Australian Government
Australian Fisheries Management Authority

R04/1072 | 28/06/2007

Ecological Risk Assessment for Effects of Fishing

REPORT FOR THE DEMERSAL TRAWL SUB-FISHERY OF THE MACQUARIE ISLAND FISHERY

Authors

Ross Daley
Catherine Bulman
Dave Stevenson
Alistair Hobday
Miriana Sporcic
Mike Fuller

CSIRO

Natural Heritage Trust
Helping Communities Helping Australia
An Australian Government Initiative

This fishery Ecological Risk Assessment report should be cited as:

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

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

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

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

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

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

Executive Summary

This assessment of the ecological impacts of the Heard and McDonald Islands 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 Macquarie Island Demersal Trawl Fishery includes the following:

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

Fishery Description

Gear:	Demersal trawl (120 mm)
Area:	Macquarie Island Fishery
Depth range:	400-1000m
Fleet size:	1 vessel
Effort:	variable up to 120 shots per year
Landings:	243 t across both areas (Aurora Trough and Macquarie Ridge) in 2005/6. Total of 721 t across both areas (1/2001-6/2006) of which 119 t research quota.
Discard rate:	2 t of bycatch (usually retained, mealed and discarded onshore) across both areas in 2005/6 Total of 14.1 t (~2%) across both areas (1/2001-6/2006)
Main target species:	Patagonian toothfish
Management:	Quota management system for 1 species and bycatch limit 200 tonnes on all other species/groups
Observer program:	observer program operating since beginning of fishery

Ecological Units Assessed

Target species:	1
Byproduct species:	74
Bycatch (Discard) Species:	3
TEP species:	90
Habitats:	-
Communities:	2

Level 1 Results

No ecological components were eliminated at Level 1 (consequence score $\geq$3 for at least one activity).

Consequence (risk) scores were between 1-3 across all 32 hazards (fishing activities) and four ecological components assessed.

Those hazards with moderate risk scores of three were:

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

Fishing (direct impact with capture) scored as major risk (=4) to TEP species. No external hazards (consequence score $\geq$3) were scored. No other risks rated as major or above (risk scores 4 or 5) were scored.

Habitats for this fishery are not currently assessed using most recent ERAEF methodology due to the quality of available habitat data. Existing Macquarie Island data includes a few CMAR survey images of low quality and restricted distribution, some associated survey descriptions, geomorphic unit mapping, and a few references to invertebrate taxa from bycatch lists. This data is considered to be of limited value at this stage in characterizing both the range of possible benthic habitats that occur within the jurisdictional boundary of the MIF and the associated risk of those habitats to demersal trawling within this region. Application of the existing habitat data from Australian waters including Tasman Rise is not considered an acceptable alternative.

Impacts from fishing on all species components were assessed in more detail at Level 2.

Level 2 Results

A total of 168 species were subsequently considered at level 2, of which expert over rides were used on 106 species. Of the 42 species assessed to be at high risk, 36 had more than 3 missing attributes.

<u>Target species</u>
The single target species was assessed to be at potentially high risk but this species has had detailed Level 3 assessments and is under comprehensive and precautionary management plans.

<u>Byproduct species</u>
A larger than expected number of byproduct species was evaluated as high risk (40 species). However most of these species are fishes that are caught in only small quantities. These high risk scores are likely to reflect uncertainty – missing information; most importantly the poorly documented taxonomy and distribution of fish species in the region. The species that were most likely to be at genuine high risk within this group were whiptails and southern flounders. However none of these species have particularly low productivity and whiptails are the only byproduct fish species caught in significant quantities.

A significant amount coral and of benthic invertebrates had been recorded in the byproduct/bycatch suggesting that habitats need assessment. These are generally not resolved to species but the families recorded represent tube anemones, black corals, fan corals and thorny corals. The invertebrate fauna of the region is poorly known but is likely to include long-lived corals, similar to those present on seamounts around southern Tasmania. The coral on some of these seamounts has been reduced and has not recovered after 10 years. These corals are difficult to age but some cold water corals are thought to live to 100 years.

<u>Bycatch (discards)</u>
The sleeper shark, a species of deepwater dogfish, is the main bycatch species. Other species of deepwater dogfish have annual fecundity of less than 1. There are broad concerns for deepwater dogfish, both domestically and internationally. The sleeper shark stands out because of its large size. This means that a relatively small number of individuals contribute to the overall biomass. Studies of other deepwater dogfishes, blue sharks and white sharks suggest survival rates of released sharks are around 50%. There have been studies of sleeper sharks in the region but they do not include yield estimates.

TEP Species
Only two TEP species were assessed as high risk. The white chinned petrel is an aggressive bird that dives on baits and has interacted with vessels in the fishery resulting in death. The wandering albatross has not been captured in the sub-fishery, but has a limited population size on Macquarie Island (40 birds). Even if one bird were captured it would comprise 2% of the population. In fact any level of harvest of this population presents significant risk given that it is recovering from depletion from external (to the MIF trawl fishery) influences. Closely related species, including shy albatross, have been killed by warp wires in trawl fisheries around continental Australia as recorded in observer data.

Habitats
Not assessed.

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

Seabird interactions have to date been considered the principle ecological risk for the Macquarie Island trawl fishery for Patagonian toothfish and this is likely to remain an important ecological issue because of the particularly low number of wandering albatross on Macquarie Island. The level of observer coverage in the fishery is best practice among Australian fisheries for ensuring compliance with mitigation measures to protect seabirds. There are opportunities to improve the collation and availability of observer data so that it can also be used to evaluate and improve the effectiveness of mitigation measures through adaptive management.

Another issue highlighted in this ERAEF assessment is concern for sleeper sharks. This concern will be best addressed across both the line and demersal trawl sub-fisheries.

Another issue is our poor knowledge of the fish taxonomy and biogeography of the area. The fish fauna of the region has been studied but the documentation of these studies is incomplete.

The remaining issue to emerge from the level 2 analysis of bycatch species is the impact of the trawl gear on benthic invertebrates. This suggests that assessment of habitats should be a priority.

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.

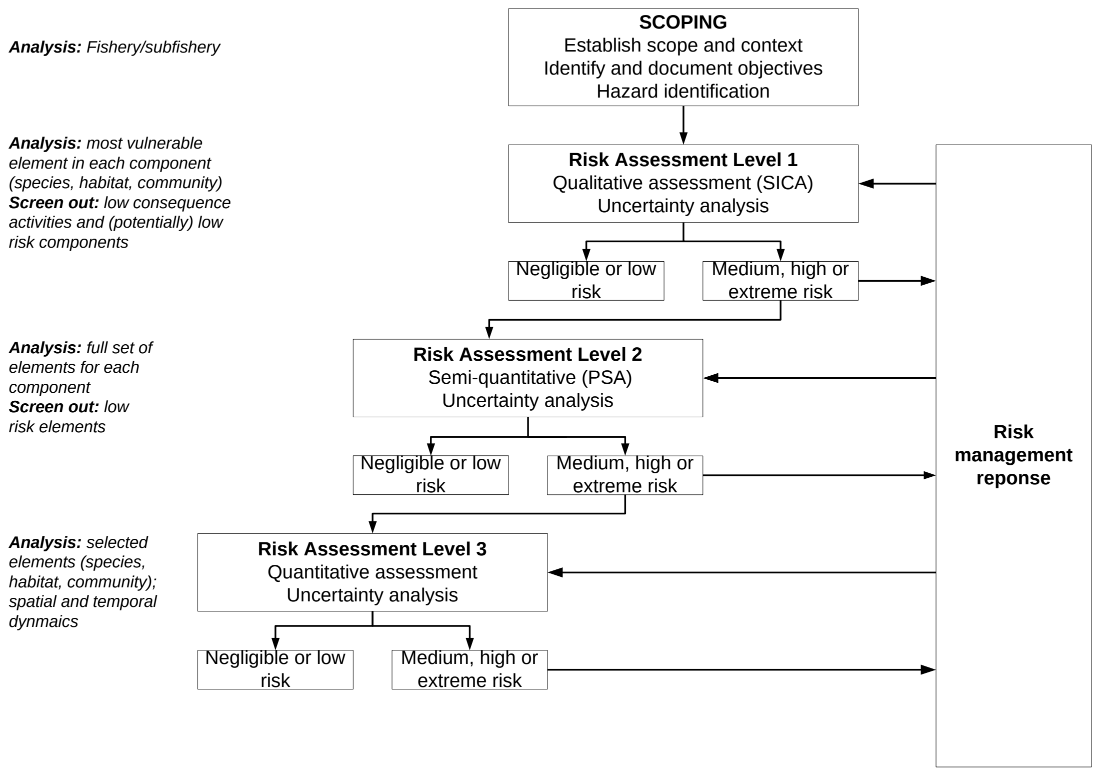


Figure 1. Overview of ERAEF showing focus of analysis for each level at the left in italics.

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.

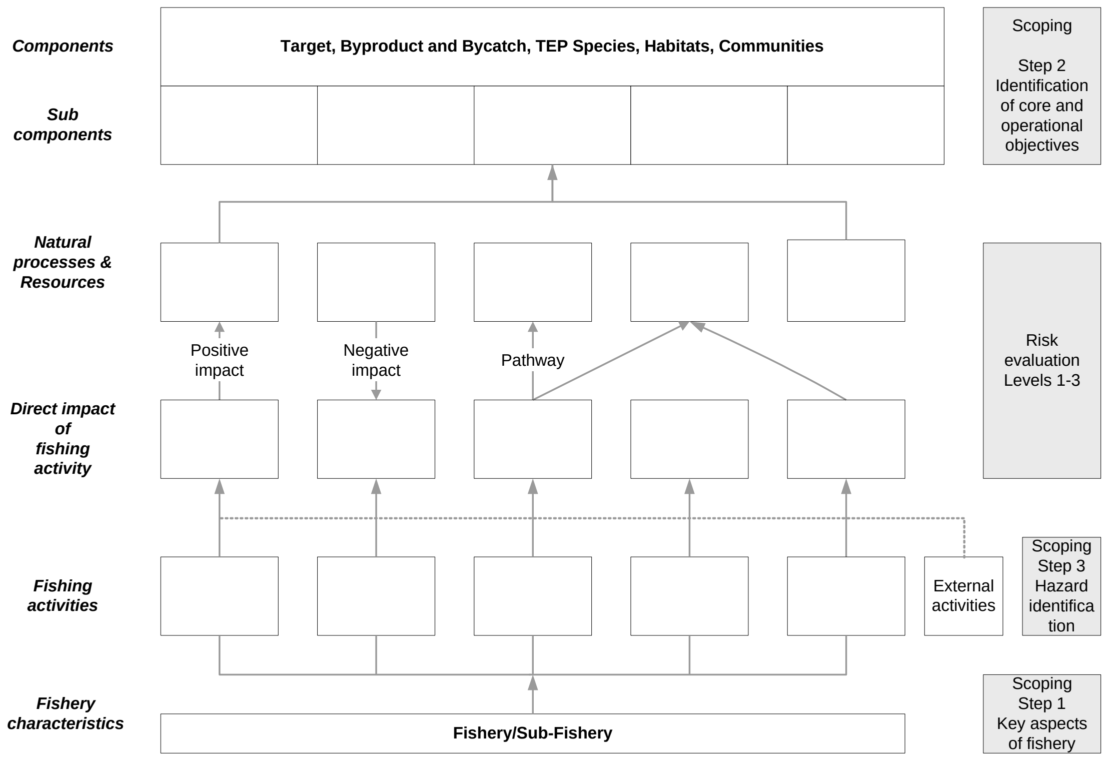


Figure 2. Generic conceptual model used in ERAEF.

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. <u>Identification of units of analysis</u> (species, habitats and communities) potentially impacted by fishery activities (section 2.2.2; Scoping Documents S2A, S2B and S2C).
2. <u>Selection of objectives</u> (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. <u>Selection of activities</u> (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

Demersal trawl sub-fishery of the Macquarie Island 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 Wieneke (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	Meeting with AAD	May 2006	Tim Lamb, Dirk Welsford (AAD)	Discussions regarding re-scoping of species and review of original comments of early draft.
Level 2 (PSA)	Email	June 2006	Tim Lamb	Provided information on coral types and information on benthic invertebrate samples
Scoping	Emails and meeting	June 2006	AAD	Feedback on scoping for subfisheries.
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 not discussed. CSIRO to amend Level 1 and Level 2 where appropriate.

2.2 Scoping

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

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

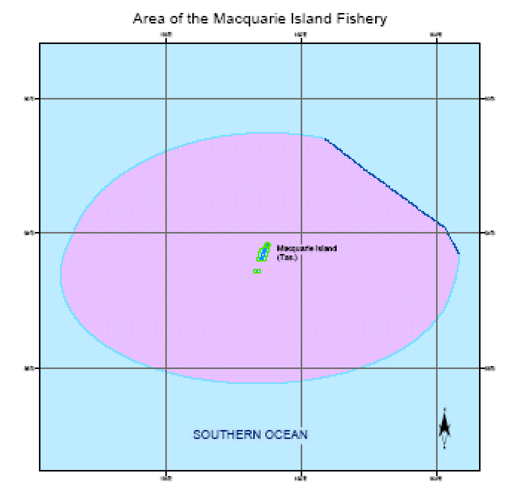
2.2.1 General Fishery Characteristics (Step 1).

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

Scoping Document S1 General Fishery Characteristics

Sub-fishery Name: Demersal trawl
Fishery Name: Macquarie Island Fishery (MIF)
Date of assessment: April 2004 (updated June 2006)

General Fishery Characteristics	
Fishery Name	Macquarie Island Fishery (MIF)
Sub-fisheries	Demersal trawl, midwater trawl
Sub-fisheries assessed	This report assesses the demersal trawl subfishery.
Start date/history	The demersal trawl fishery for Patagonian toothfish commenced in November 1994. Prior to this, there are no records of trawl fishing in the area. Fishing generally takes place in spring and summer. The Aurora Trough grounds were established during the first two years. A second set of grounds in the Northern Valleys was established in 1996/7 with high catches initially. No other grounds have been established despite extensive prospecting over the Macquarie Ridge. Following the 1998/9 season, the Aurora Trough was closed until 2003/4 season. http://www.afma.gov.au/fisheries/antarctic/default.php
Geographic extent of fishery	The Antarctic Fisheries at Macquarie extend to the limit of the 200 nautical mile AFZ for all species. Macquarie Island is part of the State of Tasmania and is located in the Southern Ocean about 1,500 kilometres south-east of Hobart. As such, waters surrounding the islands out to a distance of 3 nautical miles are Tasmanian State waters and the Tasmanian Department of Primary Industries, Water and Environment controls fishing in these waters. The Macquarie Island Fishery covers all fishing in Commonwealth waters of the AFZ around the Island, with additional provisions governing activities in the MPA.

	 Map source: http://www.afma.gov.au/fisheries/maps/default.php
Regions or Zones within the fishery	Macquarie Island is part of the State of Tasmania and is located in the Southern Ocean about 1,500 kilometres south-east of Hobart. Waters surrounding the islands out to a distance of 3 nautical miles are Tasmanian State waters and the Tasmanian Department of Primary Industries, Water and Environment controls fishing in these waters. The Macquarie Island Fishery covers all fishing in Commonwealth waters of the AFZ around the Island. The Island lies outside the Antarctic convergence. The exact location of the fishing grounds at Macquarie will remain confidential. This is a decision made by AFMA to protect the interests of the licensed operators in the fishery. There are, however, two main fishing grounds: 1) Aurora Trough – west of Macquarie Island. Closed in 1998/9 until 2003. 2) Northern Valleys – north of Macquarie Island comprising Colgate Valley, Grand Canyon and the Beer Garden grounds (Williams and Lamb 2001)
Fishing season	Fishing can occur at any time of year – actual fishing time determined by operational considerations. It is common in spring and summer between the months of October and March, except during 2000, when a fishing voyage was undertaken in July.
Target species and stock status	Patagonian toothfish (*Dissostichus eleginoides*) The Patagonian toothfish (*Dissostichus eleginoides*) is widely distributed throughout large areas of the Antarctic oceans. It is the largest Nototheniid with a maximum size greater than 2m. It is a demersal (found at or near the sea bottom) species found at depths up to 2,500 metres, although it is reported to be pelagic (living at or near the ocean surface) throughout some periods of its life (eggs to young juveniles). The fishery is dominated by immature fish < 1100mm, between 500 and 900 mm. Evidence from tagging and genetic studies suggest that there is very low exchange between the two major stocks despite the highly mobile and predatory nature of the fish and a partially pelagic life history (Reilly *et al.* 1998 cited in Tuck et *al.* 2001, Appleyard *et al.* 2002). Major uncertainties concerning Patagonian toothfish (*Dissostichus eleginoides*) a) biological aspects including reproductive biology, growth, natural mortality, lifespan, age at maturity, location of spawning grounds b) Distribution of stocks c) Stock size and proportion of fishable abundance d) Genetic transfer between stocks, emigration/immigration rates between stocks e) Spatial and temporal dynamics at Macquarie Island (Tuck *et al.* 2003) g) Dependence of other predators on Patagonian toothfish as prey items

<table>
<tr><td>Bait Collection and usage</td><td>n/a</td></tr>
<tr><td>Current entitlements</td><td>Only 1 vessel permitted to operate in the fishery.</td></tr>
<tr><td>Current and recent TACs, quota trends by method</td><td><u>Aurora Trough</u> grounds were closed from 1999 to enable the fishery to recover. A TAC of 40 tonnes to enable the continuation of tagging and monitoring programs was fully fished. Indications are that the stocks are recovering in this area.
<u>Grounds outside Aurora Trough</u>
TACs set assuming only resident stock would be found on the grounds. If the transient stock is encountered (indicated by catch rates exceeding a threshold of 10 tonnes/km² over three consecutive fishing days), the TAC increases to an upper limit. If catch rates fall below the threshold value the TAC reverts to the lower limit or if this TAC has been exceeded the fishery will be closed by AFMA.
Annual TAC in tonnes for each ground
<table>
<tr><th>Season</th><th>Aurora Trough</th><th>Macquarie Ridge (Northern Valleys)</th></tr>
<tr><td>1994-6</td><td>-</td><td>-</td></tr>
<tr><td>1996/7</td><td>750</td><td>1000</td></tr>
<tr><td>1997/8</td><td>200</td><td>1500</td></tr>
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<tr><td>2000</td><td>40 (research)</td><td>510*</td></tr>
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<tr><td>2005/6</td><td>255</td><td>125*</td></tr>
</table>
* Increases to a higher limit if catch rates exceed a threshold of 10 tonnes/km² over three consecutive fishing days.
(Source: AFMA)</td></tr>
<tr><td>Current and recent fishery effort trends by method</td><td>From 1-3 voyages a year since the first season (1994/1995). CPUE in kg/km² has varied from over 422,000 to less than 1 on the same ground (Grand Canyon) since the start of exploitation in 1996. The general trend has been for decreasing CPUE figures on most grounds (Williams and Lamb 2001, Tables 6.3 & 6.4) however since 2001 the CPUE in Aurora Trough is rising but on other grounds CPUE has declined and remained low.
Annual effort in hours in each ground
<table>
<tr><th>Season</th><th>Aurora Trough</th><th>Macquarie Ridge (Northern Valleys)</th></tr>
<tr><td>1994-6</td><td>1662</td><td>0</td></tr>
<tr><td>1996/7</td><td>219</td><td>84</td></tr>
<tr><td>1997/8</td><td>224</td><td>448</td></tr>
<tr><td>1999</td><td>45</td><td>82</td></tr>
<tr><td>2000</td><td>59</td><td>71</td></tr>
<tr><td>2001</td><td>27</td><td>20</td></tr>
<tr><td>2002</td><td>24</td><td>39</td></tr>
<tr><td>2003</td><td>0</td><td>4</td></tr>
<tr><td>2003/4</td><td>117</td><td>7</td></tr>
<tr><td>2004/5</td><td>13</td><td>12</td></tr>
<tr><td>2005/6</td><td>118</td><td>42</td></tr>
</table>
(Source: AFMA)</td></tr>
</table>

<table>
<tr><td>Current and recent fishery catch trends by method</td><td><u>Aurora Trough</u>:
The precautionary principle was applied and the ground closed in 1999 due to a decline in stocks below defined reference points. Subsequently in 2000 and 2001 a TAC of 40 tonnes was allocated to allow scientific monitoring and tagging programs to continue. The grounds were re-opened in 2003/4 season.
Annual catch in tonnes from each ground
<table>
<tr><th>Season</th><th>Aurora Trough</th><th>Macquarie Ridge (Northern Valleys)</th></tr>
<tr><td>1994-6</td><td>1351</td><td>0</td></tr>
<tr><td>1996/7</td><td>489</td><td>4.4</td></tr>
<tr><td>1997/8</td><td>200</td><td>55.1</td></tr>
<tr><td>1999</td><td>36</td><td>7.5</td></tr>
<tr><td>2000</td><td>11</td><td>4.2</td></tr>
<tr><td>2001</td><td>23</td><td>1</td></tr>
<tr><td>2002</td><td>36</td><td>7</td></tr>
<tr><td>2003</td><td>0</td><td>1.2</td></tr>
<tr><td>2003/4</td><td>352</td><td>0.3</td></tr>
<tr><td>2004/5</td><td>57</td><td>0.5</td></tr>
<tr><td>2005/6</td><td>241</td><td>1.6</td></tr>
</table>
(Source: AFMA)</td></tr>
<tr><td>Current and recent value of fishery ($)</td><td>$2.5 million based on estimate of 242 tonnes TAC at $10-11/kg. (Estimated values based on yearly TAC at $10-11/kg.)
96/97 $10 million, 97/98 $15 million, 1999 $6 million, 2000 $5 million, Note: value assumed to be ex-vessel.</td></tr>
<tr><td>Relationship with other fisheries</td><td>The Antarctic Fisheries are both managed within the context of the Australian Government’s policy position within CCAMLR. Accordingly both fisheries are managed in a manner that is consistent with, or more stringent than, CCAMLR regulations, despite the Macquarie fishery being outside CCAMLR’s jurisdiction. CCAMLR is the International Convention for the Conservation of Antarctic Marine Living Resources of which 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).
(Source:<u>http://ccamlr.org</u>)</td></tr>
<tr><td colspan="2">Gear</td></tr>
<tr><td>Fishing gear and methods</td><td>Demersal otter board trawling is used.</td></tr>
<tr><td>Fishing gear restrictions</td><td>Gear restrictions include:
• A minimum mesh size of 120mm
• Net monitor cables are prohibited
• Minimum bobbin size of 520mm and where rockhopper gear is used, rubber discs of minimum size of 40cm.</td></tr>
<tr><td>Selectivity of gear and fishing methods</td><td>Bycatch is not considered a major issue in Antarctic fisheries, as 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 bycatch taken. The data collection to date indicates that in the Macquarie Island Fishery the total bycatch recorded, which includes all grounds all years, including prospecting shots represents 8.15% of the total catch. This figure includes fish bycatch as well as rocks, corals and other benthic organisms. However, bycatch in the preceding tables accounts for about 2% of the total catch, so perhaps does not account for invertebrates.</td></tr>
<tr><td>Spatial gear zone set</td><td>Gear is set in valley 3nm west of the island on the continental slope of the island and in a complex of valleys 30nm to the north, both grounds being on the Macquarie Ridge.</td></tr>
<tr><td>Depth range gear set</td><td>Gear is set >400m usually between 600and 1200m.</td></tr>
<tr><td>How gear set</td><td>Demersal trawlers tow a net along, or just above, the ocean floor in depths up to 1,200 metres. The net is deployed and retrieved from the stern of the vessel by way of winches</td></tr>
</table>

<table>
<tr><td></td><td>and is towed behind the vessel by long wires, the 'warps'. The net opening 'mouth' is spread horizontally by the outward force acting on the otter boards being towed through the water. The bottom of the net opening, the 'footrope', is weighted down and is normally in contact with the bottom, rigged up with rubber rollers to enable it to move across the substrate without any 'hook-ups'. The top of the mouth, the 'headline', is lifted by a number of floats. Trawling relies on the principle of herding fish inward toward the path of the oncoming net mouth. As fish swim away from the warps, they are enclosed and fall back towards the tapered body of the net. The gear is hauled up toward the vessel and the fish are contained in the 'codend', the end section of the net fastened with a rope, which releases the catch on the vessel deck.</td></tr>
<tr><td>Area of gear impact per set or shot</td><td>Swept area of gear is about 0.2 to 0.4km^2 (Williams and Lamb 2001).</td></tr>
<tr><td>Capacity of gear</td><td></td></tr>
<tr><td>Effort per annum all boats</td><td>Annual effort in hours fished
<table>
<tr><th>Season</th><th>Aurora Trough</th><th>Macquarie Ridge (Northern Valleys)</th></tr>
<tr><td>1994-6</td><td>1662</td><td>0</td></tr>
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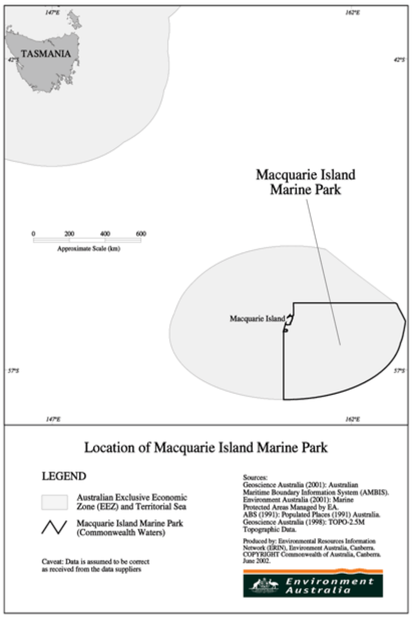
<tr><td>2005/6</td><td>118</td><td>42</td></tr>
</table>
(Source: AFMA)</td></tr>
<tr><td>Lost gear and ghost fishing</td><td>The Macquarie Island Fishery has lost following gear: 4 net buoys, a high density plastic float, an EPIRB (Emergency Position Indicating Radio Beacon), a single high density plastic net float and a 3 metre long strop.
(Source: AFMA 2001)</td></tr>
<tr><td colspan="2">Issues</td></tr>
<tr><td>Target species issues</td><td><u>Major uncertainties concerning Patagonian toothfish (Dissostichus eleginoides)</u>
a) biological aspects including lifespan, age at maturity, location of spawning grounds
b) Distribution of stocks
c) Stock size
d) Genetic transfer between stocks, emigration/immigration rates between stocks
e) Spatial and temporal dynamics at Macquarie Island (Tuck et al. 2003)
g) Dependence of other predators on Patagonian toothfish as prey items</td></tr>
<tr><td>Byproduct and bycatch issues and interactions</td><td>During 1997-2000, bycatch of fish and invertebrates averaged about 8.5%, and was relatively low in the established grounds at Aurora Trough 2.3% compared to new grounds where bycatch could be over 50%. Bycatch has risen since catches of toothfish have fallen. Between 1996/7 to 1999/2000, macrourids in particular Macrourus carinatus, constituted the largest proportion of the fish bycatch while corals and sponges dominated the invertebrates. The fishes are mostly common and widespread locally or globally and are relatively productive therefore are not likely to be threatened. However chondrichthyans are more vulnerable due to their low productivity although they are often released. Post-capture mortality is likely to be high based on studies of other deepwater dogfish and skate species. Some invertebrates are vulnerable to fishing impacts but these were predominantly located outside the fishing grounds where there is low effort (Williams et al. 2001).</td></tr>
</table>

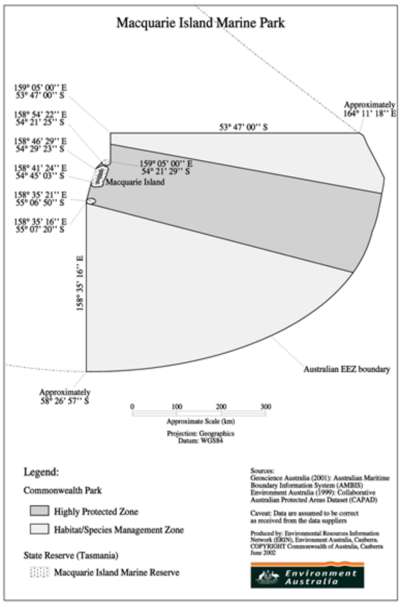
TEP issues and interactions	<u>Current TEP Interactions</u> Interactions causing injury or death to seabirds and marine mammals have been extremely low to date in Antarctic trawl operations, and SAFAG's assessment is that the current fishing operations do not pose a significant threat to seabird or marine mammal populations. If the number of reported incidents of seabird or marine mammals increases substantially, AFMA will review mechanisms to reduce the level of interactions. AFMA is continuing to investigate appropriate assessment methods for these species. <u>Marine mammals</u> 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 <u>Seabirds-general</u> Currently, the low number of reported incidents involving death or serious injury to seabirds is a positive factor favouring the fishery. During 6 voyages from 1997 to 2000, over 47,000 sighting of seabirds were made with Giant petrels and Black-browed albatrosses being the most numerous. Of the 631 trawls observed interactions were seen on 58 (22%) of them and no fatalities were observed. The birds interacting with the gear were generally the more abundant species and there are unlikely to be population effects. However fatality of a rare species such as the Wandering albatross could severely impact the very small population at Macquarie Island (Williams *et al*. 2001). However, if the number of reported incidents of seabird interactions increases substantially, AFMA will review mechanisms to reduce the level of interactions. AFMA is continuing to investigate appropriate assessment methods for these species. To reduce the incentive for seabirds to congregate around vessels, 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. "The impacts caused by increasing rabbit and rodent populations on Macquarie Island Nature Reserve and World Heritage Area are very serious and there are currently no viable population control options for any of these three species of rabbits and rodents. These impacts include devastating effects upon native fauna, flora, geomorphology, natural landscape values and nutrient recycling systems. Rabbits favour the large leafy megaherbs and grasses, which have no adaptations to cope with grazing. These vegetation types provide critical breeding habitat for a range of burrowing petrel and albatross species. Rabbit grazing is changing areas of tall tussock grassland to modified forms of herbfield, thereby affecting the breeding success of all burrowing seabird colonies on Macquarie Island. The loss of vegetation also causes destabilisation and erosion of steep peat-covered slopes, which also impacts on albatross, penguin and petrel nesting sites. Black rats prey on seabird chicks and eggs, invertebrates and also impede plant seedling recruitment. Black rats are identified as an ongoing threat to at least nine bird species that currently breed on Macquarie Island. House mice feed primarily on vegetation matter and inhibit plant regeneration through seedling recruitment and seed consumption. They are known to predate invertebrate

	species and may have had a significant impact on invertebrate populations on Macquarie Island. They may also predate burrowing seabird eggs and chicks. On other subantarctic islands they have been shown to feed on chicks of large albatross species. Up to 24 bird species are expected to benefit from a pest eradication operation on Macquarie Island. Twelve of these bird species are listed as threatened under Tasmanian and/or Commonwealth threatened species legislation. It can be expected that many seabird species would rapidly re-colonise the island given habitat restoration and removal of predatory rodents." (Source: Summary of Plan for the Eradication of Rabbits and Rodents on Subantarctic Macquarie Island 2007 http://www.parks.tas.gov.au/publications/tech/mi_pest_eradication/summary.html) <u>Penguins</u> Interactions between penguins and the trawl gear are not seen as serious concerns (Wienecke and Robertson 2002). Rockhopper penguins were the most frequently recorded species on a survey in 1999 (Eades 2001) however no interactions with gear have been recorded. <u>Chondrichthyans</u> Sleeper sharks *Somniosus antarcticus* are thought to be abundant in the Aurora Trough and therefore more susceptible. They are usually tagged and released unless obviously dead.
Habitat issues and interactions	<u>Benthic damage by trawl gear</u> The impacts of demersal and mid-water trawl fishing on habitats have to date not been assessed in detail for the Antarctic fisheries. However, in the established fishing grounds invertebrate bycatch has declined to less than 5%, while in new grounds or other grounds the catch is 30%, suggesting disturbance from trawling. Since coral/sponges are susceptible to trawling and have very specific habitat requirements and slow growth, the impact of trawling in new areas should be considered carefully and monitored. Butler *et al.* (2000) found that the fishery targets only sediment –filled troughs and canyons and therefore impacts only a small area of the seabed. However the impact on the infauna of these sediments is unknown. <u>Habitat Protection</u> A Commonwealth Marine Protected Area has been established in the Macquarie Island region. This and State Waters protect about 40% of the seabed area in the central section of the Macquarie Ridge where the known fishing grounds occur. The Macquarie Island Marine Park comprises almost one-third of the Australian Fishing Zone around Macquarie Island and contains the world's largest 'no take' area. Around two-thirds of the area of the park is zoned as IUCN category IV - habitat/species management area. Under the management plan currently being developed for the Marine Park, fishing in accordance with a concession granted by AFMA will be allowed in this zone, subject to any determinations or permits made by the Director of National Parks.
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 both the HIMI fishery that lies within CCAMLR's jurisdiction and the Macquarie Island fishery that lies outside CCAMLR's authority. In addition, the establishment of an MPA at Macquarie Island in 1999 and the continued monitoring of top predators both in terms of diet, reproductive rates and overall abundance are seen as key actions in the preservation of community ecosystems. The information available on each species will be reviewed annually by the Sub-Antarctic Fishery Assessment Group (SAFAG) and CCAMLR with the aim of continuing to develop specific bycatch limits based on population assessments. This review will incorporate data from the monitoring program including observer data and shot-by-shot logbook information recorded by industry, and will include information learned from fisheries in other parts of the world (eg sleeper sharks).

	(Source: http://www.afma.gov.au/corporate%20publications/plans/bycatch%20action%20plans/subantarctic%20-%20bycatch%20action%20plan%20-%20background%20paper.php)
Discarding	Discarding regulations: There is no restriction on the return of live un-wanted by-catch in a manner so as to maximise survival. Operators must ensure that there is no offal (waste products from fish processing) or unwanted dead fish discharged from the fishing boat. These are generally converted to fishmeal and stored on-board. However, in the event of fishmeal becoming hot, having a high moisture content or otherwise becoming dangerous, it may be disposed of under strict contingency arrangements. There is also a prohibition on the disposal of poultry (including eggshells) and brassica (broccoli cabbage, cauliflower, brussel sprouts, kale etc) products
Management: planned and those implemented	
Management Objectives	The management objectives from Macquarie Island Toothfish Fishery Management Plan 2006 are: a) To manage the fishery efficiently and cost-effectively for the Commonwealth; b) To ensure exploitation of the resources of the fishery and carrying on of any related activities are conducted in a manner consistent with the principles of ecologically sustainable development and the exercise of 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 c) To maximise economic efficiency in the exploitation of the resources of the fishery; d) To ensure AFMA's accountability to the fishing industry and to the Australian community in management of the resources of the fishery; e) to reach Government targets for the recovery of the costs of AFMA in relation to the fishery ; f) To ensure through proper conservation and management that the living resources of the AFZ are not endangered by over-exploitation ; g) To achieve the best use of the living resources of the AFZ; h) 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 2006)
Fishery management plan	The Macquarie Island Toothfish Fishery Management Plan 2006 is not in force at this stage as the process for granting Statutory Fishing Rights needs to be completed. The Plan makes provision to grant half of the Statutory Fishing Rights in the two sectors of the Fishery (Aurora Trough and Macquarie Ridge) by a tender process expected in mid-June. (Source: AFMA 2006)
Input controls	The Macquarie Island Fishery is subject to the following standards with regard to target species: Entry is limited to 3 boats under the 2006 management Plan Entry is only granted to persons holding 25.5% of statutory fishing rights issued for the fishery CCAMLR standards include: • carriage of one full-time observer • vessel monitoring systems • target species catch limits Additionally, AFMA, with the support of industry, has implemented a number of requirements that exceed those of CCAMLR, including: • carriage of two full-time observers • one boat for the Macquarie Island Fishery (until the implementation of the new Management Plan 2006)

Output controls	Annual TACs for Patagonian toothfish for each of the two grounds are set each year. Carryover provision for Patagonian toothfish – each operator may inadvertently exceed their catch by no more than 20 tonnes. This over-catch is carried into the following year and deducted from that operator's quota, prior to the allocation of quota for the new fishing season. The disincentive to over-catch in one year is that for every 1 kg (between 10 and the 20 tonne maximum) taken as over-catch, 2 kg will be deducted from the operator's quota allocation the next year Bycatch limit of 200 tonnes for all finfish excluding Patagonian toothfish. (Source: AFMA 2006)
Technical measures	No other regulations apart from 3 nm (MIF) around all islands and the closed areas MPA at Macquarie Island (see Initiatives and Strategies). These areas protect species, habitats and communities.
Regulations	Regulations regarding incidental mortality of seabirds All practical measures must be made to mitigate the incidence of seabird and marine mammal mortality. By-Catch Action Plan to ensure catch of non-target fish including elasmobranch does not deplete populations to unacceptable levels, mitigate seabird and marine mammal mortality, minimise benthic impacts MARPOL regulations Operators must conform to marine pollution regulations Discarding regulations Operators must ensure that there is no offal (waste products from fish processing) or unwanted dead fish discharged from the fishing boat. These are generally converted to fishmeal and stored on-board. However, in the event of fishmeal becoming hot, having a high moisture content or otherwise becoming dangerous, it may be disposed of under strict contingency arrangements. There is also a prohibition on the disposal of poultry (including eggshells) and brassica (broccoli cabbage, cauliflower, brussel sprouts, kale etc) products Code Of Conduct to ensure compliance with permit conditions particularly environmental issues.
Initiatives and strategies	Macquarie Island Marine Protected Area The south-east section of the AFZ has been designated as a marine park. The Macquarie Island Marine Park was proclaimed under the *National Parks and Wildlife Conservation Act 1975* (NPWC Act) on 27 October 1999 to protect the unique and vulnerable marine ecosystems of the south-eastern portion of the Macquarie Island Region. The NPWC Act was replaced by the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) on 16 July 2000. The proclamation of the Marine Park is continued in force by the *Environmental Reform (Consequential Provisions) Act 1999* as if it had been made under the EPBC Act.

<table>
<tr>
<td></td>
<td>




Map source: http://www.deh.gov.au/coasts/mpa/macquarie/maps/boundary.html

Waters around Macquarie Island from the three nautical mile boundary out to generally 200 nautical miles from the islands (the remainder of the AFZ) are under Commonwealth jurisdiction and fishing in these waters is managed by AFMA under the *Fisheries Management Act 1991*.

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.
</td>
</tr>
<tr>
<td>Enabling processes</td>
<td>There are detailed management plans for Patagonian toothfish and non-target species.
Catches and landings are monitored by logbooks and observer data.
Stock assessments on target species are conducted annual by SAFAG.
The By-catch Action Plan is reviewed biannually and outcomes are reported against performance indicators.</td>
</tr>
<tr>
<td>Other initiatives or agreements</td>
<td>While the Macquarie Island fishery lies outside CCAMLR's authority, AFMA has recognised CCAMLR's approach to ecosystem-based management and incorporated this approach in their management strategies for the fishery.</td>
</tr>
<tr>
<td>Data</td>
<td></td>
</tr>
<tr>
<td>Logbook data</td>
<td>All Australian operators are required to complete electronic catch and effort logbooks with total coverage.</td>
</tr>
<tr>
<td>Observer data</td>
<td>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.</td>
</tr>
<tr>
<td>Other data</td>
<td>A tagging program for toothfish began in 1995/96 and has continued in order to investigate the movements of toothfish and the effect of fishing in surrounding areas and</td>
</tr>
</table>

	the likelihood of refuge areas and to provide an assessment of the size of population affected by the fishery. Collections of biological data were undertaken during fishing voyages by AFMA observers, co-ordinated by AAD. A pilot genetic study of toothfish stock structure developed micro satellite techniques to differentiate two stocks. A larger project using larger sample sizes was initiated following the pilot study. A research voyage on FRV Southern Surveyor was conducted in 1999 to investigate the biological oceanography around the island. An extensive acoustic and trawl survey was also conducted.

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 *Macquarie Island Demersal 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.

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

<u>Byproduct species *Macquarie Island Demersal Trawl Fishery*</u>

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

Species Number	Taxa	Family name	Scientific name	Common name	CAAB code
826	Chondrichthyan	Squalidae	*Etmopterus granulosus*	Southern lantern shark	37020021
2773	Invertebrate		*Actinaria - undifferentiated*	Anthozoan sea anemone	14410000
1284	Invertebrate	Ommastrephidae	*Martialia hyadesi*	Flying squid	23636003
45	Invertebrate	Ommastrephidae	*Nototodarus sloanii*	Flying squid	23636006
46	Invertebrate	Ommastrephidae	*Todarodes filippovae*	Southern Ocean arrow squid	23636011
2787	Invertebrate	Asteroidea	*Asteroidea*	Sea star	26200000
2788	Invertebrate	Echinoidea	*Echinoidea*	Sea urchin	26300000
1328	Invertebrate	Pasiphaeidae	*Pasiphaea sp.*	Carid shrimp	28745901
80	Invertebrate	Lithodidae	*Lithodes murrayi*	Subantarctic king crab	28836005
2967	Invertebrate	Octocorallia	*Gorgonaceae*	Gorgonian sea fan	
2789	Invertebrate	Salpidae	*Salpidae*	Salp	
2948	Invertebrate		*Pennatulacea*	Sea pen	
2951	Invertebrate	Gorgonocephalidae	*Gorgonocephalidae*	Gorgans head sea star	
2938	Invertebrate		*Holothurian*	Sea cucumber	
2784	Invertebrate	Ocythoe tuberculata	*Octopus (pelagic)*	Pelagic octopus	
2940	Invertebrate		*Histioteuthis sp.*	Squid	
2781	Invertebrate		*Loligo sp.*	Squid	
2953	Invertebrate	Cirroteuthidae	*Cirroteuthis sp.*	Squid	
1981	Teleost	NA	*Porifera - undifferentiated*	Sponges	10000000
489	Teleost	Squalidae	*Centroscymnus crepidater*	Deepwater dogfish	37020012
626	Teleost	Synaphobranchidae	*Diastobranchus capensis*	Basket-work eel	37070001
35	Teleost	Nemichthyidae	*Labichthys yanoi*	Snipe eel	37076004
37	Teleost	Bathylagidae	*Bathylagus antarcticus*	Deep sea smelt	37098002
2881	Teleost	Gonostomatidae	*Photichthys sp.*	Bristlemouth	37106801
2902	Teleost	Stomiidae	*Stomias sp.*	Scaleless dragonfish	37112800

Species Number	Taxa	Family name	Scientific name	Common name	CAAB code
273	Teleost	Anotopteridae	*Anotopterus pharao*	Daggerfish	37129001
2934	Teleost	Gigantactis	*Gigantactinidae*	Whipnose angler fish	37217000
274	Teleost	Ceratiidae	*Ceratias tentaculatus*	Seadevil	37220003
997	Teleost	Moridae	*Mora moro*	Ribaldo	37224002
275	Teleost	Moridae	*Antimora rostrata*	Morid cod	37224008
276	Teleost	Moridae	*Halargyreus johnsonii*	Morid cod	37224009
277	Teleost	Moridae	*Lepidion microcephalus*	Ribaldo (market name -morid cod) : smallhead cod	37224010
2822	Teleost	Carapidae	*Echiodon cryomargarites*	Pearlfish	37229000
280	Teleost	Zoarcidae	*Melanostigma gelatinosum*	Eelpout	37231001
281	Teleost	Macrouridae	*Coryphaenoides serrulatus*	Whiptail	37232015
284	Teleost	Macrouridae	*Coryphaenoides subserrulatus*	Whiptail	37232016
323	Teleost	Macrouridae	*Caelorinchus matamua*	Whiptail	37232017
334	Teleost	Macrouridae	*Caelorinchus kaiyomaru*	Whiptail	37232031
342	Teleost	Macrouridae	*Idiolophorhynchus andriashevi*	Rattail/whiptail/grenadier	37232037
343	Teleost	Macrouridae	*Caelorinchus kermadecus*	Whiptail	37232040
374	Teleost	Macrouridae	*Coryphaenoides murrayi*	Whiptail	37232052
536	Teleost	Macrouridae	*Cynomacrurus piriei*	Rattail/whiptail/grenadier	37232054
1479	Teleost	Macrouridae	*Macrourus whitsoni*	[A whiptail]	37232753
537	Teleost	Melamphaidae	*Poromitra crassiceps*	Bigscale	37251004
631	Teleost	Oreosomatidae	*Pseudocyttus maculatus*	Smooth oreo	37266003
644	Teleost	Lampridae	*Lampris immaculatus*	Southern moonfish	37268002
773	Teleost	Gempylidae	*Paradiplospinus gracilis*	Snake mackerel/gemfish	37439005
2845	Teleost	Macrouridae	*Macrourus holotrachys*	[A whiptail]	
1464	Teleost	Zoarcidae	*Melanostigma sp.*	An eelpout (undifferentiated)	
333	Teleost	Nototheniidae	*Pagothenia sp.*	An icefish/notothen	
573	Teleost	Macrouridae	*Nezumia pudens*	Atacam grenadier	
788	Teleost	Paralepididae	*Magnisudis prionosa*	Barracudina	
2946	Teleost	Apogonidae	*Epigonus sp.*	Cardinal fish	
2977	Teleost	Nemichthyidae	*Nemichthyidae*	Eel	
575	Teleost	Psychrolutidae	*Neophrynichthys magnicirrus*	Fathead	

Species Number	Taxa	Family name	Scientific name	Common name	CAAB code
2936	Teleost	Bothidae	*Pseudoachiropsetta milfordi*	Flounder	
1461	Teleost	Muraenolepididae	*Muraenolepis sp.*	Morid cod (undifferentiated)	
2927	Teleost	Oreosomatidae	*Neocyttus sp.*	Oreo dory	
2922	Teleost	Alepocephalidae	*Alepocephalus spp.*	Slickhead	
576	Teleost	Cyclopteridae	*Paraliparis gracilis*	Snailfish/lumpfish	
1472	Teleost	Achiropsettidae	*Achiropsetta sp. (grey)*	Southern flounder	
1473	Teleost	Achiropsettidae	*Mancopsetta sp.*	Southern flounder	
2933	Teleost	Astronesthidae	*Astronesthes sp.*	Spangled trouble- shouter	
574	Teleost	Congiopodidae	*Zanclorhynchus spinifer*	Spiny horsefish	
2945	Teleost	Chauliodontidae	*Chauliodus sloani*	Viper fish	
2928	Teleost	Psychrolutidae	*Ebinania sp.*	Blobfish	
2833	Teleost	Myctophidae	*Gymnoscopelus opisthopterus*	Lantern fish	
2923	Teleost	Himantolophidae	*Himantolophus sp.*	Football fish	
2924	Teleost	Oneroididae	*Oneirodes sp.*	Dreamer fish	
2925	Teleost	Moridae	*Paralaemonema sp.*	Morid cod	
36	Teleost	Notacanthidae	*Notacanthus chemnitzii*	Spiny eel	37083002
1457	Teleost	Melanostomiidae	*Melanostomias sp.*	Scaleless dragonfish	

Discard species *Macquarie Island Demersal Trawl Fishery*

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

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

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

Species Number	Taxa	Family name	Scientific name	Common name	CAAB code
257	Chondrichthyan	Squalidae	*Somniosus antarcticus*	Sleeper shark; Southern Sleeper Shark	37020036
2709	Invertebrate	Subclass Zoantharia (Hexacorallia)	*Hexacorallia*	Tube anemone, black and thorny corals	11228000
298	Invertebrate	Periphyllidae	*Periphylla periphylla*	Jellyfish	

<u>TEP species *Macquarie Island Demersal Trawl Fishery*</u>
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
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
817	Marine bird	Spheniscidae	*Eudyptes robustus*	Snares penguin	40001006
818	Marine bird	Spheniscidae	*Eudyptes sclateri*	Erect-crested penguin	40001007
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
1033	Marine bird	Diomedeidae	*Thalassarche cauta*	Shy Albatross	40040002
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

Species Number	Taxa	Family name	Scientific name	Common Name	CAAB code
799	Marine bird	Diomedeidae	*Diomedea sanfordi*	Northern Royal Albatross	40040012
1084	Marine bird	Diomedeidae	*Thalassarche impavida*	Campbell Albatross	40040013
894	Marine bird	Diomedeidae	*Thalassarche salvini*	Salvin's albatross	40040016
889	Marine bird	Diomedeidae	*Thalassarche eremita*	Chatham albatross	40040017
1428	Marine bird	Diomedeidae	*Diomedea amsterdamensis*	Amsterdam Albatross	40040018
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
487	Marine bird	Procellariidae	*Pachyptila belcheri*	Thin billed prion	40041009
1532	Marine bird	Procellariidae	*Pachyptila crassirostris*	Fulmar prion	40041010
488	Marine bird	Procellariidae	*Pachyptila desolata*	Antarctic prion	40041011
1003	Marine bird	Procellariidae	*Pachyptila turtur*	Fairy Prion	40041013
492	Marine bird	Procellariidae	*Pelecanoides georgicus*	South Georgian diving petrel	40041016
1006	Marine bird	Procellariidae	*Pelecanoides urinatrix*	Common Diving-Petrel	40041017
1041	Marine bird	Procellariidae	*Procellaria aequinoctialis*	White-chinned Petrel	40041018
494	Marine bird	Procellariidae	*Procellaria cinerea*	Grey petrel	40041019
503	Marine bird	Procellariidae	*Pterodroma inexpectata*	Mottled petrel	40041028
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
1049	Marine bird	Procellariidae	*Pterodroma neglecta*	Kermadec Petrel (western)	40041033
1053	Marine bird	Procellariidae	*Puffinus assimilis*	Little Shearwater (Tasman Sea)	40041036
1056	Marine bird	Procellariidae	*Puffinus gavia*	Fluttering Shearwater	40041040
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

Species Number	Taxa	Family name	Scientific name	Common Name	CAAB code
555	Marine bird	Hydrobatidae	*Garrodia nereis*	Grey-backed storm petrel	40042003
556	Marine bird	Hydrobatidae	*Oceanites oceanicus*	Wilson's storm petrel (subantarctic)	40042004
290	Marine bird	Phalacrocoracidae	*Leucocarbo atriceps*	Imperial shag (Macquarie Island)	40048001
291	Marine bird	Phalacrocoracidae	*Phalacrocorax carbo*	Black cormorant	40048002
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
1024	Marine bird	Laridae	*Sterna striata*	White-fronted Tern	40128033
292	Marine bird	Laridae	*Sterna vittata*	Antarctic tern (NZ)	40128035
589	Marine bird	Laridae	*Catharacta lonnbergi lonnbergi*	Subantarctic skua (southern)	
588	Marine bird	Phalacrocoracidae	*Phalacrocorax albiventer purpurascens*	King cormorant	
586	Marine bird	Spheniscidae	*Eudyptes schlegeli*	Royal penguin	
896	Marine mammal	Balaenidae	*Eubalaena australis*	Southern right whale	41110001
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
1439	Marine mammal	Balaenidae	*Balaenoptera bonaerensis*	Antarctic minke whale	41112007
935	Marine mammal	Delphinidae	*Globicephala melas*	Long-finned Pilot Whale	41116004
937	Marine mammal	Delphinidae	*Grampus griseus*	Risso's dolphin	41116005
832	Marine mammal	Delphinidae	*Lagenorhynchus cruciger*	Hourglass dolphin	41116007
971	Marine mammal	Delphinidae	*Lagenorhynchus obscurus*	Dusky dolphin	41116008
61	Marine mammal	Delphinidae	*Lissodelphis peronii*	Southern right whale dolphin	41116009
1002	Marine mammal	Delphinidae	*Orcinus orca*	Killer whale	41116011
1091	Marine mammal	Delphinidae	*Tursiops truncatus*	Bottlenose dolphin	41116019
833	Marine mammal	Phocoenidae	*Australophocoena dioptrica*	Spectacled porpoise	41117001
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

Species Number	Taxa	Family name	Scientific name	Common Name	CAAB code
985	Marine mammal	Ziphiidae	*Mesoplodon bowdoini*	Andrew's beaked whale	41120004
986	Marine mammal	Ziphiidae	*Mesoplodon densirostris*	Blainville's beaked whale	41120005
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
216	Marine mammal	Otariidae	*Arctocephalus forsteri*	New Zealand Fur-seal	41131001
293	Marine mammal	Otariidae	*Arctocephalus gazella*	Antarctic fur seal	41131002
263	Marine mammal	Otariidae	*Arctocephalus tropicalis*	Subantarctic fur seal	41131004
294	Marine mammal	Otariidae	*Phocarctos hookeri*	Hooker's sea lion	41131006
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

Scoping Document S2B1 & 2. Habitats

Not assessed

Scoping Document S2C1. Demersal Communities

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

Demersal communities in which fishing activity occurs the MIF Demersal 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]																			x
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]																			
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 (250-1100m). At Heard/McDonald Is: [4]outer and upper slope plateau communities combined to form four communities: Shell Bank, inner and outer Heard Plateau (100-500m) and Western Banks (200-500m), [5]mid and upper plateau communities combined into 3 trough (Western, North Eastern and South Eastern), southern slope and North Eastern plateau communities (500-1000m), and [6] 3 groups at Heard Is: Deep Shell Bank (>1000m), Southern and North East Lower slope/abyssal, [7]Great Barrier Reef in the North Eastern Province and Transition and [8] Rowley Shoals in North Western Transition.

Scoping Document S2C2. Pelagic Communities

Pelagic communities that overlie the demersal communities in which fishing activity occurs in the MIF Demersal 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]								
Oceanic (1) 0-1000m								
Oceanic (2) >1000m								
Oceanic (1) 0-1600m								x
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.

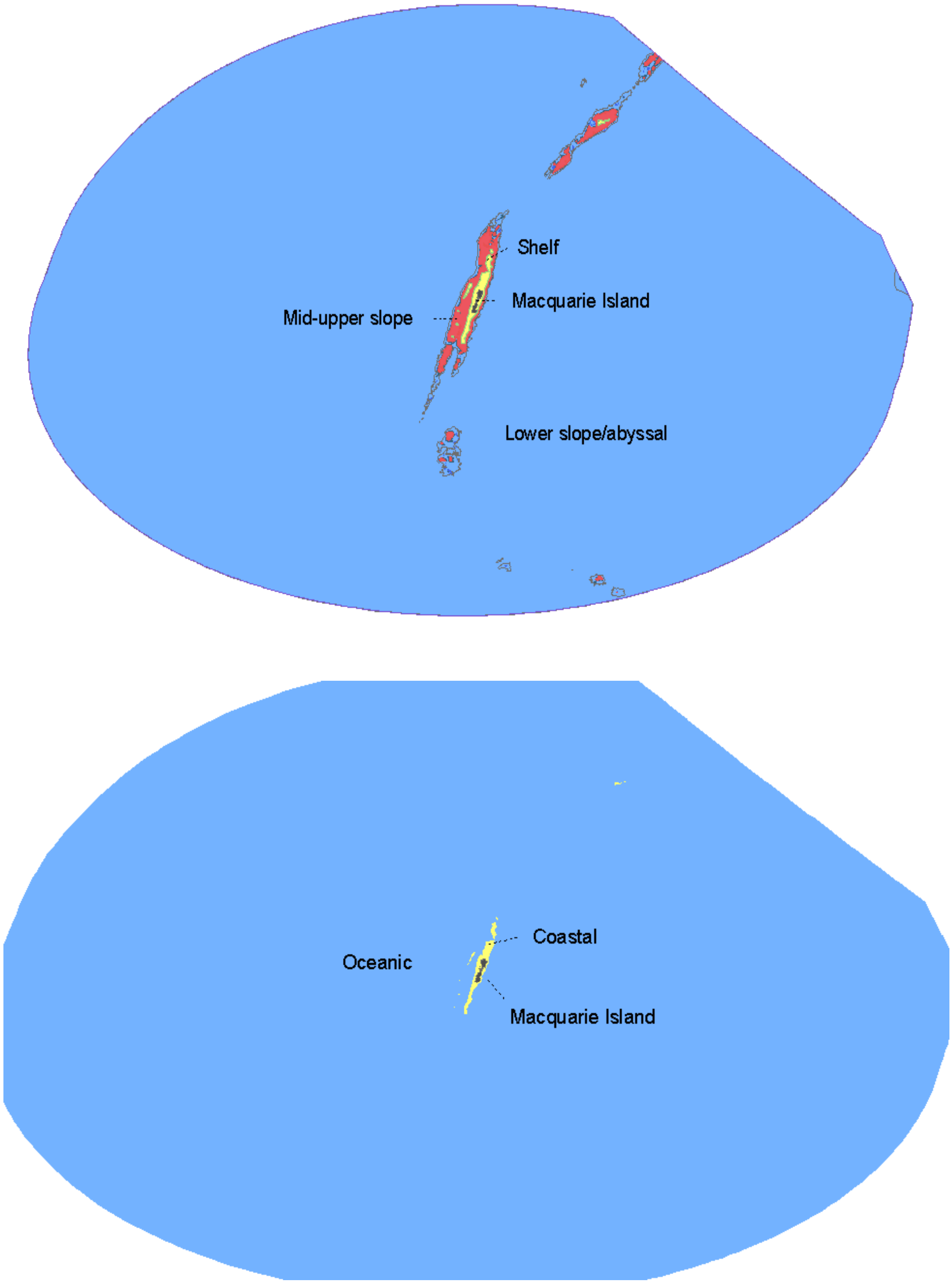


Fig S1**. (a) Demersal and (b) pelagic communities in the Macquarie Island Fishery.**

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

Table (Note: Operational objectives that are eliminated should be shaded out and a rationale provided as for the retained operational objectives)

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 interdependent from Macquarie.
		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 region
		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.
		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.
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. 1.4Maintaining bycatch/byproduct levels not a specific objective. The protection of bycatch by TACs based on precautionary principles is the preferred method.

Component	Core Objective	Sub-component	Example Operational Objectives	Example Indicators	Rationale
		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.
		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 – if bycatch exceeds 200 tonnes the fishery is reviewed
		5 Reproductive Capacity	5.1 Fecundity of the population does not change outside acceptable bounds (e.g. more than X% of reference population fecundity) Recruitment to the population does not change outside acceptable bounds	Egg production of population Abundance of recruits	5.1 Beyond the generality of the EMO “Fishing is conducted in a manner that does not threaten stocks of byproduct / bycatch species”, reproductive capacity is not currently measured for bycatch/byproduct species and is largely covered by other objectives.
		6. Behaviour /Movement	6.1 Behaviour and movement patterns of the population do not change outside acceptable bounds	Presence of population across space, movement patterns within the population (e.g. attraction to bait, lights)	6.1 Trawling does not appear to attract bycatch species or alter their behaviour and movement patterns, resulting in the attraction of species to fishing grounds.

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

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

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

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

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

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

2.2.4 Hazard Identification (Step 4)

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

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

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

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

Scoping Document S4. Hazard Identification Scoring Sheet

This table is completed once for each sub-fishery. **Table 4** provides a set of examples of fishing activities for the effects of fishing to be used as a guide to assist in scoring the hazards.
Sub-fishery Name: Demersal trawl
Fishery Name: Macquarie Island Fishery
Date completed: 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	
	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, fish escaping net.
	Incidental behaviour	0	
	Gear loss	1	Nets are towed on bottom and there have been several instances of major gear loss
	Anchoring/ mooring	0	Not recorded.
	Navigation/steaming	1	Direct interaction while vessel is steaming.
Addition/ movement of biological material	Translocation of species (boat launching, reballasting)	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 eg: MDO (marine diesel oils) vs HFO (heavy fuel oil)
	Gear loss	1	Several instances of major gear loss and numerous minor ones.
	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	Benthos 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 targeting toothfish using longlines. Area too remote for indigenous or recreational fishers.
	Aquaculture	0	None
	Coastal development	0	None
	Other extractive activities	0	None known.
	Other non-extractive activities	0	None known.
	Other anthropogenic activities	1	Tourist shipping and landings by tourists

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

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

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

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

2.2.5 Bibliography (Step 5)

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

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

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

Other publications that may provided information include

- BRS Fishery Status Reports
- Strategic Plans

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

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

In this case, 14 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 16 activity-component scenarios will be considered at Level 1. This results in 80 total scenarios (of 160 possible) to be developed and evaluated using the unit lists (species, habitats, communities).

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

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

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

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

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

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

Record the hazard identification score absence (0) presence (1) identified at Step 3 at the scoping level onto the SICA sheet. A separate sheet will be required for each component (target, bycatch and byproduct, and TEP species, habitat, and communities). Only those activities that scored a 1 (presence) will be analysed at Level 1

2.3.2 Score spatial scale of activity (Step 2)

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

Spatial scale score of activity

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

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

2.3.3 Score temporal scale of activity (Step 3)

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

Temporal scale score of activity

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

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

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

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

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

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

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

2.3.6 Select the most appropriate operational objective (Step 6)

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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 5, Appendix B).

2.3.1 Level 1 (SICA) Documents

L1.1 - Target 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									
	Fishing	1	3	3	Population size	Patagonian toothfish *Dissostichus eleginoides*	1.1	3	3	2	The Aurora Trough and the Northern Valleys fishing grounds are less than 100 nm wide. Fishing occurs from October to March but about 30 days per year. Population size most likely to be affected by capture fishing. Patagonian toothfish only target species. Catches restricted to research TACs for majority of seasons at Aurora Trough 1999 since to allow stock recovery but TAC has not been reached on the Northern Valley grounds. Commercial TACs set for past 2 seasons indicating apparent recovery of stock. =>intensity moderate =>Consequence moderate as TACs fully caught in Aurora Trough when set and indicates stock is fully exploited although stock declined on Northern Valleys ground. TAC levels being annually reviewed and adjusted to maintain fishery =>Confidence high 100% observer coverage, and research conducted in the fishery to date
	Incidental behaviour	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
Direct impact without capture	Bait collection	0									
	Fishing	1	3	3	Age/Size/Sex structure	Patagonian toothfish *Dissostichus eleginoides*	4.1	3	2	2	Mesh sizes prescribed to ensure maximum escapement of specific size classes. Post-capture survival might be at risk if fish pass through meshes. While successes of tagging studies indicate good survival, different capture methods and subsequent escape will influence survival. Biology of toothfish e.g. no air filled swim bladder suggests relatively high likelihood of post-capture survival. Catches restricted to research TACs for majority of seasons at Aurora Trough 1999 since to allow stock recovery but TAC has not been reached on the Northern Valley grounds. Commercial TACs set for past 2 seasons indicating apparent recovery of stock. =>intensity moderate =>Consequence scored as minor assuming good survival rate =>Confidence high as tagging surveys successful.
	Incidental behaviour	0									
	Gear loss	1	3	3	Population size	Patagonian toothfish *Dissostichus eleginoides*	1.1	2	2	2	Annual gear loss small. Only one vessel in the fishery =>intensity minor =>consequence minor =>Confidence high, due to records from the Macquarie fishery regarding gear loss.
	Anchoring/ mooring	0									
	Navigation/ steaming	1	3	3	Population size	Patagonian toothfish *Dissostichus eleginoides*	1.1	1	1	2	Navigation/steaming occur on about 30 days per year. Population size most likely to be affected by collision of fish with vessel =>intensity negligible =>consequence negligible unlikely for deepwater demersal species to collide with vessel =>Confidence

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
											high, 100% observer coverage and logic would indicate minimal impact.
Addition/ movement of biological material	Translocation of species	1	6	3	Population size	Patagonian toothfish *Dissostichus eleginoides*	1.1	1	2	1	Translocation of species via ballast or hull-fouling could occur while vessel on the grounds about 30 days per year. Population size most likely to be affected =>intensity negligible as remote likelihood of detection because the likelihood of temperate water species surviving and establishing as a threat to Patagonian toothfish in sub-Antarctic waters is considered negligible. =>consequence minor to recognize the potential for the spread of fish borne disease =>Confidence low, no data on susceptibility of Patagonian toothfish to fish borne diseases or evidence that translocation has occurred.
	On board processing	0									
	Discarding catch	0									
	Stock enhancement	0									
	Provisioning	0									
	Organic waste disposal	1	6	3	Behaviour/movement	Patagonian toothfish *Dissostichus eleginoides*	6.1	1	1	2	Vessels do not dispose of any plastic rubbish, or poultry products and comply strictly with MARPOL regulations therefore organic waste discharge could only be accidental; target species depths>400m therefore cannot alter behaviour of fish =>intensity negligible =>consequence negligible =>confidence high, 100% observer coverage, compliance to regulations

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 of non-biological material	Debris	1	3	3	Population size	Patagonian toothfish *Dissostichus eleginoides*	1.1	1	1	2	One vessel in the fishery complies not only with MARPOL regulations restricting the deliberate disposal of debris but also has installed signs/notices in the accommodation to remind/educate the crew as to their legal obligations for disposal of debris. =>Intensity negligible. =>consequence negligible as even accidental loss unlikely to affect deepwater species =>Confidence high, 100% observer coverage, as the regulations limit debris being deliberately thrown overboard.
	Chemical pollution	1	3	2	Behaviour/movement	Patagonian toothfish *Dissostichus eleginoides*	6.1	2	2	2	Chemical pollution might only occur accidentally and rarely. One vessel in the fishery complies not only with MARPOL regulations restricting the deliberate disposal of chemical pollution but also has installed signs/notices in the accommodation to remind/educate the crew as to their legal obligations for disposal of chemicals. =>Intensity minor =>consequence of accidental disposal to target species minor. =>Confidence high100% observer coverage and regulations limit chemicals being deliberately dumped at sea.
	Exhaust	1	3	3	Behaviour/movement	Patagonian toothfish *Dissostichus eleginoides*	6.1	1	1	2	Exhaust emissions occur daily over 30 days. =>intensity and consequence 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

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
											due to depth of water column separating target species from emissions.
	Gear loss	1	3	3	Behaviour/movement	Patagonian toothfish *Dissostichus eleginoides*	6.1	2	2	1	Annual gear loss small and the impact on habitat of the target species small and therefore unlikely to impact behaviour/movement of target species =>The limited number of vessels in the fishery coupled with the type of gear in use indicates a minor intensity =>consequence minor =>Confidence low, 100% observer coverage but no data on effect of alteration of habitat on toothfish.
	Navigation/ steaming	1	3	3	Behaviour/movement	Patagonian toothfish *Dissostichus eleginoides*	6.1	1	1	2	Navigation/steaming occurs daily over 30 days =>intensity negligible due to the limited number of vessels in the fishery. =>Consequence negligible, target species likely too deep and mobile to be impacted by noise or echo sounding from vessel =>Confidence high, logic.
	Activity/ presence on water	1	3	3	Behaviour/movement	Patagonian toothfish *Dissostichus eleginoides*	6.1	1	1	2	Only one vessel present and active daily over about 30 days. =>Intensity negligible =>Consequence negligible target species too deep and mobile to be impacted by surface activity =>Confidence high, logic
	Bait collection	0									

Direct impact of fishing	Fishing activity	Presence (1) Absence (0)	Spatial scale of Hazard (1-6)	Temporal scale of Hazard (1-6)	Sub-component	Unit of analysis	Operational objective (S2.1)	Intensity Score (1-6)	Consequence Score (1-6)	Confidence Score (1-2)	Rationale
Disturb physical processes	Fishing	1	3	3	Behaviour/movement	Patagonian toothfish *Dissostichus eleginoides*	6.1	3	2	1	Fishing occurs daily over about 30 days =>intensity moderate as localized grounds are repeatedly targeted =>Consequence minor, only a small area is affected and gear designed to minimize impact on seabed. Local changes in habitat could affect distribution of habitat-dependent species but unlikely to detect change in distribution of toothfish =>Confidence low due to lack of data from the Macquarie fishery regarding effects of benthos disturbance.
	Boat launching	0									
	Anchoring/ mooring	0									
	Navigation/ steaming	1	3	3	Behaviour/movement	Patagonian toothfish *Dissostichus eleginoides*	6.1	2	1	2	Navigation/steaming occurs daily over about 30 days =>Intensity minor due to the limited number of vessels in the fishery. =>Consequence negligible as target species too deep for vessel to alter relevant physical processes to be detectable beyond natural variation =>Confidence high, logic.
External Impacts (specify the particular example within each activity area)	Other fisheries	1	6	3	Population size	Patagonian toothfish *Dissostichus eleginoides*	1.1	2	1	2	No other fisheries operate in the AFZ. Only one alleged case of IUU fishing to have occurred in the AFZ. Fishing outside AFZ (e.g. in adjacent New Zealand AFZ) not likely to affect this species =>Intensity minor =>Consequence negligible =>Confidence high -AFMA reports no activity
	Aquaculture	0									
	Coastal development	0									
	Other extractive activities	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
	Other non extractive activities	0									
	Other anthropogenic activities	1	4	4	Behaviour/movement	Patagonian toothfish *Dissostichus eleginoides*	6.1	1	1	2	Research and tourism and the passage of research/tourist vessels. =>Intensity negligible due to the limited number of vessels/visits/groups per year. =>Consequence is seen as negligible, as target species too deep and mobile to be impacted =>Confidence was recorded as high due to data regarding numbers and activities indicates 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	Southern Sleeper shark *Somniosus antarcticus*	1.1	3	3	2	The Aurora Trough and the Northern Valleys fishing grounds are less than 100 nm wide. Fishing occurs from October to March but about 30 days per year. Population size of Southern sleeper shark most likely to be affected before other sub-components as its productivity considered much lower than bycatch species. Fishing has been restricted to research TACs for majority of seasons at Aurora Trough since 1999 to allow stock recovery but commercial TACs have been set for past 2 seasons and have been caught suggesting full exploitation of toothfish. TACs have not been caught on the Northern Valley grounds suggesting reduction in biomass. =>Intensity moderate =>Consequence rated as moderate although there are concerns that various deepwater dogfishes have been overfished =>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	Southern Sleeper shark *Somniosus antarcticus*	1.1	2	2	2	Population size most likely to be affected before other sub-components as productivity of Southern sleeper shark considered much lower than bycatch species and post-capture mortality for many sharks is high =>Intensity minor =>Consequence rated as minor as detection of change due to escapement by sleeper sharks low =>Confidence high due data collection by observers and research conducted in the fishery to date.
	Incidental behaviour	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
	Gear loss	1	3	3	Population size	Southern Sleeper shark *Somniosus antarcticus*	1.1	2	2	2	Annual gear loss small =>intensity minor; only one vessel in the fishery =>consequence minor =>Confidence high, 100% observer coverage records al gear loss from Macquarie fishery.
	Anchoring/ mooring	0	0	0							
	Navigation/ steaming	1	3	3	Behaviour/movement	Southern Sleeper shark *Somniosus antarcticus*	6.1	1	1	2	Navigation/steaming occurs on about 30 days per year. Population size most likely to be affected by collision of fish with vessel =>intensity negligible =>consequence negligible unlikely for deepwater demersal species to collide with vessel =>Confidence high, 100% observer coverage and logic would indicate minimal impact.
Addition/ movement of biological material	Translocation of species	1	6	3	Population size	Southern Sleeper shark *Somniosus antarcticus*	1.1	1	2	1	Translocation of species via ballast or hull-fouling could occur while vessel on the grounds about 30 days per year. Population size most likely to be affected =>intensity negligible as remote likelihood of detection because the likelihood of temperate water species surviving and establishing as a threat to Sleeper shark in sub-Antarctic waters is considered negligible. =>consequence minor to recognize the potential for the spread of fishborne disease =>Confidence low, no data on susceptibility of Sleeper sharks to fishborne diseases or evidence that translocation has occurred.
	On board processing	0	0	0							
	Discarding catch	0	0	0							
	Stock enhancement	0	0	0							
	Provisioning	0	0	0							

Direct impact of fishing	Fishing activity	Presence (1) Absence (0)	Spatial scale of Hazard (1-6)	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
	Organic waste disposal	1	6	3	Behaviour/movement	Southern Sleeper shark *Somniosus antarcticus*	1.1	1	1	2	Vessels do not dispose of any plastic rubbish, or poultry products and comply strictly with MARPOL regulations therefore organic waste discharge could only be accidental; target species depths>400m therefore cannot alter behaviour of fish =>intensity negligible =>consequence negligible =>confidence high, 100% observer coverage, compliance to regulations
Addition of non-biological material	Debris	1	3	3	Population size	Southern Sleeper shark *Somniosus antarcticus*	1.1	1	1	2	One vessel in the fishery complies not only with MARPOL regulations restricting the deliberate disposal of debris but also has installed signs/notices in the accommodation to remind/educate the crew as to their legal obligations for disposal of debris. =>Intensity negligible. =>consequence negligible as even accidental loss unlikely to affect deepwater species =>Confidence high, 100% observer coverage, as the regulations limit debris being deliberately thrown overboard.
	Chemical pollution	1	3	2	Population size	Southern Sleeper shark *Somniosus antarcticus*	1.1	2	2	2	Chemical pollution, accidental, might only occur rarely. One vessel in the fishery complies not only with MARPOL regulations restricting the deliberate disposal of chemical pollution but also has installed signs/notices in the accommodation to remind/educate the crew as to their legal obligations for disposal of chemicals. =>Intensity minor =>consequence of accidental disposal to target species minor. =>Confidence high100% observer coverage and 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	Southern Sleeper shark *Somniosus antarcticus*	1.1	1	1	2	The Aurora Trough and the Northern Valleys fishing grounds are less than 100 nm wide. Exhaust emissions occurs daily during the season. =>intensity and consequence 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. 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	1	3	3	Population size	Southern Sleeper shark *Somniosus antarcticus*	1.1	2	2	1	Annual gear loss small and the impact on habitat of the target species small and therefore unlikely to impact behaviour/movement =>intensity minor; only one vessel in the fishery coupled with the type of gear in use =>minor consequence =>Confidence low, 100% observer coverage but no data on effect of alteration of habitat on toothfish.
	Navigation/ steaming	1	3	3	Behaviour/movement	Southern Sleeper shark *Somniosus antarcticus*	6.1	1	1	2	Navigation/steaming occurs daily over 30 days =>Intensity negligible due to the limited number of vessels in the fishery. =>Consequence negligible, sleeper sharks species likely too deep and mobile to be impacted by noise or echo sounding from vessel =>Confidence high, logic.
	Activity/ presence on water	1	3	3	Behaviour/movement	Southern Sleeper shark *Somniosus antarcticus*	6.1	1	1	2	Only one vessel present and active daily over about 30 days =>Intensity negligible =>Consequence negligible; Sleeper sharks too deep and mobile to be impacted by surface activity =>Confidence high, logic
	Bait collection	0	0	0							

Direct impact of fishing	Fishing activity	Presence (1) Absence (0)	Spatial scale of Hazard (1-6)	Temporal scale of Hazard (1-6)	Sub-component	Unit of analysis	Operational objective (S2.1)	Intensity Score (1-6)	Consequence Score (1-6)	Confidence Score (1-2)	Rationale
Disturb physical processes	Fishing	1	3	3	Behaviour/movement	Southern Sleeper shark *Somniosus antarcticus*	6.1	3	2	1	Fishing occurs daily over about 30 days =>intensity moderate as localized grounds are repeatedly targeted =>Consequence minor, only a small area is affected and gear designed to minimize impact on seabed. However local changes in habitat could affect distribution of habitat-dependent species =>Confidence low due to lack of data from the Macquarie fishery regarding effects of benthos disturbance.
	Boat launching	0	0	0							
	Anchoring/ mooring	0	0	0							
	Navigation/ steaming	1	3	3	Behaviour/movement	Southern Sleeper shark *Somniosus antarcticus*	6.1	2	1	2	Navigation/steaming occurs daily over about 30 days =>Intensity minor due to the limited number of vessels in the fishery. =>Consequence negligible as sharks too deep for vessel to alter relevant physical processes to be detectable beyond natural variation =>Confidence high, logic.
External Impacts (specify the particular example within each activity area)	Other fisheries	1	6	3	Population size	Southern Sleeper shark *Somniosus antarcticus*	1.1	2	1	2	No other fisheries operate in the AFZ. Only one alleged case of IUU fishing to have occurred in the AFZ. Fishing outside AFZ (e.g. in adjacent New Zealand AFZ) not likely to affect this species =>Intensity minor =>Consequence negligible =>Confidence high -AFMA reports no activity
	Aquaculture	0	0	0							
	Coastal development	0	0	0							
	Other extractive activities	0	0	0							
	Other non extractive activities	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
	Other anthropogenic activities	1	4	4	Behaviour/movement	Southern Sleeper shark *Somniosus antarcticus*	6.1	1	1	2	Research and tourism and the passage of research/tourist vessels. =>Intensity negligible due to the limited number of vessels/visits/groups per year. =>consequence negligible =>Confidence was recorded as high due to data regarding numbers and activities in the region.

L1.3 – TEP 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	0	0	0							
Fishing	1	3	3	Population size	Wandering albatross *Diomedea exulans*; Grey-headed albatross *Thalassarche chrysostoma*; Black-browed Albatross *Thalassarche melanophrys*	1.1	2	4	2	The Aurora Trough and the Northern Valleys fishing grounds are less than 100 nm wide. Fishing occurs from October to March but about 30 days per year. Population size most likely to be affected before other sub-components as albatross breeding populations are critically low (Robertson *et al*. 2005). About 10-20 pairs of Wandering albatross breed on the island =>Intensity minor as no birds have been killed in the fishery although 2 birds were killed at HIMI =>consequence scored as major because of the potential of an isolated/rare TEP interaction resulting in injury/mortality which could be critical to the reproductive success of species such as Wandering Albatross =>Confidence high 100% observer coverage and research conducted in the fishery to date.
Incidental behaviour	0	0	0							
Bait collection	0	0	0							
Fishing	1	3	3	Population size	Wandering albatross *Diomedea exulans*; Grey-headed albatross *Thalassarche chrysostoma*; Black-browed Albatross *Thalassarche melanophrys*	1.1	3	2	2	Population size most likely to be affected before other sub-components as albatross breeding populations are critically low (Robertson *et al*. 2005) and interactions resulting in injury might impact survival. => Intensity moderate as 13 great albatrosses have been recorded interacting with gear with no injury up to 2001 (Williams et al. 2001) =>Consequence minor even though no fatalities recorded, the potential for injury to rare species could have serious impact on species survival =>Confidence high, due to data collection by observers and research conducted in the fishery to date.
Incidental behaviour	0	0	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
Gear loss	1	3	3	Population size	Wandering albatross *Diomedea exulans*; Grey-headed albatross *Thalassarche chrysostoma*; Black-browed Albatross *Thalassarche melanophrys*	1.1	2	2	2	Annual gear loss small =>intensity minor; only one vessel in the fishery =>consequence minor =>Confidence high, 100% observer coverage records al gear loss from Macquarie fishery.
Anchoring/ mooring	0	0	0							
Navigation/steaming	1	3	3	Population size	Wandering albatross *Diomedea exulans*; Grey-headed albatross *Thalassarche chrysostoma*; Black-browed Albatross *Thalassarche melanophrys*	1.1	2	2	2	Navigation/steaming occurs daily over 30days. Population size most likely to be affected before other sub-components as albatross breeding populations are critically low (Robertson *et al.* 2005). =>Intensity minor, due to presence of vessel and observer data on seabirds around vessels. Seabirds have flown into vessels or fishing gear by accident. =>Despite mitigating factors including reduced lighting, bans on net-sonde cables, removal of protruding wires etc., and the low population levels of some albatross species result in a minor consequence score. =>Confidence high, due to data collection by observers and research conducted in the fishery to date.
Translocation of species	1	6	3	Population size	Wandering albatross *Diomedea exulans*; Grey-headed albatross *Thalassarche chrysostoma*; Black-browed Albatross *Thalassarche melanophrys*	1.1	1	2	2	Translocation could occur daily over 30 days vessel is present. Population size most likely to be affected before major changes in geographic range or genetic structure. Behaviour/movement unlikely to be immediately affected. =>Intensity rated as negligible due small number of vessels in fishery. =>Consequences minor, as the likelihood of temperate water species surviving and establishing as a threat to species in sub-Antarctic waters is remote. The potential for the spread of disease deserves future consideration. The ban on discharge of poultry products is a mitigating factor. =>Confidence

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
										high, due to data collection by observers and research conducted in the fishery to date.
On board processing	0	0	0							
Discarding catch	0	0	0							
Stock enhancement	0	0	0							
Provisioning	0	0	0							
Organic waste disposal	1	6	3	Behaviour/movement	Wandering albatross *Diomedea exulans*; Grey-headed albatross *Thalassarche chrysostoma*; Black-browed Albatross *Thalassarche melanophrys*	6.1	2	2	1	Vessels do not dispose of any plastic rubbish, or poultry products and comply strictly with MARPOL regulations therefore organic waste discharge could only be accidental; target species depths>400m therefore cannot alter behaviour of fish =>intensity negligible =>consequence negligible =>confidence high, 100% observer coverage, compliance to regulations

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	Wandering albatross *Diomedea exulans*; Grey-headed albatross *Thalassarche chrysostoma*; Black-browed Albatross *Thalassarche melanophrys*	1.1	1	1	2	One vessel in the fishery complies not only with MARPOL regulations restricting the deliberate disposal of debris but also has installed signs/notices in the accommodation to remind/educate the crew as to their legal obligations for disposal of debris. Intensity negligible. => consequence negligible as even accidental loss unlikely to affect birds => Confidence high, 100% observer coverage, as the regulations limit debris being deliberately thrown overboard.
Chemical pollution	1	3	2	Population Size	Wandering albatross *Diomedea exulans*; Grey-headed albatross *Thalassarche chrysostoma*; Black-browed Albatross *Thalassarche melanophrys*	1.1	2	2	2	Chemical pollution, accidental, might only occur rarely. One vessel in the fishery complies not only with MARPOL regulations restricting the deliberate disposal of chemical pollution but also has installed signs/notices in the accommodation to remind/educate the crew as to their legal obligations for disposal of chemicals. =>Intensity minor => consequence of accidental disposal to birds minor. =>Confidence high 100% observer coverage and regulations limit chemicals being deliberately dumped at sea.
Exhaust	1	3	3	Behaviour/movement	Wandering albatross *Diomedea exulans*; Grey-headed albatross *Thalassarche chrysostoma*; Black-browed Albatross *Thalassarche melanophrys*	6.1	1	1	2	Exhaust emissions occurs daily during the season. =>intensity and consequence both scored as negligible. Only one vessel in the fishery and bird's mobility unlikely that exhaust gas emissions will have an affect on the birds species. Weather conditions in the region are frequently extreme, rapidly dispersing exhaust emissions. =>Confidence is high, 100% observer coverage, 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
Gear loss	1	3	3	Behaviour/movement	Wandering albatross *Diomedea exulans*; Grey-headed albatross *Thalassarche chrysostoma*; Black-browed Albatross *Thalassarche melanophrys*	6.1	2	1	2	Annual gear loss small and the impact on habitat of the birds small and therefore unlikely to impact behaviour/movement =>intensity minor; only one vessel in the fishery coupled with the type of gear in use. =>consequence negligible =>Confidence high, 100% observer coverage.
Navigation/ steaming	1	3	3	Behaviour/movement	Wandering albatross *Diomedea exulans*; Grey-headed albatross *Thalassarche chrysostoma*; Black-browed Albatross *Thalassarche melanophrys*	6.1	1	1	2	Navigation/steaming occurs daily over 30 days =>Intensity negligible due to the limited number of vessels in the fishery. =>Consequence negligible, any changes in distribution would be temporary due to mobility of birds =>Confidence high, logic.
Activity/ presence on water	1	3	3	Behaviour/movement	Wandering albatross *Diomedea exulans*; Grey-headed albatross *Thalassarche chrysostoma*; Black-browed Albatross *Thalassarche melanophrys*	6.1	1	1	2	Only one vessel present and active daily over about 30 days. =>Intensity negligible =>Consequence negligible change in distribution of birds only temporary =>Confidence high, logic
Bait collection	0	0	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
Fishing	1	3	3	Behaviour/movement	Elephant Seal *Mirounga leonina,*	6.1	2	2	1	Elephant seals chosen as most likely TEP species most susceptible to disturbance by demersal trawling =>Intensity minor due to small area affected and low numbers of vessels in fishery. =>Consequence minor as not resident =>Confidence low, due to lack of data.
Boat launching	0	0	0							
Anchoring/ mooring	0	0	0							
Navigation/steaming	1	3	3	Behaviour/movement	Minke whale *Balaenoptera bonaerensis*	6.1	1	1	2	Navigation/steaming occurs daily during season. Minke whales chosen as TEP species most susceptible to disturbance by navigation/steaming. =>intensity and consequence both rated as negligible, only one vessel involved and changes in whale distribution only temporary =>Confidence high , 100% observer coverage and data on whale interactions suggests impact minimal.
Other fisheries	1	6	3	Population size	Wandering albatross *Diomedea exulans*; Grey-headed albatross *Thalassarche chrysostoma*; Black-browed Albatross *Thalassarche melanophrys*	1.1	1	1	2	No other fisheries operate in the AFZ. Only one alleged case of IUU fishing to have occurred in the AFZ. Fishing outside AFZ (e.g. in adjacent New Zealand AFZ) possibly could cause impact on locally breeding birds =>Intensity negligible =>Consequence negligible =>confidence high -AFMA reports no activity
Aquaculture	0	0	0							
Coastal development	0	0	0							
Other extractive activities	0	0	0							
Other non-extractive activities	0	0	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	4	4	Population size	Wandering albatross *Diomedea exulans*; Grey-headed albatross *Thalassarche chrysostoma*; Black-browed Albatross *Thalassarche melanophrys*	1.1	2	2	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 minor =>Confidence was recorded as high due to data regarding numbers and activities in the region.

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	Mid-upper Slope	1.1	3	3	1	The Aurora Trough and the Northern Valleys fishing grounds are less than 100 nm wide. Fishing occurs from October to March but about 30 days per year. Fishing can alter community species composition. Catches restricted to research TACs for majority of seasons at Aurora Trough 1999 since to allow stock recovery but TAC has not been reached on the Northern Valley grounds =>intensity moderate; Commercial TACs set for past 2 seasons in Aurora Trough indicating apparent recovery of stock =>Consequence moderate as TACs fully caught in Aurora Trough when set and indicates stock is fully exploited but probably has declined on Northern Valleys ground. TAC levels being annually reviewed and adjusted to maintain fishery =>Confidence low, as no current data available.
	Incidental behaviour	0	0	0							
	Bait collection	0	0	0							

Direct impact of fishing	Fishing Activity	Presence (1) Absence (0)	Spatial scale of Hazard (1-6)	Temporal scale of Hazard (1-6)	Sub-component	Unit of analysis	Operational objective (S2.1)	Intensity Score (1-6)	Consequence Score (1-6)	Confidence Score (1-2)	Rationale
Direct impact without capture	Fishing	1	3	3	Species composition	Mid-upper Slope	3.1	3	2	1	Post-capture mortality resulting from escapement of species from net could affect species composition of community without capture on fishing grounds. =>Intensity rated as moderate only one vessel in fishery =>Consequence minor as bycatch is low and relatively small area is affected. Whether trawl damage may in time alter distribution of community significantly has not been determined. =>Confidence low as no current data available.
	Incidental behaviour	0	0	0							
	Gear loss	1	3	3	Species composition	Mid-upper Slope	1.1	1	2	2	Annual gear loss is small. Gear loss has potential to alter species composition by direct interactions with species particularly benthic species =>Intensity negligible, due to limited numbers of vessels in fishery, and management controls designed to reduce/monitor interactions with these species. =>Consequence minor, as the types of gear recorded as lost are either small or have a minimal risk of entangling rare/endangered species. =>Confidence high, as observers present on all trips and report all gear lost.
	Anchoring/ mooring	0	0	0							

Direct impact of fishing	Fishing Activity	Presence (1) Absence (0)	Spatial scale of Hazard (1-6)	Temporal scale of Hazard (1-6)	Sub-component	Unit of analysis	Operational objective (S2.1)	Intensity Score (1-6)	Consequence Score (1-6)	Confidence Score (1-2)	Rationale
	Navigation/ steaming	1	3	3	Species composition	Oceanic (1)	1.1	1	2	2	Navigation/ steaming has potential to alter species composition by direct impact 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 minor as unlikely to detect against natural mortality. However the population sizes of some species are small enough that individual mortality/injury may be sufficient to compromise species survival. =>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	6	3	Species composition	Mid-upper Slope	1.1	1	2	2	Translocation of species via ballast or hull-fouling could occur while vessel on the grounds about 30 days per year => species composition most likely to be affected =>intensity negligible as remote likelihood of detection because the likelihood of temperate water species surviving and establishing in sub-Antarctic waters is considered negligible. Circumpolar currents facilitate wide distribution of Antarctic and sub-Antarctic species through region. =>Consequence minor, due to wide distribution of Antarctic and sub-Antarctic species through region. =>Confidence high, as successful translocations involve species already

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
											adapted to particular environments and climatic regimes.
	On board processing	0	0	0							
	Discarding catch	0	0	0							
	Stock enhancement	0	0	0							
	Provisioning	0	0	0							

Direct impact of fishing	Fishing Activity	Presence (1) Absence (0)	Spatial scale of Hazard (1-6)	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
	Organic waste disposal	1	6	3	Distribution of community	Oceanic (1)	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 =>Intensity negligible. =>Consequence negligible =>Confidence high, 100% observer coverage and compliance with regulations
Addition of non-biological material	Debris	1	3	3	Distribution of community	Oceanic (1)	3.1	1	1	2	One vessel in the fishery complies not only with MARPOL regulations restricting the deliberate disposal of debris but also has installed signs/notices in the accommodation to remind/educate the crew as to their legal obligations for disposal of debris. =>Intensity negligible. =>consequence negligible as even accidental loss unlikely to impact pelagic species =>Confidence high, 100% observer coverage, as the regulations limit debris being deliberately thrown overboard.

Direct impact of fishing	Fishing Activity	Presence (1) Absence (0)	Spatial scale of Hazard (1-6)	Temporal scale of Hazard (1-6)	Sub-component	Unit of analysis	Operational objective (S2.1)	Intensity Score (1-6)	Consequence Score (1-6)	Confidence Score (1-2)	Rationale
	Chemical pollution	1	3	2	Functional group composition	Oceanic (1)	2.1	1	2	2	The Aurora Trough and the Northern Valleys fishing grounds are less than 100 nm wide. Chemical (particularly oil) pollution is considered to have a potential frequency of once every few years. Chemical (particularly oil) pollution has the potential to alter functional group composition by impacting severely on animals that cross the air/water interface, particularly avian and mammalian predators/scavengers. =>Intensity negligible, as while spread over a large area, pollution events are infrequent and discontinuous. Bans on disposal of pollutants are also part of management plans. =>Consequence minor as these events are expected to be rare from these vessels. However the potential impact of a large oil spill would be severe and deserves further investigation. =>Confidence high. No spills have been reported to date and all vessels should be operating under MARPOL regulations including Oil Record books and surveys of oily water separator monitoring equipment.
	Exhaust	1	3	3	Distribution of community	Oceanic (1)	3.1	1	1	2	Exhaust emissions occurs daily during the season. =>intensity and consequence both scored as negligible. Only one vessel in the fishery and birds most likely species to interact but their mobility renders them unlikely to be affected by exhaust gas emissions. Weather conditions in the region are

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
											frequently extreme, rapidly dispersing exhaust emissions. =>Confidence is high, 100% observer coverage, logic.
	Gear loss	1	3	3	Species composition	Mid-upper Slope	1.1	1	1	2	Annual gear loss small. Gear loss has potential to alter species composition by direct impact with rare/endangered species. =>Intensity rated as negligible due to limited numbers of vessels in fishery. =>Consequence negligible The types of gear recorded as lost are either small or have a minimal risk of entangling species or altering habitat of habitat-dependent species =>Confidence was recorded as high due records of amount and type of gear lost.
	Navigation/ steaming	1	3	3	Distribution of community	Oceanic (1)	3.1	1	1	2	Navigation/steaming has the potential to alter community distributions by attracting species to the vessel and alter foraging patterns. =>Intensity negligible, due to small number of vessels involved. =>Consequence negligible, due to the small number of vessels involved. =>Confidence high, due to observer data on interactions with vessels navigating/steaming in the fishery.

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
	Activity/ presence on water	1	3	3	Distribution of community	Oceanic (1)	3.1	1	1	2	Activity/presence has the potential to alter community distributions by attracting species to the vessel and alter foraging patterns. =>Intensity negligible, due to small number of vessels involved. =>Consequence negligible, due to the small number of vessels involved. =>Confidence high, due to observer data on interactions with vessels steaming in the fishery.
Disturb physical processes	Bait collection	0	0	0							
	Fishing	1	3	3	Distribution of community	Mid-upper slope	3.1	3	2	1	Fishing has the potential to alter distribution of community by disturbing seafloor and benthos and thus affect habitat-dependent species =>Intensity moderate, as grounds are continuously targeted once identified as productive =>Consequence minor as area relatively small and likelihood of detection small =>Confidence low, due to 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							
	Navigation/steaming	1	3	3	Distribution of community	Oceanic (1)	3.1	1	1	2	Navigation/steaming has the potential to alter community distributions by wake mixing of the pelagic community. =>Intensity negligible, due to small number of vessels involved and known wind mixing depths exceeding wake mixing. =>Consequence negligible, due to the small number of vessels involved.

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
											=>Confidence high, due to consideration of logical constraints
External Impacts (specify the particular example within each activity area)	Other fisheries: IUU fishing	1	6	3	Species composition	Mid-upper slope	1.1	1	1	2	No other fisheries operate in the AFZ. Only one alleged case of IUU fishing to have occurred in the AFZ. Fishing outside AFZ (e.g. in adjacent New Zealand AFZ) possibly could cause impact on locally breeding birds but unlikely to affect other community members =>Intensity negligible =>Consequence negligible unable to detect variations =>Confidence high - AFMA reports no activity
	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	4	4	Distribution of community	Coastal pelagic	3.1	1	1	1	Tourism and research vessel voyages occur over this spatial scale within the AFZ. Tourism/research vessels visit the area several times a year. Distribution of the coastal pelagic community thought to be most likely impacted. =>Intensity negligible due to small number of trips/vessels involved. =>Consequence

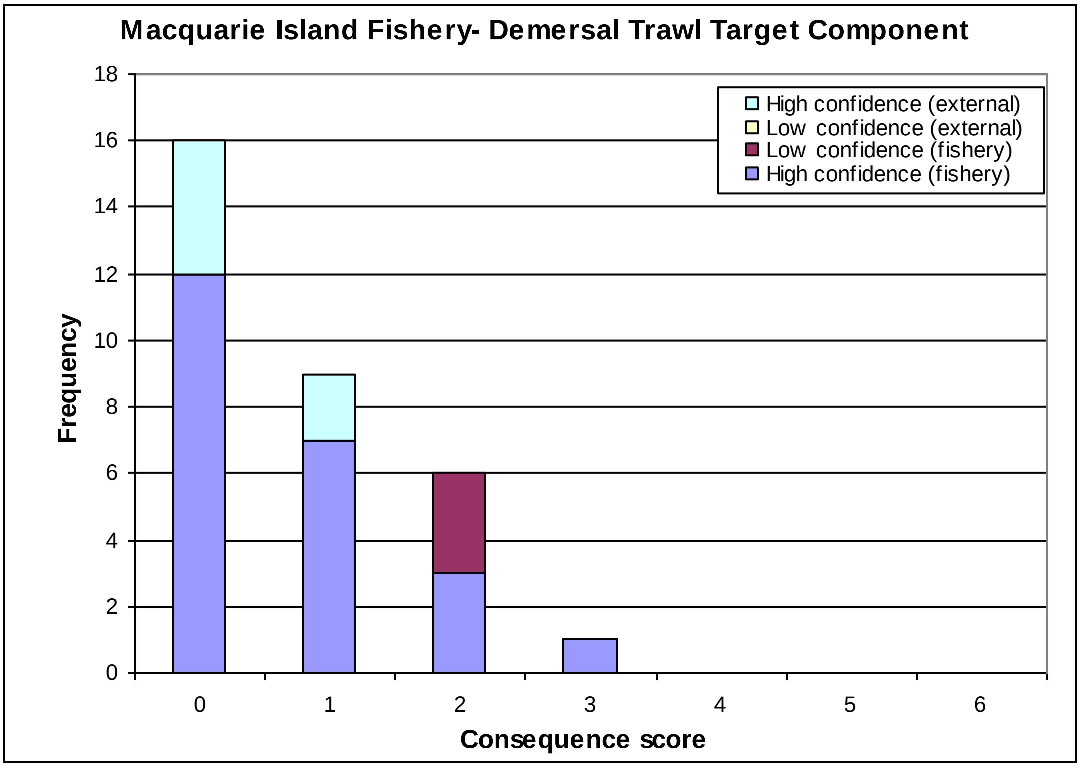
Direct impact of fishing	Fishing Activity	Presence (1) Absence (0)	Spatial scale of Hazard (1-6)	Temporal scale of Hazard (1-6)	Sub-component	Unit of analysis	Operational objective (S2.1)	Intensity Score (1-6)	Consequence Score (1-6)	Confidence Score (1-2)	Rationale
											also negligible. =>Confidence low, as specific operations conducted by each vessel may vary.

2.3.11 Summary of SICA results

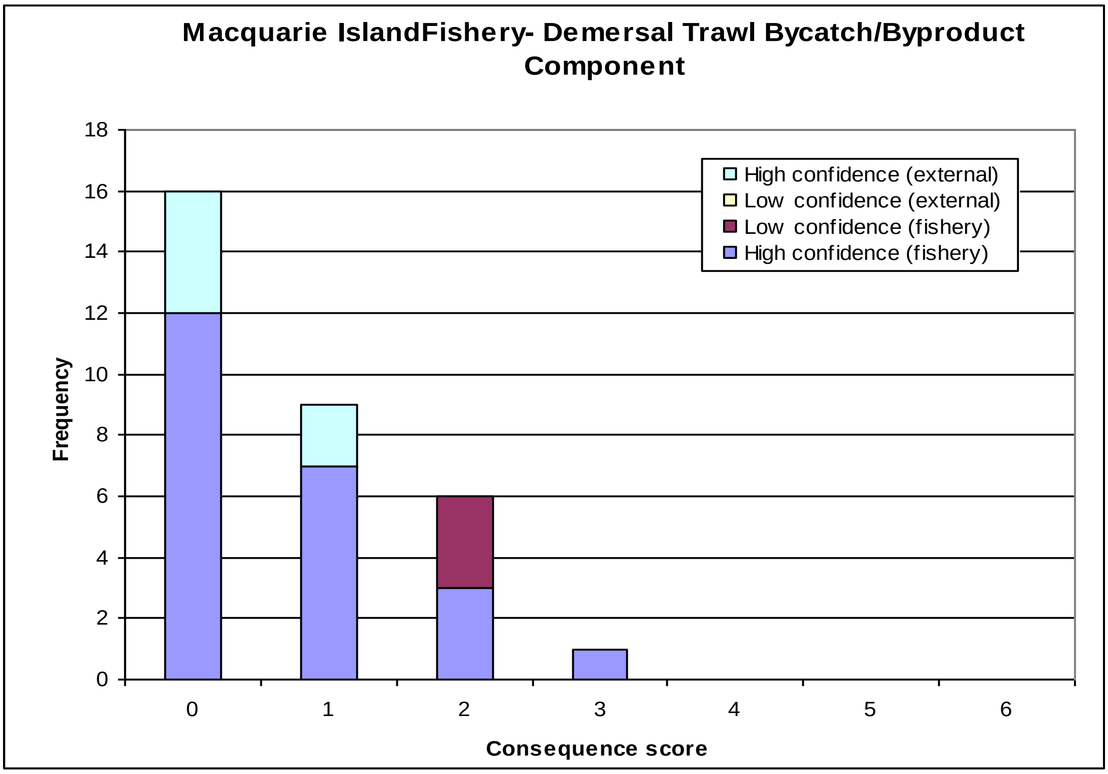
The report provides a summary table (**Level 1 (SICA) Document L1.6**) of consequence scores for all activity/component combinations and a table showing those that scored 3 or above for consequence, and differentiating those that did so with high confidence (in bold).

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

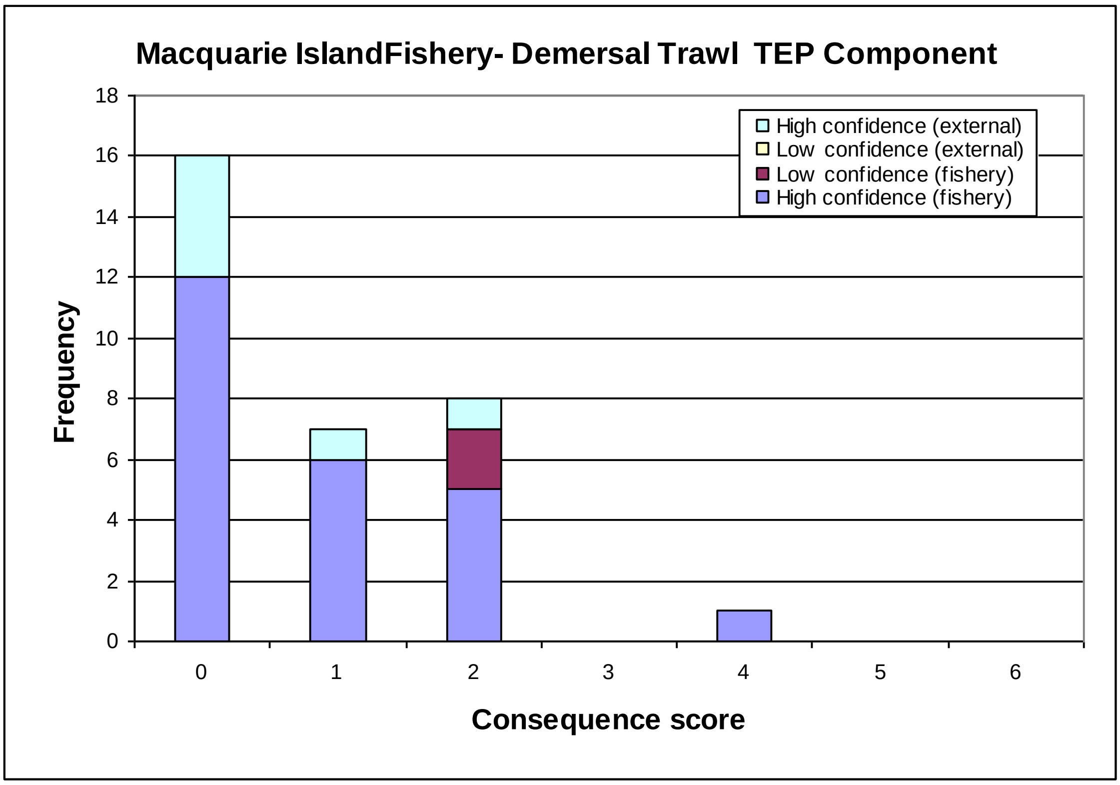
Direct impact	Activity	Target species	Byproduct and bycatch species	TEP species	Communities
Capture	Bait collection	0	0	0	0
	Fishing	3	3	4	3
	Incidental behaviour	0	0	0	0
Direct impact without capture	Bait collection	0	0	0	0
	Fishing	2	2	2	2
	Incidental behaviour	0	0	0	0
	Gear loss	2	2	2	2
	Anchoring/ mooring	0	0	0	0
	Navigation/ steaming	1	1	2	2
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	2	1
Addition of non-biological material	Debris	1	1	1	1
	Chemical pollution	2	2	2	2
	Exhaust	1	1	1	1
	Gear loss	2	2	1	1
	Navigation/ steaming	1	1	1	1
	Activity/ presence on water	1	1	1	1
Disturb physical processes	Bait collection	0	0	0	0
	Fishing	2	2	2	2
	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	1	1	1	1
	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	2	1



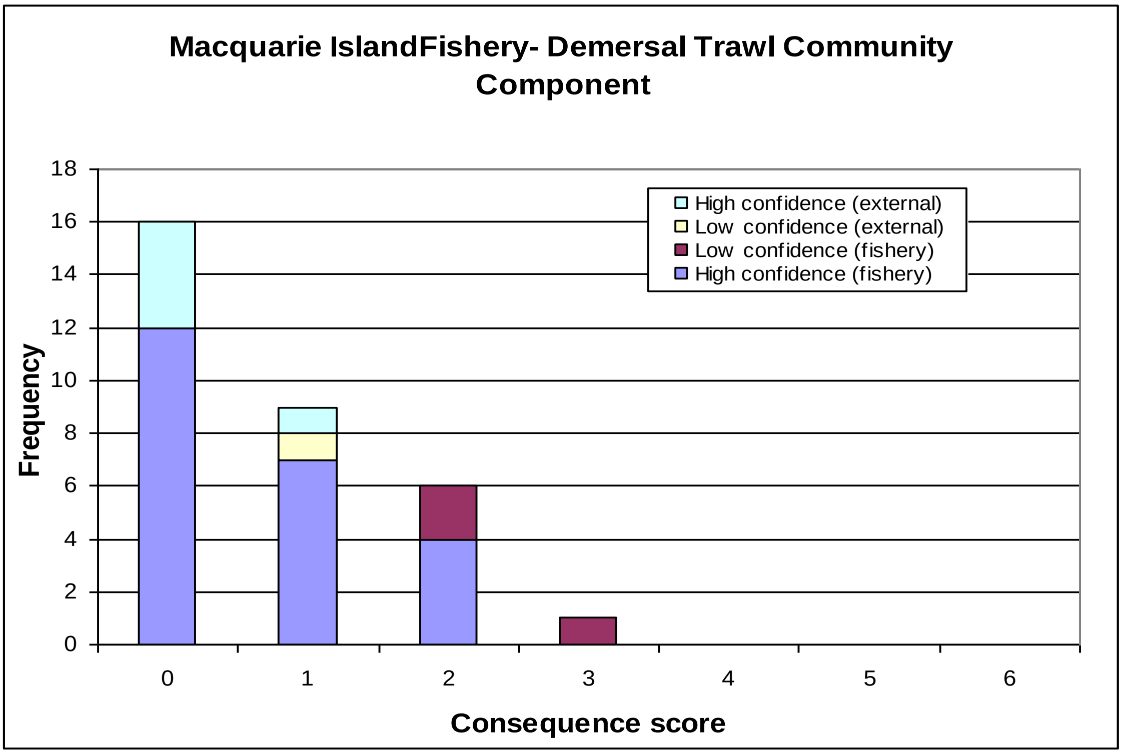
Target species: Frequency of consequence score differentiated between high and low confidence.



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



TEP species: Frequency of consequence score differentiated between high and low confidence (SICA excel workbook)



Communities: Frequency of consequence score differentiated between high and low confidence (SICA excel workbook).

2.3.12 Evaluation/discussion of Level 1

No ecological components were eliminated at Level 1. All of the components examined had consequence score $\geq$3 for one activity.

Consequence (risk) scores ranged from 1- 4 across all 32 hazards (fishing activities) and four ecological components assessed.

Those hazards with risk scores of three or more were:

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

Fishing (direct impact with capture) was scored as a major risk (=4) to TEP species. No significant external hazards (consequence score $\geq$3) were scored and no other risks rated as major or above (risk scores 4 or 5) were scored.

The Patagonian toothfish (*Dissostichus eleginoides*) was the most vulnerable target species and is currently the only target species in this sub-fishery. The direct impact of fishing was identified to most likely impact the population size of the Patagonian toothfish. The consequence of the intensity was scored as moderate, as only a small area was likely to be affected. Also, annual TACs may be adjusted and recent declines in CPUE (e.g. Macquarie Ridge compared to the Aurora Trough) are also reviewed to maintain the fishery.

The Southern Sleeper shark *Somniosus antarcticus* was the most vulnerable discard species and was impacted directly by capture by fishing. The consequence was moderate and probably reflects either the abundance or susceptibility to capture in the Aurora Trough where most of the fishing effort is targetted.

The albatrosses, Wandering albatross *Diomedea exulans*; Grey-headed albatross *Thalassarche chrysostoma* and Black-browed Albatross Thalassarche *melanophrys* were considered the most vulnerable TEP species particularly since only 10-20 pairs of Wandering Albatross breed on Macquarie Island. While no deaths have occurred attributable to the fishery, the potential risk of a serious impact on the Wandering Albatross population from a fatal interaction with fishing gear was considered to be sufficient for further evaluation at Level 2

The mid-upper slope community was considered the most vulnerable, based on the direct impact of capture on fishing, as demersal trawl gear may alter this community on fishing grounds (i.e. Macquarie Ridge or Aurora Trough). The consequence score was moderate, since any impact would be over a small area. Also, the confidence score was low, since it is not known whether trawl damage can alter the species composition of this mid-upper slope community.

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 species,
- byproduct/bycatch species,
- TEP species.

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 fromdata 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

Similarly 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.

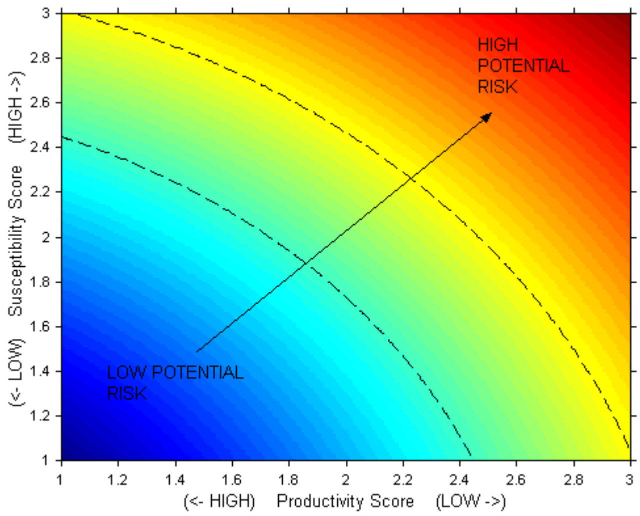


Figure 13. The axes on which risk to the ecological units is plotted. The x-axis includes attributes that influence the productivity of a unit, or its ability to recover after impact from fishing. The y-axis includes attributes that influence the susceptibility of the unit to impacts from fishing. The 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	Taxa name	Scientific name	CAAB Code	Family name	Common name	Code role in fishery	Source	Reason for removal
1366	Teleost	Ophidiidae	37228901	Ophidiidae	Cusk eel	NA	AAD Database	Insufficient taxonomic resolution
2786	Invertebrate	Echinodermata	26000000			NA	AAD Database	Insufficient taxonomic resolution
2949	Invertebrate	Ophiuroidae	NA			NA	AAD Database	Insufficient taxonomic resolution
2959	Not Allocated	Durvillaeaceae	NA	Durvilleaceae		NA	AAD Database	Insufficient taxonomic resolution
2964	Teleost	Nomeidae	NA	Nomeidae		NA	AAD Database	Temperate pelagic fish. Misidentification, probably Icicthys australis (R. Williams AAD)
2989	Not Allocated		NA		Nil commercial catch	NA	AAD Database	Insufficient taxonomic resolution
3223	Not Allocated		NA	Unknown	Unknown (from aad - himi, mif)	NA	AAD Database	Insufficient taxonomic resolution
1479	Teleost	Macrourus whitsoni	37232753	Macrouridae	Whiptail ; bigeye grenadier	NA	AAD Database	Possible misid for M. carinatus
776	Teleost	Tubbia tasmanica	37445002	Centrolophidae	Rudderfish, tasmanian rudderfish	NA	AAD Database	Misidentification,probably Icicthys australis (R. Williams AAD)
302	Chondrichthyan	Bathyraja irrasa	NA	Rajidae	Skate	NA	Sample from HIMI	Mislabeled: Sample from HIMI
304	Chondrichthyan	Bathyraja murrayi	NA	Rajidae	Skate	NA	Sample from HIMI	Mislabeled: Sample from HIMI
1281	Invertebrate	Kondakovia longimana	23623004	Onychoteuthidae	Hooked squid	NA	AAD Database	Deleted Taxa, 20060616; Hobday
1480	Chondrichthyan	Bathyraja eatonii	37031750	Rajidae	[A skate]	NA	Sample from HIMI	Mislabeled: Sample from HIMI
1481	Chondrichthyan	Bathyraja maccaini	37031751	Rajidae	[A skate]	NA	Sample from HIMI	Mislabeled: Sample from HIMI
2990	Not Allocated		NA		Marine pollution	NA	AAD Database	Not a biological unit
2991	Not Allocated		NA		Rocks	NA	AAD Database	Not a biological unit
2992	Not Allocated		NA		Unlisted non-fish species	NA	AAD Database	Insufficient taxonomic resolution

ERA species	Taxa name	Scientific name	CAAB Code	Family name	Common name	Code role in fishery	Source	Reason for removal
2993	Not Allocated		NA		Unlisted fish species	NA	AAD Database	Insufficient taxonomic resolution
2772	Algae	Algae	NA			NA	AAD Database	Insufficient taxonomic resolution
2770	Not Allocated		NA		Bycatch	NA	AAD Database	Synonym
2913	Not Allocated		99800800	Unidentified	Unidentified	NA	AAD Database	Synonym
2918	Not Allocated	Elasmobranchii sp.	NA			NA	AAD Database	Synonym
2780	Invertebrate	Loliginidae, Ommastrephidae	NA			NA	AAD Database	Synonym
2783	Invertebrate	Octopodidae	22630000	Octopodidae		NA	AAD Database	Synonym
2942	Invertebrate	Penaeoidea & Caridea - undifferentiated	NA			NA	AAD Database	Insufficient taxonomic resolution
1459	Teleost	Myctophidae indet	NA	Myctophidae	Lanternfish	NA	AAD Database	Synonym
2055	Teleost	Congridae, Colocongridae - undifferentiated	37067000	Congridae, Colocongridae	Conger & short-tail conger eels	NA	AAD Database	Synonym
2111	Teleost	Nototheniidae - undifferentiated	37404000	Nototheniidae	Icefishes	NA	AAD Database	Synonym
2122	Teleost	Bothidae, Achiropsettidae, Paralichthyidae - undifferentiated	37460000	Bothidae, Achiropsettidae, Paralich	Left eye flounders	NA	AAD Database	Synonym
2932	Teleost	Centrolophidae	NA	Centrolophidae		NA	AAD Database	Synonym – probably Icicthys australis (R. Williams AAD)
2937	Teleost	Anglerfish Indet	NA	Lophiformes		NA	AAD Database	Synonym
2805	Teleost	Bathylagus sp.	37098800	Bathylagidae		NA	AAD Database	Synonym for B. antarcticus
2965	Teleost	Caelorinchus sp.	NA	Macrouridae		NA	AAD Database	Synonym
2809	Teleost	Ceratiidae	37220800	Ceratiidae		NA	AAD Database	Synonym
2777	Invertebrate	Gastropoda	22200000			NA	AAD Database	Insufficient taxonomic resolution
1458	Teleost	Gymnoscopelus sp.	NA	Myctophidae	Lanternfish	NA	AAD Database	Synonym
2280	Invertebrate	Invertebrata	910360000			NA	AAD Database	Synonym
1447	Invertebrate	Lithodes sp.	NA	Lithodidae	King crab (undifferentiated)	NA	AAD Database	Synonym: Considered as Lithodes murrayi (R. Williams AAD)
2776	Invertebrate	Lithodidae	NA	Lithodidae		NA	AAD Database	Synonym: Considered as Lithodes murrayi (R. Williams AAD)
1467	Teleost	Macrouridae	NA	Macrouridae	Whiptail	NA	AAD Database	Synonym
1466	Teleost	Macrourus sp.	NA	Macrouridae	Whiptail	NA	AAD Database	Synonym

ERA species	Taxa name	Scientific name	CAAB Code	Family name	Common name	Code role in fishery	Source	Reason for removal
2080	Invertebrate	Melamphaidae - undifferentiated	37251000	Melamphaidae	Big scales	NA	AAD Database	Synonym for P. crassiceps
1462	Teleost	Lepidion sp.	NA	Moridae	Morid cod	NA	AAD Database	Synonym
2281	Invertebrate		923600000		Squid indet	NA	AAD Database	Synonym
2062	Teleost	Stomiidae - undifferentiated	37112000	Stomiidae	Scaly dragonfishes	NA	AAD Database	Synonym
1463	Teleost	Echiodon sp.	NA	Carapidae	Pearlfishes (undifferentiated)	NA	AAD Database	Synonym
2074	Teleost	Carapidae - undifferentiated	37229000	Carapidae	Pearlfishes	NA	AAD Database	Synonym for Echiodon
2779	Invertebrate	Cephalopoda	22600000			NA	AAD Database	Synonym
2775	Invertebrate		20000000		Crustaceans	NA	AAD Database	Synonym
2968	Teleost	Oreosomatidae	NA	Oreosomatidae		NA	AAD Database	Synonym
2963	Invertebrate	Ascidiacea	NA	Ascidiidae		NA	AAD Database	synonym for salp
561	Teleost	Hoplostethus atlanticus	37255009	Trachichthyidae	Orange roughy	NA	AAD Database	Out of range

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 *Macquarie Island Demersal 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	408264	N	0	0	1.86	3.00	3.53	N	High	Spatial uncertainty	

Byproduct species *Macquarie Island Demersal 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													
826	Etmopterus granulosus	southern lantern shark	0	N	0	0	2.43	1.67	2.95	Y	Med	Low attribute score	Expert override: override applied to availability - reduced from 3 to 1 because mainly off continental Australia (Daley, Stevens & Graham 1997).
Invertebrate													
2773	Actinaria - undifferentiated	anthozoan sea anemone	4	Y	7	3	3.00	3.00	4.24	N	High	Missing data	
2787	Asteroidea	sea star	8	Y	7	3	3.00	3.00	4.24	N	High	Missing data	
2788	Echinoidea	sea urchin	1	Y	7	3	3.00	3.00	4.24	N	High	Missing data	
1328	Pasiphaea sp.	carid shrimp	0	Y	7	2	3.00	3.00	4.24	N	High	Missing data	
2967	Gorgonaceae	gorgonian sea fan	6,502	Y	7	3	3.00	3.00	4.24	N	High	Missing data	
2789	Salpidae	salp	0	Y	7	3	3.00	3.00	4.24	N	High	Missing data	
2948	Pennatulacea	Sea pen	0	Y	7	3	3.00	3.00	4.24	N	High	Missing data	
2951	Gorgonocephalidae	gorgans head seastar	315	Y	7	3	3.00	3.00	4.24	N	High	Missing data	

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
2938	Holothurian	sea cucumber	2	Y	7	3	3.00	3.00	4.24	N	High	Missing data	
2784	Octopus (pelagic)	pelagic octopus	2	Y	7	3	3.00	3.00	4.24	N	High	Missing data	
2940	Histioteuthis sp.	squid	1	Y	7	3	3.00	3.00	4.24	N	High	Missing data	
2781	Loligo sp.	squid	0	Y	7	3	3.00	3.00	4.24	N	High	Missing data	
2953	Cirroteuthis sp.	squid	0	Y	7	3	3.00	3.00	4.24	N	High	Missing data	
80	Lithodes murrayi	Subantarctic king crab	4,977	Y	6	1	2.71	3.00	4.05	N	High	Missing data	
1981	Porifera - undifferentiated	sponges	48	Y	7	0	3.00	2.33	3.80	N	High	Missing data	
40	Onykia ingens	squid	444	Y	6	0	2.86	1.67	3.31	N	High	Missing data	
1284	Martialia hyadesi	flying squid	4	Y	6	2	2.86	1.22	3.11	Y	Med	Missing data	Expert override: rare in observer data therefore encounterability reduced to 1. Widely distributed outside the fishing grounds therefore based on stock likelihood rationale (see Stock Likelihood table in PSA) availability reduced to 1.
45	Nototodarus sloanii	flying squid	0	Y	6	1	2.86	1.22	3.11	Y	Med	Missing data	Expert override: rare in observer data therefore encounterability reduced to 1. Widely distributed outside the fishing grounds therefore based on stock likelihood rationale (see Stock Likelihood table in PSA) availability reduced to 1.

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
46	Todarodes filippovae	Southern Ocean arrow squid	0	N	2	0	1.86	1.22	2.22	Y	Low		Expert override: rare in observer data therefore encounterability reduced to 1. Widely distributed outside the fishing grounds therefore based on stock likelihood rationale (see Stock Likelihood table in PSA) availability reduced to 1.
Teleost													
2881	Photichthys sp.	bristlemouth	0	Y	7	3	3.00	3.00	4.24	N	High	Missing data	
2902	Stomias sp.	scaleless dragonfish	0	Y	7	3	3.00	3.00	4.24	N	High	Missing data	
2934	Gigantactinidae	whipnose angler fish	0	Y	7	3	3.00	3.00	4.24	N	High	Missing data	
2946	Epigonus sp.	cardinal fish	0	Y	7	3	3.00	3.00	4.24	N	High	Missing data	
2977	Nemichthyidae	eel	0	Y	7	3	3.00	3.00	4.24	N	High	Missing data	
2927	Neocyttus sp.	oreo dory	0	Y	7	3	3.00	3.00	4.24	N	High	Missing data	
2922	Alepocephalus spp.	slickhead	2	Y	7	3	3.00	3.00	4.24	N	High	Missing data	
2933	Astronesthes sp.	spangled trouble-shouter	0	Y	7	3	3.00	3.00	4.24	N	High	Missing data	
2928	Ebinania sp.	blobfish	10	Y	7	3	3.00	3.00	4.24	N	High	Missing data	
2923	Himantolophus sp.	football fish	0	Y	7	3	3.00	3.00	4.24	N	High	Missing data	
2924	Oneirodes sp.	dreamer fish	0	Y	7	3	3.00	3.00	4.24	N	High	Missing data	

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
2925	Paralaemonema sp.	morid cod	6	Y	7	3	3.00	3.00	4.24	N	High	Missing data	
1473	Mancopsetta sp.	Southern flounder	0	Y	6	1	2.86	3.00	4.14	N	High	Missing data	
575	Neophrynichthys magnicirrus	fathead	2	Y	5	1	2.57	3.00	3.95	N	High	Missing data	
1472	Achiropsetta sp. (grey)	Southern flounder	0	Y	4	0	2.43	3.00	3.86	N	High	Missing data	
1457	Melanostomias sp.	scaleless dragonfish	0	Y	4	0	2.43	3.00	3.86	N	High	Missing data	
2822	Echiodon cryomargarites	pearlfish	1	Y	4	2	2.29	3.00	3.77	N	High	Missing data	
2945	Chauliodus sloani	viper fish	0	Y	7	3	3.00	1.67	3.43	Y	High	Missing data	Expert override: widely distributed outside the fishing grounds therefore based on stock likelihood rationale (see Stock Likelihood table in PSA) availability reduced to 1.
	Lepidonotothen squamifrons	Grey rockcod ; an icefish	2,724	N	0	0	1.43	3.00	3.32	N	High	Widely distributed	
274	Ceratias tentaculatus	seadevil	0	N	2	0	2.29	2.33	3.27	N	High	Spatial uncertainty	
2845	Macrourus holotrachys	[a whiptail]	575	N	1	0	2.14	2.33	3.17	N	Med	Spatial uncertainty	
574	Zanclorhynchus spinifer	Spiny horsefish	6	N	3	0	2.14	2.33	3.17	N	Med	Spatial uncertainty	
323	Caelorinchus matamua	whiptail	0	N	0	0	2.00	2.33	3.07	N	Med	Spatial uncertainty	
489	Centroscymnus crepidater	deepwater dogfish	0	N	0	0	2.57	1.67	3.06	N	Med	Spatial uncertainty	
281	Coryphaenoides serrulatus	whiptail	0	N	0	0	1.86	2.33	2.98	N	Med	Spatial uncertainty	

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
284	Coryphaenoides subserrulatus	whiptail	38	N	0	0	1.86	2.33	2.98	N	Med	Spatial uncertainty	
334	Caelorinchus kaiyomaru	whiptail	0	N	0	0	1.86	2.33	2.98	N	Med	Spatial uncertainty	
342	Idiolophorhynchus andriashevi	rattail/whiptail/grenadier	0	N	0	0	1.86	2.33	2.98	N	Med	Spatial uncertainty	
343	Caelorinchus kermadecus	whiptail	1	N	0	0	1.86	2.33	2.98	N	Med	Spatial uncertainty	
374	Coryphaenoides murrayi	whiptail	24	N	0	0	1.86	2.33	2.98	N	Med	Spatial uncertainty	
536	Cynomacrurus piriei	rattail/whiptail/grenadier	3	N	0	0	1.86	2.33	2.98	N	Med	Spatial uncertainty	
336	Macrourus carinatus	whiptail ; Bigeye grenadier	54	N	0	0	1.86	2.33	2.98	N	Med	Spatial uncertainty	
1464	Melanostigma sp.	an eelpout (undiferentiated)	0	N	0	0	1.86	2.33	2.98	N	Med	Spatial uncertainty	
2936	Pseudoachiropsetta milfordi	flounder	3	Y	2	2	1.71	2.33	2.90	N	Med	Missing data	
273	Anotopterus pharao	daggerfish	0	N	3	0	2.29	1.67	2.83	Y	Med	Spatial uncertainty	<u>Expert override</u>: widely distributed outside the fishing grounds therefore based on stock likelihood rationale (see Stock Likelihood table in PSA) availability reduced to 1.
644	Lampris immaculatus	Southern moonfish	0	N	3	0	2.43	1.44	2.83	N	Med	Spatial uncertainty	
576	Paraliparis gracilis	snailfish/lumpfish	0	N	1	0	1.57	2.33	2.81	N	Med	Spatial uncertainty	
626	Diastobranchus capensis	basket-work eel	9	N	2	0	2.00	1.89	2.75	N	Med	Spatial uncertainty	
773	Paradiplospinus gracilis	snake mackerel/gemfish	1	N	0	0	1.43	2.33	2.74	N	Med	Spatial uncertainty	

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
333	Pagothenia sp.	an icefish/notothen	0	N	0	1	1.43	2.33	2.74	N	Med	Spatial uncertainty	
35	Labichthys yanoi	snipe eel	0	N	3	0	2.29	1.44	2.70	N	Med	Spatial uncertainty	
36	Notacanthus chemnitzii	spiny eel	0	N	3	0	2.29	1.44	2.70	N	Med	Spatial uncertainty	
631	Pseudocyttus maculatus	Smooth oreo	0	N	0	0	1.86	1.67	2.50	N	Low		
573	Nezumia pudens	Atacamgrenadier	0	N	0	0	1.86	1.67	2.50	Y	Low		Expert override: widely distributed outside the fishing grounds therefore based on stock likelihood rationale (see Stock Likelihood table in PSA) availability reduced to 1.
280	Melanostigma gelatinosum	eelpout	0	N	0	0	1.57	1.89	2.46	N	Low		
997	Mora moro	Ribaldo	0	N	2	0	1.71	1.67	2.39	N	Low		
275	Antimora rostrata	morid cod	328	N	1	0	1.71	1.67	2.39	N	Low		
276	Halargyreus johnsonii	Morid cod	154	N	2	0	1.71	1.67	2.39	N	Low		
788	Magnisudis prionosa	barracudina	0	N	1	0	1.71	1.67	2.39	Y	Low		Expert override: widely distributed outside the fishing grounds therefore based on stock likelihood rationale (see Stock Likelihood table in PSA) availability reduced to 1.
1461	Muraenolepis sp.	morid cod (undifferentiated)	4	N	2	0	1.71	1.67	2.39	N	Low		
37	Bathylagus antarcticus	deep sea smelt	0	N	3	0	2.00	1.22	2.34	Y	Low		Expert override: widely distributed outside the fishing grounds therefore based on stock likelihood rationale (see Stock Likelihood table in PSA) availability reduced to 1.

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
537	Poromitra crassiceps	bigscale	0	N	3	0	2.00	1.22	2.34	N	Low		
2833	Gymnoscopelus opisthopterus	lantern fish	0	N	1	2	1.57	1.67	2.29	N	Low		
277	Lepidion microcephalus	Ribaldo (market name -morid cod) : smallhead cod	2	N	2	0	1.71	1.22	2.11	Y	Low		Expert override: widely distributed outside the fishing grounds therefore based on stock likelihood rationale (see Stock Likelihood table in PSA) availability reduced to 1.

Bycatch species *Macquarie Island Demersal 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													
257	Somniosus antarcticus	Sleeper shark; Southern Sleeper Shark	9,189	N	0	0	2.57	3.00	3.95	Y	High	Spatial uncertainty	Expert override: override applied to availability - increased from 1 to 3 because restricted to Southern Ocean (Scott 1976;Yano, Stevens and Compagno 2004).
Invertebrate													
2709	Hexacorallia	tube anenome, black and thorny corals	1,381	Y	7	3	3.00	3.00	4.24	N	High	Missing data	
298	Periphylla periphylla	jellyfish	34	Y	6	2	2.86	1.67	3.31	N	High	Missing data	

TEP species *Macquarie Island Demersal 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
Marine Birds													
451	Diomedea exulans	Wandering Albatross	0	N	1	0	2.57	3.00	3.95	Y	High	Spatial uncertainty	Expert override: Never recorded in catch by observers although non-injurious interactions have been observed ocassionally (13 great albatrosses/637 bird interactions:Williams et al 2001) therefore encounterability reduced from 3 to 1
1041	Procellaria aequinoctialis	White-chinned Petrel	present	N	1	0	2.29	2.33	3.27	Y	High	Spatial uncertainty	Expert override:an aggressive bird that dives on baits() only one possible death recorded in catch by observers ("petrel spp":Bycatch Action Plan 2003) therefore encounterability reduced from 3 to 1
889	Thalassarche eremita	Chatham albatross	0	Y	3	1	2.86	1.22	3.11	Y	Med	Missing data	Expert override: Never recorded in catch by observers and breeds in NZ therefore encounterability reduced from 3 to 1
753	Diomedea epomophora	Southern Royal Albatross	0	N	1	0	2.57	1.67	3.06	Y	Med	Spatial uncertainty	Expert override: Never recorded in catch by observers although non-injurious interactions have been observed ocassionally (13 great albatrosses/637 bird interactions:Williams et al 2001) therefore encounterability reduced from 3 to 1

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
799	Diomedea sanfordi	Northern Royal Albatross	0	N	1	0	2.57	1.67	3.06	Y	Med	Spatial uncertainty	Expert override: Never recorded in catch by observers although non-injurious interactions have been observed ocassionally (13 great albatrosses/637 bird interactions:Williams et al 2001) therefore encounterability reduced from 3 to 1
1084	Thalassarche impavida	Campbell Albatross	0	N	1	0	2.57	1.67	3.06	Y	Med	Spatial uncertainty	Expert override: Never recorded in catch by observers therefore encounterability reduced from 3 to 1
894	Thalassarche salvini	Salvin's albatross	0	N	3	0	2.57	1.67	3.06	Y	Med	Spatial uncertainty	Expert override: Never recorded in catch by observers although seen in area (Eades 2001) therefore encounterability reduced from 3 to 1
1428	Diomedea amsterdamensis	Amsterdam Albatross	0	N	1	0	2.57	1.67	3.06	Y	Med	Spatial uncertainty	Expert override: Never recorded in catch by observers although non-injurious interactions have been observed ocassionally (13 great albatrosses/637 bird interactions:Williams et al 2001) therefore encounterability reduced from 3 to 1
553	Thalassoica antarctica	Antarctic petrel	present	N	3	0	2.57	1.67	3.06	Y	Med	Spatial uncertainty	Expert override:only one possible death recorded in catch by observers ("petrel spp":Bycatch Action Plan 2003) therefore encounterability reduced from 3 to 1
589	Catharacta lonnbergi lonnbergi	Subantarctic skua (southern)	0	N	2	0	2.57	1.67	3.06	Y	Med	Spatial uncertainty	Expert override: Never recorded in catch by observers therefore encounterability reduced from 3 to 1

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
1426	Eudyptes chrysolophus	Macaroni penguin	0	N	2	0	2.43	1.67	2.95	Y	Med	Spatial uncertainty	Expert override: Never recorded in catch by observers but have been observed (Eades 2001) therefore encounterability reduced from 3 to 1
817	Eudyptes robustus	Snares penguin	0	N	2	0	2.43	1.67	2.95	Y	Med	Spatial uncertainty	Expert override: Never recorded in catch by observers therefore encounterability reduced from 3 to 1
818	Eudyptes sclateri	Erect-crested penguin	0	N	2	0	2.43	1.67	2.95	Y	Med	Spatial uncertainty	Expert override: Never recorded in catch by observers but have been observed (Eades 2001) therefore encounterability reduced from 3 to 1
1032	Thalassarche bulleri	Buller's Albatross	0	N	1	0	2.43	1.67	2.95	Y	Med	Spatial uncertainty	Expert override: Never recorded in catch by observers although have been observed in the area (Williams et al 2001) therefore encounterability reduced from 3 to 1
1033	Thalassarche cauta	Shy Albatross	0	N	1	0	2.43	1.67	2.95	Y	Med	Spatial uncertainty	Expert override: a/a
1035	Thalassarche chrysostoma	Grey-headed Albatross	0	N	1	0	2.43	1.67	2.95	Y	Med	Spatial uncertainty	Expert override: a/a
1085	Thalassarche melanophrys	Black-browed Albatross	present	N	1	0	2.43	1.67	2.95	Y	Med	Spatial uncertainty	Expert override: Never recorded in catch by observers although often observed interacting with vessel without injury (473/637 bird interactions:Williams et al 2001) and very abundant therefore encounterability reduced from 3 to 1. Additional information: there are two species, melanophrys & impavada, both of which have been observed in the area (Eades 2001)

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1009	Phoebetria palpebrata	Light-mantled Albatross	0	N	1	0	2.43	1.67	2.95	Y	Med	Spatial uncertainty	Expert override: Never recorded in catch by observers although have been observed in the area (Williams et al 2001) therefore encounterability reduced from 3 to 1
314	Fulmarus glacialoides	Southern fulmar	0	N	1	0	2.43	1.67	2.95	Y	Med	Spatial uncertainty	Expert override: a/a
939	Halobaena caerulea	Blue Petrel	present	N	3	0	2.43	1.67	2.95	Y	Med	Spatial uncertainty	Expert override:only one possible death recorded in catch by observers ("petrel spp":Bycatch Action Plan 2003) representing a very small proportion of the population therefore encounterability reduced from 3 to 1
1052	Lugensa brevirostris	Kerguelen Petrel	0	N	3	0	2.43	1.67	2.95	Y	Med	Spatial uncertainty	Expert override: Never recorded in catch by observers therefore encounterability reduced from 3 to 1
1532	Pachyptila crassirostris	fulmar prion	present ?	N	3	0	2.43	1.67	2.95	Y	Med	Spatial uncertainty	Expert override:only two possible deaths recorded in catch by observers ("prion spp":Bycatch Action Plan 2003) representing a very small proportion of the population therefore encounterability reduced from 3 to 1
1003	Pachyptila turtur	Fairy Prion	present ?	N	3	0	2.43	1.67	2.95	Y	Med	Spatial uncertainty	Expert override: a/a
1047	Pterodroma macroptera	Great-winged Petrel	0	N	2	0	2.43	1.67	2.95	Y	Med	Spatial uncertainty	Expert override: Never recorded in catch by observers therefore encounterability reduced from 3 to 1
1048	Pterodroma mollis	Soft-plumaged Petrel	0	N	3	0	2.43	1.67	2.95	Y	Med	Spatial uncertainty	Expert override: Never recorded in catch by observers although seen in area (Eades 2001) therefore encounterability reduced from 3 to 1

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1053	Puffinus assimilis	Little Shearwater (Tasman Sea)	0	N	3	0	2.43	1.67	2.95	Y	Med	Spatial uncertainty	Expert override: Never recorded in catch by observers therefore encounterability reduced from 3 to 1
1060	Puffinus tenuirostris	Short-tailed Shearwater	0	N	1	0	2.43	1.67	2.95	Y	Med	Spatial uncertainty	Expert override: Never recorded in catch by observers although observed in the area (Eades 2001) therefore encounterability reduced from 3 to 1
917	Fregetta tropica	Black-bellied Storm-Petrel	0	N	3	0	2.43	1.67	2.95	Y	Med	Spatial uncertainty	Expert override:only one possible death recorded in catch by observers ("petrel spp":Bycatch Action Plan 2003) therefore encounterability reduced from 3 to 1
325	Catharacta skua	Great Skua	0	N	1	0	2.43	1.67	2.95	Y	Med	Spatial uncertainty	Expert override: Never recorded in catch by observers although have been observed in the area (Williams et al 2001) therefore encounterability reduced from 3 to 1
586	Eudyptes schlegeli	Royal penguin	0	N	2	0	2.43	1.67	2.95	Y	Med	Spatial uncertainty	Expert override: Never recorded in catch by observers although have been observed in the area (Eades 2001) therefore encounterability reduced from 3 to 1
1513	Pygoscelis adeliae	Adelie penguin	0	N	2	0	2.29	1.67	2.83	Y	Med	Spatial uncertainty	Expert override: Never recorded in catch by observers therefore encounterability reduced from 3 to 1
1008	Phoebetria fusca	Sooty Albatross	0	N	1	0	2.29	1.67	2.83	Y	Med	Spatial uncertainty	Expert override: Never recorded in catch by observers although have been observed in the area (Williams et al 2001) therefore encounterability reduced from 3 to 1

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595	Daption capense	Cape Petrel	present	N	1	0	2.29	1.67	2.83	Y	Med	Spatial uncertainty	Expert override:only one possible death recorded in catch by observers ("petrel spp":Bycatch Action Plan 2003) representing a very small proportion of the population therefore encounterability reduced from 3 to 1
73	Macronectes giganteus	Southern Giant-Petrel	present	N	1	0	2.29	1.67	2.83	Y	Med	Spatial uncertainty	Expert override: Never recorded in catch by observers although non-injurious interactions have been observed (149 giant albatrosses/637 bird interactions:Williams et al 2001) therefore encounterability reduced from 3 to 1
981	Macronectes halli	Northern Giant-Petrel	present	N	1	0	2.29	1.67	2.83	Y	Med	Spatial uncertainty	Expert override: Never recorded in catch by observers although non-injurious interactions have been observed (149 giant albatrosses/637 bird interactions:Williams et al 2001) therefore encounterability reduced from 3 to 1
487	Pachyptila belcheri	Thin billed prion	present?	N	2	0	2.29	1.67	2.83	Y	Med	Spatial uncertainty	Expert override:only two possible deaths recorded in catch by observers ("prion spp":Bycatch Action Plan 2003) representing a very small proportion of the population therefore encounterability reduced from 3 to 1
494	Procellaria cinerea	Grey petrel	0	N	1	0	2.29	1.67	2.83	Y	Med	Spatial uncertainty	Expert override:only one possible death recorded in catch by observers ("petrel spp":Bycatch Action Plan 2003) and one seen in area (Eades

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503	Pterodroma inexpectata	Mottled petrel	0	N	2	0	2.29	1.67	2.83	Y	Med	Spatial uncertainty	2001) therefore encounterability reduced from 3 to 1 Expert override: Never recorded in catch by observers although seen in area (Eades 2001) therefore encounterability reduced from 3 to 1
504	Pterodroma lessoni	White-headed petrel	0	N	1	0	2.29	1.67	2.83	Y	Med	Spatial uncertainty	Expert override: a/a
1049	Pterodroma neglecta	Kermadec Petrel (western)	0	N	2	0	2.29	1.67	2.83	Y	Med	Spatial uncertainty	Expert override: Never recorded in catch by observers therefore encounterability reduced from 3 to 1
1057	Puffinus griseus	Sooty Shearwater	0	N	1	0	2.29	1.67	2.83	Y	Med	Spatial uncertainty	Expert override: Never recorded in catch by observers although have been observed in the area (Williams et al 2001) therefore encounterability reduced from 3 to 1
290	Leucocarbo atriceps	Imperial shag (Macquarie Island)	0	N	2	0	2.29	1.67	2.83	Y	Med	Spatial uncertainty	Expert override: Never recorded in catch by observers therefore encounterability reduced from 3 to 1
291	Phalacrocorax carbo	Black cormorant	0	N	1	0	2.29	1.67	2.83	Y	Med	Spatial uncertainty	Expert override: Never recorded in catch by observers although have been observed in the area (Williams et al 2001) therefore encounterability reduced from 3 to 1
555	Garrodia nereis	Grey-backed storm petrel	0	N	3	0	2.43	1.44	2.83	Y	Med	Spatial uncertainty	Expert override: Never recorded in catch by observers although have been observed in the area (Eades 2001) therefore encounterability reduced from 3 to 1
785	Aptenodytes patagonicus	King penguin	0	N	1	0	2.14	1.67	2.71	Y	Med	Spatial uncertainty	Expert override: a/a

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787	Eudyptes chrysocome	Rockhopper penguin	0	N	1	0	2.14	1.67	2.71	Y	Med	Spatial uncertainty	Expert override: a/a
1511	Pygoscelis antarctica	chinstrap penguin	0	N	1	0	2.14	1.67	2.71	Y	Med	Spatial uncertainty	Expert override: a/a
819	Pygoscelis papua	Gentoo penguin	0	N	1	0	2.14	1.67	2.71	Y	Med	Spatial uncertainty	Expert override: Never recorded in catch by observers therefore encounterability reduced from 3 to 1
488	Pachyptila desolata	Antarctic prion	present	N	2	0	2.14	1.67	2.71	Y	Med	Spatial uncertainty	Expert override:only two possible deaths recorded in catch by observers ("prion spp":Bycatch Action Plan 2003) but is frequently seen and breeds on the island (Eades 2001) therefore encounterability reduced from 3 to 1
492	Pelecanoides georgicus	South Georgian diving petrel	0	N	2	0	2.14	1.67	2.71	Y	Med	Spatial uncertainty	Expert override:only one possible death recorded in catch by observers ("petrel spp":Bycatch Action Plan 2003) therefore encounterability reduced from 3 to 1
1056	Puffinus gavia	Fluttering Shearwater	0	N	2	0	2.14	1.67	2.71	Y	Med	Spatial uncertainty	Expert override: Never recorded in catch by observers therefore encounterability reduced from 3 to 1
973	Larus dominicanus	Kelp Gull	0	N	1	0	2.14	1.67	2.71	Y	Med	Spatial uncertainty	Expert override: Never recorded in catch by observers although one non-injurious interaction observed (Williams et al 2001) therefore encounterability reduced from 3 to 1
1023	Sterna paradisaea	Arctic tern	0	N	1	0	2.14	1.67	2.71	Y	Med	Spatial uncertainty	Expert override: Never recorded in catch by observers therefore encounterability reduced from 3 to 1
292	Sterna vittata	Antarctic tern (NZ)	0	N	1	0	2.14	1.67	2.71	Y	Med	Spatial uncertainty	Expert override: Never recorded in catch by observers although one

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													may have been in the area (Eades 2001) therefore encounterability reduced from 3 to 1
1024	Sterna striata	White-fronted Tern	0	N	1	0	2.00	1.67	2.60	Y	Low		Expert override: a/a
588	Phalacrocorax albiventer purpurascens	King cormorant	0	N	1	0	2.14	1.44	2.58	Y	Low		Expert override: Never recorded in catch by observers although have been observed in the area (Williams et al 2001) therefore encounterability reduced from 3 to 1
1006	Pelecanoides urinatrix	Common Diving-Petrel	present	N	1	0	1.86	1.67	2.50	Y	Low		Expert override:only one possible death recorded in catch by observers ("petrel spp":Bycatch Action Plan 2003) therefore encounterability reduced from 3 to 1
556	Oceanites oceanicus	Wilson's storm petrel (subantarctic)	0	N	1	0	2.00	1.44	2.47	Y	Low		Expert override: a/a
Marine Mammal													-
256	Balaenoptera acutorostrata	Minke Whale	0	N	0	0	2.86	1.30	3.14	Y	Med	Spatial uncertainty	Expert override: Never recorded in catch by observers therefore encounterability reduced from 3 to 1
959	Hyperoodon planifrons	Southern Bottlenose Whale	0	N	1	0	2.86	1.30	3.14	Y	Med	Spatial uncertainty	Expert override: a/a
988	Mesoplodon grayi	Gray's Beaked Whale	0	N	1	0	2.86	1.30	3.14	Y	Med	Spatial uncertainty	Expert override: a/a
990	Mesoplodon layardii	Strap-toothed Beaked Whale	0	N	1	0	2.86	1.30	3.14	Y	Med	Spatial uncertainty	Expert override: only one found on shore. Distibution poorly known but circumpolar s. Hemisphere therefored encounterability reduced to 1

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1098	Ziphius cavirostris	Cuvier's Beaked Whale	0	N	0	0	2.86	1.30	3.14	Y	Med	Spatial uncertainty	Expert override: Never recorded in catch by observers therefore encounterability reduced from 3 to 1
935	Globicephala melas	Long-finned Pilot Whale	0	N	0	0	2.86	1.22	3.11	Y	Med	Spatial uncertainty	Expert override: a/a
937	Grampus griseus	Risso's Dolphin	0	N	0	0	2.86	1.22	3.11	Y	Med	Spatial uncertainty	Expert override: Never recorded in catch by observers although observed in the area but usually lives in warmer waters therefore encounterability reduced from 3 to 1
1002	Orcinus orca	Killer Whale	0	N	0	0	2.86	1.22	3.11	Y	Med	Spatial uncertainty	Expert override: widely distributed outside the fishing grounds therefore based on stock likelihood rationale (see Stock Likelihood table in PSA) availability reduced to 1.
1091	Tursiops truncatus	Bottlenose Dolphin	0	N	0	0	2.86	1.22	3.11	Y	Med	Spatial uncertainty	Expert override: a/a
833	Australophocoena dioptrica	Spectacled porpoise	0	Y	4	1	2.86	1.22	3.11	Y	Med	Missing data	Expert override: a/a
985	Mesoplodon bowdoini	Andrew's Beaked Whale	0	N	1	0	2.86	1.22	3.11	Y	Med	Spatial uncertainty	Expert override: widely distributed outside the fishing grounds (South Pacifc and Indian Oceans) therefore based on stock likelihood rationale (see Stock Likelihood table in PSA) availability reduced to 1.
986	Mesoplodon densirostris	Blainville's Beaked Whale	0	N	0	0	2.86	1.22	3.11	Y	Med	Spatial uncertainty	Expert override: widely distributed outside the fishing grounds in temperate and tropical regions therefore based on stock likelihood rationale (see Stock Likelihood table in PSA) availability reduced to 1.

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989	Mesoplodon hectori	Hector's Beaked Whale	0	N	0	0	2.86	1.22	3.11	Y	Med	Spatial uncertainty	Expert override: a/a
261	Balaenoptera borealis	Sei Whale	0	N	0	0	2.86	1.15	3.08	Y	Med	Spatial uncertainty	Expert override: a/a
268	Balaenoptera physalus	Fin Whale	0	N	0	0	2.86	1.15	3.08	Y	Med	Spatial uncertainty	Expert override: a/a
1439	Balaenoptera bonaerensis	Antarctic Minke Whale	0	N	1	0	2.86	1.15	3.08	Y	Med	Spatial uncertainty	Expert override: a/a
1036	Physeter catodon	Sperm Whale	0	N	0	0	2.86	1.15	3.08	Y	Med	Spatial uncertainty	Expert override: a/a
269	Berardius arnuxii	Arnoux's Beaked Whale	0	N	0	0	2.86	1.15	3.08	Y	Med	Spatial uncertainty	Expert override: Never recorded in catch by observers although sighted in area therefore encounterability reduced from 3 to 1
984	Megaptera novaeangliae	Humpback Whale	0	N	0	0	2.71	1.44	3.07	Y	Med	Spatial uncertainty	Expert override: a/a
832	Lagenorhynchus cruciger	Hourglass dolphin	0	N	1	1	2.71	1.44	3.07	Y	Med	Spatial uncertainty	Expert override: a/a
61	Lissodelphis peronii	Southern Right Whale Dolphin	0	N	1	0	2.71	1.44	3.07	Y	Med	Spatial uncertainty	Expert override: a/a
993	Mirounga leonina	Elephant seal	present	N	0	0	2.71	1.44	3.07	Y	Med	Spatial uncertainty	Expert override: Have been captured but abundant: 100,000 live outside fishing grounds therefore availabilty reduced to 1 and encounterability reduced to 1.
297	Lobodon carcinophagus	Crabeater seal	0	N	2	0	2.57	1.67	3.06	Y	Med	Spatial uncertainty	Expert override: Never recorded in catch by observers therefore encounterability reduced from 3 to 1
295	Hydrurga leptonyx	Leopard seal	0	N	0	0	2.71	1.22	2.98	Y	Med	Spatial uncertainty	Expert override: Never recorded in catch by observers therefore encounterability reduced from 3 to 1. Distributed main on ice on Antarctic

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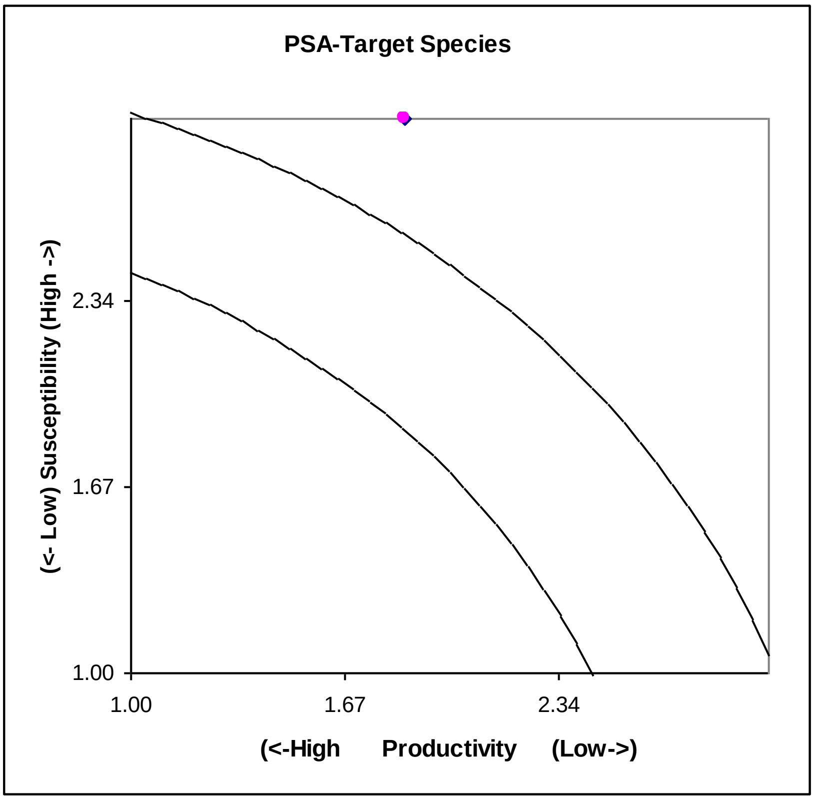
													continent therefore availability redued to 1
296	Leptonychotes weddelli	Weddell seal	0	N	2	0	2.71	1.22	2.98	Y	Med	Spatial uncertainty	Expert override: a/a
896	Eubalaena australis	Southern Right Whale	0	N	0	0	2.71	1.15	2.95	Y	Med	Spatial uncertainty	Expert override: Never recorded in catch by observers therefore encounterability reduced from 3 to 1
216	Arctocephalus forsteri	New Zealand Fur-seal	0	N	0	0	2.43	1.67	2.95	Y	Med	Spatial uncertainty	Expert override: a/a
971	Lagenorhynchus obscurus	Dusky Dolphin	0	N	0	0	2.29	1.67	2.83	N	Med	Spatial uncertainty	Expert override:a/a
263	Arctocephalus tropicalis	Subantarctic fur seal	0	N	0	0	2.29	1.67	2.83	Y	Med	Spatial uncertainty	Expert override: a/a
294	Phocarctos hookeri	Hooker's sea lion	0	N	2	0	2.29	1.67	2.83	Y	Med	Spatial uncertainty	Expert override: a/a
265	Balaenoptera musculus	Blue Whale	0	N	0	0	2.57	1.15	2.82	Y	Med	Spatial uncertainty	Expert override:a/a
293	Arctocephalus gazella	Antarctic fur seal	0	N	2	0	2.29	1.22	2.59	Y	Low		Expert override: Never recorded in catch by observers therefore encounterability reduced from 3 to 1. 95% of population breeds on Sth Gerogia therefore availability reduced to 1

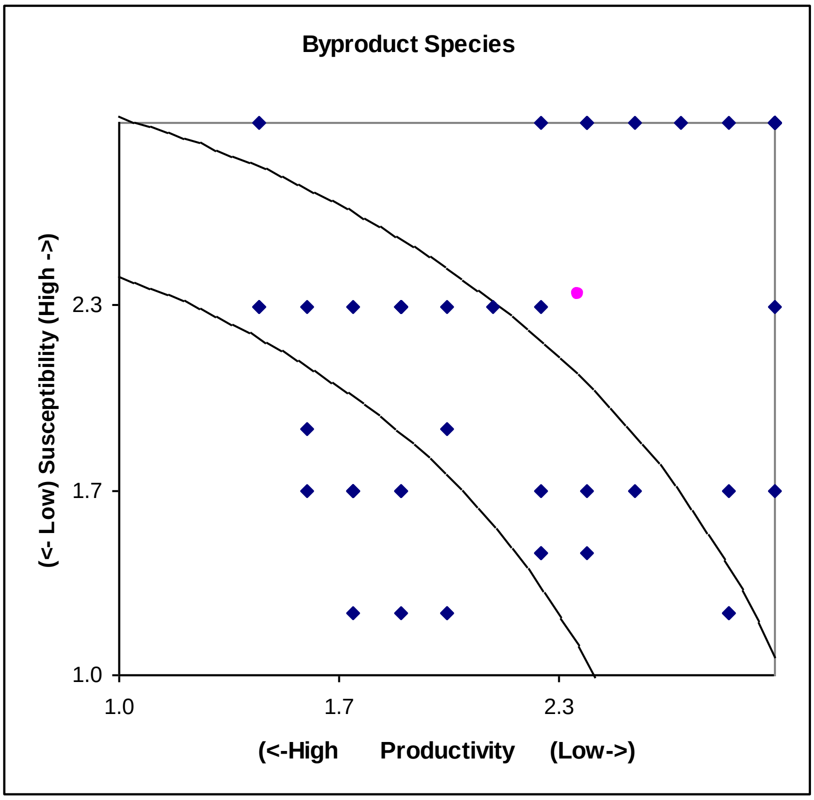
2.4.4 PSA Plot for individual units of analysis (Step 4)

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).

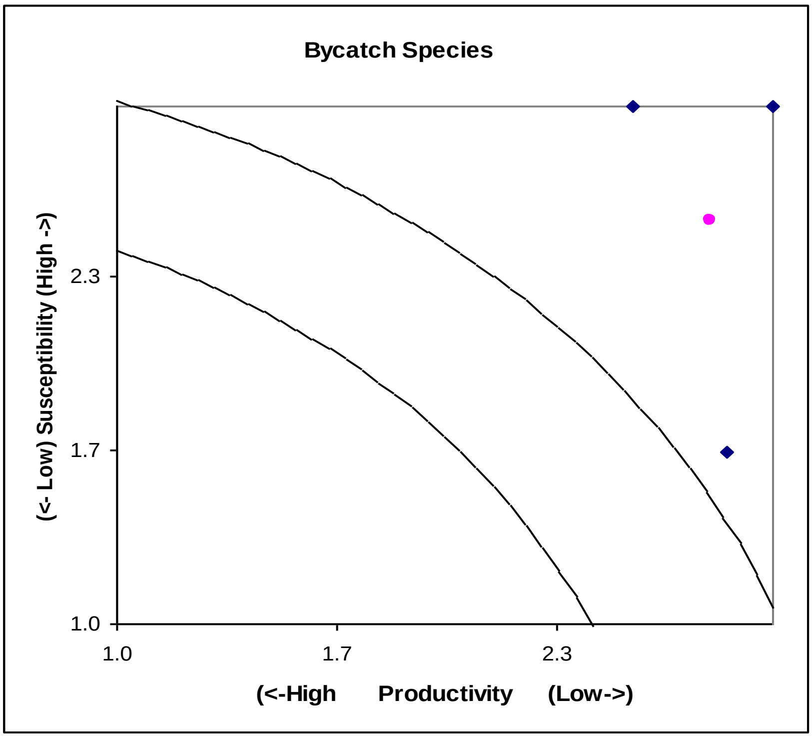
Results of the PSA plot from PSA workbook ranking worksheet



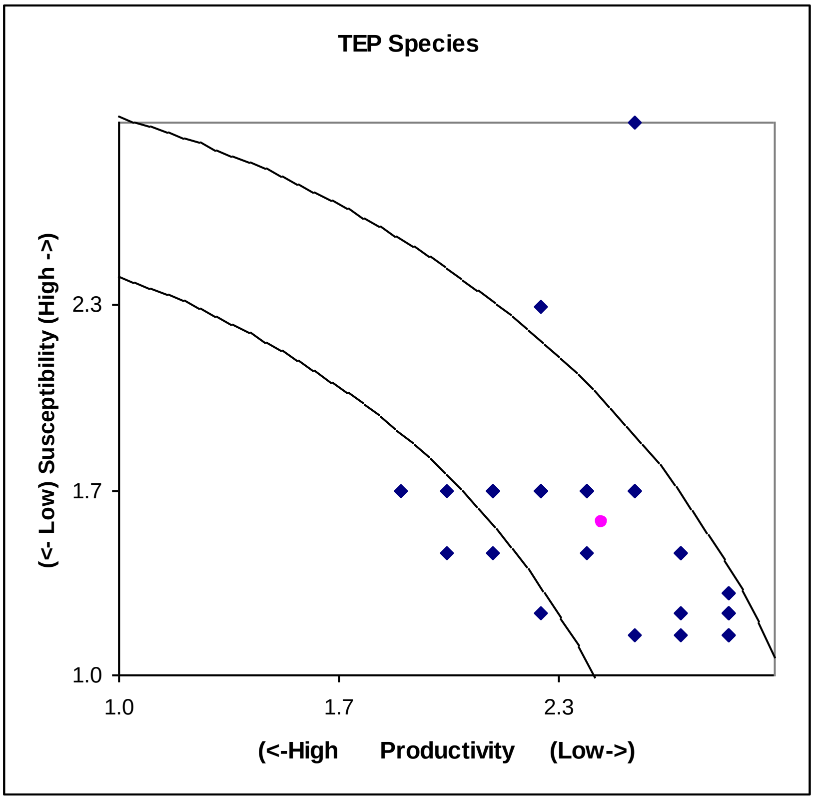
PSA plot for target species



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)**.

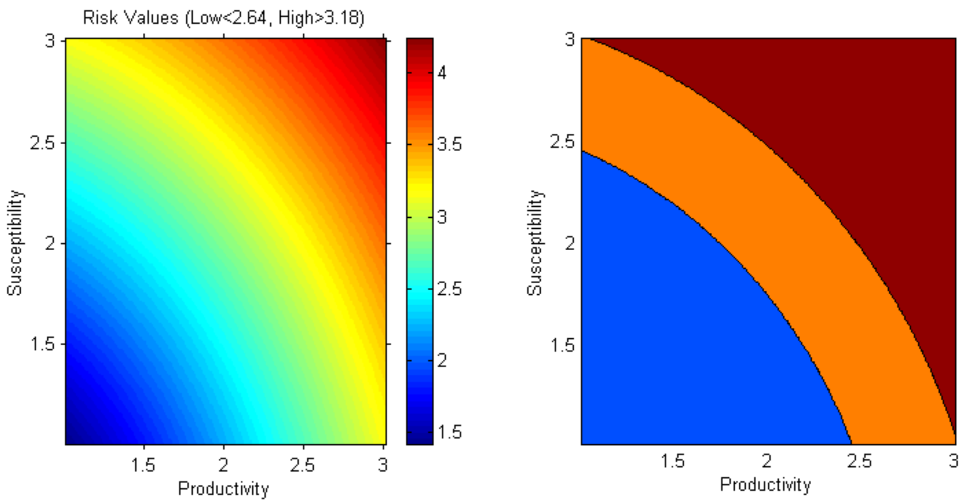


Figure 17. Overall risk values in the PSA plot. Left panel. Colour map of the distribution of the euclidean overall risk values. Right panel. The PSA plot contoured to show the low risk (blue), medium risk (orange) and high risk (red) values.

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.

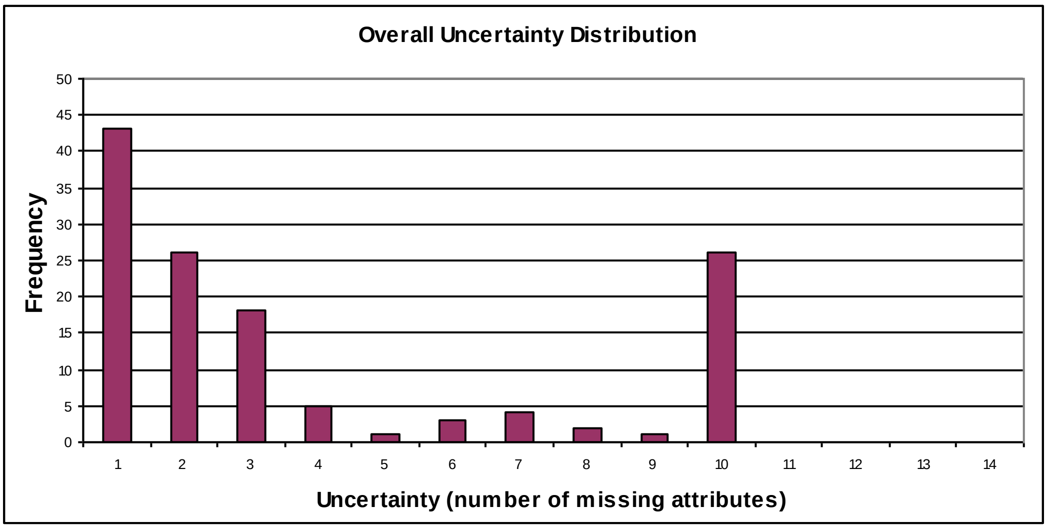
The validity of the ranking can also be examined by comparing the results with those from other data sources or modelling approaches that have already been undertaken in specific fisheries. For example, the PSA results of the individual species (target, byproduct and bycatch and TEP) can be compared 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 61% of species, and so the most conservative score was used, while information on maximum size, size at maturity and reproductive strategy could be found or calculated for 78-79 % of units. For the susceptibility attributes, bathymetry overlap was missing in 21% of species, and so the most conservative score was used. The current method of scoring the availability and post-capture mortality attributes provides a value for each attribute for each species – some of these are based on good information, whereas others are merely sensible default values.

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

Productivity Attributes	**Average age at maturity**	**Average max age**	**Fecundity**	**Average max size**	**Average size at Maturity**	**Reproductive strategy**	**Trophic level (FishBase)**
Total species scores for attribute	111	92	107	131	132	133	65
n species scores with attribute unknown, (conservative score used)	57	76	61	36	36	35	103
% unknown information	34	45	36	21	21	21	61
		Encounterability					
Susceptibility Attributes	**Availability**	**Bathymetry overlap**	**Habitat**	**Selectivity**	**PCM**		
Total species scores for attribute	168	133	137	133	168		
n species scores with attribute unknown, (conservative score used)		35	31	35			
% unknown information	0	21	18	21	0		

Each species considered in the analysis had information for an average of 4.60 (66%) productivity attributes and 4.4 (88%) susceptibility attributes. This meant that, on average, conservative scores were used for less than 25% 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 maximum size and size at maturity. 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.

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**
Average age at maturity	X						
Average max age	0.52	X					
Fecundity	0.10	0.04	X				
Average max size	0.41	0.27	0.23	X			
Average size at Maturity	0.32	0.25	0.25	0.84	X		
Reproductive strategy	0.03	0.03	0.54	0.28	0.29	X	
Trophic level (fishbase)	0.12	0.06	0.53	0.27	0.35	0.69	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.

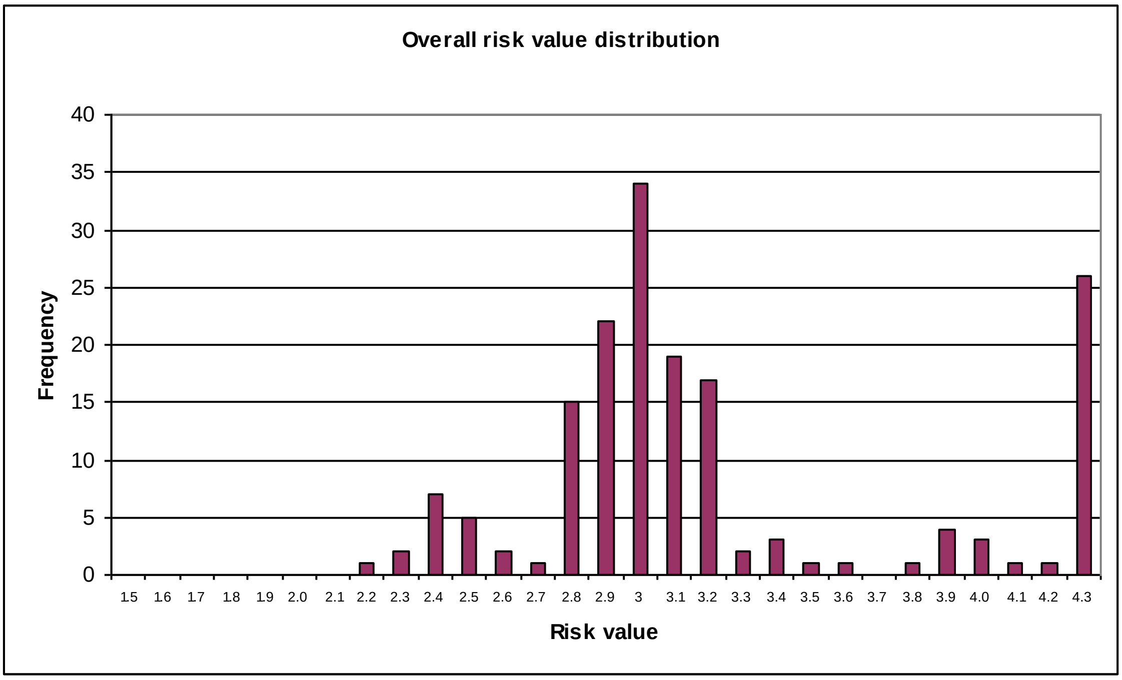
	Availability	**Encounterability**	**Selectivity**	**Post-capture mortality**
Availability	X			
Encounterability	-0.08	X		
Selectivity	0.15	0.06	X	
Post-capture mortality	-	-	-	X

Productivity and susceptibility values for Species

The average productivity score for all species was 2.44 ± 0.1 (mean ± SD of scores calculated using n-1 attributes) and the mean susceptibility score was 1.93 (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 3 attributes out of 12 possible for each species unit.

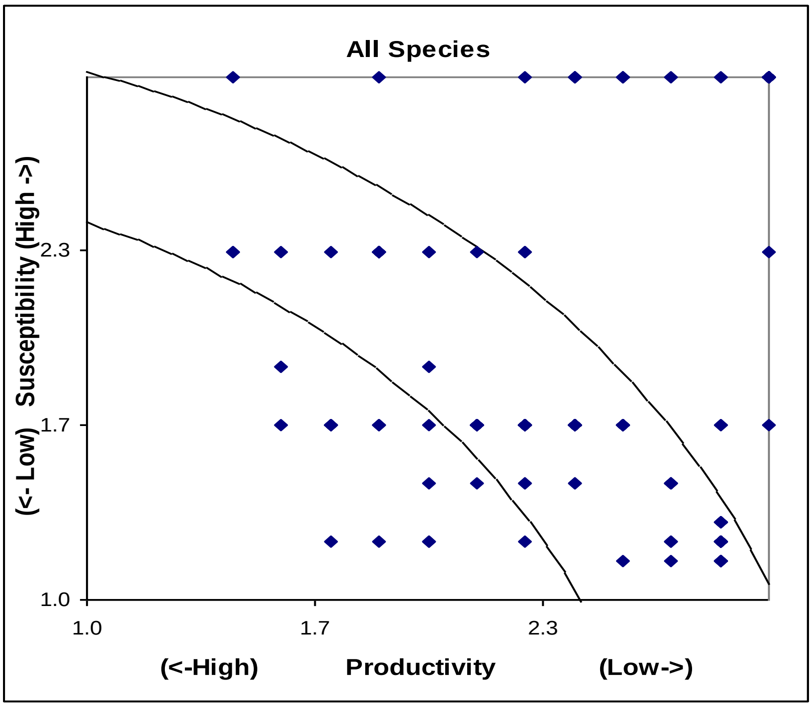
Overall Risk Values for Species

The overall risk values (Euclidean distance on the PSA plot) could fall between 1 and 4.24 (scores of 1&1 and 3&3 for both productivity and susceptibility respectively). The mean observed overall risk score was 3.15, with a range of 2.11 – 4.24**.** The actual values for each species are shown in *Summary of PSA results* (above). A total of 42 units (26%) were classed as high risk, 104 (62%) were in the medium risk category, and 18 (11%) were classed as low risk**.**



Frequency distribution of the overall risk values generated for the 168 units in the Macquarie Island 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 Macquarie Island 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 251 species were considered. Of these, 83 species were eliminated from the species list. Forty-nine of the species eliminated had insufficient taxonomic resolution or were synonyms of other species that have been considered. A further 34 species were eliminated by the AAD. A total of 168 species were subsequently considered at level 2, of which expert over rides were used on 100 species. Of the 42 species assessed to be at high risk, 36 had more than 3 missing attributes.

The average number of missing attributes was high: 3 out of a possible 12. This largely reflects the remoteness of the Antarctic region, where there have been fewer studies of the bio-geography, taxonomy and biology of demersal fishes and invertebrates, compared to the Australian continental EEZ.

Summary of average productivity, susceptibility and overall risk scores.

Component	Measure	
All species	Number of species Average of productivity total Average of susceptibility total Average of overall risk value (2D) Average number of missing attributes	168 2.45 1.93 3.14 4.4
Target species	Number of species Average of productivity total Average of susceptibility total Average of overall risk value (2D) Average number of missing attributes	1 1.86 3.00 3.53 0
Byproduct species	Number of species Average of productivity total Average of susceptibility total Average of overall risk value (2D) Average number of missing attributes	74 2.39 2.35 3.38 4.97
Bycatch species	Number of species Average of productivity total Average of susceptibility total Average of overall risk value (2D) Average number of missing attributes	3 2.81 2.56 3.83 6
TEP species	Number of species Average of productivity total	90 2.48

Component	Measure	
	Average of susceptibility total Average of overall risk value (2D) Average number of missing attributes	1.55 2.94 1.29

PSA risk categories for each species component.

Risk Category	High	Medium	Low	Total
Target species	1			1
Byproduct species	36	25	13	74
Bycatch species	3			3
TEP species	2	83	5	90
Total	42	108	18	168

PSA risk categories for each taxa.

Risk Category	High	Medium	Low	Total
Chondrichthyan	1	1		2
Invertebrate	18	2	1	21
Marine bird	2	52	4	58
Marine mammal	0	31	1	32
Teleost	21	22	12	55
Total	42	108	18	168

Discussion

Target species

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

Byproduct species

Of the 74 byproduct species, 36 are classified as high risk, 25 as medium risk and 13 as low risk. The large number of high risk scores was influenced by missing information. The average number of missing attributes was high: 5.1 out of a possible 11. However some species need further consideration. These species include whiptails, southern flounders and benthic invertebrates.

Among the whiptails, several species have restricted Southern Ocean distributions but only *Macrourus holotrachys* is caught in significant numbers (0.5 t per year). This is a relatively long-lived species, living to 52 years but matures early (12 years) and has high fecundity (15,000) and was assessed as mediumk risk.

The southern flounders have restricted distributions but are not caught in significant numbers. The age structure and fecundity of these species are unknown.

The main benthic invertebrates reported in observer data are ‘gorgonians’ presumably sea-fan corals – 6.5 t per over the last five years. The species composition of this part of the bycatch is not clear.

<u>Bycatch species</u>
There were only three bycatch species from observer data that were considered. These are jellyfish, sleeper shark, and ‘Subclass Zoantharia’. Of these, only the latter two are reported in significant quantities annually: 9.2 t and 1.4 t over the last five years respectively.

<u>TEP species</u>
Of the 90 TEP species, only two birds were considered high risk: the white-chinned petrel and the wandering albatross.

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

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

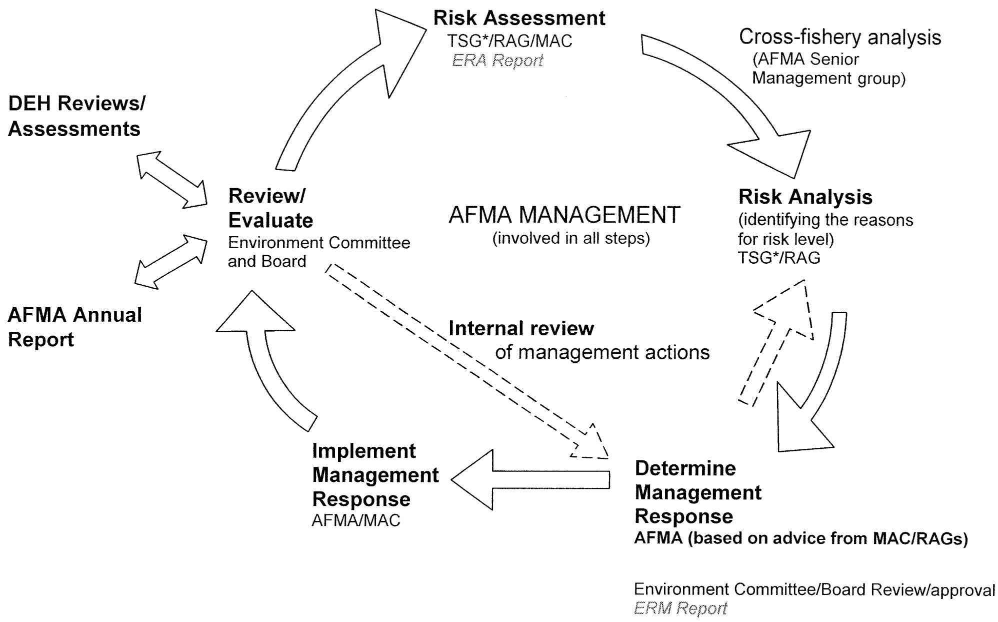
For example, if in a Level 2 analysis of habitat types, two of seven habitat types were determined to have risk from the sub-fishery, only those two habitat types would be considered at Level 3.

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

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

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

Figure x: Ecological Risk Management Framework



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

2.4.8 High/Medium risk categorisation (Step 8)

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

- **Category 1: Missing data** (*>3 missing attributes in either Productivity or Susceptibility estimation)*. Rationale: A total of more than 3 missing attributes (out of 12 possible) could lead to a change in risk score if the information became known. This is because where information is missing for an attribute, that attribute is automatically scored as high risk. The choice of 3 attributes was identified using sensitivity analysis.
- **Category 2**: **Spatial overlap**

  - **2A. Widely distributed** *(More than 80% of the full range of a species is outside the jurisdictional boundary of the fishery).* Rationale: These species may have refuge outside the fishery.
  - **2B. Low overlap** *(<20% overlap between effort and the species distribution inside the fishery).* Refers to the preferred Availability attribute used to calculate Susceptibility. Rationale: This cutoff (20%) has no strong rationale, other than being a low percentage overlap. Additional work to determine what threshold might be applicable is required. However, the categories are to be used as a guide for management, and additional effort to decide on cutoffs may be misplaced if the categories are just used as a guide. A similar analysis could be undertaken for the encounterability and selectivity attributes, but there is more information available for availability (overlap) for most species and overlap may be more informative about risk. A subtle change in fishing practice could modify encounterability or selectivity, while to change availability requires a major change in fleet location, which will be easier to detect.
- **Category 3**: **Low (susceptibility) attribute score** (*One of the susceptibility attribute scores = 1).* Rationale: These species may be scored high risk based on productivity risk alone, even if their susceptibility is very low.
- **Category 4**: **Spatial uncertainty** (*No detailed distributional dat*a *available*) Availability was calculated using less reliable mapping data or distributional categories: Global/Southern Hemisphere/Australia, with stock likelihood overrides where necessary. Rationale: the absence of fine scale catch and species distribution data (e.g. TEP species) means that the substitute attribute (precautionary) was used. Spatial data should be sought.
- **Category 5 Other**: *risk score not affected by 1-4 considered above*

Categorisation results - High risk species

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

Of the 42 species classified as high risk in this fishery, 36 had missing data (Category 1), 1 was widely distributed outside the fishery (Category 2A) and 5 had spatial data missing (Category 4).

Risk Category	Description	Total
Category 1	High risk - Missing data	36
Category 2A	High risk - Widely distributed outside fishery	1
Category 2B	High risk - Low overlap inside fishery	0
Category 3	High risk – One susceptibility attribute scored low	
Category 4	High risk - Spatial uncertainty	5
Category 5	High risk - Other	0

Risk Category	Description	Total
	Total High risk	42

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

2.5 Level 3

Elements of Level 3 assessment have already occurred for the target species Patagonian toothfish at Macquarie Island. Annual stock assessments are carried out for the target species (e.g. Tuck 2006), as well as ongoing monitoring of bycatch/byproduct species via the observer program.

3. General discussion and research implications

The Macquarie Island Fishery targets Patagonian toothfish using demersal trawl gear in 600 – 1,200 m on two fishing grounds – the Aurora Trough and the Northern Valleys.

Overall there were proportionally more high risk scores for byproduct/discard teleosts and invertebrates in the MIF fishery than other fisheries evaluated by ERAEF. 40 out of 77 byprodcut and bycatch species were high risk at MIF. These high risk scores largely reflect uncertainty – missing attributes and poorly known distributions. However a few species of sharks and fish may be genuine high risk species. Conversely the TEP scores reflect greater certainty than for other fisheries. This has been aided by 100% observer coverage. This level of coverage is best practice in Australian fisheries but there are opportunities to improve the way this data is collated and summarised. These opportunities are currently being pursued by AFMA working with AAD. This will ensure that effectiveness of mitigation measures can be evaluated, as well as compliance. Only two of the TEP species considered were high risk. Both of these were birds.

In the past, the principal ecological concern for the MIF has been incidental capture of birds and this is likely to remain the case. Continued monitoring of seabird interactions to ensure mitigation measures remain effective is a priority for this fishery.

Habitats were not examined in detail but the byproduct/discard species examined at level 2 included large amounts of coral. There are concerns relating to the benthic impacts of trawling across a range of fisheries. Deepsea impacts are of greatest concern because corals are often long lived, slow to recover and provide a range of habitats for invertebrates and demersal fishes.

3.1 Level 1

The fishery is likely to have moderate impacts on the single target species but this species is already under comprehensive management plans.

The sleeper shark was considered the most vulnerable discard species which is caught in significant numbers in the Aurora trough. It is not clear whether these catches reflect abundance or susceptibility to capture.

A number of albatross species were considered vulnerable to the fishery, particularly the wandering albatross which has a reduced population size on the Island – 40 birds.

Habitats were not examined.

In the level one community analysis, the mid-upper slope community was considered most vulnerable. Demersal trawl gear may alter this community on the fishing grounds.

3.2 Level 2

Level 1 analyses suggested target, byproduct/bycatch species and TEP species components were at moderate risk from capture fishing. These risks were further analysed at level two. The level 2 assessments found 42 species at high risk, 108 at medium risk and 18 at low risk. Each of the species components included one or more high risk species

3.2.1 Species at risk

<u>Target</u>
The target species was assessed to be at potentially high risk with one low susceptibility attribute. However, this species has had detailed Level 3 assessments and is under comprehensive and precautionary management plans.

Overall, of the list of 42 species rated as high from the PSA analyses, the authors consider that 8 non-target species, three of which are invertebrates, need further evaluation or management response. This expert judgment is based on taxonomy/identification, distribution, stock structure, and movements, and overlap with the demersal trawl fishery.

Species	Risk Category
• *Lithodes murrayi*	Missing data
• *Gorgonaceae (gorgonian sea fans)*	Missing data
• *Hexacorrallia (tube anenome, black and thorny corals)*	Missing data
• *Lepidonotothen squamifrons*	Widely distributed
• *Macrourus holotrachys (med risk)*	Spatial uncertainty
• *Mancopsetta* sp.	Missing data
• *Achiropsetta* sp.	Missing data
• *Somniosus antarcticus*	Spatial uncertainty
• *Diomedea exulans*	Spatial uncertainty
• *Procellaria aequinoctialis*	Spatial uncertainty

<u>Byproduct</u>
Within the byproduct species, 36 were classified as high risk 20 teleosts species were at high risk, of which the scores of 19 were influenced by missing information or spatial uncertainty in one case, mostly due to lack of precise taxonomic resolution and therefore corresponding data. The catches of these species were either insignificant or not reported during the assessment period. The species that were considered most likely to be at risk within this group was the the grey rockcod *Lepidonotothen squamifrons* which is caught in significant quantities. At a lesser risk level, the whiptail *Macrourus holotrachys* is the only whiptail caught in quantity during the assessment period but might also be of concern along with other whiptails and the southern flounders. However none of these species

have particularly low productivity and whiptails are the only byproduct fish species caught in significant quantities.

The remaining 16 species were invertebrates for which there was also missing information. The Subantarctic king crab *Lithodes murrayi* was caught in significant quantities and represents high risk Gorgonian sea fans have also been caught in significant amounts of benthic invertebrates suggesting that habitats need assessment.

<u>Bycatch</u>
The sleeper shark is a poorly known deepwater dogfish. Other species of deepwater dogfish have annual fecundity of less than 1. Studies of other deepwater dogfishes, blue sharks and white sharks suggest survival rates of released sharks are around 50%. There are no yield estimates for sleeper sharks.

The 'subclass zooantharia' recorded in observer data could include tube anemones, black corals or thorny corals. The invertebrate fauna of the region is poorly known but is likely to include long-lived corals, similar to those present on seamounts around southern Tasmania. The coral on some of these seamounts has been reduced and has not recovered after 10 years. These corals are difficult to age but some cold water corals are thought to live to 100 years.

<u>TEP Species</u>
Only two TEP species were assessed as high risk due to spatial uncertainty of the core range of the species and overlap with the fishery. An over-ride was applied to *Procellaria aequinoctialis* White-chinned petrel to reduce its encounterability although the White chinned petrel is an aggressive bird that dives on baits and has interacted with the fishery resulting in death. *Diomedea exulans* the wandering albatross has not been captured in the sub-fishery, but has a limited population size on Macquarie Island (40 birds), therefore the over-ride was not applied to this species. Even if one bird were captured it would comprise 2% of the population. In fact any level of harvest of this population presents significant risk given that it is recovering from depletion from external (to the MIF trawl fishery) influences. Closely related species, including shy albatross, have been killed by warp wires in trawl fisheries around the Australian continent as recorded in observer data.

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:

- Maintain and monitor mitigation measures for seabird mitigation and continue to ensure compliance
- Continue to standardise the way observer data is compiled. Increase the frequency and availability of data summaries. Develop the application observer data to evaluate the effectiveness of mitigation measures and assist with adaptive management.
- Complete the guide to Fishes of Macquarie Island
- Examine the risk to habitats posed by demersal trawling at Macquarie Island
- Collect data on mortality rates of sleeper sharks caught in trawl nets and consider methods to evaluate mortality of sleeper sharks released after capture

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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
28/9/2006	**Written comment from AFMA**	**Update the executive summary: Discard: quoted incorrectly, figures given for catch rates of quota species.**	**Discard figures corrected.**

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 27June 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 generations free from impact.

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

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

Sub-component	**Score/level**					
	1 Negligible	**2 Minor**	**3 Moderate**	**4 Major**	**5 Severe**	**6 Intolerable**
Population size	**1. Population size** Almost none are killed.	**1. Population size** Insignificant change to population size/growth rate (r). Unlikely to be detectable against background variability for this population.	**1. Population size**. State of reduction on the rate of increase 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	**2. Water quality** Detectable impact on water quality. Time to recover from local	**2. Water quality** Moderate impact on water quality. Time to recover from local	**2. Water quality** Time to recover from local impact on the scale of months to	**2. Water quality** Impact on water quality with 50 - 90% of the habitat	**2. Water quality** The dynamics of the entire habitat is in danger of being

Sub-component	Score/level					
	1 Negligible	**2 Minor**	**3 Moderate**	**4 Major**	**5 Severe**	**6 Intolerable**
	detectable. Time taken to recover to pre-disturbed state on the scale of hours.	impact on the scale of days to weeks, at larger spatial scales recovery time of hours to days.	impact on the scale of weeks to months, at larger spatial scales recovery time of days to weeks.	years, at larger spatial scales recovery time of weeks to months.	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.	changed in a major 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	**4. Habitat types** The reduction of habitat type areal extent may threaten ability to recover adequately, or cause strong downstream effects in habitat distribution and extent. Time to	**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

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

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

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

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

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