as a threat to fish in sub-Antarctic waters is considered negligible =>However consequence scored as minor due to the potential for the spread of disease =>Confidence low due absence of data on susceptibility of species to fish-borne diseases. The potential for the spread of disease deserves future consideration. The ban on discharge of poultry products is a mitigating factor.
	On board processing	0	0	0							
	Discarding catch	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
	Stock enhancement	0	0	0							
	Provisioning	0	0	0							
	Organic waste disposal	1	3	3	Behaviour/movement	Black-browed Albatross *Thalassarche melanophrys*	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 and unlikely to alter behaviour of birds =>intensity negligible =>consequence negligible =>confidence high, 100% observer coverage, compliance to regulations. The ban on disposal of bycatch waste/fish meal viewed as mitigating factor.
Addition of non-biological material	Debris	1	3	3	Population Size	Black-browed Albatross *Thalassarche melanophrys*	1.1	1	1	2	The limited number of vessels in the fishery coupled with MARPOL regulations restricting the deliberate disposal of debris, the installation of signs/notices in the accommodation to remind/educate the crew as to their legal obligations for disposal of debris are all seen to reduce the intensity for debris disposal.=>intensity negligible =>Provided deliberate disposal of debris does not occur, the consequences of accidental disposal are seen as negligible =>Confidence is high as the regulations limit debris being deliberately thrown overboard. Accidental loss of material overboard is seen as minor and not sufficient to affect these TEP species.
	Chemical pollution	1	3	3	Population Size	Black-browed Albatross *Thalassarche melanophrys*	1.1	2	2	2	Chemical pollution only occurs accidentally and rarely. =>Intensity rated as minor due to the limited number of vessels in the fishery coupled with MARPOL regulations and the installation of signs/notices in the accommodation to remind/educate the crew as to their legal obligations for disposal of chemicals were all viewed as mitigating factors. =>The consequences minor. =>Confidence is high as the regulations limit chemicals being deliberately dumped at sea.

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
	Exhaust	1	3	3	Population Size	Black-browed Albatross *Thalassarche melanophrys*	1.1	1	1	2	Exhaust emissions occur daily during the season. =>Intensity and consequences rated as negligible. The limited number of vessels in the fishery coupled with the local weather conditions makes it highly unlikely that exhaust gas emissions will have an affect on TEP species. Weather conditions in the region are frequently extreme, rapidly dispersing exhaust emissions. =>Confidence high , logic
	Gear loss	0	0	0							
	Navigation/ steaming	1	3	3	Behaviour/movement	Black-browed Albatross *Thalassarche melanophrys*	1.1	2	1	1	Distribution of birds might be disturbed by noise or radio signals =>Intensity minor due to the limited number of vessels in the fishery. =>Consequence negligible effects temporary and local. =>Confidence was recorded as low
	Activity/ presence on water	1	3	3	Behaviour/movement	Black-browed Albatross *Thalassarche melanophrys*	6.1	1	1	2	Vessel present and active daily during season and may affect behaviour/movement of birds by attracting or repelling. =>Intensity negligible due to the limited number of vessels in the fishery =>Consequence negligible as any alteration to behaviour is temporary =>Confidence was recorded as high due to data from the HIMI fishery on seabird interactions.
Disturb physical processes	Bait collection	0	0	0							
	Fishing	1	3	3	Behaviour/movement	Antarctic fur seal *Arctocephalus gazella*	6.1	1	1	2	Antarctic fur seals may be affected by mixing effects of water through nets =>intensity negligible as disturbance to the water column is a frequent event in the Southern Ocean. =>Consequence is negligible. Only a small area is affected. Separating trawl disturbance from the effects of wind mixing in the Southern Ocean would not be possible. =>Confidence recorded as high due to constraints imposed by logical consideration.
	Boat launching	0	0	0							
	Anchoring/ mooring	0	0	0							

Direct impact of fishing	Fishing activity	Presence (1) Absence (0)	Spatial scale of Hazard (1-6)	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	Black-browed Albatross *Thalassarche melanophrys*	6.1	1	1	2	Birds resting on surface might be affected by disturbance by wake mixing of vessel =>Intensity negligible as disturbance to the water column is a frequent event in the Southern Ocean. =>Consequence is negligible. Only a small area is affected. Separating wake mixing from the effects of wind mixing in the Southern Ocean would not be possible. =>Confidence recorded as high due to constraints imposed by logical consideration.
External Impacts (specify the particular example within each activity area)	Other fisheries	1	3	3	Population size	Black-browed Albatross *Thalassarche melanophrys*	1.1	2	2	2	Some demersal trawling in similar areas to midwater trawling and also adjacent areas might also impact seabirds. =>Intensity rated as minor as few birds captured across whole fishery =>Consequence is minor as unlikely to be detectable =>Confidence was recorded as high, 100% observer coverage and logbook
	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	Black-browed Albatross *Thalassarche melanophrys*	1.1	2	1	2	Research and tourism and the passage of research/tourist vessels occurs several times at most in a year. Population size most likely to be affected before other sub-components as some albatross numbers are critically low. =>Intensity minor due to the limited number of vessels/visits/groups per year. =>Consequence negligible as only a small area is affected and vessels not conducting activities likely to attract trap or injure birds. =>Confidence was recorded as high as activities of these vessels/groups are generally carefully planned and monitored.

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	Heard Plateau 0-1000m pelagic	1.1	3	3	1	Midwater trawling occurs in a small area on the southern Heard Plateau (~30nm x 30nm) Fishing occurs less than 100 days per year. Mid-water trawl gear has potential to alter community species composition on fishing grounds. =>Intensity rated as moderate as while there are limited numbers of vessels in fishery =>Consequence rated as moderate, as only a small area is affected and catch rates for midwater fishery are relatively low and variable. TAC levels for target and non-target species being annually reviewed and adjusted to maintain fishery. Escapement for icefish set for 75% to allow maintenance of food supply for predators. Whether mid-water trawling may in time alter pelagic community structure significantly has not been determined but possible if functional groups are removed. =>Confidence was recorded as low due to lack of data.
	Incidental behaviour	0	0	0							
Direct impact without capture	Bait collection	0	0	0							
	Fishing	1	3	3	Species composition	Heard Plateau 0-1000m pelagic	1.1	3	2	1	Mid-water trawl gear has potential to alter community species composition on fishing grounds by reducing survival of escaped fish =>Intensity rated as moderate as while there are limited numbers of vessels in fishery and variable effort, specific grounds are targetted =>Consequence rated as minor, as only a small area is affected and catch rates for midwater fishery are relatively low and variable. TAC levels for target and non-target species being annually reviewed and adjusted to maintain fishery. Escapement for icefish set for 75% to allow maintenance of food supply for predators. Whether mid-water trawling may in time alter pelagic community

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
											structure significantly has not been determined. =>Confidence was recorded as low due to lack of data.
	Incidental behaviour	0	0	0							
	Gear loss	0									
	Anchoring/ mooring	0	0	0							
	Navigation/ steaming	1	3	3	Functional group composition	Heard Plateau 0-1000m pelagic	2.1	1	1	2	Navigation/ steaming has potential to alter species composition by direct impact (collision) with rare/endangered species. =>Intensity rated as negligible due to limited numbers of vessels in fishery, and management controls designed to reduce/monitor interactions with these species. =>Consequence negligible. =>Confidence was recorded as high as the data on population sizes and incidents is well documented.
Addition/ movement of biological material	Translocation of species	1	3	3	Species composition	Heard Plateau 0-1000m pelagic	1.1	1	2	2	Translocation of species has potential to alter species composition by the introduction of new species to the region. =>Intensity rated as negligible due to perceived difficulties of translocating new species, particularly temperate species successfully. Circumpolar currents facilitate wide distribution of Antarctic and sub-Antarctic species through region. =>Consequence rated as minor, due to wide distribution of Antarctic and sub-Antarctic species through region. =>Confidence was recorded as high as successful translocations involve species already adapted to particular environments and climatic regimes.

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
	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 and unlikely to alter distribution of community members =>intensity negligible =>consequence negligible =>confidence high, 100% observer coverage, compliance to regulations. The ban on disposal of bycatch waste/fish meal viewed as mitigating factor.
Addition of non-biological material	Debris	1	3	3	Distribution of community	Heard Plateau 0-1000m pelagic	3.1	1	1	2	Accidental loss of debris might occur rarely. The limited number of vessels in the fishery coupled with MARPOL regulations restricting the deliberate disposal of debris and the installation of signs/notices in the accommodation to remind/educate the crew as to their legal obligations for disposal of debris. =>All are seen to reduce the intensity for debris disposal, therefore scored as negligible. =>Consequence rated as negligible provided deliberate disposal of debris does not occur =>Confidence high, 100% observer coverage and compliance with disposal regulations.
	Chemical pollution	1	3	3	Functional group composition	Heard Plateau 0-1000m pelagic	2.1	2	2	2	Chemical pollution only occurs accidentally and rarely. =>Intensity rated as minor due to the limited number of vessels in the fishery coupled with MARPOL regulations and the installation of signs/notices in the accommodation to remind/educate the crew as to their legal obligations for disposal of chemicals were all viewed as mitigating factors. =>The consequences minor. =>Confidence is high as the regulations limit chemicals being deliberately dumped at sea.

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
	Exhaust	1	3	3	Distribution of community	Heard Plateau 0-1000m pelagic	1.1	1	1	2	Exhaust emissions occur daily during the season. =>Intensity and consequences both rated as negligible. The limited number of vessels in the fishery coupled with the local weather conditions makes it highly unlikely that exhaust gas emissions will have an affect distribution of community. Weather conditions in the region are frequently extreme, rapidly dispersing exhaust emissions. =>Confidence high , logic
	Gear loss	0									
	Navigation/ steaming	1	3	3	Distribution of community	Heard Plateau 0-1000m pelagic	3.1	2	1	1	Distribution of community might be disturbed by noise or radio signals =>Intensity minor due to the limited number of vessels in the fishery. =>Consequence negligible effects temporary and local. =>Confidence was recorded as low, no data on effect of oceanic community.
	Activity/ presence on water	1	3	3	Distribution of community	Heard Plateau 0-1000m pelagic	3.1	1	1	2	Vessel present and active daily during season and may affect distribution of community members. =>Intensity negligible due to the limited number of vessels in the fishery =>Consequence negligible as any alteration to distribution is temporary =>Confidence was recorded as high, logic and observer records
Disturb physical processes	Bait collection	0	0	0							
	Fishing	1	3	3	Distribution of community	Heard Plateau 0-1000m pelagic	3.1	1	1	1	=>Intensity negligible as disturbance to the water column is a frequent event in the Southern Ocean. =>Consequence is negligible. Only a small area is affected. Separating trawl disturbance from the effects of wind mixing in the Southern Ocean would not be possible =>Confidence was recorded as low due insufficient data. Research into the benthic impacts of the fishery is recognised as a current priority.
	Boat launching	0	0	0							
	Anchoring/ mooring	0	0	0							

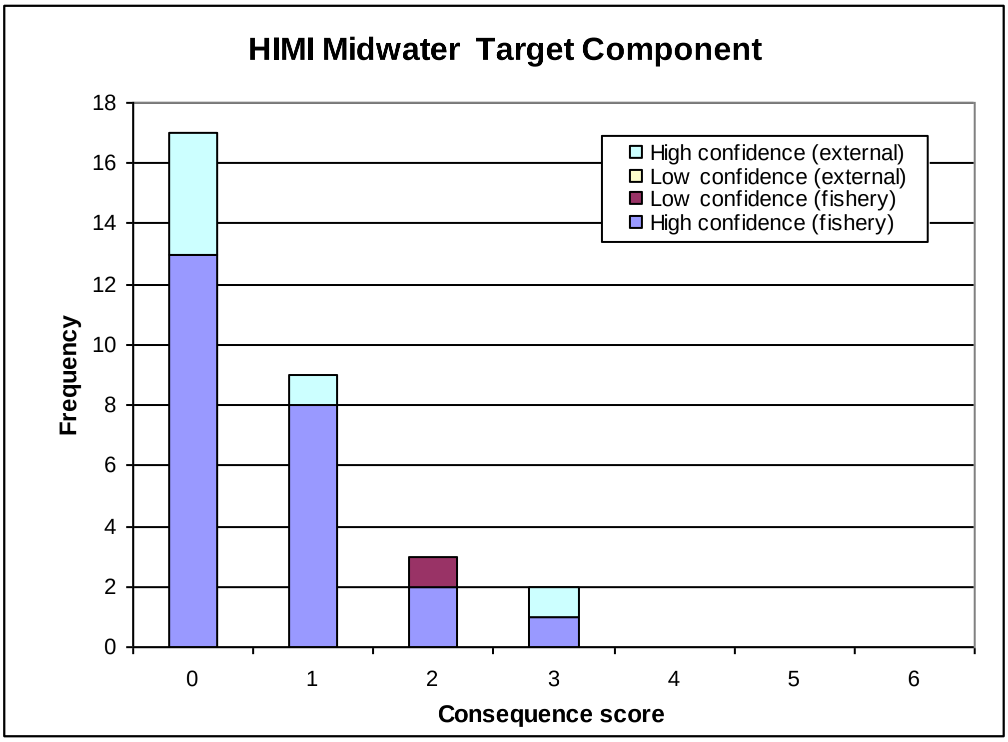
Direct impact of fishing	Fishing Activity	Presence (1) Absence (0)	Spatial scale of Hazard (1-6)	Temporal scale of Hazard (1-6)	Sub-component	Unit of analysis	Operational objective (S2.1)	Intensity Score (1-6)	Consequence Score (1-6)	Confidence Score (1-2)	Rationale
	Navigation/steaming	1	3	3	Distribution of community	Heard Plateau 0-1000m pelagic	3.1	1	1	2	Navigation/steaming has the potential to alter community distributions by wake mixing of the pelagic community. =>Intensity rated as negligible due to small number of vessels involved and known wind mixing depths exceeding wake mixing. =>Consequence also rated as negligible, due to the small number of vessels involved. =>Confidence was recorded as high due consideration of logical constraints
External Impacts (specify the particular example within each activity area)	Other fisheries: e.g. HIMI Demersal Trawl, autolongline	1	3	3	Species composition	Heard Plateau 0-1000m pelagic	1.1	3	2	2	Longlining occurs in adjacent areas but unlikely to impact pelagic communities. However demersal fishing in the area also targets icefish and some other non-target species. and therefore likely to have greatest impact on pelagic plateau communities. =>Intensity moderate =>Consequence is minor as TACs are applied non-target and target across all fishing methods. =>Confidence was recorded as high due high observer coverage.
	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	2	2	2	Research and tourism and the passage of research/tourist vessels occurs several times at most in a year. Species composition might be affected by research fishing. =>Intensity minor due to the limited number of vessels/visits/groups per year. =>Consequence minor as catches small and infrequent =>Confidence was recorded as high as activities of these vessels/groups are generally carefully planned and monitored.

2.3.11 Summary of SICA results

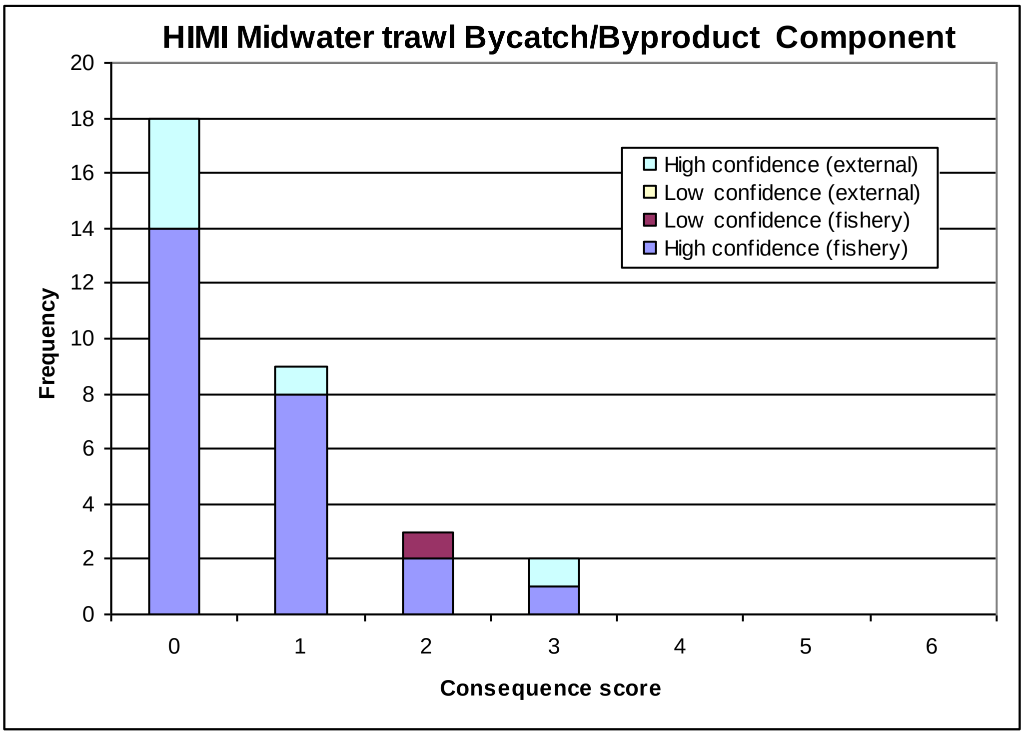
The report provides a summary table (**Level 1 (SICA) Document L1.6**) of consequence scores for all activity/component combinations and a table showing those that scored 3 or above for consequence, and differentiating those that did so with high confidence (in bold).

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

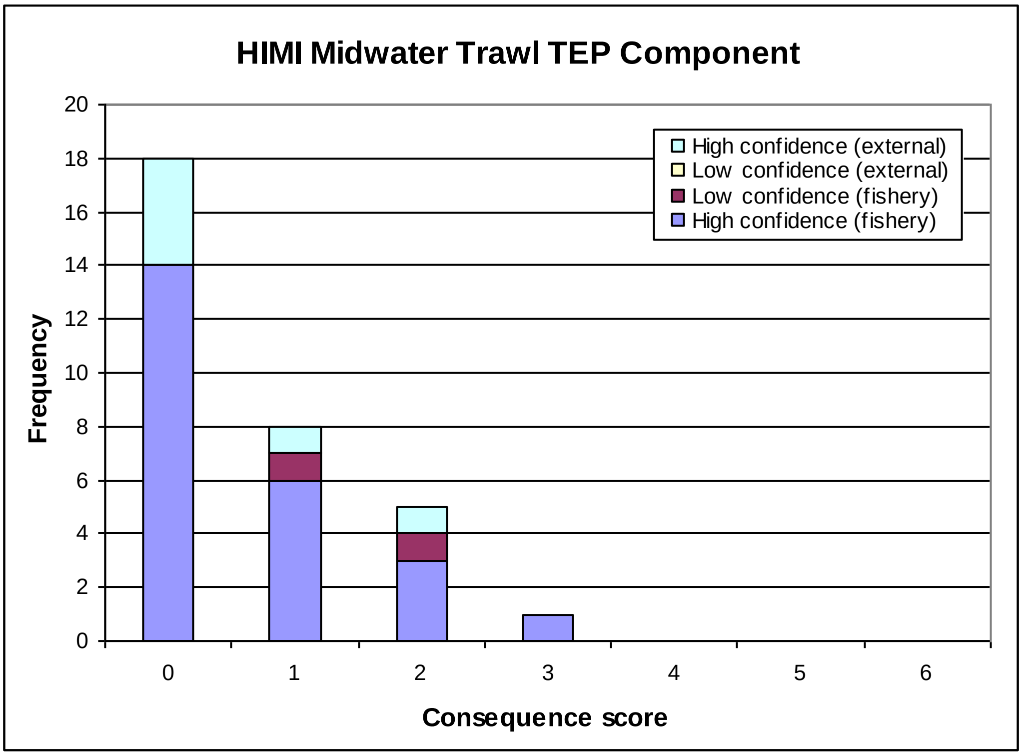
Direct impact	Activity	Target species	Byproduct and bycatch species	TEP species	Communities
Capture	Bait collection	0	0	0	0
	Fishing	3	3	3	3
	Incidental behaviour	0	0	0	0
Direct impact without capture	Bait collection	0	0	0	0
	Fishing	2	2	2	2
	Incidental behaviour	0	0	0	0
	Gear loss	0	0	0	0
	Anchoring/ mooring	0	0	0	0
	Navigation/ steaming	1	1	2	1
Addition/ movement of biological material	Translocation of species	2	2	2	2
	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	1	1
Addition of non-biological material	Debris	1	1	1	1
	Chemical pollution	2	2	2	2
	Exhaust	1	1	1	1
	Gear loss	0	0	0	0
	Navigation/ steaming	1	1	1	1
	Activity/ presence on water	1	1	1	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	3	3	2	2
	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	2



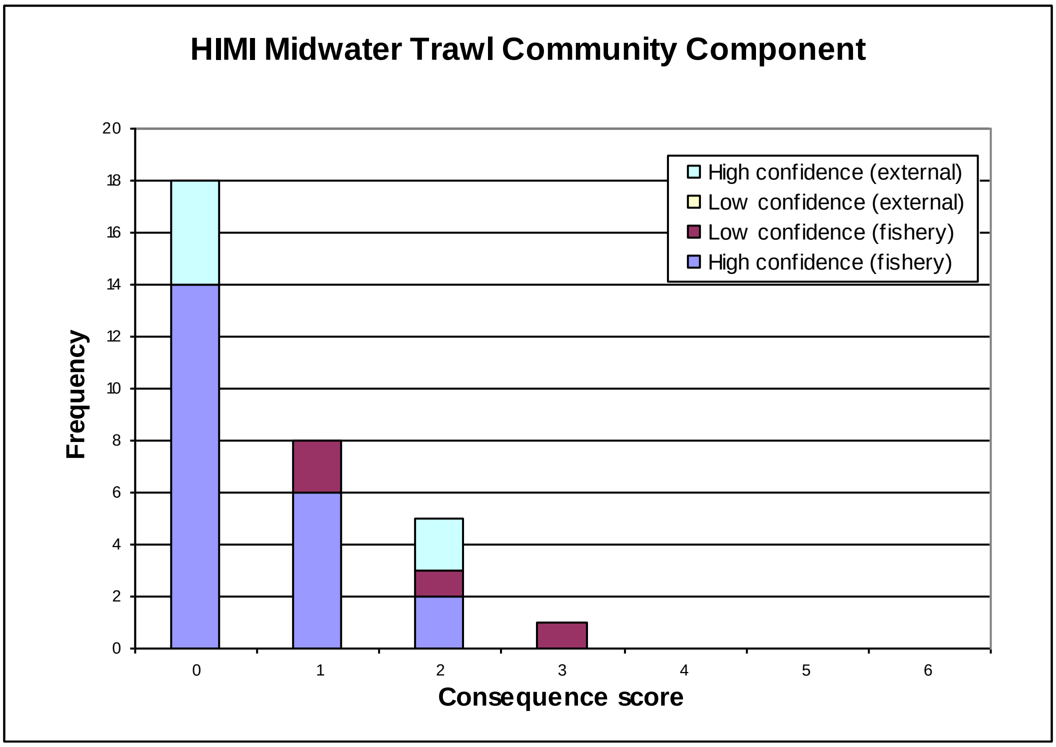
Target species: Frequency of consequence score differentiated between high and low confidence.



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 (SICA excel workbook)



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

2.3.12 Evaluation/discussion of Level 1

Habitats were not evaluated

None of the four ecological components examined were eliminated at Level 1 (consequence (risk) score ≥3 for at least one activity).

Risk scores were between 1-3 across all 32 hazards (fishing activities) and four ecological components assessed. A number of hazards (fishing activities) were eliminated at Level 1 (risk scores 1 or 2). The hazards retained (risk scores of ≥3) were:

- Fishing (direct impact with and without capture on target, bycatch/byproduct, TEP species and community components)

No risks were rated as major (=4), severe (=5) or intolerable (=6).

Risks from fishing (with capture) were assessed to be moderate for all components. All risks from fishing were assessed to be moderate largely because the fishery operates with strict quotas on target and non-target species and the intensity of the activity is relatively small particularly when compared to midwater trawl fisheries in temperate waters or to the demersal trawl fishery for icefish in the area. All confidence scores of these moderate consequences were high, except for communities. High level observer coverage provides good quality data collection and knowledge of most organisms removed from the ecosystem. Interactions with TEP species are minimised by employment of many mitigating measures including minimisation of lighting, using certain types of gear, time of setting of gear and avoiding attracting birds to dead fish in nets, discarded of offal or fish. Until recently bird fatalities were rare however twelve albatrosses and petrels were killed with midwater gear. Albatrosses are in low numbers in the region, therefore were chosen as the “worst case”.

The moderate risk scores (=3) were also obtained for the external hazard “other fisheries” for target and byproduct/bycatch components. Demersal trawling might impact Mackerel icefish (target species component) and Porbeagle (bycatch/byproduct species component). All confidence scores were high, since there is 100% observer coverage in the HIMI fishery

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
- TEP
- Communities

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 from direct impacts of fishing only, 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).

<u>Species</u>

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 location at which fishing activity occurs	Fishing takes place where habitat occurs

Aspect	Attribute	Concept	Rationale
	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.

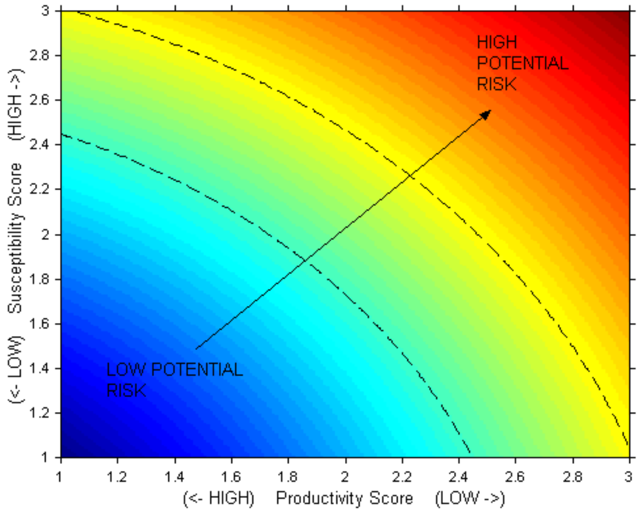


Figure 13. The axes on which risk to the ecological units is plotted. The x-axis includes attributes that influence the productivity of a unit, or its ability to recover after impact from fishing. The y-axis includes attributes that influence the susceptibility of the unit to impacts from fishing. The 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
3401	Chondrichthyan	Bathyraja sp.	37031752	Rajidae	a skate	BP	Undifferentiated taxa
1663	Chondrichthyan	Bathyraja sp. (false maccaini)		Rajidae	skate	TEP	Unresolved taxa issues
1451	Chondrichthyan	Bathyraja spp.		Rajidae	skate	BP	Undifferentiated taxa
1453	Chondrichthyan	Rajiformes		Rajidae	skate	BP	Undifferentiated taxa
1360	Chondrichthyan	Etmopterus sp.	37020097	Squalidae	Lantern shark	TEP	Undifferentiated taxa
1454	Chondrichthyan	Rajiformes Egg		Rajidae	skate	BP	Undifferentiated taxa
2963	Invertebrate	Ascidiacea		Ascidiidae			<100 kg caught in 5 years
3399	Invertebrate	Pycnogonidae - undifferentiated	33017000		Tardigrada, Pentastomida, Pycnogonida plus minor Arthropod groups - minor invertebrate phyla plus scorpions, spiders, sea spiders, horseshoe crabs	BP	Undifferentiated taxa
2281	Invertebrate	Squid Indet	923600000		squid	BP	Undifferentiated taxa
3398	Invertebrate	Axiidae - undifferentiated	28801000		Polychaete worm ; Slow prawns		Undifferentiated taxa
2779	Invertebrate	Cephalopoda	22600000			BP	Undifferentiated taxa
2709	Invertebrate	Coral	11228000	Subclass Zoantharia (Hexacorallia)	hexacoral	DI	Undifferentiated taxa
2775	Invertebrate	Crustaceans	20000000			BP	Undifferentiated taxa
2788	Invertebrate	Echinoidea	26300000	Echinoidea		DI	Undifferentiated taxa
2967	Invertebrate	Gorgonians			coral	BP	Undifferentiated taxa
2951	Invertebrate	Gorgonocephalidae			urchin	DI	Undifferentiated taxa

Era Species Id	Taxa Name	Scientific Name	CAAB Code	Family Name	Common Name	Role	Reason For Removal
2938	Invertebrate	Holothurian				DI	Undifferentiated taxa
2280	Invertebrate	Invertebrata	910360000				Undifferentiated taxa
2780	Invertebrate	Loliginidae, Ommastrephidae				BP	Undifferentiated taxa
1445	Invertebrate	Medusae		Cnidaria	jellyfish	DI	Undifferentiated taxa
2783	Invertebrate	Octopodidae	22630000	Octopodidae		BP	Undifferentiated taxa
40	Invertebrate	Onykia ingens	23623005	Onychoteuthidae	squid	BP	Data translation error; should be included
2011	Invertebrate	Ophiuroidea - undifferentiated	25160000		brittlestars	BP	Undifferentiated taxa
1328	Invertebrate	Pasiphaea sp.	28745901	Pasiphaeidae	carid shrimp	BP	Undifferentiated taxa
2942	Invertebrate	Penaeoidea & Caridea - undifferentiated				BP	Undifferentiated taxa
298	Invertebrate	Periphylla periphylla		Periphyllidae	jellyfish	DI	Data translation error; should be included
1988	Invertebrate	Phylum Brachiopoda - undifferentiated	19100000		brachiopods		Undifferentiated taxa
1698	Marine mammal	Phocidae	41136000	Phocidae	seal	TEP	Undifferentiated taxa
1697	Marine mammal	Otariidae	41131000	Otariidae	seal	TEP	Undifferentiated taxa
1474	Marine bird	Phalacrocorax nivalis		Phalacrocoracidae	Heard Island cormorant	TEP	Data translation error; should be included
1475	Marine bird	Tringa nebularia		Scolopacidae	Greenshank	TEP	Land bird (wader)
1670	Marine bird	Leucocarbo atriceps nivalis			Imperial shag (Heard Island)	TEP	Data translation error; should be included

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 Midwater Trawl Fishery*

ERA species ID	Scientific Name	Common Name	Total logbook catch (kg) 2000-05	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	80,270	N	0	0	1.86	2.33	2.98	N	Med	Spatial uncertainty	
1390	Champsocephalus gunnari	Mackerel icefish	963,477	N	0	0	1.43	2.33	2.74	N	Med	Spatial uncertainty	

Byproduct species *HIMI Midwater Trawl Fishery*

ERA species ID	Scientific Name	Common Name	Total logbook catch (kg) 2000-05	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]	461	N	0	0	2.43	1.67	2.95	N	Med	Low attribute score	
1481	Bathyraja maccaini	[a skate]	0	N	0	1	2.43	1.67	2.95	N	Med	Low attribute score	
302	Bathyraja irrasa	skate	20	N	0	0	2.43	1.67	2.95	N	Med	Low attribute score	
304	Bathyraja murrayi	skate	17	N	0	0	2.29	1.67	2.83	N	Med	Low attribute score	
826	Etmopterus granulosus	southern lantern shark	0	N	0	0	2.43	1.44	2.83	Y	Med	Low attribute score	Expert override: mainly continental Aust (Daley, Stevens & Graham 1997) Additional distributional information: moves up in the water column(op cit)
1482	Raja georgiana	[a skate]	0	N	0	0	2.14	1.67	2.71	N	Med	Low attribute score	
Invertebrate													
2787	Asteroidea	0	68	Y	7	3	3.00	1.67	3.43	N	High	Missing data	Supporting information: Except for a few species which inhabit brackish waters, asteroids are benthic organisms found in marine environments. (Brusca and Brusca,

ERA species ID	Scientific Name	Common Name	Total logbook catch (kg) 2000-05	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
													2003; Canada's Aquatic Environments, 2002; Waggoner, 1994 cited in Mulcrone, R. 2005. "Asteroidea" (On-line), Animal Diversity Web. Accessed April 25, 2007 at http://animaldiversity.ummz.umich.edu/site/accounts/information/Asteroidea.html) therefore usually out of range of midwater fishing nets. Taxon usually assessed in “Habitat” component.
Teleost													
2805	Bathylagus sp.	0	0	Y	7	3	3.00	3.00	4.24	N	High	Missing data	
1493	Mancopsetta maculata	[a southern flounder]	0	N	3	0	2.29	1.67	2.83	N	Med	Low attribute score	
644	Lampris immaculatus	Southern moonfish	23	N	3	0	2.43	1.44	2.83	Y	Med	Low attribute score	Expert override: override applied to encounterability. Species is epipelagic-rarely encountered (23 kg caught)and diet shows tendency to consume floating debris (Jackson et al 2000) therefore unlikely to interact with midwater gear. Supporting information: regarded as bathydemersal (Froese, R. and D. Pauly. (Eds) 2007.FishBase. World Wide Web electronic publication. www.fishbase.org, version (02/2007).) therefore out of range of fishing net
2845	Macrourus holotrachys	0	302	N	2	1	2.43	1.44	2.83	N	Med	Low attribute score	
1466	Macrourus sp.	whiptail	0	N	1	0	2.14	1.67	2.71	N	Med	Low attribute score	

ERA species ID	Scientific Name	Common Name	Total logbook catch (kg) 2000-05	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
2867	Notothenia (Notothenia) rossii rossii	Marbled rockcod	0	N	0	0	1.57	1.89	2.46	N	Low		
2868	Nototheniops mizops	icefish	0	N	0	0	1.57	1.89	2.46	N	Low		
2863	Notothenia (Gobionotothen) acuta	Triangular notothen	11	N	0	0	1.43	1.89	2.37	N	Low		
536	Cynomacrurus piriei	rattail/whiptail/grenadier	8	N	0	0	1.86	1.44	2.35	N	Low		
537	Poromitra crassiceps	bigscale	0	N	3	0	2.00	1.07	2.27	N	Low		
1461	Muraenolepis sp.	Moray cod (undifferentiated)	0	N	2	0	1.71	1.44	2.24	N	Low		
770	Channichthys rhinoceratus	Unicorn icefish	2,043	N	0	1	1.43	1.67	2.20	N	Low		
768	Lepidonotothen squamifrons	Grey rockcod ; an icefish	0	N	0	0	1.43	1.44	2.03	N	Low		
1459	Myctophidae indet	lanternfish	0	N	0	1	1.29	1.22	1.77	N	Low		

Bycatch species *HIMI Midwater Trawl Fishery*

ERA species ID	Scientific Name	Common Name	Total logbook catch (kg) 2000-05	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													
972	Lamna nasus	Porbeagle shark	3,065	N	0	0	2.71	1.67	3.19	N	High	Low attribute score	
257	Somniosus antarcticus	Sleeper shark; Southern Sleeper Shark	0	N	0	0	2.57	1.67	3.06	Y	Med	Low attribute score	Expert override: override applied to availability - increased from 1 to 3 because restricted to Southern Ocean (Scott 1976;Yano, Stevens and Compagno 2004).
Invertebrate													
1981	Porifera - undifferentiated	sponges	135	Y	7	3	3.00	1.67	3.43	Y	High	Missing data	Expert override: override applied because of missing attribute - adult sponges usually sessile (Marshall & Williams 1972) therefore usually out of range of midwater fishing nets. Taxon usually assessed in “Habitat” component.

<u>TEP species *HIMI Midwater Trawl Fishery*</u>

ERA species ID	Scientific Name	Common Name	Total logbook catch (kg) 2000-05	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
Marine Birds													
1085	Thalassarche melanophrys	Black-browed Albatross	0	N	1	0	2.43	3.00	3.86	N	High	Spatial uncertainty	<u>Supporting information</u>: have been killed (see Scoping Document S1 General Fishery Characteristics, SARAG 26, May 2006)
1690	Pachyptila spp.	Prions	0	Y	7	1	3.00	1.67	3.43	Y	High	Missing data	<u>Observer override</u>: applied to encounterability because never been reported captured or killed as a result of fishing operations based on observer reports (SARAG 26, May 2006; Robertson et al. 2005).
1695	Fregata spp.	frigate birds	0	Y	7	1	3.00	1.67	3.43	Y	High	Missing data	<u>Observer override</u>: a/a
1696	Catharacta spp.	Skuas	0	Y	7	1	3.00	1.67	3.43	Y	High	Missing data	<u>Observer override</u>: a/a
753	Diomedea epomophora	Southern Royal Albatross	0	N	1	0	2.57	1.67	3.06	Y	Med	Low attribute score	<u>Observer override</u>: a/a
451	Diomedea exulans	Wandering Albatross	0	N	1	0	2.57	1.67	3.06	Y	Med	Low attribute score	<u>Observer override</u>: a/a
799	Diomedea sanfordi	Northern Royal Albatross	0	N	1	0	2.57	1.67	3.06	Y	Med	Low attribute score	<u>Observer override</u>: a/a
1031	Thalassarche carteri	Indian Yellow-nosed Albatross	0	N	1	0	2.57	1.67	3.06	Y	Med	Low attribute score	<u>Observer override</u>: a/a

ERA species ID	Scientific Name	Common Name	Total logbook catch (kg) 2000-05	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
1428	Diomedea amsterdamensis	Amsterdam Albatross	0	N	1	0	2.57	1.67	3.06	Y	Med	Low attribute score	Observer override: a/a
553	Thalassoica antarctica	Antarctic petrel	0	N	3	0	2.57	1.67	3.06	Y	Med	Low attribute score	Observer override: a/a
589	Catharacta lonnbergi lonnbergi	Subantarctic skua (southern)	0	N	2	0	2.57	1.67	3.06	Y	Med	Low attribute score	Observer override: a/a
1427	Aptenodytes forsteri	Emperor penguin	0	N	1	0	2.43	1.67	2.95	Y	Med	Low attribute score	Observer override: a/a
1426	Eudyptes chrysolophus	Macaroni penguin	0	N	2	0	2.43	1.67	2.95	Y	Med	Low attribute score	Observer override: a/a
1032	Thalassarche bulleri	Buller's Albatross	0	N	1	0	2.43	1.67	2.95	Y	Med	Low attribute score	Observer override: a/a
1035	Thalassarche chrysostoma	Grey-headed Albatross	0	N	1	0	2.43	1.67	2.95	Y	Med	Low attribute score	Observer override: a/a
1009	Phoebetria palpebrata	Light-mantled Albatross	0	N	1	0	2.43	1.67	2.95	Y	Med	Low attribute score	Observer override: a/a
314	Fulmarus glacialoides	Southern fulmar	0	N	1	0	2.43	1.67	2.95	Y	Med	Low attribute score	Observer override: a/a
939	Halobaena caerulea	Blue Petrel	0	N	3	0	2.43	1.67	2.95	Y	Med	Low attribute score	Observer override: a/a

ERA species ID	Scientific Name	Common Name	Total logbook catch (kg) 2000-05	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
1052	Lugensa brevirostris	Kerguelen Petrel	0	N	3	0	2.43	1.67	2.95	Y	Med	Low attribute score	Observer override: a/a
1532	Pachyptila crassirostris	fulmar prion	0	N	3	0	2.43	1.67	2.95	Y	Med	Low attribute score	Observer override: a/a
1047	Pterodroma macroptera	Great-winged Petrel	0	N	2	0	2.43	1.67	2.95	Y	Med	Low attribute score	Observer override: a/a
1048	Pterodroma mollis	Soft-plumaged Petrel	0	N	3	0	2.43	1.67	2.95	Y	Med	Low attribute score	Observer override: a/a
1060	Puffinus tenuirostris	Short-tailed Shearwater	0	N	1	0	2.43	1.67	2.95	Y	Med	Low attribute score	Observer override: a/a
917	Fregetta tropica	Black-bellied Storm-Petrel	0	N	3	0	2.43	1.67	2.95	Y	Med	Low attribute score	Observer override: a/a
325	Catharacta skua	Great Skua	0	N	1	0	2.43	1.67	2.95	Y	Med	Low attribute score	Observer override: a/a
1513	Pygoscelis adeliae	Adelie penguin	0	N	2	0	2.29	1.67	2.83	Y	Med	Low attribute score	Observer override: a/a
1034	Thalassarche chlororhynchos	Yellow-nosed Albatross, Atlantic Yellow-	0	N	1	0	2.29	1.67	2.83	Y	Med	Low attribute score	Observer override: a/a
1008	Phoebetria fusca	Sooty Albatross	0	N	1	0	2.29	1.67	2.83	Y	Med	Low attribute score	Observer override: a/a

ERA species ID	Scientific Name	Common Name	Total logbook catch (kg) 2000-05	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
595	Daption capense	Cape Petrel	0	N	1	0	2.29	1.67	2.83	Y	Med	Low attribute score	Observer override: a/a
73	Macronectes giganteus	Southern Giant-Petrel	0	N	1	0	2.29	1.67	2.83	Y	Med	Low attribute score	Observer override: a/a
981	Macronectes halli	Northern Giant-Petrel	0	N	1	0	2.29	1.67	2.83	Y	Med	Low attribute score	Observer override: a/a
1041	Procellaria aequinoctialis	White-chinned Petrel	0	N	1	0	2.29	1.67	2.83	Y	Med	Low attribute score	Observer override: a/a
494	Procellaria cinerea	Grey petrel	0	N	1	0	2.29	1.67	2.83	Y	Med	Low attribute score	Observer override: a/a
504	Pterodroma lessoni	White-headed petrel	0	N	1	0	2.29	1.67	2.83	Y	Med	Low attribute score	Observer override: a/a
1057	Puffinus griseus	Sooty Shearwater	0	N	1	0	2.29	1.67	2.83	Y	Med	Low attribute score	Observer override: a/a
1437	Chionis minor nasicornis/minor	Black-faced sheathbill	0	N	2	0	2.29	1.67	2.83	Y	Med	Low attribute score	Observer override: a/a
555	Garrodia nereis	Grey-backed storm petrel	0	N	3	0	2.43	1.44	2.83	Y	Med	Low attribute score	Observer override: a/a
785	Aptenodytes patagonicus	King penguin	0	N	1	0	2.14	1.67	2.71	Y	Med	Low attribute score	Observer override: a/a

ERA species ID	Scientific Name	Common Name	Total logbook catch (kg) 2000-05	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
787	Eudyptes chrysocome	Rockhopper penguin	0	N	1	0	2.14	1.67	2.71	Y	Med	Low attribute score	Observer override: a/a
1511	Pygoscelis antarctica	chinstrap penguin	0	N	1	0	2.14	1.67	2.71	Y	Med	Low attribute score	Observer override: a/a
819	Pygoscelis papua	Gentoo penguin	0	N	1	0	2.14	1.67	2.71	Y	Med	Low attribute score	Observer override: a/a
488	Pachyptila desolata	Antarctic prion	0	N	2	0	2.14	1.67	2.71	Y	Med	Low attribute score	Observer override: a/a
1438	Pagodroma nivea	Snow petrel	0	N	1	0	2.14	1.67	2.71	Y	Med	Low attribute score	Observer override: a/a
492	Pelecanoides georgicus	South Georgian diving petrel	0	N	2	0	2.14	1.67	2.71	Y	Med	Low attribute score	Observer override: a/a
973	Larus dominicanus	Kelp Gull	0	N	1	0	2.14	1.67	2.71	Y	Med	Low attribute score	Observer override: a/a
1023	Sterna paradisaea	Arctic tern	0	N	1	0	2.14	1.67	2.71	Y	Med	Low attribute score	Observer override: a/a
292	Sterna vittata	Antarctic tern (NZ)	0	N	1	0	2.14	1.67	2.71	Y	Med	Low attribute score	Observer override: a/a
1006	Pelecanoides urinatrix	Common Diving-Petrel	0	N	1	0	1.86	1.67	2.50	Y	Low		Observer override: a/a
556	Oceanites oceanicus	Wilson's storm petrel (subantarctic)	0	N	1	0	2.00	1.44	2.47	Y	Low		Observer override: a/a

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Marine mammal													
833	Australophocoena dioptrica	Spectacled porpoise	0	Y	4	1	2.86	1.44	3.20	Y	High	Missing data	Observer override: a/a
989	Mesoplodon hectori	Hector's Beaked Whale	0	N	0	0	2.86	1.44	3.20	Y	High	Low attribute score	Observer override: a/a
256	Balaenoptera acutorostrata	Minke Whale	0	N	0	0	2.86	1.30	3.14	Y	Med	Low attribute score	Observer override: a/a
959	Hyperoodon planifrons	Southern Bottlenose Whale	0	N	1	0	2.86	1.30	3.14	Y	Med	Low attribute score	Observer override: a/a
988	Mesoplodon grayi	Gray's Beaked Whale	0	N	1	0	2.86	1.30	3.14	Y	Med	Low attribute score	Observer override: a/a
990	Mesoplodon layardii	Strap-toothed Beaked Whale	0	N	1	0	2.86	1.30	3.14	Y	Med	Low attribute score	Observer override: a/a
1098	Ziphius cavirostris	Cuvier's Beaked Whale	0	N	0	0	2.86	1.30	3.14	Y	Med	Low attribute score	Observer override: a/a
935	Globicephala melas	Long-finned Pilot Whale	0	N	0	0	2.86	1.22	3.11	Y	Med	Low attribute score	Observer override: a/a
937	Grampus griseus	Risso's Dolphin	0	N	0	0	2.86	1.22	3.11	Y	Med	Low attribute score	Observer override: a/a
1002	Orcinus orca	Killer Whale	0	N	0	0	2.86	1.22	3.11	Y	Med	Low attribute score	Observer override: a/a

ERA species ID	Scientific Name	Common Name	Total logbook catch (kg) 2000-05	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
1091	Tursiops truncatus	Bottlenose Dolphin	0	N	0	0	2.86	1.22	3.11	Y	Med	Low attribute score	Observer override: a/a
1439	Balaenoptera bonaerensis	Antarctic Minke Whale	0	N	1	0	2.86	1.15	3.08	Y	Med	Low attribute score	Observer override: a/a
261	Balaenoptera borealis	Sei Whale	0	N	0	0	2.86	1.15	3.08	Y	Med	Low attribute score	Observer override: a/a
268	Balaenoptera physalus	Fin Whale	0	N	0	0	2.86	1.15	3.08	Y	Med	Low attribute score	Observer override: a/a
968	Kogia breviceps	Pygmy Sperm Whale	0	N	0	0	2.86	1.15	3.08	Y	Med	Low attribute score	Observer override: a/a
1036	Physeter catodon	Sperm Whale	0	N	0	0	2.86	1.15	3.08	Y	Med	Low attribute score	Observer override: a/a
269	Berardius arnuxii	Arnoux's Beaked Whale	0	N	0	0	2.86	1.15	3.08	Y	Med	Low attribute score	Observer override: a/a
984	Megaptera novaeangliae	Humpback Whale	0	N	0	0	2.71	1.44	3.07	Y	Med	Low attribute score	Observer override: a/a
832	Lagenorhynchus cruciger	Hourglass dolphin	0	N	1	1	2.71	1.44	3.07	Y	Med	Low attribute score	Observer override: a/a
61	Lissodelphis peronii	Southern Right Whale Dolphin	0	N	1	0	2.71	1.44	3.07	Y	Med	Low attribute score	Observer override: a/a

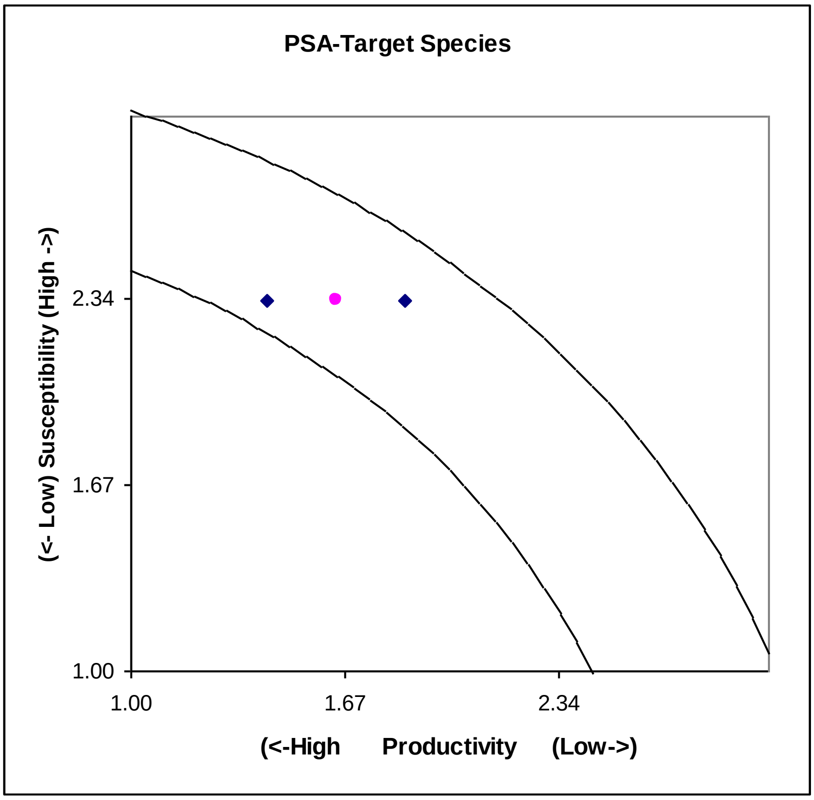
ERA species ID	Scientific Name	Common Name	Total logbook catch (kg) 2000-05	Missing > 3 attributes (Y/N)	Number of missing productivity attributes (out of 7)	Number of missing susceptibility attributes (out of 5)	Productivity (additive) 1- low risk, 3 - high risk	Susceptibility (mult) 1- low risk, 3 - 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
969	Kogia simus	Dwarf Sperm Whale	0	N	0	0	2.71	1.44	3.07	Y	Med	Low attribute score	Observer override: a/a
297	Lobodon carcinophagus	Crabeater seal	0	N	2	0	2.57	1.67	3.06	Y	Med	Low attribute score	Observer override: a/a
1441	Ommatophoca rossii	Ross seal	0	N	3	0	2.57	1.67	3.06	Y	Med	Low attribute score	Observer override: a/a
295	Hydrurga leptonyx	Leopard seal	0	N	0	0	2.71	1.22	2.98	Y	Med	Low attribute score	Observer override: never been captured. Additional distributional infromaton:lives on ice/Antarctic continent
296	Leptonychotes weddelli	Weddell seal	0	N	2	0	2.71	1.22	2.98	Y	Med	Low attribute score	Observer override: never been captured. Additional distributional infromaton:lives on ice/Antarctic continent
993	Mirounga leonina	Elephant seal	0	N	0	0	2.71	1.22	2.98	Y	Med	Low attribute score	Observer override: never been captured. Additional distributional infromaton:100, 000 pairs on Island but not common on fishing grounds
896	Eubalaena australis	Southern Right Whale	0	N	0	0	2.71	1.15	2.95	Y	Med	Low attribute score	Observer override: applied to encounterability because never been reported captured or killed as a result of fishing operations based on reports to SARAG 26, May 2006 & Robertson et al. 2005.
971	Lagenorhynchus obscurus	Dusky Dolphin	0	N	0	0	2.29	1.67	2.83	N	Med	Low attribute score	

ERA species ID	Scientific Name	Common Name	Total logbook catch (kg) 2000-05	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
293	Arctocephalus gazella	Antarctic fur seal	0	N	2	0	2.29	1.67	2.83	Y	Med	Low attribute score	Observer override: a/a
263	Arctocephalus tropicalis	Subantarctic fur seal	0	N	0	0	2.29	1.67	2.83	Y	Med	Low attribute score	Observer override: a/a
265	Balaenoptera musculus	Blue Whale	0	N	0	0	2.57	1.15	2.82	Y	Med	Low attribute score	Observer override: a/a

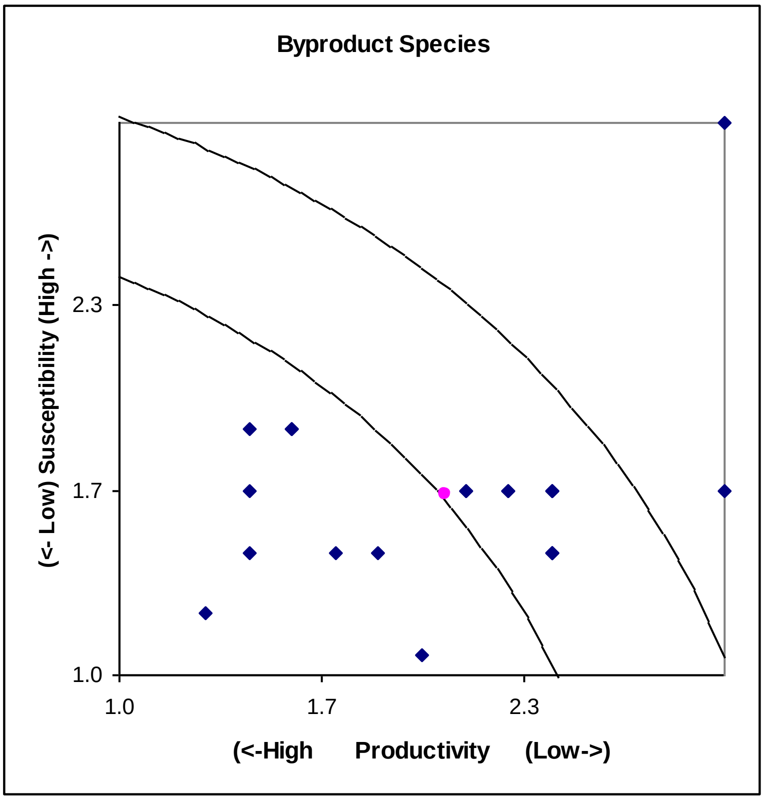
2.4.4 PSA Plot for individual units of analysis (Step 4)

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).

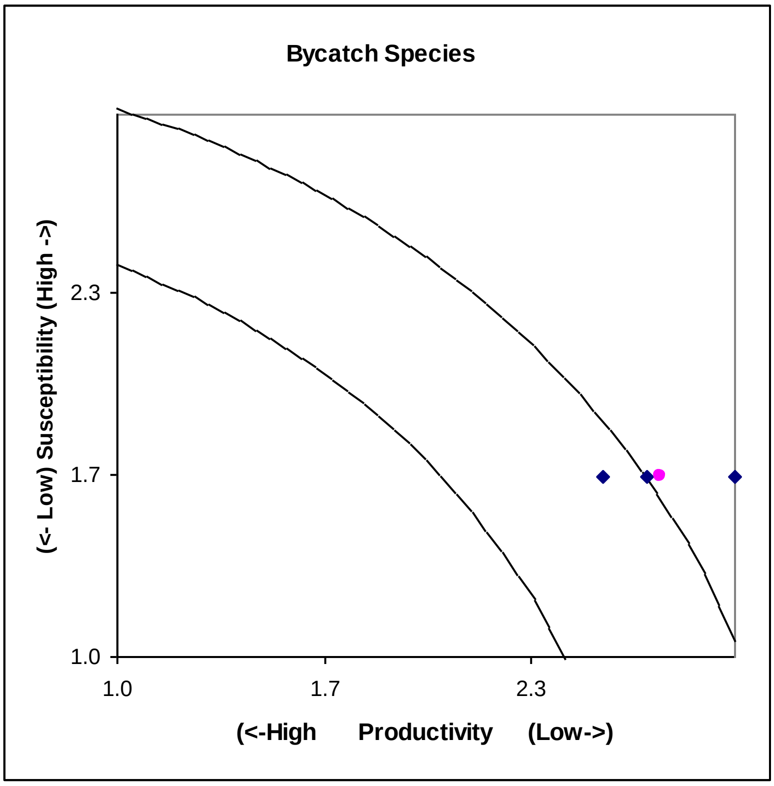
Results of the PSA plot from PSA workbook ranking worksheet



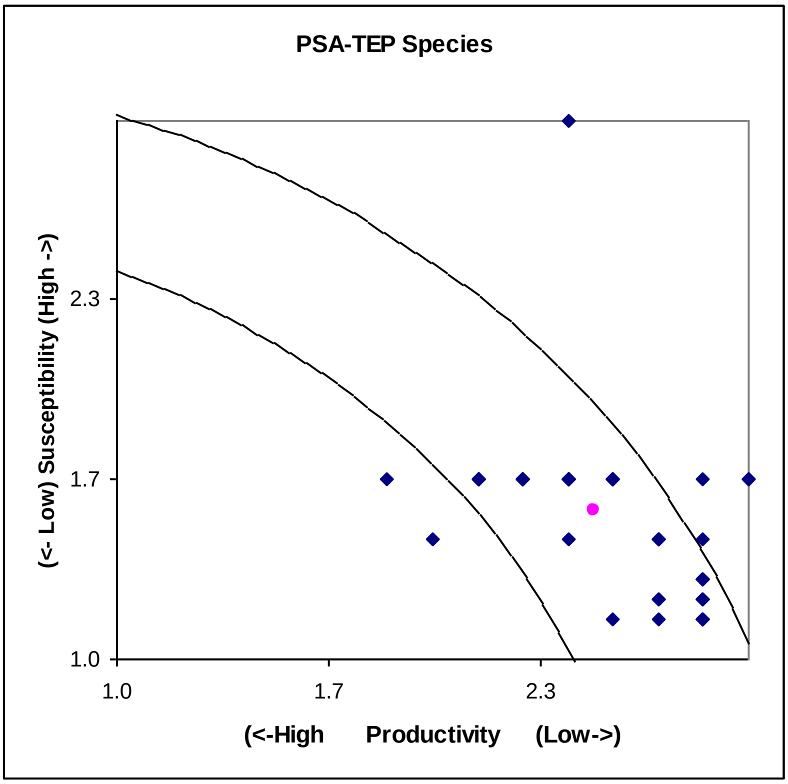
PSA plot for target species



PSA plot for byproduct species



PSA plot for bycatch species



PSA plot for TEP 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**).

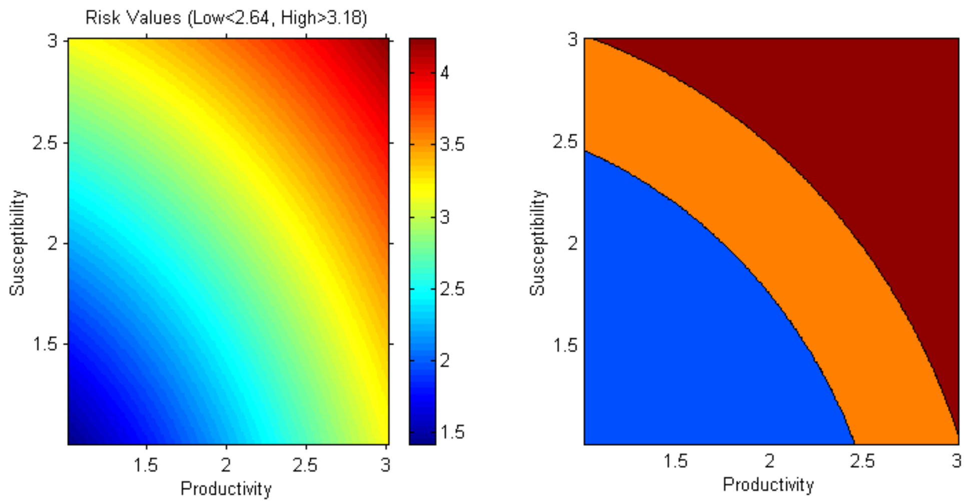


Figure 17. Overall risk values in the PSA plot. Left panel. Colour map of the distribution of the euclidean overall risk values. Right panel. The PSA plot contoured to show the low risk (blue), medium risk (orange) and high risk (red) value.

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.

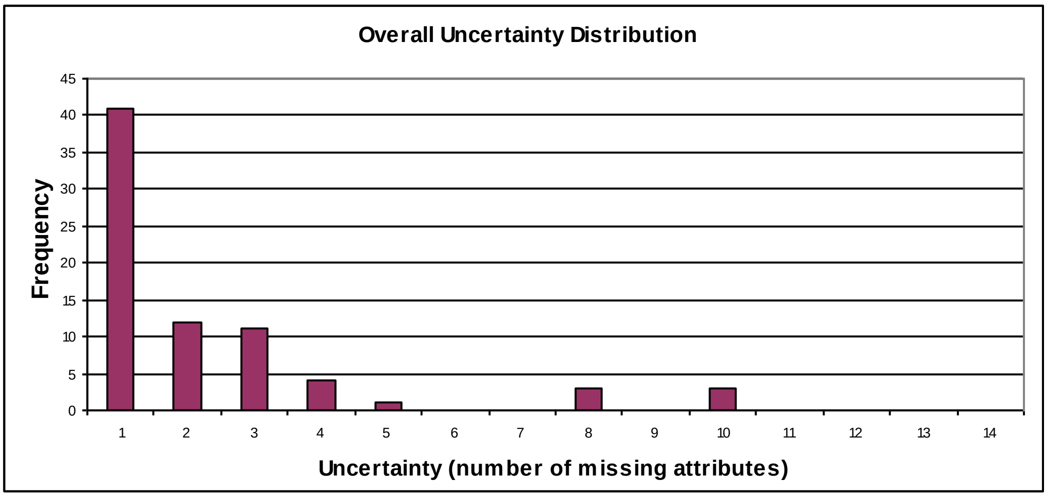
The validity of the ranking can also be examined by comparing the results with those from other data sources or modelling approaches that have already been undertaken in specific fisheries. For example, the PSA results of the individual species (target, byproduct and bycatch and TEP) can be compared 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.

<u>Availability of information</u>
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, trophic level was missing in 58% of species, and so the most conservative score was used, while information on average size at maturity could be found or calculated for 94% of species. For susceptibility attributes, bathymetry overlap was missing in 8% of species. The current method of scoring availability and post-capture mortality 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 (FishBase)
Total species scores for attribute	89	81	89	95	100	96	44
n species scores with attribute unknown, (conservative score used)	17	25	17	11	6	10	62
% unknown information	16	24	16	10	6	9	58
Susceptibility Attributes	**Availability**	**Encounterability**		**Selectivity**	**PCM**		
		Bathymetry overlap	**Habitat**				
Total species scores for attribute	106	97	103	100	106		
n species scores with attribute unknown, (conservative score used)	0	9	3	6	0		
% unknown information	0	8	3	6	0		

Each species considered in the analysis had information for an average of 5.6 (80%) productivity attributes and 4.8 (96%) susceptibility attributes. This meant that, on average, conservative scores were used for less than 14 % 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

<u>Correlation between attributes</u>

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 reproductive strategy and trophic level. 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 strongest susceptibility correlation was between availability and selectivity, while the rest were very weak (see matrix below). The susceptibility correlation could not be calculated between the post-capture mortality and any other aspect, because there was no variation in the post-capture mortality 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	0.40	X					
Fecundity	0.12	0.27	X				
Max size	0.11	0.33	0.09	X			
Min size at maturity	0.13	0.34	0.35	0.77	X		
Reproductive strategy	-0.08	0.21	0.65	0.25	0.41	X	
Trophic level	0.02	0.23	0.68	0.14	0.34	0.78	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.

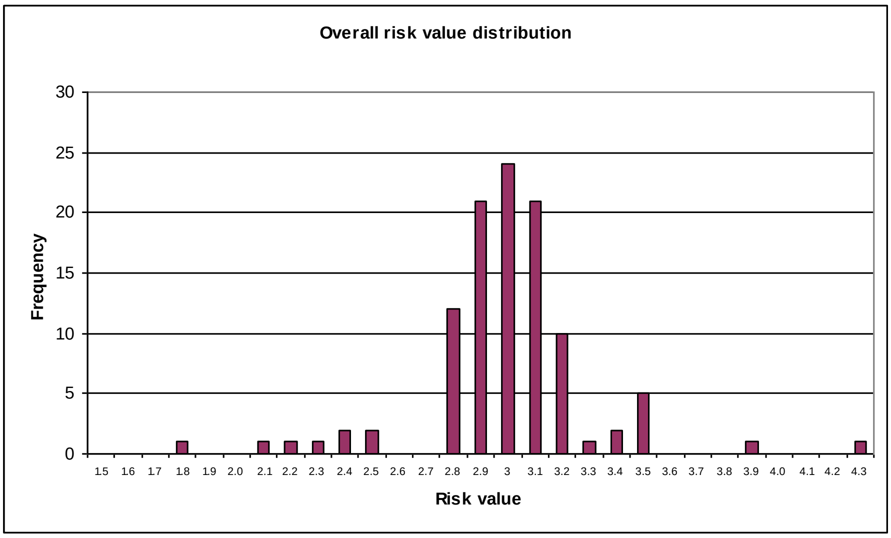
	Availability	Encounterability	Selectivity	Post-capture mortality
Availability	X			
Encounterability	-0.12	X		
Selectivity	0.28	0.06	X	
Post-capture mortality	-	-	-	X

<u>Productivity and susceptibility values for Species</u>

The average productivity score for all species was 2.42 ± 0.11 (mean ± SD of scores calculated using n-1 attributes) and the mean susceptibility score was 1.59 ± 0.32 (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 1.51 attributes out of 12 possible for each species unit.

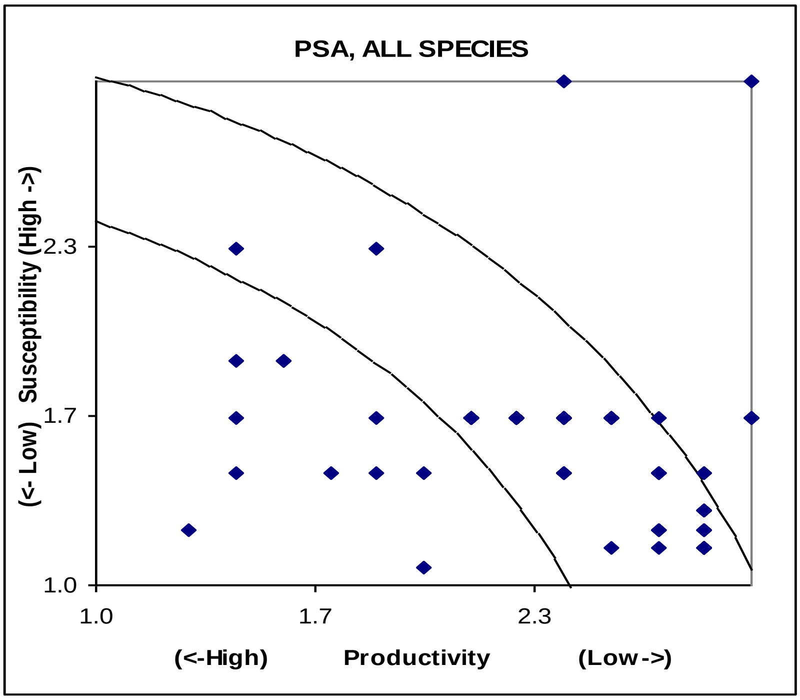
<u>Overall Risk Values for Species</u>

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 2.92, with a range of 1.77 – 4.24**.** The actual values for each species are shown in *Summary of PSA results* (above). A total of 11 species (10%) were classed as high risk, 87 (82%) were in the medium risk category, and 8 (8%) were classed as low risk**.**



Frequency distribution of the overall risk values generated for the 106 species in the HIMI midwater trawl fishery PSA.

The distribution of the overall risk values of all species is shown on the PSA plot below. The species are distributed in all parts of the plot, indicating that both high and low risk units are potentially impacted in the fishery.



PSA plot for all species in the HIMI midwater trawl 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:

<u>Overall</u>
A total of 138 species were considered. Of these, 32 species were eliminated from the species list. Most of these species were synonyms or had insufficient taxonomic resolutions. A total of 106 species were subsequently considered at level 2 of which expert overrides were used in 86. Of the 10 species assessed to be of high risk, 7 species had more than 3 missing attributes and are likely to be false positives. There are three high risk species and some medium risk species that need further consideration.

The average number of missing attributes was high for bycatch species: 3.3 out of a possible 12, but low for TA, byproduct and TEP species: 0, 2.00 and 1.4 respectively. This largely reflects the remoteness of the Sub-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.

Summary of average productivity, susceptibility and overall risk scores.

Component	Measure	
All species	Number of species	106
	Average of productivity total	2.43
	Average of susceptibility total	1.62
	Average of overall risk value (2D)	2.95
	Average number of missing attributes	1.63
Target species	Number of species	2
	Average of productivity total	1.64
	Average of susceptibility total	2.33
	Average of overall risk value (2D)	2.86
	Average number of missing attributes	0
Byproduct species	Number of species	22
	Average of productivity total	2.08
	Average of susceptibility total	1.65
	Average of overall risk value (2D)	2.56
	Average number of missing attributes	2.00
Bycatch species	Number of species	3
	Average of productivity total	2.76
	Average of susceptibility total	125
	Average of overall risk value (2D)	3.23
	Average number of missing attributes	3.33
TEP species	Number of species	80
	Average of productivity total	2.51
	Average of susceptibility total	1.55
	Average of overall risk value (2D)	2.97
	Average number of missing attributes	1.4

PSA risk categories for each species component.

Risk Category	High	Medium	Low	Total
Target species	0	2		2
Byproduct species	2	10	9	21
Bycatch species	2	1		3
TEP species	6	72	2	80
Total	10	85	11	106

PSA risk categories for each taxon.

Risk Category	High	Medium	Low	Total
Chondrichthyan	1	7		8
Invertebrate	2			2
Marine bird	4	43	2	49
Marine mammal	2	29		31
Teleost	1	6	9	16
Total	11	85	11	106

Discussion

Target species
Two target species were considered: tooth fish and icefish. Icefish is the principal target however toothfish, which are categorised as a target species in the HIMI fisheries, are also captured incidentally in the midwater fishery. Therefore toothfish were considered in this assessment as a target species even though they were not specifically targetted by the fishing method. Both were medium risk. Toothfish is mainly lower in the water column than the gear. Both targets species are under comprehensive management plans.

Byproduct species
Two byproduct species were high risk-Asteroidea and *Bathylagus* sp. Both have missing attributes and are likely to be false positives. Skates were medium risk because they are too low in the water column for the gear resulting in a reduced overlap susceptibility score.

Bycatch species
Three bycatch species were considered: sleeper shark, sponges and porbeagle shark. The sleeper shark is mainly lower in the water column than the gear and scored medium risk. Sponges had missing attributes and likely to be a false positive result. Only 135 kg of sponges have been recorded in observer data over the last five years. The porbeagle shark is mainly pelagic but may feed in the water column. Studies of closely related white sharks suggest about half survive when released (Malcolm 2003).

TEP species
Birds
Four marine birds were evaluated as high risk. One of these species has been captured: black browed albatross. Three high risk birds have missing attributes and are likely to be false positives: prions, frigate birds and skuas. 'Prions' is a collective term obtained from the bycatch action plan. More recent data suggests the 'prion' catch is Antarctic prions – only two have been killed. Frigate birds occur mainly outside the sub-Antarctic fishing grounds. The high risk score for skuas has been affected by poor taxonomic resolution. There are taxonomic problems with this group of species. White-chinned petrels have been captured but are abundant – medium risk.

Cetaceans
Two species of beaked whales were scored high risk: Hector's beaked whale and the spectacled porpoise. The distributions of these species are poorly known – potentially false positives. However, beaked whales (dolphins) have been captured in mid-water fisheries of continental Australia and represent a risk is their distribution can be further resolved.

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.

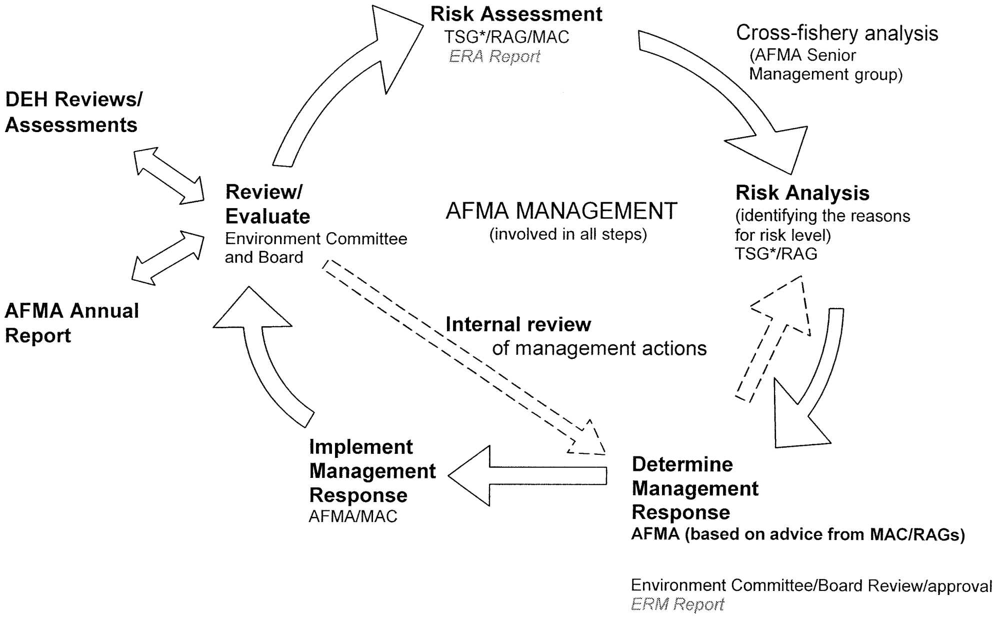
For example, if in a Level 2 analysis of habitat types, two of seven habitat types were determined to have risk from the sub-fishery, only those two habitat types would be considered at Level 3.

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 data 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 10 species classified as high risk, 7 had missing information (Category 1), two had low susceptibility attributes and one 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	7
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	2
Category 4	High risk - Spatial uncertainty	1
Other	High risk -other	0
	Total High	10

These categories do not result in a down-grading of risk. They are intended as a tool to focus the subsequent discussions. 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 the consideration of the high risk species. These categories may also indicate false positives in the high risk species category.

2.5 Level 3

The management arrangements for the HIMI fishery enable the establishment of a range of measures designed to maintain the fish stocks at ecologically sustainable levels. Annual stock assessments for each target species are conducted prior to the allocation of TACs. Recently, The HIMI Icefish fishery was accredited under the Marine Stewardship Council.

The stock assessment models are based on statistical analysis of data collected using random-stratified trawl survey. The age structure of the stock is determined by applying length frequency data to a mixture analysis and subsequent TACs are calculated in accord with the reference point. Results obtained by de la Mare et al. (1998) suggest that even the unexploited stock had a 5% probability that the current stock size is lower than the reference point. The major uncertainty in this method is the estimate of natural mortality, and variability in growth. There is a requirement that there is no more than a 5% probability that the residual stock is less than 75% of the level that would result had there been no fishing to provide food source for other foraging animals in the ecosystem.

3. General discussion and research implications

The fishery operates in sub-Antarctic waters adjacent to Heard Island and McDonald Islands located in the Southern Indian Ocean about 4,000 km south-west of Perth. The islands lie south of the Polar Front. 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). 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.

The midwater fishery targets Mackerel icefish on the outer Heard Plateau. It has been variable due to the unreliability of the stock. Risks involved in this fishery are moderate.

3.1 Level 1

The main issues identified through this assessment were the risks presented by midwater trawling activities impacting on all species and consequently community assessments. However, the risks were identified as moderate only, i.e., that while there is an impact it is within sustainable levels prescribed by management. The stock of icefish, the principal target of the midwater fishery, is assessed annually and while there is uncertainty surrounding some of the parameters used in the assessments, it would seem unlikely that the stocks will be fished beyond ecological sustainability. Accreditation by the MSC also supports the ecological sustainability of this stock.

The impact of fishing on TEP species, however, is of more concern. Even though the effort in the fishery remains relatively low and variable and prescribed mitigation measures were in place, the capture of 12 birds within a week, seven of which were black browed albatross, heightened the risk of this activity to TEP species. The population of black browed albatross at Heard Island is low – around 600 pairs.

Similarly, the risk to porbeagles (bycatch or byproduct species) remains high. This species is mainly pelagic and while it is sometimes caught in demersal fisheries, midwater trawling is a larger threat. The other by-product species commonly caught in the midwater trawls were mostly macrourids and notothenids with higher productivity and also managed by TAC limits therefore were not considered especially vulnerable.

The hazard presented by translocation of species was assessed as not significant. However the apparent absences present the classical problem for risk assessment – a low probability event combined with a potentially high impact consequence. For the HIMI midwater fishery, translocation risks are most likely due to hull and net fouling, and bilge. However, the risk of temperate water species found in the other areas where the vessels operate establishing in the much colder and more extreme environments of the Polar Front would logically seem remote.

Communities were also considered at risk from direct fishing impacts largely as a result of the risk imposed on species components. While effort is low it is unlikely that significant impact on functional groups would occur and consideration of spatial overlap of the fishery with the community at a higher level assessment could probably reduce the risk.

3.2 Level 2

The components that Level 1 analyses suggested were at moderate risk from fishing were target, byproduct/bycatch species and TEP species. This assessment was confirmed by the Level 2 analyses.

Of the 106 species assessed, 10 were found to be at high risk. Of the 10 high risk species, 7 were likely to be false positives because of missing attribute data. There are three high risk species and some medium risk species that need further consideration.

3.2.1 Species at risk

Overall, of the 10 species rated as high risk from the PSA analyses, the authors consider that 7 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 other fisheries in the area.

Species	*Risk Category*	*Role in fishery*
• *Thalassarche melanophrys*)	Spatial uncertainty	TEP
• *Pachyptila* spp	Missing data	TEP
• *Fregata* spp	Missing data	TEP
• *Catharacta* spp	Missing data	TEP
• *Australophocoena dioptrica*	Missing data	TEP
• *Mesoplodon hectori*	Low attribute score	TEP
• *Lamna nasus*	Low attribute score	Bycatch

Of the six TEP species found to be at high risk, three bird species, *Pachyptila* species, *Fregetta* species and *Catharacta* species and one cetacean the Spectacled porpoise *Australophocoena dioptrica* had 8-10 missing attributes. A recommendation is to review the attributes associated with distribution or other missing attributes to reduce this uncertainty, and in all probability eliminate any bird species from the high risk category such as the frigate birds which are unlikely to occur in this region. The distribution of Hector's beaked whale is also poorly known and resolution of this attribute may also eliminate this species. However the main reason for this species to score as a high risk while other species in the family Ziphidae scored medium risk is that its slightly smaller size resulted in a high selectivity score for the fishing gear.

The Black browed albatross was high risk compared to other birds because an override for encounterability was not used because it has been caught in fishing operations and should remain. White chinned petrels were also caught but its larger population size reduces it to medium risk. Overall, more than half the birds occurring in the HIMI region are breeding and the risk that mortality from fishing operations will impact the populations remains of concern. Midwater trawling in other fisheries where effort is much greater does kill birds in greater numbers than in the HIMI fishery. The immediate and voluntary response to the incident that resulted in most of the fatalities has so far prevented further fatalities but while the effort in the fishery remains low, it is recommended that the risk be re-assessed after a suitable monitoring and assessment period.

The by-product or by-catch species judged to be at high risk were *Bathylagus* sp., invertebrates (Porifera and Asteroidea) and porbeagles *Lamna nasus*. All except the last had missing attributes. The invertebrates are normally out of range of the gear. These were caught accidentally so are unlikely to present a real risk unless accidents occur regularly. *Bathylagus* sp has not been caught regularly in the fishery being generally a bathypelagic family and is in all likelihood a false positive result reflecting ten missing attributes. The porbeagle remains as a high risk species. It matures at 10 years, lives to 30 years, and has a litter size of one. The closest taxonomic relative to the porbeagle is the White shark from southern Australia which is listed as a vulnerable species under EPBC legislation. A more detailed risk analysis of chondrichthyan species in southern Australia is being undertaken currently within an FRDC project (FRDC 202/033), and results from this study should be available shortly.

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

Not assessed

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:

- Collection of biological data to determine productivity of porbeagles
- Continued monitoring of bird interactions with the gear while fishing.
- Systematic bird surveys to estimate the proportion of interactions/mortalities to sightings that occur. Potentially as part of existing observer programs with better sample design and analysis.
- Determine sustainable levels of TEP species mortality arising from fishing operations.

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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
29/8/06		No specific comments made	

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	**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**
		spawning units up to 5%.				
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	**6. Behaviour/ movement** Possible detectable change in behaviour/ movement but minimal impact on population dynamics. Time to return to original behaviour/	**6. Behaviour/ movement** Detectable change in behaviour/ movement with the potential for some impact on population dynamics. Time to return to original behaviour/	**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 in behaviour/ movement with impacts on population dynamics. Time to return to original behaviour/	**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**
	pre-disturbed state on the scale of hours.	movement on the scale of days to weeks.	movement on the scale of weeks to months.	scale of months to years.	movement on the 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

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.	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 is 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 area 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.	5. **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.