Australia's National
Science Agency

Ecological Risk Assessment for the Effects of Fishing

Report for the Macquarie Island Toothfish Fishery: Automatic Longline Sub-fishery, 2019 - 2023

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10 April 2026

Report for the Australian Fisheries Management Authority

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Citation

Sporcic, M., Fuller, M., Gerber, C., Dell, J. (2026). Ecological Risk Assessment for the Effects of Fishing. Report for the Macquarie Island Toothfish Fishery: Automatic Longline Sub-fishery, 2019 - 2023. Report for the Australian Fisheries Management Authority.

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Notes to this document

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

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

Thus, table and figure numbers within the fishery ERA Report document 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.

This document also reflects some changes in methods that are detailed in AFMA's ERA guide (2017):

> Australian Fisheries Management Authority (2017). Guide to AFMA's Ecological Risk Management. 130 p. (Commonwealth of Australia, Canberra).

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Acronyms

IUU Illegal Unreported and Unregulated
IWL Integrated Weight Line

Acknowledgements

Thanks to Yvette Lamont (AFMA) for providing summary statistics from AFMA logbook and information for the Scoping section of the report. Tim Lamb (AAD) is also thanked for providing Observer data for this fishery which were used in the report. Both Tim Lamb (AAD) and Yvette Lamont (AFMA) are also thanked for providing useful information that was also incorporated in the report. Many thanks also to Elissa Mastroianni (AFMA) and Rachel Downes (AFMA) for providing updated Scoping information that was used in the report. Also, Rachel Downes (AFMA) and Sub-Antarctic Resource Assessment Group (SARAG) Industry members are thanked for their reviews of the report. Lastly, Linda Thomas (CSIRO) and Franzis Althaus (CSIRO) are thanked for their individual reviews of the report.

Executive Summary

The “Ecological Risk Assessment for Effect of Fishing” ERAEF was developed jointly by CSIRO Oceans and Atmosphere (now CSIRO Environment) and the Australian Fisheries Management Authority (Hobday et al., 2007, 2011a). This assessment of the ecological impacts of the Macquarie Island Toothfish Fishery - Automatic Longline was undertaken using the ERAEF method version 9.2, with some additional modifications currently in the final stages of development with AFMA. This revised ERAEF provides a hierarchical framework for a comprehensive assessment of the ecological risks arising from fishing, with impacts assessed against five revised ecological components: key commercial and secondary commercial species; byproduct and bycatch species; protected species; habitats; and (ecological) communities (see ERM Guide, AFMA, 2017).

The 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 (including PSA – Productivity Susceptibility Analysis and SAFE – Sustainability Assessment for Fishing Effects); 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 represents 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 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 specific fishery. Level 1 screens out activities that are judged to have low impact, and potentially screens out components with all low impact scores. Level 2 is a screening or prioritization process for individual species, habitats and communities at risk from direct impacts of fishing, using either PSA or bSAFE. 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 assess absolute levels of risk.

This MITF Longline ERA is based on analyses of data (to 2023) conducted in 2024. It should be noted that this is the first level 1 (SICA) ERA. A level 2 (SAFE) assessment has previously been conducted in 2011 (Zhou & Fuller, 2011).

This 2019-2023 assessment of the Macquarie Island Toothfish Fishery - Automatic Longline consists of the following:

- Scoping
- Level 1 results for all components, except habitats
- Level 2 for protected species

Fishery Description

Gear Demersal automatic longline
Area Macquarie Island
Mean depth range ~623 to 1162 m below the surface
Fleet size 1 vessel fishing
Effort 1.797 - 2.560 million hooks p.a.
Landings 438 t - 538 t p.a. of key commercial species
Key commercial species Patagonian Toothfish
Management Input and output controls
Observer program AFMA Observer Program (OP); Observer coverage rate: 100%, except for 2020-2021 season due to COVID-19 restrictions (50%). E-Monitoring employed when Observer could not board vessel.

Ecological Components Assessed

A total of 40 species across all ecological components were assessed in this ERAEF (Table 0.1). The following components were not assessed in this report: Habitats.

Table 0.1: Ecological components assessed in 2026 (data from 2019 to 2023). NA: not assessed.

Ecological components assessed	2026
Key/secondary commercial species	1
Commercial species/Bait	NA
Byproduct species	NA
Bycatch species	35
Protected species	4
Benthic habitats	NA
Pelagic habitats	NA
Demersal communities	3
Pelagic communities	2

Level 1 Results and Summary

Approximately 95% of all assessed hazards (fishing activities) were eliminated at Level 1 (risk scores 1 or 2). Those remaining consist of:

- Direct impact/capture from fishing (protected species and communities)
- Direct impact/without capture from fishing (protected species)

The most vulnerable species that triggered a Level 2 analysis were the protected White-chinned Petrel *Procellaria aequinoctialis* and the Porbeagle Shark *Lamna nasus* with and without capture from fishing. For the latter species, the moderate risk score from the capture from fishing was due to (i) the number of interactions with MITF-Longline operations (42: 12 alive, 29 dead, 1 injured), (ii) low productivity (slow growth rate, late maturing and low fecundity) of the southern population and (iii) the southern population being genetically, biologically and geographically distinct from the northern population.

Fishing by direct capture was considered a moderate risk (3) to communities (i.e., Demersal: Upper mid-slope 250-1100 m), due to the potential for the Integrated Weight Line (IWL) to interact with communities that consist of organisms that are often fragile and slow to grow and recover following disruption. The communities component triggered a Level 2 analysis but was not analysed in this assessment. Also, a Level 1 for the habitats component was not assessed, as it was outside the project scope.

Table 0.2: Outcomes of assessments for ecological components conducted in 2024.

Ecological Component	2024
Key/secondary commercial species	Level 1
Byproduct and bycatch species	Level 1
Protected species	Level 2
Habitats	not assessed
Communities	Level 2

Level 2 Results and Summary

A total of 4 unique species were evaluated at Level 2 (3 with PSA and 1 with bSAFE, which includes any unassessable species in a bSAFE, subsequently assessed in a PSA). Under the revised ERAEF framework (AFMA, 2017), key commercial species that undergo tiered assessments are not assessed at Level 2. However,

Table 0.3: Stock assessments including status detail (where available) of key commercial species in the Macquarie Island Toothfish Fishery - Automatic longline. NSTOF: not subject to overfishing, NOF: not overfished. [1]: based on ABARES classification in Patterson & Curtotti (2023).

Common name	Scientific name	ERA classification	Fishing mortality[1]/Biomass[1]	Reference(s)	Year last assessed
Patagonian Toothfish	*Dissostichus eleginoides*	Key Commercial	NSTOF / NOF	Bessell-Browne & Hillary (2023)	2023 (data to 2022)

an ERA should be considered for species that are subject to lower tiered assessments (e.g., Tier 4/5, based on catch/effort or catch data only) when the model-based assumptions may not be satisfied.

PSA and Residual Risk

For ecological components in the sub-fishery not explicitly listed here, no species were assessed at Level 2.

Bycatch species
The bycatch species component was not evaluated in this assessment since it was eliminated at Level 1.

Protected species
A total of three out of four protected species were assessed in the PSA. All three species were found to be at medium risk. Of these, none were non-robust (i.e., data deficient) species.

bSAFE and Residual Risk

For ecological components in the sub-fishery not explicitly listed here, no species were assessed at Level 2.

Bycatch species
The bycatch species component was not evaluated in this assessment since it was eliminated at Level 1.

Protected species
There was one out of four protected species assessed in the bSAFE. No species were above the limit (bSAFE-MSM and bSAFE-LIM) reference points, i.e., it was assessed at low risk.

Summary

All three seabird species were evaluated at medium risk following a PSA. These comprised the following Petrel species: White-chinned Petrel *Procellaria aequinoctialis*, Southern Giant Petrel *Macronectes giganteus* and Northern Giant Petrel *Macronectes halli*. The protected Porbeagle Shark *Lamna nasus* was evaluated at low risk following a bSAFE analysis.

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

1.1 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 1.1). 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.

1.2 Conceptual Model

The approach makes use of a general conceptual model of how fishing impacts 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 the impacts of fishing for strategic assessment under EPBC legislation. The five revised components are:

- Key commercial species and secondary commercial species
- Byproduct and bycatch species
- protected[1] species (formerly referred to as threatened, endangered and Protected[2] species or TEPs)
- Habitats
- Ecological communities

This conceptual model (Figure 1.2) 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, protected 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 the achievement of management objectives.

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).

[1]The term "protected species" refers to species listed under [Part 13] of the EPBC Act (1999) and replaces the term "Threatened, endangered and protected species (TEPs)" commonly used in past Commonwealth (including AFMA) documents.

[2]Note "protected" (with small "p") refers to all species covered by the EPBC Act (1999) while "Protected" (capital P) refers only to those protected species that are threatened (vulnerable, endangered or critically endangered).

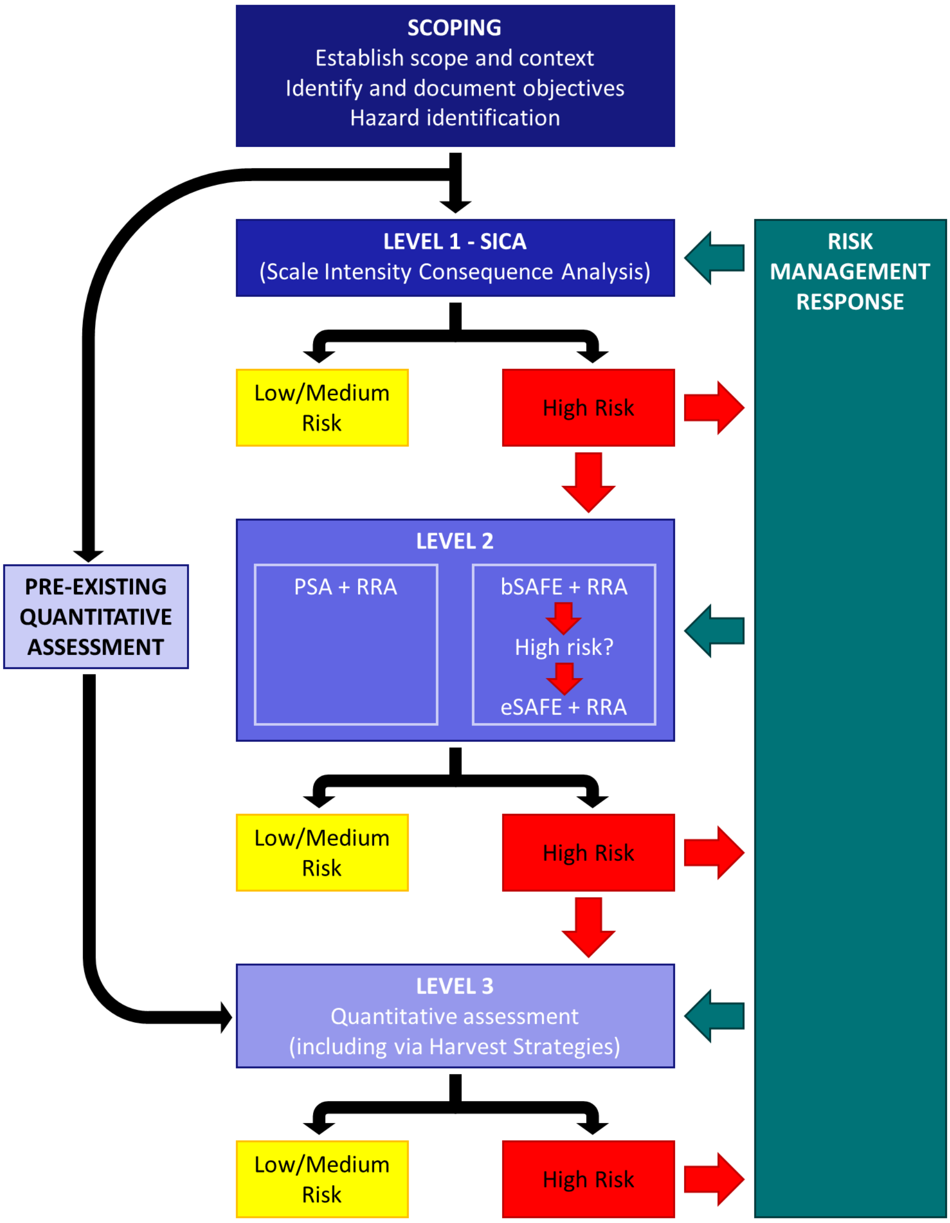

Figure 1.1: Structure of the 3 level hierarchical ERAEF methodology. SICA – Scale Intensity Consequence Analysis; PSA – Productivity Susceptibility Analysis; SAFE – Sustainability Assessment for Fishing Effects; RRA – Residual Risk Analysis. T1 – Tier 1. eSAFE may be used for species classified as high risk by bSAFE.

1.3 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.

1.4 Scoping

In the first instance, scoping is based on a 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.

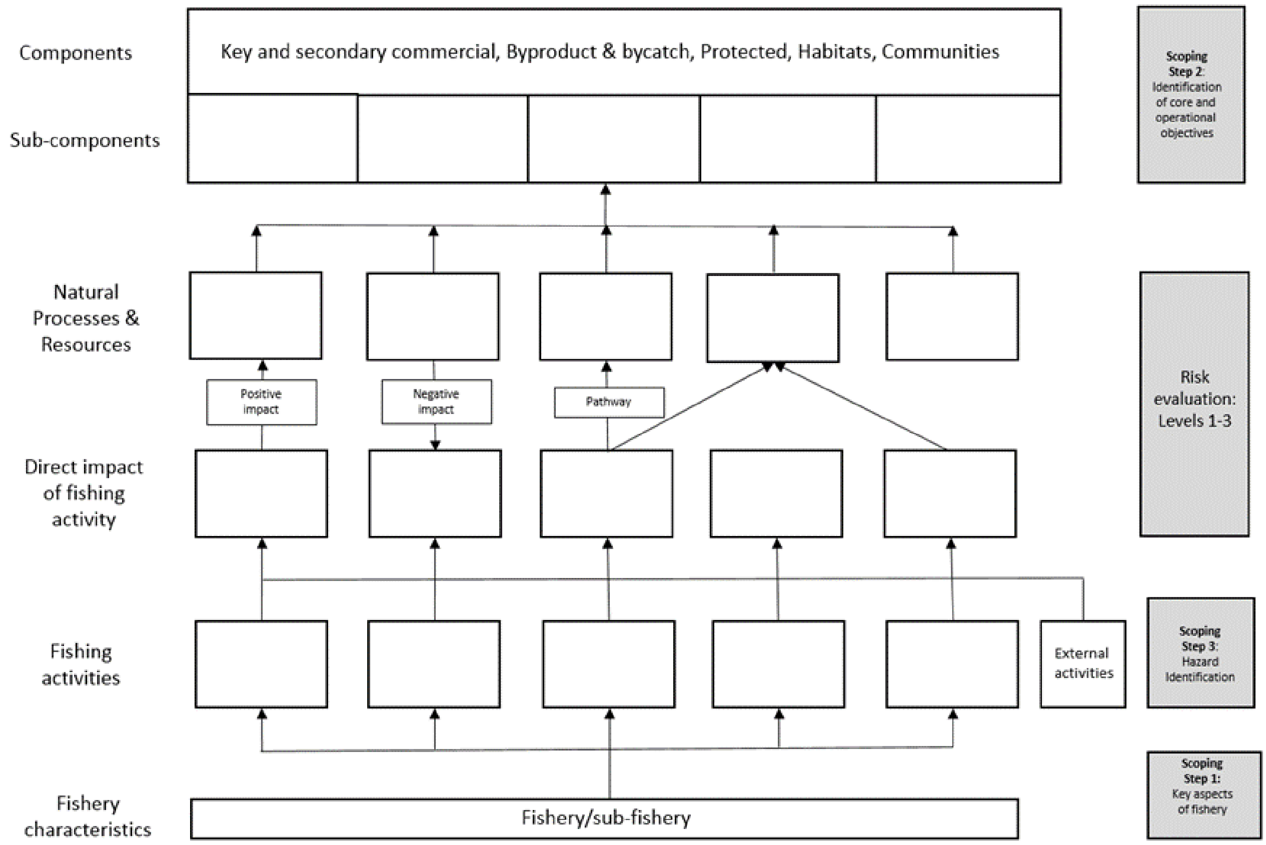

Figure 1.2: Generic conceptual model used in ERAEF.

1. **Identification of units of analysis** (species, habitats and communities) potentially impacted by fishery activities (Section 2.2.2; Scoping Documents S2A, S2B1, S2B2 and S2C1, S2C2).
2. **Selection of objectives** (Section 2.2.4; Scoping Document S3). The primary objective to be pursued for species assessed under ERAF is that of ensuring populations are maintained at biomass levels above which recruitment failure is likely, as stated in Chapter 2 (AFMA, 2017 Ecological Risk Management (ERM) Guide). This is consistent with current legislation and fisheries policies and represents a change from when the ERAEF was first developed and there was less policy or legislation-based guidance on sustainability objectives, with stakeholders able to choose from a range of "sustainability" objectives (e.g., Tables 5A-C in Hobday et al., 2007).
3. **Selection of activities** (hazards) (Section 2.2.5; 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/or consultation with the stakeholders are 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.

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

The SICA 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) should be prepared by the draft fishery ERAF report author and reviewed at an appropriate stakeholder meeting (e.g., Resource Assessment Group meeting). Due to the number of activities (up to 24) in each of the 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. Documenting the rationale for each SICA element 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, Smith et al., 2007). Level 1 analysis potentially results 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.

1.6 Level 2. PSA and SAFE (Semi-quantitative and Quantitative Methods)

When the risk of an activity at Level 1 (SICA) on a species component is moderate or higher and no planned management interventions that would remove this risk are identified, an assessment is required at Level 2 (to determine if the risk is real and provide further information on the risk). The tools used to assess risk at Level 2 allow units (e.g., all individual species) within any of the ecological species components (e.g., key/secondary commercial, byproduct/bycatch, and protected species) to be effectively and comprehensively screened for risk. The analysis units are identified at the scoping stage. To date, Level 2 tools have been designed to measure risk from direct impacts of fishing only (i.e., risk of overfishing, leading to an overfished fishery), which in all assessments to date has been the hazard with the greatest risks identified at Level 1[3].

In the period since the first ERAEF was implemented across Commonwealth fisheries, much of the management focus has been on the assessment results associated with Level 2 and Level 2.5 or 3 risk assessment methods, which comprise semi-quantitative or rapid simple quantitative methods (e.g., PSA and SAFE). This level has been subject to the greatest level of change and improvement which are discussed in the following sections. Additional improvements are being developed for implementation in the near future (see Chapter 4.13 of AFMA ERM Guide, AFMA, 2017).

Level 2 was originally designed to rely on a single risk assessment methodology, the Productivity-Susceptibility Analysis (PSA) (see Chapter 4.9 of AFMA ERM Guide, AFMA, 2017). However, a more quantitative method called the Sustainability Assessment for Fishing Effects (SAFE) (see Chapter 4.10 of AFMA ERM Guide, AFMA, 2017) was developed early in the implementation of the ERAEF and classed as a Level 2.5 or Level 3 tool.

Under the revised ERAEF:

- bSAFE has now been reclassified as the preferred Level 2 method (over PSA) where sufficient spatial and biological data (to support bSAFE) are available. Typically this has been used for teleost and chondrichthyan species.
- Species estimated to be at high risk under bSAFE may then be assessed under eSAFE which may provide reduced estimates of uncertainty pertaining to the actual risk.
- Where either the data or species biological characteristics are insufficient to support bSAFE analyses, it is recommended that PSA be applied instead. This will be the case for many protected species, invertebrate bycatch species and some other species.
- At Level 2, either PSA or SAFE methods should be applied to any given species, not both.
- For high risk species it is a management choice whether to progress to eSAFE, pursue a Level 3 fully quantitative stock assessment, or take more immediate management action to reduce the risk. The types of considerations required in making that choice (i.e., moving up the ERAEF assessment hierarchy or taking direct management action) are outlined in Chapter 5.5 of the AFMA ERM Guide (AFMA, 2017).

It is also recognised that a number of additional tools, including some of the "data poor" assessment tools that are used to inform harvest strategies, could potentially be included within the Level 2 toolkit. They are distinguished from Level 3 quantitative tools (i.e., stock assessment models) that are more data-rich and able to more precisely quantify uncertainty.

1.6.1 PSA (Productivity Susceptibility Analysis)

Details of the PSA method are described in the accompanying ERAEF Methods Document and also summarised in Section 4.8.3 of the AFMA ERM Guide (AFMA, 2017). Stakeholders can provide input and

[3] Future iterations of the methodology will include PSAs modified to measure the risk due to other activities, such as gear loss.

suggestions on appropriate attributes, including novel ones, for evaluating risk in the specific fishery. 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 initial stakeholder involvement. Stakeholder input is required after preliminary attribute values are obtained. In particular, where information is missing, expert opinion can be used to derive the most "reasonable" conservative estimate. For example, if species attribute values for annual fecundity have been categorized as low, medium or high on the set (<5, 5-500, >500), estimates for species with no data can still be made. Also, the estimated fecundity of a broadcast-spawning fish species with unknown fecundity is still likely to be greater than the high fecundity category (>500). Susceptibility attribute estimates, such as "fraction alive when landed", can also be made based on input from experts such as scientific observers. Feedback to stakeholders regarding comments received during the preliminary PSA consultations is considered crucial. The final PSA is completed by scientists and results are presented to the relevant stakeholder group (e.g., RAG and/or MAC) before decisions regarding Level 3 analysis are considered. The stakeholder group may also decide on priorities for analysis at Level 3.

1.6.2 Residual Risk Analysis

There were several limitations due to the semi-quantitative nature of a Level 2 PSA assessment. For example, certain management arrangements which mitigate the risks posed by a fishery, as well as additional information concerning levels of direct mortality, may not be easily taken into account in assessments. To overcome this, Residual risk analyses (RRA) are used to consider additional information, particularly mitigating effects of management arrangements that were not explicitly included in the ERAs or introduced after the ERA process commenced. Priority for this process has typically been focused on those species attributed a high risk rating (those likely to be most at risk from fishing activities). It could in theory be used to also determine if some species have been incorrectly classified as low risk.

Recently revised Residual risk guidelines have been developed (AFMA, 2018) to assist in making accurate judgements of residual risk consistently across all fisheries. At the moment, they are applied to species and not applicable to habitats or communities.

These guidelines are not seen as a definitive guide on the determination of residual risk and it is expected they may not apply in a small number of cases. Care must also be taken when applying them to ensure residual risk results are appropriate in a practical sense. There are a number of conditions that underpin the residual risk guidelines and should be understood before the guidelines are applied:

- All assessments and management measures used within the residual risk analysis must be implemented prior to the assessment with sufficient data to demonstrate the effect. Any planned or proposed measures can be referred to in the assessment but cannot be used to revise the risk score.
- When applied, the guidelines generally result in changes to particular "attribute" scores for a particular species. Only after all of the guidelines have been applied to a particular species, should the overall risk category be re-calculated. This will ensure consistency, as well as facilitate the application of multiple guidelines.
- Unless there is clear and substantiated information to support applying an individual guideline, then the attribute and residual risk score should remain unchanged. All supporting information considered in applying these Guidelines must be clearly documented and referenced where applicable. This is consistent with the precautionary approach applied in ERAs, with residual risk remaining high unless there is evidence to the contrary ensuring a transparent process is applied.

The results (including supporting information and justifications) from residual risk analyses must be documented in "Residual Risk Reports" for each fishery (or can be integrated into the Level 2 risk assessment report). These will be publicly available documents.

1.6.3 SAFE (Sustainability Assessment for Fishing Effects)

The SAFE method developed is split into two categories: base SAFE (bSAFE) and an enhanced SAFE (eSAFE). eSAFE has greater data processing requirements and is recommended to only be used to assess species estimated to be at high risk via the bSAFE. It is also able to more appropriately model spatial availability aspects when sufficient data are available.

bSAFE

Relative to the PSA approach, the bSAFE approach (Zhou et al., 2007; Zhou & Fuller, 2011; Zhou & Griffiths, 2008):

- is a more quantitative approach (analogous to stock assessment) that can provide absolute measures of risk by estimating fishing mortality rates relative to fishing mortality rate reference points (based on life history parameters);
- requires fewer productivity data than the PSA;
- can account for cumulative risk and
- potentially outperforms PSA in several areas, including the strength of relationship to Tier 1 assessment classifications (Zhou et al., 2016).

Like PSA, the bSAFE method is a transparent, relatively rapid and cost-effective process for screening large numbers of species for risk, and is far less demanding of data and much simpler to apply than a typical quantitative stock assessment.

As such it is recommended that bSAFE be used as the preferred Level 2 assessment tool for all fish species and some invertebrates and reptiles (e.g., some sea snakes) with sufficient data.

In estimating fishing mortality, bSAFE utilises much of the same information as the PSA, to estimate:

- Spatial overlap between species distribution and fishing effort distribution
- Catchability resulting from the probability of encountering the gear and size-dependent selectivity
- Post-capture mortality

The fishing mortality is essentially the fraction of overlap between fished area and the species distribution area within the jurisdiction, adjusted by catchability and post-capture mortality. Uncertainty around the estimated fishing mortality is estimated by including variances in encounterability, selectivity, survival rate and fishing effort between years.

The three biological reference points are based on a simple surplus production model:

- **F_{MSY}** – instantaneous fishing mortality rate that corresponds to the maximum number of fish in the population that can be killed by fishing in the long term. The latter is the maximum sustainable fishing mortality (MSM) at B_{MSM}, similar to the target species MSY.
- **F_{LIM}** – instantaneous fishing mortality rate that corresponds to the limit biomass B_{LIM} where B_{LIM} is assumed to be half of the biomass that supports a maximum sustainable fishing mortality ($0.5B_{MSM}$)
- **F_{CRASH}** – minimum unsustainable instantaneous fishing mortality rate that, in theory, will lead to population extinction in the long term.

This methodology produces quantified indicators of performance against fishing mortality-based reference points and as such does allow calibration with other stock assessment and risk assessment tools that measure fishing mortality. It allows the risk of overfishing to be determined, via the score relative to the reference line. Uncertainty (error bars) is related to the variation in the estimation of the scores for each axis.

It is recommended that species assessed as being potentially at high risk under bSAFE are then progressed to analysis by eSAFE which may narrow uncertainties around the risk (but is more time and resource intensive than bSAFE).

Assumptions and issues to be aware of:

- Comparisons of PSA and SAFE analyses for the same fisheries and species support the claim that the PSA method generally avoids false negatives but can result in many false positives. Limited testing of SAFE results against full quantitative stock assessments suggests that there is less “bias” in the method, but that both false negatives and false positives can arise.
- SAFE analyses retain some of the key precautionary elements of the PSA method, including assumptions that fisheries are impacting local stocks (within the jurisdictional area of the fishery).

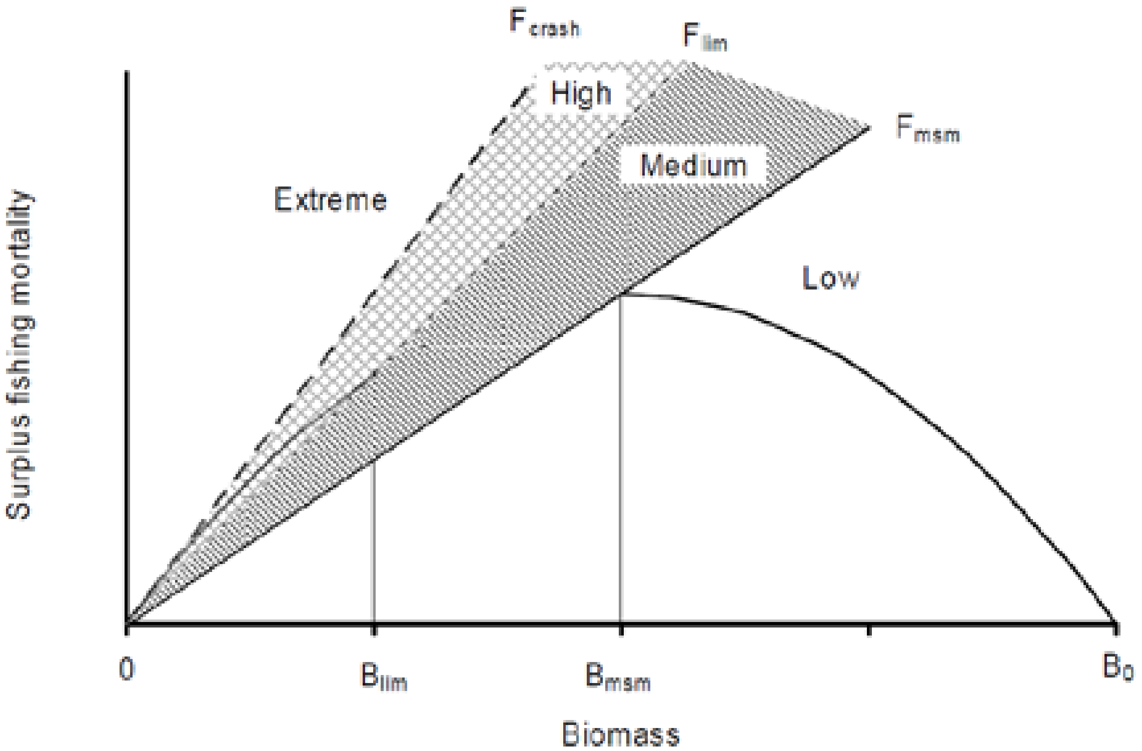

Figure 1.3: Stock productivity, biological reference points and ecological risk assessment for managing bycatch species.

- Although the bSAFE analyses provide direct estimates of uncertainty in both the exploitation rate and associated reference points, they are less explicit about uncertainties arising from key assumptions in the method, including spatial distribution and movement of stocks.
- The method assumes there would be no local depletion effects from repeat trawls at the same location (i.e., populations rapidly mix between fished and unfished areas). The fishing mortality will likely be overestimated if this assumption is not satisfied (ERA TWG 2015). The method also assumes that the mean fish density does not vary between a fished area and non-fished area within their distributional range. Hence, the level of risk would be over-estimated for species found primarily in non-fished habitats, while risk would be under-estimated for species that prefer fished habitats (ERA TWG 2015).
- The SAFE methodology makes greater assumptions than Tier 1 stock assessments in coming to its F estimates (due to a lack of the data relative to that used in a Tier 1 assessment) and it is not capable of measuring risk of a stock being already overfished (so the type of risk it measures relates only to overfishing, which may then lead to future overfished state). The limitations of SAFE with respect to measuring overfished risks are the same essentially as for PSA.

eSAFE

Enhanced SAFE (eSAFE) appears, based on calibration with Level 3 assessments, to provide improved estimates of fishing mortality relative to the base SAFE (bSAFE) method. The eSAFE requires more spatially explicit data and takes more analysis time than bSAFE, and so might only be used to further assess species that were identified as at high risk using bSAFE (and which have not had further direct management action taken). The eSAFE enhances the bSAFE method by estimating varying fish density across their distribution range as well as species- and gear-specific catch efficiency for each species.

1.7 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 analysis. 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 considered unlikely.

1.8 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 to address the requirements of the EPBC Act as evaluated by the Department of Climate Change, Energy, the Environment and Water.

1.9 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.

Fishery re-assessments for byproduct and bycatch species under the ERAEF will be undertaken every five years[4] or sooner if triggered by re-assessment triggers. The five-year timeframe is based on a number of factors including:

- The time it takes to implement risk management measures; for populations to respond to those measures to a degree detectable by monitoring processes; and to collect sufficient data to determine the effectiveness of those measures.
- Alignment with other management and accreditation processes.
- The cost of re-assessments.
- The review period for Fishery Management Strategy (FMS).

For byproduct and bycatch species, in the periods between scheduled five-year ERA reviews[5], AFMA will develop and monitor a set of fishery indicators and triggers, on an annual basis, in order to detect any changes (increase or decrease) in the level of risk posed by the fishery to any species. Where indicators exceed specified trigger levels, AFMA will investigate the causes and provide opportunity for RAG comment/advice during that process. Pending outcomes of that review, and RAG advice, AFMA can if necessary, request a species-specific or full fishery re-assessment (i.e., prior to the scheduled re-assessment dates).

The ERA TWG (September 2015) identified five key indicators upon which such triggers could be based, these being changes in:

- Gear type/use
- Mitigation measures (use or type)
- Area fished
- Catch or interaction rate
- Fishing effort

Where possible, the triggers should look to take into account additional sources of risk from interacting non-Commonwealth fisheries. In addition, if a major management change is planned for a fishery, such as a move from input to output controls, the fishery will need to be reassessed prior to that management change coming into effect. In considering each indicator and trigger level, the RAG should consider the following:

- The data upon which the indicator is based must be sufficiently representative of actual changes in catch, effort, area, gear or mitigation methods. Consideration should be given to the level of uncertainty associated with the data underpinning any prospective indicator.
- The trigger level chosen should not be overly sensitive to the normal inter-annual variance that is typical of the indicator and independent of fishing pressure, assuming such variance is unlikely to relate to a significant change in the risk posed by the fishery to any or all species.

[4] Based on a recommendation by the ERA Technical Working Group, September 2015.

[5] In contrast to key and secondary commercial species managed via catch/effort limits under Harvest Strategies, which depending on species and Harvest Strategy, can be re-assessed any time between 1 and 5 years.

- The trigger level should equate to the minimum level of change that the RAG (by its expert opinion) considers might potentially represent a significant change in the risk posed by the fishery.
- The trigger level could represent an absolute change (number/level) in an indicator or a percentage change in an indicator.
- The RAG should consider whether a "temporal" condition should be placed on the trigger (i.e., the trigger is breached two years in a row) to further reduce the likelihood of natural population variance or data errors triggering a re-assessment unnecessarily.

The final set of indicators and triggers will be developed for each fishery by AFMA in consultation with its fishery RAG (or for fisheries lacking a RAG, the ERA TWG), in association with the next planned re-assessment (see Chapter 6 in AFMA ERM Guide, AFMA, 2017). A RAG may choose a subset of these indicators and triggers, or include an additional indicator/trigger(s), based on consideration of the availability and reliability of data upon which to base any of the above indicators/triggers, however justification of this must be provided.

Research is currently underway to develop specific guidance for RAG to aid in the selection of appropriate triggers, which will in the meantime be determined using RAG expert opinion. In the longer term, it may be possible to refine indicators and triggers using the existing PSA and SAFE methods to test which attributes the end risk scores are most sensitive to (ERA TWG 2015)[6]. The RAG will record both the final set of indicators and triggers chosen, and a justification for those, in the RAG minutes. Once the final set of indicators and triggers is determined for a fishery, they will require implementation within the FMS and a monitoring and review process.

[6] ERA TWG recommendation, September 2015

2 Scoping and Stakeholder Engagement

The focus of analysis is the fishery as identified by the responsible management authority (AFMA). The assessment area is defined by the fishery management jurisdiction within the Australian Fisheries Zone (AFZ). The fishery may also be divided into sub-fisheries based on 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 are 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.

The results presented below are for the Macquarie Island Toothfish Fishery - Automatic Longline. A full description of the ERAEF method is provided in the methodology document (Hobday et al., 2007; Hobday et al., 2011b).

2.1 Stakeholder Engagement

Table 2.1: Summary Document SD1. Summary of stakeholder involvement for Macquarie Island Toothfish Fishery - Automatic Longline.

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 emails	03 March 2023	Danait Ghebrezgabhier (AFMA); Claire Wallis (AFMA)	Various information supplied to AFMA. Project discussed, training for Scoping analysis provided.
Scoping	Emails	18, 19 April 2024	Yvette Lamont (AFMA)	Revised Scoping information provided to CSIRO.
Scoping	Email	26 April 2024	Miriana Sporcic (CSIRO)	Species list completed and bycatch species queried.
Scoping	Emails, phone calls	02, 03 May 2024	Yvette Lamont (AFMA)	Revised Scoping and data provided to CSIRO.
Scoping	Email	03 May 2024	Yvette Lamont (AFMA)	Revised AFMA logbook data provided to CSIRO.
Scoping	Email	06 May 2024	Yvette Lamont (AFMA)	AFMA logbook data queried by CSIRO.
Level1, Level 2, Draft report	Email	06 June 2024	Danait Ghebrezgabhier (AFMA); Ryan Murphy (AFMA); Yvette Lamont (AFMA)	Draft report submitted to AFMA.
Level1, Level 2, Report	Email	10 April 2026	Steve Hall (AFMA); Natalie Couchman (AFMA); Rachel Downes (AFMA); Sarah Kirkcaldie (AFMA); Elissa Mastroianni (AFMA); Kerrie Bennetts (AFMA)	Report submitted to AFMA.

2.2 Scoping

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

- Step 1. Document 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 came from a range of documents such as the Fishery’s Management Plan, Assessment Reports, Bycatch Action Plans, and any other relevant background documents.

The following sections comprise the **Scoping Document S1 General Fishery Characteristics**.

Fishery Assessed: Macquarie Island Toothfish Fishery

Date of revised ERAEF assessment: April 2026

Assessor: AFMA and authors of this report (CSIRO)

2.2.1.1 General Fishery Characteristics

Fishery Name

Macquarie Island Toothfish Fishery

Sub-fisheries

Historically, trawl and longline fishing methods in the Macquarie Island Toothfish Fishery (MITF) have been regarded as separate sub-fisheries (Daley et al., 2007). As of the 1 July 2023 trawling is no longer permitted in the MITF. This assessment will only pertain to the MITF demersal automatic longline sub-fishery.

Sub-fisheries assessed

This Ecological Risk Assessment (ERA) will assess the Macquarie Island Toothfish Fishery - Automatic Longline sub-fishery.

Start date/history

The MITF has a rich history for conservation, the island was made a wildlife sanctuary in 1933 under the Animals and Birds Protection Act 1928, declared ‘Macquarie Island Wildlife Reserve in 1972’, and renamed in 1978 to the ‘Macquarie Island Nature Reserve’. Macquarie Island was inscribed on the World Heritage List in 1997, based on its outstanding natural values. The listing includes the in-shore waters of the Tasmanian park, the Macquarie Island Nature Reserve, and some of the waters in the Macquarie Island Marine Park that surround this area (National-Oceans-Office, 2012). The Macquarie Island Marine Park was first proclaimed in 1999 and its design had not been modified in over two decades until proposed changes in 2023 which led to its expansion.

The Macquarie Island Toothfish Fishery started as a demersal otter board trawling fishery which was established in 1994. Two major trawl fishing ground were utilised, the Aurora Trough and the Macquarie Ridge Northern Ground region. Toothfish tagging research began in the 1995/96 season and a Total Allowable Catch (TAC) was set from a tagging-based stock assessment. The 1996/97 season had a TAC of 750 t, 1997/98 was 200 t and the commercial fishery was subsequently closed, re-opened in 2003/04 only to be closed the next season due to concerns about stock levels based on tagging results. In 2007 a longline trial was agreed to by the Australian Fisheries Management Authority (AFMA) board to test whether longline methods could be employed in the fishery without adversely affecting seabirds. After a successful trial over three years, longlining became another primary method of fishing in 2010. A single TAC was adopted in 2012/13 (Day & Hillary, 2017). From 1 July 2023 trawling was no longer permitted in the MITF, with longlining the only permitted method.

The key commercial species for this fishery is the Patagonian toothfish (*Dissostichus eleginoides*). It is managed by AFMA under input and output controls, the latter as individually transferable quotas allocated as Statutory Fishing Rights (SFR's) under the Macquarie Island Toothfish Fishery Management Plan 2006 (hereinafter referred to as the Management Plan).

Geographic extent of fishery

The Macquarie Island is a subantarctic island located between Tasmania, New Zealand, and Antarctica approximately 1500 km southeast of Hobart and 1300 km north of the Antarctic continent (Figure 2.1).

The Island is the exposed crest of the Macquarie Ridge, a spreading north-south ocean floor ridge raised by the integration of the Indian-Australian and Pacific tectonic plates. The Antarctic Polar Front is 20 nautical miles south of Macquarie Island. This complex system moves seasonally and sometimes reaches Macquarie Island, causing a marked drop in surface water temperature (National-Oceans-Office, 2012).

Regions or Zones within the fishery

Macquarie Island is part of the State of Tasmania and located in the Southern Ocean. Waters surrounding the islands extending to a distance of three nautical miles are classified as Tasmanian State waters. The Tasmanian Department of Natural Resources and Environment (DNRE) controls fishing in these waters which were classified as a Nature Reserve in the year 2000 and closed to fishing. Waters from the 12 nm boundary to the 200 nautical miles outer boundary are Commonwealth jurisdiction and managed by AFMA under the Fisheries Management Act 1991 (AFMA, 2010). Although the Macquarie Island Toothfish Fishery is not part of the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), AFMA generally requires that fisheries in waters adjacent to the CCAMLR area (which includes Macquarie Island) are managed in a complementary manner to the CCAMLR requirements, which are considered as more precautionary than the guidelines of the Commonwealth Fisheries Harvest Strategy Policy (AMP, 2023).

In the Macquarie Island Toothfish Fishery Management Plan 2006 the area of the fishery is divided into two sectors: The Aurora Trough and the Macquarie Ridge (Office-of-Parliamentary-Counsel, 2006), which are managed as a single management unit with one quota species, however, stock assessments account for a northern and a southern region. Macquarie Island features valuable geomorphological formations along with unique terrestrial and oceanic ecosystems. The goal of the Marine Park is to protect these features, and organisms that reside within the area. The Marine Park is critically important to the South-east Marine Park Network and the National Representative System of Protected Marine Areas as it is the only representative example of the Macquarie Province bioregion. From the 1 July 2023 the Macquarie Island Marine Park expanded to encompass the entire Macquarie Island EEZ, a total area of 475,465 km^2 (a 300% expansion compared with its previous size). The Marine Park is separated into three zones (Figure 2.2) that have management restrictions depending on the level of protection they are afforded (see also Section 2.2.1.2.1).

Fishing season

The fishing season starts on 15 April and ends on 14 April the following year, the core longline fishing season runs from the 15 April to the 31 August.

2.2.1.1.1 Key/secondary commercial species and stock status

The Macquarie Island Toothfish Fishery is a single species fishery targeting the Patagonian Toothfish (*Dissostichus eleginoides*). The Patagonian Toothfish is a large, long-lived, bottom dwelling species that is widely distributed throughout the Antarctic oceans. Toothfish commonly inhabit water from 300 m to 2,400 m, grow to 2 m in length and weigh approximately 200 kg. The predominant food source of Toothfish is squid, small fish, and crustaceans. Toothfish are believed to be able to live to more than 50 years and reach maturity at around 10 years of age, possibly older around Macquarie Island. As juveniles, Patagonian

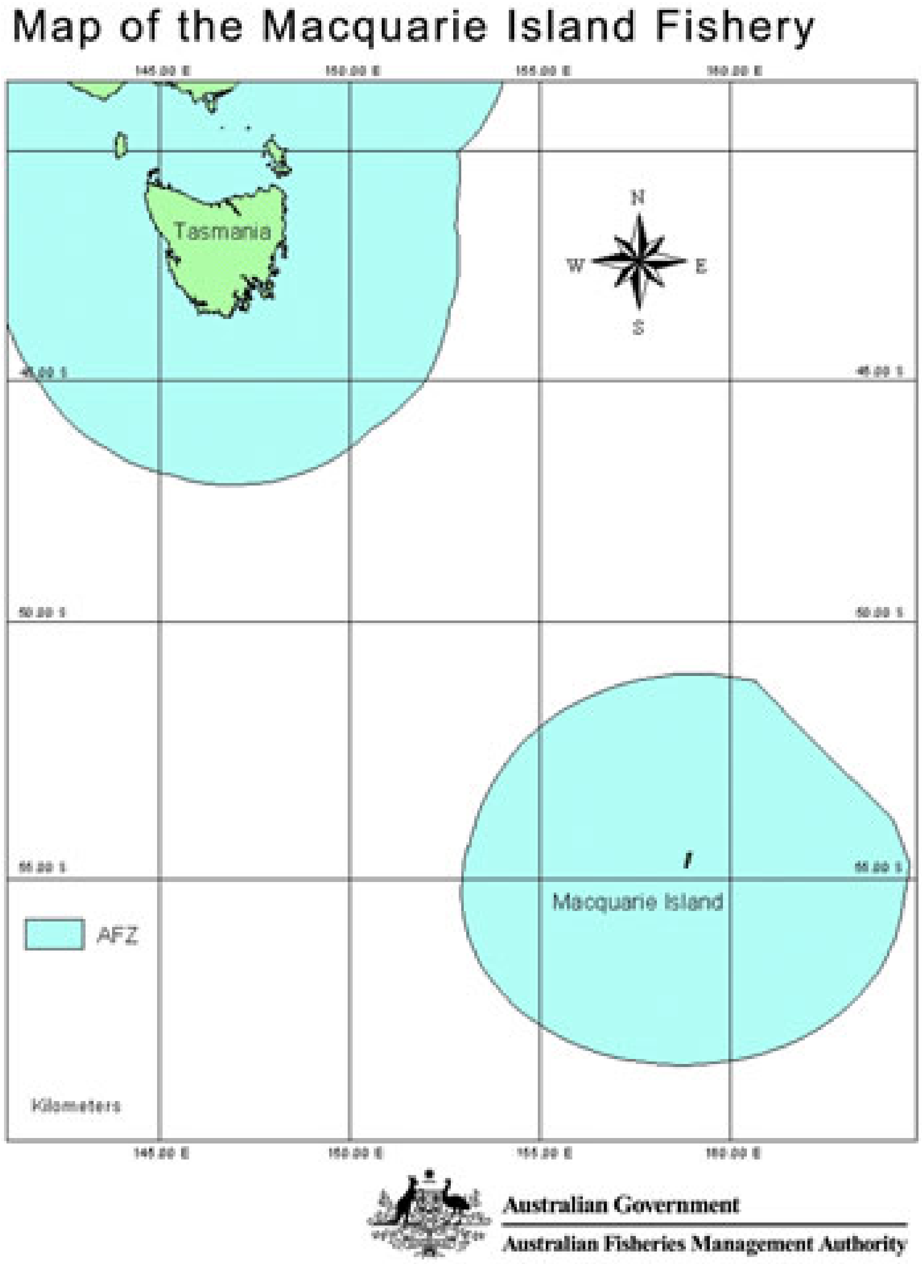

Figure 2.1: Geographic extent of fishery. Source: https://www.afma.gov.au/fisheries/macquarie-island-toothfish-fishery#referenced-section-8

Toothfish are believed to be found in pelagic waters from 50 m to around 700 m (Patterson & Curtotti, 2023).

Tagging and genetic research suggests that the stock of Patagonian Toothfish at the MITF is distinct from other regional Toothfish populations in the Southern Ocean (Appleyard et al., 2002; Patterson & Curtotti, 2022). Toothfish movements suggest they are generally quite sedentary with Grilly et al. (2022) finding that only approximately 7% of individuals recaptured between 2001-2019 travelled more than 200 km. The separation of stocks due to their sedentary nature may lead to a restricted gene flow and therefore unlikely to be easily replaced by immigration from other stocks (Appleyard et al., 2002; Day & Hillary, 2017), highlighting the importance of monitoring stock and biomass in the MITF.

The 2023 stock assessment uses Template Model Builder and fits to data, obtained from tag- recapture, length composition and age-at-length from otoliths obtained between 1995-2022 (Bessell-Browne & Hillary, 2023). There was a slightly lower estimated female spawning stock biomass (SSB) in this assessment compared to the previous 2021 assessment (2022: 0.73 SSB_0; 95% confidence interval 0.6-0.81, 2021: 0.85SSB_0; 95% confidence interval 0.78-0.92). Average recruitment was almost identical to the previous

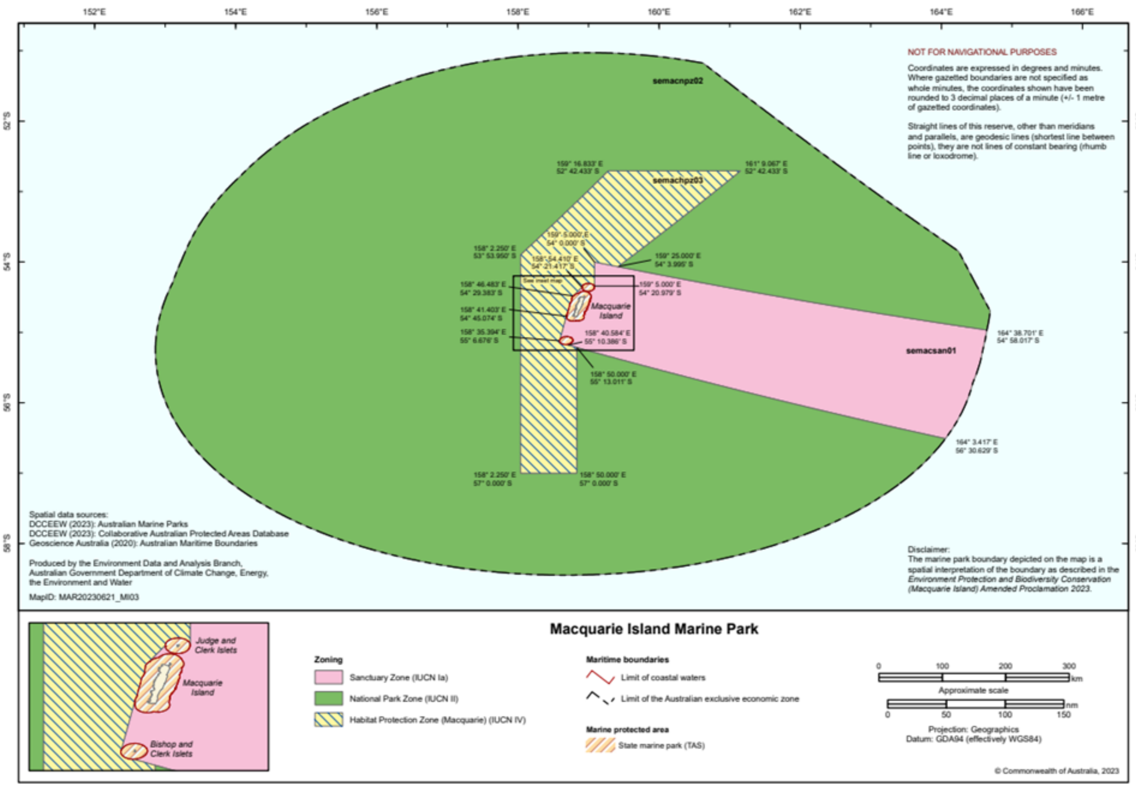

Figure 2.2: Macquarie Island Marine Park.
Source: https://parksaustralia.gov.au/marine/files/Final*Mac*Island*MP*zoning*with*island_inset.pdf

assessment and the most recent recruitment estimates remained above average, albeit highly uncertain.

A single TAC estimate for the MITF is calculated using the CCAMLR Harvest Control Rule (HCR) and while the MITF is considered a single reproductive stock, the assessment was based on northern and southern areas. CCAMLR catch limits use a two-part decision rule to determine what proportion of the stock can be fished. This HCR sets a TAC at a level that results in $0.5SSB_0$ at the end of the 35-year projection period.

The recommended TAC for the 2025-2026 and 2026-2027 season ranged between 451 t - 499 t, with an average of 472 t when accounting for the two fishing areas. This corresponds to an approximate 27% decrease from the previous 2021 average of 644 t, driven by a lower estimated stock status (Bessell-Browne & Hillary, 2023). An updated Patagonian Toothfish assessment is due in 2025.

The Patagonian Toothfish is listed by ABARES as ‘not subject to overfishing’ regarding fishing mortality and not overfished based on the estimated biomass (Butler et al., 2023). There are no secondary commercial species in the MITF however there is a yearly bycatch limit of 50 t per species.

Bait collection and usage

Longlining MITF vessels use squid as bait, two different species of squid *Nototodarus gouldii* and *Nototodarus sloanii* are sourced predominantly from New Zealand.

Daume et al. (2017) reported in the Marine Stewardship Council (MSC) Assessment for MITF that approximately 40t of squid is used per longlining trip. The high productivity of bait used (~80 t) compared to catch (~300-400 t) suggests that there should not be an overall detrimental impact on the source populations.

Current entitlements

There is currently two SFR holders, with only one vessel actively fishing in the MITF. Vessels are required to hold a minimum of 25.5% of the quota amount to be active in the fishery. See Table 2.2, Table 2.3 and Table 2.4.

Table 2.2: Entitlements over the last six quota years. ^SFR: Statutory Fishing Rights. Source: AFMA.

Quota year	No. of SFR^ concession holders	No. of quota SFRs	No. of active vessels	No. of inactive vessels/ concessions	Fishing method
2018-19	2	20000	1	1	Longline
2019-20	2	20000	1	1	Longline
2020-21	2	20000	1	1	Longline
2021-22	2	20000	1	1	Longline
2022-23	2	20000	1	1	Longline
2023-24	2	20000	1	1	Longline

Table 2.3: MITF concessions authorising the use of auto longline fishing gear. Source: AFMA

Permit type	No. permits
MITF Demesal longline SFR	2

Table 2.4: Number of boats to use demersal longline fishing gear in the MITF 2018/19 to 2023/24 fishing seasons.

Year	No. of SFR concession holders	No. active boats
2018-19	2	1
2019-20	2	1
2020-21	2	1
2021-22	2	1
2022-23	2	1
2023-24	2	1

Current and recent TACs, quota trends by method

Total Allowable Catch for the single quota species (Patagonian Toothfish) for the last six fishing seasons are shown in Table 2.5.

Table 2.5: Agreed Total Allowable Catch (TAC (t)) for the Patagonian Toothfish and bycatch species in the MITF fishing seasons 2013-14 to 2023-2024. TACs apply to all fishing methods in the MITF.

Common name	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	22-23	23-24
Patagonian Toothfish	415	410	460	450	450	450	450	555	635	635
All other bycatch species	50	50	50	50	50	50	50	50	50	50

Current and recent fishery effort trends by method

There has been an overall increase in the number of days fished and sets employed since 2019 across two trips each year (Table 2.6). Effort based on the number of hooks set decreased in 2022 by 9% relative to the previous year and increased by 29% in 2023 compared to the previous year (Table 2.7). This may be due to the increase in quota available for the 2022 and 2023 seasons.

Table 2.6: Annual fishing effort MITF Set longline (Demersal longline) between 2019-2023. *Data STATLANT reporting (https://www.nafo.int/Data/STATLANTold). No.: Number. Source: AFMA CCAMLR Logbook effort data.

Year	2019	2020	2021	2022	2023
No. of sets	267	332	298	341	378
No. of trips	2	2	2	2	4
*No. of days away from Port	128	135	156	168	256
*No. of days on ground	106	110	126	148	173
*No. of days fished	81	100	127	127	139

Table 2.7: Annual (calendar year) hook effort (total hooks set, number of sets and number of hooks per set) for bottom longline years 2019-2023 inclusive. Source: AFMA CCAMLR Logbook effort data.

Year	No. of hooks	No. of sets	No. hooks/set
2019	1797020	267	6730
2020	2002427	332	6031
2021	2236952	298	7507
2022	2452517	341	7192
2023	2560350	378	6773

Current and recent fishery catch trends by method

Catch numbers for 2018-19 to 2023-24 fishing seasons are shown in Table 2.8.

Table 2.8: Fishing Season total catch (Green weight; kg) of Patagonian Toothfish (*Dissostichus eleginoides*) caught by auto longline in the MITF 2019-2023 inclusive. Source: AFMA CCAMLR Logbook data.

Year	Patagonian toothfish catch (kg)	Other retained catch (kg)	Total
2019	450565	3289	453854
2020	538121	6014	544135
2021	453760	10922	464682
2022	438190	99996	538186
2023	460773	261623	722395

Current and recent value of fishery ($)

The current and recent value for this sub-fishery is confidential and withheld in this report in accordance with Fisheries Management Policy 12.

Relationship with other fisheries

The Macquarie Island Toothfish Fishery (MITF), due to its location and Australia being a signatory country, has incorporated CCAMLR conservation measures in MITF management even though it is outside of CCAMLR's jurisdiction. CCAMLR is an international commission with 27 member countries, of which, Australia is one along with 10 ascending states. CCAMLR is charged with ensuring the conservation and sustainable use of Antarctic living marine resources.

Australia is a signatory to the convention that applies to the High Seas. Included in the High Seas is the area of the South Pacific Regional Fisheries Management Organisation (SPRFMO). Australia is a member of SPRFMO and manages in accordance with SPRFMO conservations measures where relevant.

2.2.1.2 Gear

Fishing methods and gear

Bottom longlining is the primary fishing method in the MITF. Bottom longlines are set horizontally along the ocean floor and are held in place using anchors (Figure 2.3). The rope mainline has baited hooks spaced 2-5 m on monofilament or braided cords called snoods. The snoods are generally attached to the mainline with swivels to allow rotation. Most longline fishers use auto longline methods which are baited by machines otherwise would be baited by hand. Longlines can be many kilometres long and have several thousand hooks. The mainline is attached at both ends to downlines which have a large buoy on the surface, and anchors at the bottom to hold the gear in place. Weights are placed along the mainline to ensure it remains close to the bottom. Hauling is performed with hydraulic winches and gear can be hauled from either end by retrieving the downline.

During the longline fishing season fishers use an Integrated Weight Line (IWL), with an Integrated Weight of at least 50g/m, and paired streamer lines used in conjunction with night setting (i.e., setting can only occur during the hours of darkness between the times of nautical twilight).

Note: Nautical dusk and nautical dawn are defined as set out in the Nautical Almanacs for the relevant latitude, local time and date.

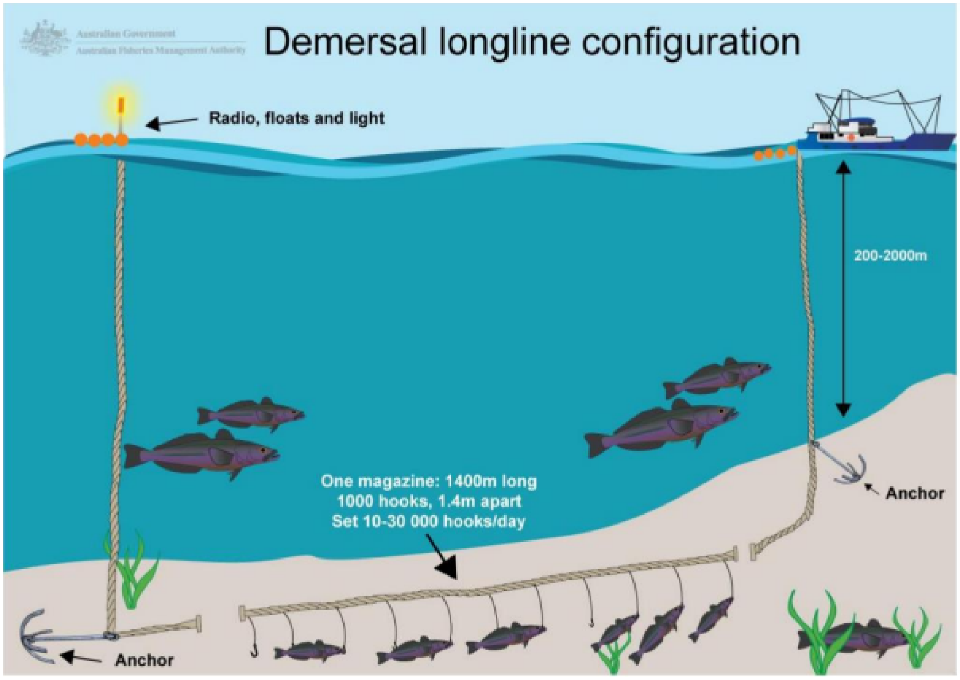

Figure 2.3: Demersal longline configuration. Source: https://www.sprfmo.int/assets/Meetings/02-SC/11th-SC-2023/Deepwater/SC11-DW03_rev3-Australia-FOP-for-an-exploratory-toothfish-fishery-on-the-Macquarie-Ridge.pdf

Fishing gear restrictions

Permitted methods include longline. Longline methods may only be used between the 15 April and the 31 August each year to mitigate interaction risk with seabirds. Trawling is no longer permitted in the Macquarie Island Fishery due to expanded Category IV MPA over total fishable area as of 1 July 2023.

Operators of the MITF are permitted to use the gear/methods outlined in their gear limitations of their Statutory Fishing Right (SFR) and permit conditions. Restrictions include the use of Integrated Weight Line (IWL), paired streamers, night setting, reducing light showing from the boat and ensuring Bird Exclusion Devices (BEDs) are used to discourage birds from accessing baits during hauling of longlines.

Selectivity of fishing methods

In comparison to many other fishing methods, longlining is considered to be relatively selective. The species and size selectivity of the longline gear is dependent on a number of factors such as the:

- horizontal and vertical distribution of the gear given that certain species are found in selected areas and over selected substrates, and that species are found at various depths according to various environmental influences
- variety of bait used since the gear is based on the foraging behaviour of fish and as feeding stimulants may be species-specific
- hook and other gear design since the selectivity is related to the ability of the hook to penetrate the mouth of the fish.

Spatial gear zone set

The three regions of the fishery are the Aurora Trough, the Northern Macquarie Ridge and the Southern Macquarie Ridge. Industry agreed to, as far as possible, adopt a fishing strategy (recommended by Sub-Antarctic Resource Assessment Group (SARAG)) whereby the 450 t TAC would be taken in approximately the following proportions: 250 t from the Aurora Trough, 120 t from Northern Macquarie Ridge and 80 t from Southern Macquarie Ridge.

Depth range gear set

The mean end fishing depth in 2023 was 1162 m, deeper compared with previous years, which ranged between 623 to 911 m (Table 2.9).

Table 2.9: MITF mean start and end depths (m) between 2019-2023. Source: AFMA CCAMLR Logbook data.

Year	Mean start depth (m)	Mean end depth (m)
2019	634	623
2020	624	703
2021	707	763
2022	906	911
2023	1136	1162
Mean 2019-2023:	801	832

How gear set

This is described above in Section 2.2.1.2.

Area of gear impact per set or shot

Area of impact varies and is subject to the metres of line, weights, and number of hooks used in a shot.

Capacity of gear

Most Australian pelagic longline vessels can set thousands of hooks per fishing operation. The number of hooks per set varied between 6031 and 7507 over the 2019-23 assessment period (Table 2.7).

Effort per annum all boats

The overall effort varied between 267 sets and 378 over the 2019-2023 assessment period and have remained relatively consistent over time (Table 2.6). This corresponds to 1,797,020 hooks in 2019 to 2,560,350 hooks in 2023 (Table 2.7).

Lost gear and ghost fishing

Vessels fishing in the MITF are required to try to retrieve any lost gear whilst fishing in accordance with SFR conditions set AFMA. Operators will also retrieve illegal fishing gear they may come across if it is safe to do so. All gear lost or retrieved must be recorded in logbooks.

In 2016, industry members requested that they be allowed to retrieve lost gear outside of the longline season under the Antarctic Marine Living Resources Conservation Act. The retrieval of gear outside the longline season was discussed at SARAG 54 in September 2016 and advice was sought from the Australian Antarctic Division. It was agreed that the SFR conditions should be amended to allow the concession holder to retrieve any fishing gear that has previously been reported to AFMA as lost under paragraph 27 1(b) of the Management Plan or that has been lost by Illegal, Unreported or Unregulated fishing operators (AFMA, 2019).

Key/secondary commercial species issues and Interactions

The continuing assessment of the Patagonian Toothfish population status has been identified as a priority research area for the sub-Antarctic fisheries strategic research plan (Hillary & Day, 2018). Tagging experiments for MITF began in the season of 1995/96 and has continued since then to provide vital information about the stock structure of the Patagonian Toothfish and contributes to decisions regarding setting TACS. The Fishery Assessment Plan (FAP) has been developed to address the research needs of the MITF and set out monitoring responsibilities and how they are shared across holders over the fishing seasons. See Section 2.2.1.1.1 for further detail about stock status.

Byproduct and bycatch issues and interactions

Byproduct species are defined as species which do not make a significant contribution to the overall catch but are sometimes landed for sale. There were no byproduct species retained for sale in the MITF. Bycatch species are defined as species caught as part of fishing activities but are rarely landed. The MITF has a TAC of 50 t for each species caught other than key commercial species. This limit has never been exceeded for any one species in a season. In the 2021-22 season, 2.4% of the total catch was mostly Grenadier (*Macrourus spp.*) and Violet Cod (*Antimora rostrata*). The total bycatch in the season 2020-21 was 6 t and this increased in the season 2021-22 to 11 t (Patterson & Curtotti, 2022). The total bycatch in season 2022-23 was 21 t (Patterson & Curtotti, 2023), a 10 t increase from the previous year. Overall, bycatch is not considered a major issue in the sub-Antarctic fisheries as there is 100% Observer coverage which contributes to accurate bycatch reporting. It is important to note that Observer coverage was 50% due to COVID-19 restrictions in the 2020-21 fishing season (Patterson & Curtotti, 2022). See also Table 2.11 for bycatch over this assessment period.

Protected species issues and interactions

Fishing operations in the MITF are fully compliant with mitigation plans such as the 'Recovery Plan for Threatened Albatrosses and Giant petrels' and 'Sub-Antarctic Fur Seal and Southern Elephant Seal Recovery Plan' as well as the implementation of gear limitations to reduce interactions. Restricting light, the use of plastic bands, the implementation of seabird mitigation gear and prohibition on discarding bycatch, offal, poultry, or brassica products to not attract or encourage foraging birds or seals to the vessel, these key actions are taken to prevent interactions.

All operators in the MITF must record all interactions with protected species listed under the EPBC Act. Recorded interactions are provided quarterly to the Department of Climate Change, Energy, the Environment and Water (DCCEEW). A 100% Observer coverage is expected on all trips to observe and report any interactions which can help inform potential further mitigations measures if needed.

Seabirds are protected species under the EPBC act and as such, any interaction with them must be recorded in logbooks and strict gear limitations to mitigate interactions adhered to. The use of BEDs and move on obligations are used to help reduce seabird interaction rates.

Overall, 44 protected species interactions were recorded over the 2019-23 assessment period, comprising 42 chondrichthyans and two seabirds (Table 2.10).

Seabirds

There was one interaction with Giant Petrels (*Macronectes spp*) in 2022 (1 alive) and one interaction with the White-chinned Petrel (*Procellaria aequinoctialis*) in 2023 (1 dead).

Chondrichthyans

A total of 42 Porbeagle Shark (*Lamna nasus*) interactions were recorded over the 2019-23 assessment period (42: 12 alive, 29 dead, 1 injured). The most common cause of interaction this period was due to entanglement or hooked on the line.

Table 2.10: Recorded protected species interactions from the AFMA Logbook database for fishing season 2019-2023 inclusive. A: alive; D: Dead; I: Injured. *Recorded wildlife interactions from the AFMA Wildlife CCAMLR Logbook database.

Scientific name	Common name	19			20			21			22			23			Total			TOTAL
		A	D	I	A	D	I	A	D	I	A	D	I	A	D	I	A	D	I	-
*Lamna nasus**	Porbeagle Shark	11	15	1		3			10		1	1					12	29	1	42
Macronectes spp	Giant Petrels										1						1	0	0	1
Procellaria aequinoctialis	White-chinned Petrel														1		0	1	0	1
	Total:	11	15	1	0	3	0	0	10	0	2	1	0	0	1	0	13	30	1	44

2.2.1.2.1 Habitat issues and interactions

Impacts of longlining

Bottom longlining has less impact on benthic communities than trawl methods (Pham et al., 2014). The previous Ecological Risk Assessment in 2007 indicated that the anchors and the physical process of having gear near the sea floor impacts the habitat and benthic ecosystems (Daley et al., 2007). Research has found that longline methods can impact epifauna and the seabed through line shearing, hooking, blunt impact and entanglement (Clark et al., 2016; Sampaio et al., 2012). Welsford et al. (2014) assessed the vulnerability of benthic habitats to impacts by demersal gears in the Heard Island and McDonald Islands (HIMI) fishery, which found that many vulnerable organisms live on the sea floor in depths less than 1200 m which suggests fishing at lower depths may disturb few taxa. However, Welsford et al. (2014) also found that bottom impacts of fishing are negligible due to the extent of the marine reserve and the fact that large areas of the HIMI Fishery which have had no interaction with gear (99.3%). Similarly, in the MITF, the area covered by the Macquarie Island Marine Park is likely to offer some protection from the impacts of gear with benthic communities. More research would be beneficial to identify the benthic taxa and communities in the MITF area and to assess the impacts of demersal fishing specific to the habitats of the MITF.

CCAMLR conservation measures

The MITF is managed in accordance with the conservation measures of CCAMLR even though it is located outside of the CCAMLR jurisdiction. CCAMLR seeks to protect key ecosystems, their processes, and vulnerable species by implementing comprehensive CMM's to support the conservation of Antarctic marine living resources. CCAMLR also implement marine protected areas with limited access for research.

A key conservation measure implemented in the MITF is the prohibition on discarding bycatch or offal as to not attract or encourage foraging birds or seals to the vessel. Further the restrictions of bands being used potentially lessons any impact on ecosystems. Restrictions on entry to the fishery with a maximum of three vessels is also considered important in the limiting of bycatch and the impact of fishing on benthic ecosystems.

Protected areas

As of 1 July 2023, the Macquarie Island Marine Park has almost tripled in size from 162,000 km² to 475,465 km² due to an effort to protect vulnerable habitats and species. The Park is managed under three different zonings, the Sanctuary Zone (IUCN la), National Park Zone (IUCN II) and Habitat Protection Zone (Macquarie) (IUCN IV). Each zone has different rules for managing activities with the goal of protecting marine habitats and species as outlined in Figure 2.4. Figure 2.2 shows around two-thirds of the area of the park is zoned as IUCN category IV and fishing in these areas are subject to a government issued permit. Any management determinations under these permits are enforceable and all fishing activity is monitored and used for assessment. Fishing in this area is subject to assessment, in accordance with a permit, class approval or activity licence issued by DCCEEW.

Community issues and interactions

No specific issues have been identified however AFMA recognises the importance of incorporating ecosystem considerations into management approaches. As a part of AFMA's partnership approach, Management Advisory Committees (MACs) were created which provide advice to the AFMA Commission on a variety of issues including management plans. Resource Assessment Groups (RAGs) were established to provide independent advice on stock status, research priorities and environmental needs which is reviewed annually by the AFMA Commission. Bycatch and total catch limits are based on population assessments which incorporate logbook data, observer data and considerations of information learned from other sub-Antarctic fisheries e.g., the Heard and McDonald Islands Fishery (HIMI).

The establishment of the Macquarie Island Marine Park and the areas it preserves is an important action towards the preservation of vulnerable communities and ecosystems.

It has become evident that climate change is affecting water temperatures, salinities and other water properties. Temperatures at the Macquarie Island have risen 0.5% and there has been a substantial increase

Commercial fishing activity prescriptions for Macquarie Island Marine Park

Commercial fishing activity	Sanctuary Zone (IUCN Ia)	National Park Zone (IUCN II)	Habitat Protection Zone (Macquarie) (IUCN IV)
Dropline	×	×	×
Hand collection (including using hookah, scuba, snorkel)	×	×	×
Hand net (hand, barrier, skimmer, cast, scoop, drag, lift)	×	×	×
Longline (demersal, auto-longline)	×	×	A
Longline (pelagic)	×	×	×
Minor line (handline, rod & reel, trolling, squid jig, poling)	×	×	×
Net (demersal)	×	×	×
Net (pelagic)	×	×	×
Purse seine	×	×	×
Trap, pot	×	×	A
Trawl (demersal)	×	×	×
Trawl (midwater)	×	×	×
Trotline	×	×	×

× Activity is not allowed.

A Authorisation required. Activity is allowable, subject to assessment, in accordance with a permit, class approval or activity licence issued by the Director.

Figure 2.4: Australian Marine Parks website; Macquarie Island Marine Park. Source: https://parksaustralia.gov.au/marine/files/MIMP-Tables-MIMPv2.pdf

in rainfall of approximately 200 mm per year (BOM, 2023). Potential impacts on oceanic species distribution, their ability to adapt and expand their range might lead to population decline and key community changes. Studies on the Southern Elephant Seal population on Macquarie Island has declined since the 1960's which has been linked to changing oceanic conditions due to climate change, impacting foraging success and therefore first-year survival and recruitment rates (Clausius et al., 2017). While ecosystem models account to some extent for cumulative pressures, the way in which they interact may not be linear and is currently the focus of research. Irrespective, whole of ecosystem-based advice is being sought and accepted by fishery management.

Discarding

Discarding is not permitted in the MITF. The SFR conditions and Management Plans for the MITF require all bycatch and offal be retained (with some exceptions where species are likely to survive release) to limit possible interactions with marine mammals and seabirds. All retained bycatch is processed into minced offal, which is discharged at sea, outside the area of the fishery in the high seas to avoid potential environmental impacts from the waste. Live, unwanted bycatch such as Skates, Sharks, Jellyfish, Sponges, Crabs, and Coral are generally returned to the ocean as these species have a high chance of survival and this is permitted.

Prior to 2017 management arrangements for the MITF did not include specific detail on the handling of skates and rays, however in consideration of WG-FSA 2017 and subsequent consultation AFMA developed a draft Skate Best Practice Handling Guide (AFMA, 2019). To ensure the correct handling and assessment of skates and rays, AFMA amended statutory fishing right conditions to reflect the new requirements.

If seabirds are caught alive, every effort must be made to release them alive and where possible remove any hooks without jeopardising the life of the seabird. All plastic and the disposal of poultry (including eggshells) and brassica (broccoli, cabbage, cauliflower, Brussels sprouts, kale etc.) products is prohibited.

The AFMA Observer Program also records retained key commercial species and bycatch (in numbers and/or weight) in the MITF.

Table 2.11: Discarded/Released species caught by automatic longline in the MITF 2019-2023 inclusive. Dis: Discarded; Rel: Released; No: Number. Source: AFMA CCAMLR Logbook data.

Year	CAAB	Common Name	Scientific Name	Disc/Rel alive no without tag	Dis/Rel alive no with tag	No. lost at surface	Total Released No.
2019	37224008	Violet Cod	*Antimora rostrata*	0	0	1	0
2019	37232901	Rattails, Grenadiers	*Macrourus* sp.	0	0	9	0
2019	37404792	Patagonian Toothfish	*Dissostichus eleginoides*	137	934	333	1071
2019	28836000	Stone Crab	Lithodidae	1230	0	0	1230
2020	37020036	Antarctic Sleeper Shark	*Somniosus antarcticus*	0	0	2	0
2020	37224008	Violet cod	*Antimora rostrata*	0	0	2	0
2020	37232901	Rattails, Grenadiers	*Macrourus* sp.	0	0	14	0
2020	37404792	Patagonian Toothfish	*Dissostichus eleginoides*	0	1093	890	1093
2020	37405000	Plunderfish	*Pogonophryne* sp.	0	0	4	0
2020	80600000	Invertebrates	*Invertebrata*	0	0	2	0
2020	28836000	Stone Crab	Lithodidae	0	0	28	0
2021	37070001	Basketwork Eel	*Diastobranchus capensis*	0	0	5	0
2021	37223000	Moray Cods	*Muraenolepis* sp.	0	0	6	0
2021	37224008	Violet Cod	*Antimora rostrata*	0	0	49	0
2021	37232901	Rattails, Grenadiers	*Macrourus* sp.	0	0	133	0
2021	37305000	Blobfish	*Ebinania* sp.	0	0	5	0
2021	37404792	Patagonian Toothfish	*Dissostichus eleginoides*	0	932	1608	932
2021	28836000	Stone Crab	Lithodidae	0	0	79	0
2022	37070001	Basketwork Eel	*Diastobranchus capensis*	0	0	1	0
2022	37224008	Violet Cod	*Antimora rostrata*	0	0	213	0
2022	37224902	Patagonian Cod	*Lepidion* sp.	0	0	2	0
2022	37232901	Rattails, Grenadiers	*Macrourus* sp.	0	0	97	0
2022	37404792	Patagonian Toothfish	*Dissostichus eleginoides*	0	927	849	927
2022	37407000	Crocodile Icefishes	Channichthyidae	0	0	4	0

Table 2.11: *(continued)*

Year	CAAB	Common Name	Scientific Name	Disc/Rel alive no without tag	Dis/Rel alive no with tag	No. lost at surface	Total Released No.
2022	37404000	An Icefish	Nototheniidae	0	0	1	0
2022	37990082	Sharks, Skates and Rays	*Elasmobranchii*	26	0	0	26
2022	28836000	Stone Crab	Lithodidae	0	0	7	0
2023	37020036	Antarctic Sleeper Shark	*Somniosus antarcticus*	8	0	7	8
2023	37223000	Moray Cods	*Muraenolepis* sp.	0	0	2	0
2023	37224008	Violet Cod	*Antimora rostrata*	0	0	225	0
2023	37224902	Patagonian Cod	*Lepidion* sp.	0	0	4	0
2023	37232901	Rattails, Grenadiers	*Macrourus* sp.	0	0	387	0
2023	37404792	Patagonian Toothfish	*Dissostichus eleginoides*	6	998	647	1004
2023	37407000	Icefishes	Channichthyidae	0	0	2	0
2023	37232750	Abyssal Grenadier	*Coryphaenoides armatus*	0	0	1	0
2023	37990028	Chimaeras, etc. nei	*Chimaeriformes*	0	0	4	0
2023	37990082	Sharks, Skates and Rays	*Elasmobranchii*	9	0	0	9
2023	37990030	Skates and Rays	*Rajiformes*	2	0	0	2
2023	28836000	Stone Crab	Lithodidae	0	0	22	0

2.2.1.3 Management: planned and those implemented

Management objectives

The management objectives of the Macquarie Island Toothfish Fishery management plan 2006 are as follows:

a) to manage the fishery efficiency and cost-effectively for the Commonwealth;

b) to ensure that the exploitation of the resources of the fishery and the carrying on of any related activities are conducted in a manner consistent with the principles of ecologically sustainable development and the exercise of the precautionary principle and, in particular, the need to have regard to the impact of fishing activities on non-target species and the long-term sustainability of the marine environment; and

c) to maximise economic efficiency in the exploitation of the resources within the fishery; and

d) to ensure AFMA's accountability to the fishing industry and to the Australian community in management of the resources of the fishery; and

e) to reach Government targets for the recovery of the costs of AFMA in relation to the fishery; and

f) to ensure, through proper conservation and management, that the living resources of the AFZ are not endangered by over-exploitation; and

g) to ensure the best use of the living resources of the AFZ; and

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.

Fishery management plan

The Macquarie Island Toothfish Fishery Management Plan 2006 is they key document for managing the MITF. The document outlines the obligations, conditions, and procedures for permit holders for that specific fishery as well as the obligations and standards to which AFMA manages the fishery. The information included is:

•Geographical coordinates of the fishery

•Objectives

•Total Allowable Catch

•Bycatch requirements

•Fishery assessment plan

•Obligation of the Statutory Fishing Right (SFR) holders

The Commonwealth fisheries Harvest Strategy Policy [HSP; DAFF (2007)] is not prescribed for fisheries under International agreements.

Input controls

The MITF is managed through a system of input controls in the form of:

• The permit holder must be holding 25.5% of SFRs to enter the fishery and fish with longline methods.

•Entry into the fishery is limited to only three vessels under the Macquarie Island Toothfish Fishery Management Plan 2006. However, only one vessel is currently active.

•Other input controls include the gear limitations as per the fishery permit conditions. Gear requirements are detailed earlier in this report.

•Obligations to use VMS whenever in the fishery.

•Closures if quota is obtained or seabirds listed in permit conditions are caught.

•Macquarie Island Marine Park.

Output controls

The MITF is managed through a system of output controls in the form of:

•Individual transferable quotas and TAC's which are allocated as a percentage of SFRs under the Macquarie Island Toothfish Fishery Management Plan 2006.

•TAC's set for bycatch species at 50 t per species.

•If an operator inadvertently exceeds their quota there is the ability to transfer no more than 20 tonnes to the next year and deduct it from the beginning quota. The total number and weight of each species taken, including amounts taken for personal consumption and/or rendered to offal will be decremented against quota allocations and the TAC for each species.

Table 2.12: Species permitted to be taken in the MITF. See Table 2.13 for other output controls.

Common name	Scientific name	Restrictions
Patagonian Toothfish	*Dissostichus eleginoides*	Quota species; set bi-annually.

Table 2.12: ***(continued)***

Common name	Scientific name	Restrictions
Bycatch species		As part of the biennial TAC setting the determination for the seasons includes a 50 t catch limit (for each fishing year) for other species in the MITF.

Table 2.13: Other output controls for MITF.

Common name	Restrictions
Skates and rays	The MITF concession holder must ensure that all skates and rays must be brought on board or alongside the roller to be checked for tags and for their condition to be assessed. Unless otherwise specified by scientific observer(s) all other skates and rays caught alive with a high probability of survival should be released alive, by cutting snoods, and when practical removing the hooks.
Bycatch species	The MITF concession holder must ensure that no offal or bycatch is discharged from the boat in the fishery with the exception of paragraphs 18 and 20 of these conditions or within the Exclusive Economic Zone (EEZ) of another country.

Technical measures

Technical measures such as closures, marine park areas and gear measures are discussed in other sections.

Regulations

The Fisheries Management Regulations 1992 prescribes detail on the management arrangements implemented in Commonwealth fisheries. These have since been superseded by the Fisheries Management Regulations 2019 (F2019L00383) (Office-of-Parliamentary-Counsel, 2019b) and Fisheries Administration Regulations 2019 (F2019L00386) (Office-of-Parliamentary-Counsel, 2019a). Specifically, they cover bans on vessels over 130 m, administration of and standard conditions for fishing concessions including VMS operation, carrying observers, processing fish, marine environment impacts, payments and fees, registers and administration, allocation of SFRs, discarding offal at sea (not attributed to this fishery). Additional regulations were introduced regarding navigation in closures. Additional rules are contained in the Management Plan and SFR conditions.

Under the EPBC Act 1999, interactions with a protected species must be reported within seven days of the incident occurring to the Department of Climate Change, Energy, the Environment and Water (DCCEEW). A *Memorandum of Understanding between AFMA and the Department for the Reporting of Fisheries Interactions with Protected Species* (Reporting MOU) streamlines those reporting requirements. AFMA reports its protected species interactions quarterly to the DCCEEW.

Amendments to the International Maritime Organisation's International Convention for the Prevention of Pollution from Ships (MARPOL) Annex V which came into force on 1 January 2013 prohibit the discharge of all garbage, from all ships, into the sea (except as provided otherwise, under specific circumstances). As MITF operates under the management of AFMA in conjunction with CCAMLR, it is compulsory for vessels to record loss of gear in their vessel logbook.

Part 13A of the EPBC Act regulates international movement and export of native specimens and wildlife products. To export regulated native specimens requires a permit or a relevant exemption (*Independent Review of the EPBC Act*, 2020). The MITF was assessed as meeting all EPBC Act requirements and received an exemption in relation to protect species provisions. Export approval was extended to allow exporting of fish until 2026. The DCCEEW has included several recommendations on the exemption and AFMA must adhere to these throughout the length of the exemption (AFMA, 2023).

Initiatives, strategies and incentives

•The Management Arrangements Booklet 2022/23 documents all management requirements including information about TACS and individual transferable quotas, bycatch, and protected species mitigations. It also contains the Macquarie Island Toothfish Fishery Management Plan 2006 (AFMA, 2023). Recently, the Management Arrangements Booklet 2024-2025 has also become available (AFMA, 2024).

•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.

•The Catch Documentation Scheme (CDS) is used to track the movements of Toothfish and ensure they are being harvested in a manner consistent with CCAMLR Conservation Measures and to prevent illegal, unreported, and unregulated (IUU) Toothfish entry into the major global markets of CCAMLR Contracting Parties. The CDS requires concession holders to ensure on the landing or transhipment of (*Dissostichus*) is accompanied with an accurately completed *Dissostichus* Catch Document (DCD). Catch can only be landed in states that fully implement CCAMLR Catch Documentation Scheme (CDS). Although the MITF is not part of CCAMLR, the same catch documentation is required.

•The Threat Abatement Plan (TAP) for the incidental catch (or bycatch) of seabirds during oceanic longline fishing operations 2018 (Commonwealth-of-Australia, 2018). The TAP seeks to continue to implement existing, as well as new actions needed to abate the listed key threatening process of incidental catch (or bycatch) of seabirds during oceanic longline fishing operations in a feasible, effective, and efficient way. The plan binds the Commonwealth and its agencies into responding to the impact of longline fishing activities on seabirds, and identifies the research, management and other actions needed to reduce the impacts of this key threatening process on affected seabird species. The ultimate goal is to achieve zero seabird bycatch and the TAP recognises six key actions to obtain this goal:

- Mitigation
- Education
- International initiatives
- Research and development and uptake
- Innovation
- Data collection and analysis

The TAP is to be reviewed every five years.

Enabling processes

There are detailed management plans and monitoring for Patagonian Toothfish. Catches and landings are monitored by logbooks, CDS, and Observer data. As per the requirements set by the Fisheries Management Act 1991 (Office-of-Parliamentary-Counsel, 1991), the submission of paper and electronic logbooks is compulsory and provide ongoing records of fishing operations. CDS is a landing obligation aimed at monitoring the movements of Patagonian Toothfish from harvest to market. Observers are required to be on 100% of fishing trips and are required to observe at least 50% of hooks for seabird bycatch and protected species interactions in hauls, record catch composition, collect biological samples and perform tagging (a rate of two tags per tonne across all regions). This data and tagging information obtained from the annual and 5-year strategic Management Plan is utilised to inform annual TAC decisions by the AFMA Commission and SARAG, research priorities, and modify monitoring mechanisms if necessary.

Vessel monitoring systems (VMS), Automatic Location Communicators (ALCs) and Electronic Monitoring (EM) are also other methods employed to monitor and manage compliance by permit holders whilst operating in the fishery.

Other initiatives or agreements

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.

The expansion of the Macquarie Island Marine Park seeks to preserve the vulnerable species that are endemic and migrate to the island to breed and the unique topographical and oceanographic features of the Island and surrounding waters.

2.2.1.4 Data

Logbook data

All Australian operators are required to complete either a paper or electronic catch and effort logbooks. Logbooks and their submission are a compulsory measure as of the Fisheries Management Act 1991. Catch and effort data and all interactions with protected species are recorded on a shot-by-shot basis in daily electronic logbooks are compiled into a centralised database by AFMA.

Observer data

Each vessel in the MITF is required to have an Observer onboard for the entire duration of every trip. The contradictions to this rule are during extenuating circumstances for example, the 50% coverage in the 2020-21 season due to COVID-19 restrictions. However, electronic monitoring was used when an Observer could not board a vessel. Observer data also includes length, weight and sex of each fish caught during a trip and report on other wildlife that might be seen, weather conditions and the fate of species in bycatch. Observer data can be used for research programs and supporting management decisions.

Observer data is collated in the Australian Antarctic Division (AAD) centralised database and data have been made available outside AFMA in the form of Observer trip reports and as raw data. Annual percentage coverage rates are listed in Table 2.14.

Table 2.14: Percentage of Observer coverage in the MITF by fishing season. All vessels are required to carry two Observers on each trip, and 100% of hauls are observed. *However, due to travel restrictions imposed during the COVID-19 pandemic, it was not possible to place observers on all trips in the 2020–21 season, and an Observer was present on only 1 of 2 trips. Electronic monitoring was used when an Observer could not board the vessel. Source: AFMA.

Fishing season	Number of boat days	Number of observed days	Observer coverage (%)
2018-19	119	119	100
2019-20	150	150	100
*2020-21	118	59	50
2021-22	153	153	100
2022-23	133	133	100
2023-24	256	256	100

Other data

Results of the updated MITF stock assessment are presented to SARAG and other stakeholders involved in managing this fishery. The SARAG membership includes representatives from multi-disciplinary research fields (including stock assessment, fish biology and ecological interactions), and from several organisations with expertise related to the fishery (including the AAD, ABARES, CSIRO Environment, Tasmanian Department of Primary Industries Water and Environment, AFMA and industry). Results also form the basis of publications in the scientific literature.

The updated stock assessment provides the most up-to-date information, conditional on an agreed one-year lag of data and methods, to facilitate the management of Australia's sub-Antarctic fisheries, and provide stakeholders greater confidence when making key commercial and sustainability decisions. Information from the stock assessments feed directly into the TAC setting process for Macquarie Island Patagonian Toothfish. As harvest strategies are being developed or revised for this and other Australian fished species (a process required by the Commonwealth Fisheries Harvest Strategy Policy), improvements in the assessments developed have direct and immediate impacts on quota levels and other fishery management measures.

Legislative instruments and directions

Fisheries Management Act 1991 (Office-of-Parliamentary-Counsel, 1991)

Fisheries Management Regulations 2019 (Office-of-Parliamentary-Counsel, 2019b)

Fisheries Administration Regulations 2019 (Office-of-Parliamentary-Counsel, 2019a)

Macquarie Island Toothfish Fishery Management Plan 2006 (Amended 2012) (Office-of-Parliamentary-Counsel, 2006)

Macquarie Island Toothfish Fishery (Total Allowable Catch) Determination 2023 (Office-of-Parliamentary-Counsel, 2023)

Macquarie Island Toothfish Fishery (Fishing Year) Determination 2021 (Office-of-Parliamentary-Counsel, 2021)

2.2.2 Unit of Analysis Lists (Step 2)

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

- **Species Components**: (key commercial and secondary commercial; byproduct/discards and protected species components). [Scoping document S2A Species]
- **Habitat Component**: habitat types. [Scoping document S2B1 and S2B2 Habitats]
- **Community Component**: community types. [Scoping document S2C1 and S2C2 Communities]

Ecological Units Assessed

Key commercial and secondary species 1 (C1), 0 (C2), 0 (CB)
Byproduct and bycatch species 0 (BP), 35 (BC)
Protected species 4
Habitats Not assessed
Communities 5 (3 demersal, 2 pelagic)

Scoping Document S2A. Species

Each species identified during the scoping is added to the ERAEF database used to run the Level 1 and/or 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.cmar.csiro.au/caab/

Key/Secondary Commercial Species

- *Key commercial species* – defined in the Harvest Strategy Policy (HSP) Guidelines as a species that is, or has been, specifically targeted and is, or has been, a significant component of a fishery.
- *Secondary commercial species* – commercial species that, while not specifically targeted, are commonly caught and generally retained, and comprise a significant component of a fishery's catch and economic return. These can include quota species in some fisheries.
- *Commercial bait species*

Table 2.15: Key commercial species (C1) and/or secondary commercial species (C2) and/or commercial bait species (CB) list for the Macquarie Island Toothfish Fishery - Automatic Longline. LOG: refers to AFMA Logbook data. OBS: refers to AFMA Observer data.

ERA Species ID	Role in Fishery	Taxa	Family Name	CAAB Code	Scientific Name	Common Name	Source(s)
765	C1	Teleost	Nototheniidae	37404792	*Dissostichus eleginoides*	Patagonian Toothfish	LOG, OBS

Byproduct Species

List the byproduct species of the sub-fishery. Byproduct species refers to any species that are retained for sale but comprise a minor component of the fishery catch and economic return. Byproduct are considered to be commercial species under the CPFB 2000. This list is obtained by reviewing all available fishery literature, including logbooks, observer reports and discussions with stakeholders.

There are no recorded byproduct species that have interacted with this fishery within the assessment period.

Bycatch (Discard) Species

Bycatch species are species that are not retained (i.e., are discarded, and includes catch that does not reach the deck of the vessel but which nonetheless is killed (or affected) as a result of the interaction with the fishing gear) and as such make no contribution to the value of the fishery. The term bycatch does not include discards of commercial species. Here, 'bycatch species' refers to general bycatch species only (i.e., species of fish, sharks, invertebrates, etc., that are never retained for sale), it excludes protected species, which are a separate category.

Table 2.16: Bycatch species list for the Macquarie Island Toothfish Fishery - Automatic Longline. LOG: refers to AFMA Logbook data. OBS: refers to AFMA Observer data.

ERA Species ID	Role in Fishery	Taxa	Family Name	CAAB Code	Scientific Name	Common Name	Source(s)
838	BC	Chondrichthyan	Etmopteridae	37020005	*Etmopterus lucifer*	Blackbelly Lantern Shark	LOG, OBS
826	BC	Chondrichthyan	Etmopteridae	37020021	*Etmopterus granulosus*	Southern Lantern Shark	Expanded from 37020907 (Etmopterus sp.), LOG, OBS.
257	BC	Chondrichthyan	Somniosidae	37020036	*Somniosus antarcticus*	Antarctic Sleeper Shark	LOG, OBS
6171	BC	Chondrichthyan	Rajidae	37031041	*Amblyraja hyperborea*	Arctic Skate	OBS
10557	BC	Chondrichthyan	Arhynchobatidae	37031752	*Bathyraja sp. (Macquarie ridge)*	Macquarie Ridge Skate	OBS
786	BC	Chondrichthyan	Chimaeridae	37042005	*Chimaera fulva*	Deep Water Ghost Shark	OBS
6036	BC	Chondrichthyan	Etmopteridae	NA	*Etmopterus viator*	Blue-Eye Lantern Shark	Expanded from 37020907 (Etmopterus sp.), OBS.
10555	BC	Invertebrate	Pectinidae	23270057	*Adamussium colbecki*	Antarctic Scallop	OBS
1284	BC	Invertebrate	Ommastrephidae	23636003	*Martialia hyadesi*	A Flying Squid	Expanded from 23636000 (Ommastrephidae), OBS.
46	BC	Invertebrate	Ommastrephidae	23636011	*Todarodes filippovae*	Southern Ocean Arrow Squid	Expanded from 23636000 (Ommastrephidae), OBS.
80	BC	Invertebrate	Lithodidae	28836005	*Lithodes macquariae*	Murray's Stone Crab	OBS
10556	BC	Invertebrate	Lithodidae	28836017	*Neolithodes brodiei*	Brodie's Stone Crab	OBS
626	BC	Teleost	Synaphobranchid	37070001	*Diastobranchus capensis*	Basketwork Eel	LOG, OBS
275	BC	Teleost	Moridae	37224008	*Antimora rostrata*	Violet Cod	LOG, OBS
277	BC	Teleost	Moridae	37224010	*Lepidion microcephalus*	Small-Headed Cod	Expanded from 37224902, LOG, OBS
6343	BC	Teleost	Moridae	37224017	*Lepidion schmidti*	Giant Cod	Expanded from 37224902, LOG, OBS
280	BC	Teleost	Zoarcidae	37231001	*Melanostigma gelatinosum*	Limp Eelpout	Expanded from Zoarcidae (37231000), OBS.
281	BC	Teleost	Macrouridae	37232015	*Coryphaenoides serrulatus*	Serrulate Whiptail	Expanded from 37232000, LOG, OBS.

Table 2.16: *(continued)*

ERA Species ID	Role in Fishery	Taxa	Family Name	CAAB Code	Scientific Name	Common Name	Source(s)
284	BC	Teleost	Macrouridae	37232016	*Coryphaenoides subserrulatus*	Long-Rayed Whiptail	Expanded from 37232000, LOG, OBS.
336	BC	Teleost	Macrouridae	37232036	*Macrourus carinatus*	Ridgescale Grenadier	OBS
6582	BC	Teleost	Macrouridae	37232039	*Coryphaenoides dossenus*	Humpback Whiptail	Expanded from 37232000, LOG, OBS.
6875	BC	Teleost	Macrouridae	37232051	*Coryphaenoides mcmillani*	Mcmillan's Whiptail	Expanded from 37232000, LOG, OBS.
374	BC	Teleost	Macrouridae	37232052	*Coryphaenoides murrayi*	Abyssal Whiptail	Expanded from 37232000, LOG, OBS.
10558	BC	Teleost	Macrouridae	37232139	*Macrourus caml*	Caml Grenadier	OBS
10559	BC	Teleost	Macrouridae	37232750	*Coryphaenoides armatus*	Abyssal Grenadier	LOG, OBS
1479	BC	Teleost	Macrouridae	37232753	*Macrourus whitsoni*	Whitson's Grenadier	OBS
2845	BC	Teleost	Macrouridae	37232754	*Macrourus holotrachys*	Bigeye Grenadier	OBS
8309	BC	Teleost	Psychrolutidae	37305005	*Ebinania macquariensis*	Macquarie Blobfish	Expanded from 37305000, LOG, OBS. Also, 37305003 was possibly recorded in list (E. sp).
10560	BC	Teleost	Psychrolutidae	37305007	*Ambophthalmos magnicirrus*	A Blobfish	OBS
1487	BC	Teleost	Nototheniidae	37404752	*Paranotothenia magellanica*	An Icefish	Expanded from 37404000, LOG, OBS.
10561	BC	Teleost	Nototheniidae	37404762	*Notothenia rossii*	An Icefish	Expanded from 37404000, LOG, OBS.
768	BC	Teleost	Nototheniidae	37404793	*Lepidonotothen squamifrons*	Grey Rockcod	LOG, OBS
779	BC	Teleost	Achiropsettidae	37460052	*Neoachiropsetta milfordi*	Armless Deepsea Flounder	Expanded from 37460000, OBS.
1493	BC	Teleost	Achiropsettidae	37460076	*Mancopsetta maculata*	Spotted Armless Flounder	LOG, OBS

Table 2.16: *(continued)*

ERA Species ID	Role in Fishery	Taxa	Family Name	CAAB Code	Scientific Name	Common Name	Source(s)
10562	BC	Teleost	Nototheniidae	NA	*Notothenia microlepidota*	An Icefish	Expanded from 37404000, LOG, OBS.

Protected Species

A protected species[7] refers to all species listed/covered under the EPBC Act 1999, which include Protected[8] species (listed threatened species i.e., vulnerable, endangered or critically endangered), cetaceans, listed migratory species, and listed marine species.

Protected species that occur in the area of the sub-fishery. Protected 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 protected species has been generated for this sub-fishery and included in the PSA workbook species list. This list was initially provided by AFMA which was further validated and reviewed using information on EPBC Act List of Threatened Fauna website; http://www.environment.gov.au/cgi-bin/sprat/public/publicthreatenedlist.pl and available literature on protected species occurrence and distribution such as Expert Panel on a Declared Commercial Fishing Activity (2014); birds: Menkhorst et al. (2017), Reid et al. (2002), Marchant and Higgins (1990); marine mammals: Woinarski et al.(2014), Jefferson et al. (2015); teleosts: Atlas of Living Australia Fishmap http://fish.ala.org.au/ , CAAB http://www.cmar.csiro.au/caab/index.html, Fishes of Australia http://fishesofaustralia.net.au/).

Table 2.17: Protected species list for the Macquarie Island Toothfish Fishery - Automatic Longline. LOG: refers to AFMA Logbook data. OBS: refers to AFMA Observer data.

ERA Species ID	Role in Fishery	Taxa	Family Name	CAAB Code	Scientific Name	Common Name	Source(s)
972	PS	Chondrichthyan	Lamnidae	37010004	*Lamna nasus*	Porbeagle Shark	LOG, OBS
73	PS	Marine bird	Procellariidae	40041007	*Macronectes giganteus*	Southern Giant Petrel	LOG
981	PS	Marine bird	Procellariidae	40041008	*Macronectes halli*	Northern Giant Petrel	Expanded from 40041907 (Macronectes spp.), LOG.
1041	PS	Marine bird	Procellariidae	40041018	*Procellaria aequinoctialis*	White-Chinned Petrel	LOG

[7]The term "protected" species refers to species listed under [Part 13] the EPBC Act 1999 and replaces the term "Threatened, endangered and protected species (PS)" commonly used in past Commonwealth Government (including AFMA) documents.

[8]Note "protected" (with small "p") refers to all species covered by the EPBC Act 1999 while "Protected" (capital P) refers only to those protected species that are threatened (vulnerable, endangered or critically endangered).

Scoping Document S2B1. Benthic Habitats

Benthic habitats were not assessed in this report.

Scoping Document S2B2. Pelagic Habitats

Pelagic habitats were not assessed in this report.

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 based on the 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 (Interim Marine and Coastal Regionalisation for Australia Technical Group, 1998; Last et al., 2005). The spatial boundaries for the pelagic communities are based on pelagic bioregionalisation and oceanography (Condie et al., 2003; Lyne & 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.

Table 2.18: Demersal communities in which fishing activity can occur (white shading). Shaded blue cells indicate all communities present within the province. Crosses refer to communities where fishing has occurred in the Macquarie Island Toothfish Fishery - Automatic Longline.

Demersal Community	Cape Province	North Eastern Transition	North Eastern Province	Central Eastern Transition	Central Eastern Province	South Eastern Transition	Central Bass	Tasmanian Province	Western Tasmanian Transition	Southern Province	South Western Transition	Central Western Province	Central Western Transition	North Western Province	North Western Transition	Timor Province	Timor Transition	Heard/McDonald Islands	Macquarie Island
Inner Shelf 0 – 110 m[1]																			
Outer Shelf 110 – 250 m																			
Upper Slope 250 – 565 m																			
Mid–Upper Slope 565 – 820 m																			
Mid Slope 820 – 1100 m																			
Lower Slope/ Abyssal > 1100 m																			
Inner Shelf Arafura 0 – 110 m																			
Inner Shelf Groote 0 – 110 m																			
Inner Shelf Cape York 0 – 110 m																			
Inner Shelf Gulf of Carpentaria 0 – 110 m																			
Cape York Shelf Reef 0 – 110 m																			
Inner Shelf Reef 0 – 110 m[7 8]																			
Slope Reef 110 – 250 m[8]																			

Table 2.18: *(continued)*

Demersal Community	Cape Province	North Eastern Transition	North Eastern Province	Central Eastern Transition	Central Eastern Province	South Eastern Transition	Central Bass	Tasmanian Province	Western Tasmanian Transition	Southern Province	South Western Transition	Central Western Province	Central Western Transition	North Western Province	North Western Transition	Timor Province	Timor Transition	Heard/McDonald Islands	Macquarie Island
Seamount 0 – 110 m																			
Seamount 110 – 250 m																			
Seamount 250 – 565 m																			
Seamount 565 – 820 m																			
Seamount 820 – 1100 m																			
Seamount > 1100 m																			
Plateau 0 – 110 m																			
Plateau 110 – 250 m																			
Plateau 250 – 565 m																			
Plateau 565 – 820 m																			
Plateau 820 – 1100 m																			
Shelf (Territorial Seas) 0 – 100 m																			
Shelf 0 – 250 m[2]																			X
Upper-Mid Slope 250 – 1100 m[3]																			X
Inner Heard Plateau 100 – 500 m[4]																			
Outer Heard Plateau 100 – 500 m[4]																			
Shell Bank 100 – 500 m[4]																			
Western Banks 200 – 500 m[4]																			
North Eastern Plateau 500 – 1000 m[5]																			
North Eastern Trough 500 – 1000 m[5]																			
South Eastern Trough 500 – 1000 m[5]																			

Table 2.18: ***(continued)***

Demersal Community	Cape Province	North Eastern Transition	North Eastern Province	Central Eastern Transition	Central Eastern Province	South Eastern Transition	Central Bass	Tasmanian Province	Western Tasmanian Transition	Southern Province	South Western Transition	Central Western Province	Central Western Transition	North Western Province	North Western Transition	Timor Province	Timor Transition	Heard/McDonald Islands	Macquarie Island
Western Trough 500 – 1000 m[5]																			
Southern Upper Slope 500 – 1000 m[5]																			
Shell Bank Deep > 1000 m[6]																			
North East Lower Slope/ Abyssal > 1000 m[6]																			
Southern Lower Slope/ Abyssal > 1100 m																			X

Note:
[1] Three inner shelf communities occur in the Southern (Eyre, Eucla and South West Coast).
At Macquarie Island: [2] inner & outer shelves (0-250 m), and [3] upper and midslope communities combined (250-1000 m).
At Heard/McDonald Islands: [4] outer and upper slope plateau communities combined to form four communities: Shell Bank, inner and outer Heard Plateau (100-500 m) and Western Banks (200-500 m), [5] mid and upper plateau communities combined into 3 trough, southern slope and North Eastern plateau communities (500-1000 m), and [6] 2 groups at Heard Is: Deep Shell Bank (>1000 m) 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

Table 2.19: Pelagic communities in which fishing activity occurs in the Macquarie Island Toothfish Fishery - Automatic Longline (cross; x). Shaded cells indicate all communities that exist in the province.

Pelagic Community	Northeastern	Eastern	Southern	Western	Northern	Northwestern	Heard and McDonald Is	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								X

Note:
[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 Island: coastal pelagic zone to 250m.
[3] At Heard and McDonald Is: coastal pelagic zone broadened to cover entire plateau to maximum of 1000 m.

2.2.3 Units Excluded from Analysis

Species lists for Level 2 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.

A list of the species/species groups/taxa excluded in this fishery is provided in Table 2.20.

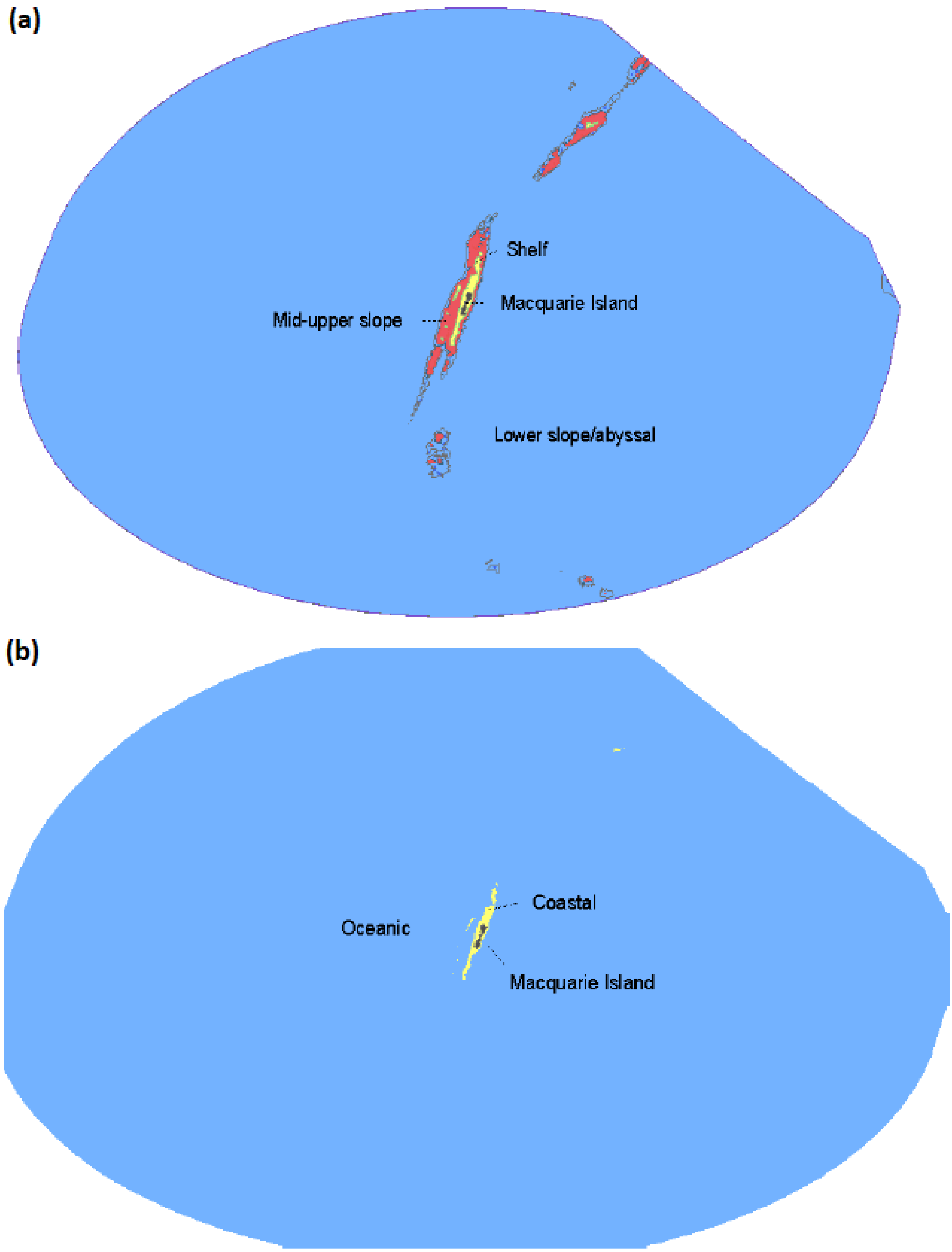

Figure 2.5: (a) Demersal communities around Macquarie Island based on bioregionalisation schema. (b) Australian pelagic provinces. Hatched areas indicate coastal epipelagic zones overlying the shelf. Offshore (oceanic) provinces comprise two or more overlaying pelagic zones as indicated in Table 2.19. Seamounts (black) and plateaux (light green) are illustrated in their demersal or pelagic provinces.

Table 2.20: Species/species groups/taxa excluded from analysis because they were either not identified at the species level, not interacted in the fishery or outside the fishery's jurisdictional boundary. No obs/ints: No observations or interactions. These entries have been excluded from the protected species list since the last ERA because they have not been observed within the fishery and/or occur outside the depth range of the fishery. OBS: refers to AFMA Observer data. LOG: refers to AFMA Logbook data. CSIRO: Commonwealth Scientific and Industrial Research Organisation.

Role in Fishery	Taxa	Family Name	CAAB Code	Scientific Name	Common Name	Rationale
BC	Algae			Algae	Algae	OBS. Insufficient taxonomic resolution
BC	Benthos	Demospongiae		Demospongiae	Silicieous Sponge	LOG, OBS. Part of benthos
BC	Benthos	Hexactinellida	10300000	Hexactinellida	Glass Sponge	OBS. Part of benthos
BC	Benthos		10000000	Porifera	Sponge	LOG, OBS. Part of benthos
BC	Benthos		10180000	Demospongiae	Silicieous Sponge	OBS. Part of benthos
BC	Benthos		10300000	Hexactinellida	Glass Sponge	OBS. Part of benthos
BC	Benthos		11077000	Stylasteridae	Hydrocorals	LOG, OBS. Part of benthos
BC	Benthos		11160000	Antipatharia	Black Corals	LOG, OBS. Part of benthos
BC	Benthos		11186000	Gorgoniidae	Gorgonians	LOG, OBS. Part of benthos
BC	Benthos		11208000	Pennatulacea	Sea Pens	LOG, OBS. Part of benthos
BC	Benthos		11290000	Scleractinia	Stony Corals	LOG, OBS. Part of benthos
BC	Benthos		80600000	Invertebrata	Invertebrates	LOG, OBS. Insufficient taxonomic resolution
BC	Benthos			Alcyonacea	Soft corals	LOG. Part of benthos
BC	Chondrichthyan	Chimaeridae		*Chimaera sp.1*	Deep-water Ghost Shark	LOG, OBS. This is a synonym of *C. fulva* (37042005), which was added to list.
BC	Chondrichthyan	Etmopteridae	37020021	*Etmopterus baxteri*	Lucifer Shark	OBS. This is a synonym of *E. granulosus*
BC	Chondrichthyan	Etmopteridae	37020907	*Etmopterus* sp.	Dogfishes	Added 2 species to list (37020021: *E. granulosus* and *E. viator*), LOG, OBS.
BC	Chondrichthyan	Somniosidae	37020025	*Centroscymnus coelolepis*	Deepwater Dogfish	LOG, OBS. Possible mis-identification. Outside fishery range
BC	Chondrichthyan	Somniosidae	37020906	*Centroscymnus* spp	Sleeper Sharks	LOG. Existing species in list (37020036), LOG, OBS. Other *Centroscymnus* spp. outside fishery range.
BC	Chondrichthyan	Somniosidae		*Somniosus rostratus*	Little Sleeper Shark	LOG, OBS. Possible mis-identification. Species outside fishery range. One existing species of family Somniosidae in list (37020036).

Table 2.20: *(continued)*

Role in Fishery	Taxa	Family Name	CAAB Code	Scientific Name	Common Name	Rationale
BC	Chondrichthyan		37990028	Chimaeriformes	Chimaeras, etc. nei	LOG. Insufficient taxonomic resolution. Currently *Chimaera fulva* (37402005) was added to list as a synonym of *C. sp 1* (LOG, OBS). Taxonomy requires to be resolved from two specimens (CSIRO H4863-02; CSIRO H4859-02).
BC	Chondrichthyan		37990030	Rajiformes	Skates and Rays	LOG. Insufficient taxonomic resolution. Existing Skate in list.
BC	Chondrichthyan			Elasmobranchii	Sharks, Skates and Rays	LOG. Insufficient taxonomic resolution
BC	Invertebrate	Bathylasmatidae		Bathylasmatidae	Goose and acorn barnacles	LOG. Insufficient taxonomic resolution
BC	Invertebrate	Cidaridae		Cidaroida	Pencil Spine Urchin	LOG. Insufficient taxonomic resolution
BC	Invertebrate	Lithodidae	28836000	Lithodidae	Stone Crab	LOG, OBS. Insufficient taxonomic resolution. Two existing species in list (28836005, 28836017).
BC	Invertebrate	Ommastrephidae	23636000	*Ommastrephes, Illex*	Shortfin, Flying Squids nei	LOG, OBS. Insufficient taxonomic resolution. Added 2 species to list (23636011, 23636017).
BC	Invertebrate	Pectinidae	23270000	Pectinidae	Scallops nei	OBS. Existing species in list (23270057).
BC	Invertebrate	Veneridae		*Paphia textile*	Textile venus	LOG. Insufficient taxonomic resolution. Scientific name is *Paratapes textile*. Bivalve, unlikely.
BC	Invertebrate		11500000	Cnidaria	Cnidaria	OBS. Part of benthos
BC	Invertebrate		14410000	Actiniaria	Anemones	LOG, OBS. Part of benthos
BC	Invertebrate		23000000	Mollusca	Marine Molluscs	OBS. Insufficient taxonomic resolution
BC	Invertebrate		23199000	Bivalvia	Bivalves	LOG, OBS
BC	Invertebrate		25000000	Echinodermata	Echinoderms	OBS. Insufficient taxonomic resolution
BC	Invertebrate		25102000	Asteroidea	Sea Stars	LOG, OBS
BC	Invertebrate		25170000	Euryalida	Basket Stars	LOG, OBS. Insufficient taxonomic resolution
BC	Invertebrate		25450000	Holothuroidea	Sea Cucumber	LOG, OBS
BC	Invertebrate		33000000	Pycnogonida	Sea Spider	LOG. Insufficient taxonomic resolution
BC	Invertebrate		35000000	Ascidiacea	Sea Squirt	LOG, OBS. Part of benthos
BC	Invertebrate			Annelida	Annelid Worm	LOG. Insufficient taxonomic resolution

Table 2.20: *(continued)*

Role in Fishery	Taxa	Family Name	CAAB Code	Scientific Name	Common Name	Rationale
BC	Invertebrate			Prawns/Shrimps	Prawns/Shrimps	OBS. Insufficient taxonomic resolution
BC	Teleost	Artedidraconidae	37405904	*Pogonophryne* spp.	Plunderfish	LOG, OBS. Species distribution outside the fishery range.
BC	Teleost	Artedidraconidae, Harpagiferidae	37405000	Artedidraconidae, Harpagiferidae	Plunderfishes	LOG. Species distribution outside the fishery range (Artedidraconidae). Species within family Harpagiferidae are unlikely to be caught during fishing operations (~ <10 cm).
BC	Teleost	Bothidae, Achiropsettidae, Paralichthyidae	37460000	Bothidae, Achiropsettidae, Paralichthyidae	Lefteye Flounders	LOG, OBS. One existing species in list (37460076). Added one species to list (37460052)
BC	Teleost	Bramidae	37324001	*Brama brama*	Ray's Bream, Pomfret	LOG. Possible mis-identification
BC	Teleost	Bramidae	37342000	Bramidae	Pomfrets	OBS. Possible mis-identification
BC	Teleost	Channichthyidae	37407000	Channichthyidae	Icefishes	LOG. Species distributions of Crocodile Icefishes are outside fishery range.
BC	Teleost	Congridae	37067000	Congridae	Conger Eels	LOG, OBS. Possible mis-identification. No species of family Congridae identified to occur within fishery range.
BC	Teleost	Macrouridae	37232901	*Macrourus* sp.	Rat tails, Grenadiers	LOG, OBS. 4 existing species in list (37232000, 37232036, 37232139, 37232753).
BC	Teleost	Macrouridae	37232902	*Coryphaenoides* sp.	Whiptail	LOG, OBS. 1 existing species in list (37232750). Added 5 species to list (37232105, 37232016, 37232039, 37232051, 37232052).
BC	Teleost	Macrouridae		*Macrourus caml/whitsoni*	Caml/Whitson's Grenadier morph	OBS. 2 existing species in list (37232139, 37232753).
BC	Teleost	Macrouridae		*Macrourus carinatus/holotrachys*	Holotrachys/Carinatus Grenadier morph	OBS. 2 existing species in list (37232036, 37232000).
BC	Teleost	Moridae	37224902	*Lepidion* sp.	Patagonian Cod	Added 2 species to list (37224010, 37224017), LOG, OBS.
BC	Teleost	Muraenolepididae	37223753	*Muraenolepis* sp.	Moray Cods	LOG, OBS. Species distributions outside fishery range.

Table 2.20: *(continued)*

Role in Fishery	Taxa	Family Name	CAAB Code	Scientific Name	Common Name	Rationale
BC	Teleost	Muraenolepididae		*Muraenolepis microps*	Smalleye Moray Cod	LOG, OBS. Possible mis-identification. Species distribution outside fishery range.
BC	Teleost	Nototheniidae	37404000	Nototheniidae	Cod Icefishes	Two existing species in list: 37404792, OBS; and 37434793, LOG, OBS. Added 3 species to list (37404752, 37404762, *N. microlepidota*), LOG, OBS.
BC	Teleost	Nototheniidae	37404795	*Dissostichus mawsoni*	Antarctic Toothfish	LOG, OBS. Possible mis-identification. Species outside fishery range.
BC	Teleost	Ophidiidae	37228961	Ophidiidae	Cusk Eels	LOG, OBS. Possible mis-identification. The species *Holcomycteronus brucei* (37228110) from family Ophidiidae appears outside fishery range.
BC	Teleost	Psychrolutidae	37305000	*Ebinania* sp.	Blobfish	LOG, OBS. Added 1 species to list (*Ebinania macquariensis*, 37305005)
BC	Teleost	Psychrolutidae		*Psychrolutes macrocephalus*	A Blobfish	LOG. Species distribution outside fishery range (Africa).
BC	Teleost	Salmonidae		*Oncorhynchus nerka*	Sockeye(=Red) Salmon	LOG. Possible mis-identification. Species distribution outside fishery range (freshwater species).
BC	Teleost	Salmonidae		*Stenodus leucichthys*	Sheefish	LOG. Possible mis-identification. Species outside fishery range (freshwater species in North America).
BC	Teleost	Synaphobranchidae	37070000	Synaphobranchidae	Cutthroat eels	LOG. Existing species in list (37027001), LOG, OBS.
BC	Teleost	Zoarcidae	37231000	Zoarcidae	Eelpouts	LOG, OBS. Added 1 species to list (372321001).
BC				Unknown	Unknown species	LOG. Insufficient taxonomic resolution
PS	Marine Bird	Procellariidae	40041907	*Macronectes* spp.	Giant-petrels nei	LOG. 1 existing species in list (40041007). Added 1 species to list (40041008).

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

Objectives are identified for each sub-fishery for the five ecological components (key/secondary commercial, bycatch/byproduct, protected species, 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:

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

For fisheries that have completed Ecological Sustainable Development (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) and/or provided by existing fisheries legislation, policies or Guidelines, those should be used (e.g., AFMA ERM Guide objective). 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**).

Key Commercial and Secondary Commercial Species

Core objectives:

- Avoid recruitment failure of the key/secondary commercial species
- Avoid negative consequences for species or population sub-components

Table 2.21: Scoping Document S3. Identification of operational objectives and rationale for C1-C2 component. Operational objectives that are eliminated are shaded out. EMO: Existing Management Objective; AMO: Existing AFMA Objective

Sub-component	Example Operational Objectives	Example indicators	Rationale
1. Population size	1.1 No trend in biomass	Biomass, numbers, density, CPUE, yield	1.1 Increases in biomass of the key/secondary commercial species would be acceptable.
	1.2 Maintain biomass above a specified level		1.2. To ensure that population at acceptable level by the assessment.
	1.3 Maintain catch at specified level		1.3. TAC levels are specified.
	1.4 Species do not approach extinction or become extinct		1.4. This is a general objective for all AFMA fisheries as per Fisheries Management Act 1991 (objective (b): ensuring that the exploitation of fisheries resources and the carrying on of any related activities are conducted in a manner consistent with the principles of ecologically sustainable development).
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 known distribution range	2.1 Not currently monitored. No specific management objective based on the geographic range of key/secondary commercial species.

Table 2.21: *(continued)*

Sub-component	Example Operational Objectives	Example indicators	Rationale
3. Genetic structure	3.1 Genetic diversity does not change outside acceptable bounds	Frequency of genotypes in the population, effective population size (Ne), number of spawning units	3.1 Not currently monitored in this fishery, difficult and expected to respond at a slower rate than some of the other indicators.
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 species suggests that the fishery is not targeting recruitment or spawning grounds.
5. Reproductive Capacity	5.1 Fecundity of the population does not change outside acceptable bounds (e.g., more than X% of reference population fecundity)	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 Recruitment to the population does not change outside acceptable bounds		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. Changes to behaviour that are deleterious to the species and populations are to be avoided.

Byproduct and Bycatch

Core objectives:

- Avoid recruitment failure of the byproduct and bycatch species
- Avoid negative consequences for species or population sub-components

Table 2.22: Scoping Document S3. Identification of operational objectives and rationale for BP-BC component. Operational objectives that are eliminated are shaded out. EMO: Existing Management Objective; AMO: Existing AFMA Objective

Sub-component	Example Operational Objectives	Example indicators	Rationale
1. Population size	1.1 No trend in biomass	Biomass, numbers, density, CPUE, yield	1.1 Increases in biomass of the byproduct and bycatch species would be acceptable.

Table 2.22: ***(continued)***

Sub-component	Example Operational Objectives	Example indicators	Rationale
	1.2 Maintain biomass above a specified level		1.2. To ensure that population at acceptable level by the assessment. Covered by EMO and AMO that ensures the fishery does not threaten bycatch species.
	1.3 Maintain catch at specified level		1.3. TAC levels are specified. EMO/AMO - annual reviews of all information on bycatch species with the aim of developing species specific bycatch limits.
	1.4 Species do not approach extinction or become extinct		1.4. This is a general objective for all AFMA fisheries as per Fisheries Management Act 1991 (objective (b): and mentions specifically non-target species and the long term sustainability of the marine environment.)
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 byproduct/bycatch species.
3. Genetic structure	3.1 Genetic diversity does not change outside acceptable bounds	Frequency of genotypes in the population, effective population size (Ne), 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 Not currently monitered. No reference levels established. No specific management objectiove for the age/size structure of byproduct/bycatch species.
5. Reproductive Capacity	5.1 Fecundity of the population does not change outside acceptable bounds (e.g., more than X% of reference population fecundity)	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.
	5.2 Recruitment to the population does not change outside acceptable bounds		

Table 2.22: *(continued)*

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 Longlining may attract attract bycatch species or alter their behaviour and movement patterns, resulting in the attraction of species to fishing grounds.

Protected Species

Core objectives:

- Avoid recruitment failure of protected species
- Avoid negative consequences for protected species or population sub-components
- Avoid negative impacts on the population from fishing

Table 2.23: Scoping Document S3. Identification of operational objectives and rationale for PS component. Operational objectives that are eliminated are shaded out. EMO: Existing Management Objective; AMO: Existing AFMA Objective

Sub-component	Example Operational Objectives	Example indicators	Rationale
1. Population size	1.1 Species do not further approach extinction or become extinct	Biomass, numbers, density	1.1 EMO – This is a general objective for all AFMA fisheries as per Fisheries Management Act 1991 objective (1b): ensuring that the exploitation of fisheries resources and the carrying on of any related activities are conducted in a manner consistent with the principles of ecologically sustainable development); and objective (2): ensuring, through proper conservation and management measures, that the living resources of the AFZ are not endangered by over-exploitation. Therefore the fishery is conducted in a manner that avoids mortality of, or injuries to, endangered, threatened or protected species.
	1.2 No trend in biomass	CPUE, yield	1.2 A positive trend in biomass is desirable for protected species.
	1.3 Maintain biomass above a specified level		1.3 Maintenance of protected species biomass above specified levels not currently a fishery operational objective.
	1.4 Maintain catch at specified level		1.4 The above EMO states 'must avoid mortality/injury to protected species'.
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 protected species may have serious consequences e.g. population fragmentation and/or forcing species into sub-optimal areas.

Table 2.23: *(continued)*

Sub-component	Example Operational Objectives	Example indicators	Rationale
3. Genetic structure	3.1 Genetic diversity does not change outside acceptable bounds	Frequency of genotypes in the population, effective population size (Ne), number of spawning units	3.1 Because population size of protected species is often small, protected species are sensitive to loss of genetic diversity. Genetic monitoring may be an effective approach to measure possible fishery impacts.
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 protected species populations is 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) 5.2 Recruitment to the population does not change outside acceptable bounds	Egg production of population Abundance of recruits	5.1 The reproductive capacity of protected species is of concern because potential fishery induced changes in reproductive ability may have immediate impact on the population size of protected species.
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 Longlining operations may attract protected species and alter behaviour and movement patterns, resulting in the habituation of protected 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 Interactions with protected species and fishery are minimised 7.2 Survival after interactions is maximised 7.3 Interactions do not affect the viability of the population or its ability to recover	Number of interactions Survival rate of species after interactions Number of interactions, biomass or numbers in population	7.1, 7.2, 7.3 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 protected species.

Table 2.23: ***(continued)***

Sub-component	Example Operational Objectives	Example indicators	Rationale

Habitats

Core objectives:

- Avoid negative impacts on quality of environment
- Avoid reduction in the amount and quality of habitat

Table 2.24: Scoping Document S3. Identification of operational objectives and rationale for Habitats component. Operational objectives that are eliminated are shaded out. EMO: Existing Management Objective; AMO: Existing AFMA Objective

Sub-component	Example Operational Objectives	Example indicators	Rationale
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 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 – General objective for all AFMA fisheries as per Fisheries Management Act 1991 (objective 1b): ensuring that the exploitation of fisheries resources and the carrying on of any related activities are conducted in a manner consistent with the principles of ecologically sustainable development. The fishery is conducted, in a manner that minimises the impact of fishing operations on benthic habitat.
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 Longlining operations may result in changes to the local habitat types on fishing grounds.
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 Longlining operations may result in local disruption to pelagic and benthic processes.

Communities

Core objectives:

- Avoid negative impacts on the composition/function/distribution/structure of the community

Table 2.25: Scoping Document S3. Identification of operational objectives and rationale for Communities component. Operational objectives that are eliminated are shaded out. EMO: Existing Management Objective; AMO: Existing AFMA Objective

Sub-component	Example Operational Objectives	Example indicators	Rationale
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 – General objective for all AFMA fisheries as per Fisheries Management Act 1991 (objective 1b): ensuring that the exploitation of fisheries resources and the carrying on of any related activities are conducted in a manner consistent with the principles of ecologically sustainable development) 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.
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 Longlining operations have unknown impacts on the benthos on fishing grounds. The current MPA and conservation areas reserve large areas of the known habitat types from fishing disturbance.
4. Trophic/size structure	4.1 Community size spectra/trophic structure does not vary outside acceptable bounds	Size spectra of the community Number of octaves, Biomass/number in each size class Mean trophic level Number of trophic levels	4.1 Longlining operations for key/secondary commercial 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, crabon, nitrogen, phosphorus flux	5.1 Longlining operations not preceived to have a detectable effect on bio and geochecmical cycles, but other activities may e.g., aquaculture.

2.2.5 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 organisms/habitat.

Scoping Document S4. Hazard Identification Scoring Sheet

This table is completed once for each sub-fishery. Table A.1 provides a set of examples of fishing activities for the effects of fishing to be used as a guide to assist in scoring the hazards.

Fishery name Macquarie Island Toothfish Fishery - Automatic Longline

Table 2.26: Hazard identification, score (i.e., presence/absence) and rationale(s) for the Macquarie Island Toothfish Fishery - Automatic Longline.

Direct impact of Fishing	Fishing Activity	Presence (1) Absence (0)	Documentation of Rationale
Capture	Bait collection	0	Bait not caught by this fishery.
	Fishing	1	Longlining specifically targets Patagonian toothfish and other species.
	Incidental behaviour	0	Vessel too large and operating offshore for recreational fishing by crew.
Direct impact without capture	Bait collection	0	Bait not caught by this fishery.
	Fishing	1	Disorientation/injury/mortality as a result of momentary entanglement but animal may free itself, e.g., dolphin, escaping target species. Birds may strike vessel.
	Incidental behaviour	0	Vessel too large and offshore for recreational fishing by crew.
	Gear loss	1	No major gear loss has been reported.
	Anchoring/ mooring	0	Fishery generally operates in deeper water; vessel does not anchor at night when not fishing.
	Navigation/ steaming	1	Steaming/navigation within fishing grounds may result in collisions (e.g., seabirds or whales vessel interactions), seabird collisions with night-time lights/navigation lights.

Table 2.26: *(continued)*

Direct impact of Fishing	Fishing Activity	Presence (1) Absence (0)	Documentation of Rationale
Addition/ movement of biological material	Translocation of species	1	Temperate Ballast water from lower latitude ports has an unknown impact. Frozen bait- squid, and other small pelagic species used.
	On board processing	0	Fish processed on-board but discarding of offal and bycatch prohibited within fishery jurisdiction.
	Discarding catch	0	Discarding prohibited within the fishery jurisdiction.
	Stock enhancement	0	None occurs.
	Provisioning	1	Negligible provisioning will occur during baiting and retrieval as biological material is lost from hooks.
	Organic waste disposal	0	Disposal of organic wastes strictly controlled under MARPOL regulations.
Addition of non-biological material	Debris	0	General rubbish generated during general fishing vessel operations is retained and disposed of ashore.
	Chemical pollution	0	Waste discharge from vessel controlled under MARPOL regulations and Fisheries Management Plan.
	Exhaust	1	Vessel introduces exhaust into the environment.
	Gear loss	1	Minor components may be lost. Major gear loss: none reported.
	Navigation/ steaming	1	Fishing vessel navigates to and from fishing grounds.
	Activity/ presence on water	1	Vessel introduces noise and visual stimuli into the environment.
Disturb physical processes	Bait collection	0	Bait not collected by this fishery.
	Fishing	1	Longlines may disturb sediment/benthos upon retrieval.
	Boat launching	0	Not applicable. Vessels in fishery come from designated ports.
	Anchoring/ mooring	0	Does not occur on fishing grounds.
	Navigation/ steaming	1	Small number of vessels navigate within fishing grounds.
External Hazards	Other capture fishery methods	1	IUU has been recorded in the past, and IUU gear sighted in AFZ in ERA period.
	Aquaculture	0	None occurs.
	Coastal development	0	None occurs.

Table 2.26: *(continued)*

Direct impact of Fishing	Fishing Activity	Presence (1) Absence (0)	Documentation of Rationale
	Other extractive activities	0	None occurs.
	Other non-extractive activities	0	None occurs.
	Other anthropogenic activities	1	Tourist/shipping occurs to Macquarie Island but unlikely to occur on fishing grounds.

2.2.6 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 Reports: see Table 0.3 and references within.
- **Fisheries Management Act 1991 (Office-of-Parliamentary-Counsel, 1991).**
- **Fisheries Management Regulations 2019 (Office-of-Parliamentary-Counsel, 2019b).**
- **Fisheries Administration Regulations 2019 (Office-of-Parliamentary-Counsel, 2019a).**
- **Macquarie Island Toothfish Fishery Management Plan 2006 (Amended 2012) (Office-of-Parliamentary-Counsel, 2006).**
- **Macquarie Island Toothfish Fishery (Total Allowable Catch) Determination 2023 (Office-of-Parliamentary-Counsel, 2023).**
- **Macquarie Island Toothfish Fishery (Fishing Year) Determination 2021 (Office-of-Parliamentary-Counsel, 2021).**
- AFMA At a glance web page https://www.afma.gov.au/fisheries/macquarie-island-toothfish-fishery
- Bycatch Action Plans
- Ecological Risk Assessment Report (Zhou & Fuller, 2011)

Other publications that provided information include:

- ABARES Fishery Status Reports: referenced in this report
- Strategic Plans

Further details and data on the fishery and on the processes and methods used for the assessment can also be found in the appendices A to C.

2.2.7 Decision Rules to Move to Level 1 (Step 6)

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

In this case, 12 out of 26 possible internal activities were identified as occurring in this fishery. Two out of six external activities were identified. Thus, a total of 14 activity-component scenarios will be considered at Level 1. This results in 56 total scenarios (of 128 possible) to be developed and evaluated using the unit lists (species, communities).

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 (key and secondary; bycatch and byproduct; protected species; habitats; 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. A 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

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 (key/secondary commercial, bycatch and byproduct, and protected species, habitats, and communities). Only those activities that scored a 1 (presence) will be analysed at Level 1.

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 (Table 3.1). 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.

Table 3.1: 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 in Step 2 is not used directly, but the analysis is used in making judgments about the level of intensity in 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.

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 (Table 3.2). 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.

Table 3.2: Temporal scale score of activity.

Decadal	Every several years	Annual	Quarterly	Weekly	Daily
(1 day every 10 years or so)	(1 day every several years)	(1-100 days per year)	(100-200 days per year)	(200-300 days per year)	(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 4. 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 a score of 3 is appropriate.

The temporal scale score in Step 3 is not used directly, but the analysis is used in making judgements about the level of intensity in 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.

3.4 Choose the Sub-component Most Likely to be Affected by Activity (Step 4)

The most vulnerable sub-component must be used for the analysis of each identified hazard. This selection must be made based on the 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.

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 the 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 the 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.

3.6 Select the Most Appropriate Operational Objective (Step 6)

To provide a 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.

3.7 Score the Intensity of the Activity for the Component (Step 7)

The score for the intensity of an activity considers the direct impacts in line with the categories shown in the conceptual model (Figure 1.2: 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 in Table 3.3.

Table 3.3: 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.

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 defined in Table 3.4. A more detailed description of the consequences at each level for each component (key/secondary commercial, bycatch and byproduct, protected species, habitats, and communities) is provided as a guide for scoring the consequences of the activities in the description of consequences table (see Tables B.1 to B.5 in Appendix B).

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.

Table 3.4: 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)

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 (Table 3.5). 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.

Table 3.5: 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

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.

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 Tables above).

3.10.1 Key/Secondary Commercial Species Component

Table 3.6: Level 1 (SICA) Document L1.1
Key commercial/secondary commercial species. Commercial bait species are also included here.

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	4	Population size	Patagonian Toothfish (*Dissostichus eleginoides*)					The three regions of the fishery are the Aurora Trough, the Northern Macquarie Ridge and the Southern Macquarie Ridge. All fishing grounds are less than 100 nm wide. Fishing occurs between 15 April and 30 August, and between 81 and 139 days per year. Population size most likely to be affected by capture fishing. Patagonian Toothfish only key commercial species. However, this species undergoes a stock assessment, and therefore no further action is required for this activity.
	Incidental behaviour	0									
Direct impact without capture	Bait collection	0									

Table 3.6: ***(continued)***

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
	Fishing	1	3	4	Population size	Patagonian Toothfish (*Dissos-tichus elegi-noides*)	1.2, 1.3	3	1	2	In comparison to many other fishing methods, longlining is considered to be relatively selective. A lower diversity of species that are susceptible to longline gear are found in the upper water column in comparison to the range of species that may be impacted on by other methods such as demersal trawling. Based on the catch list supplied by AAD this activity has been marked with the following scores. Intensity: minor, based on expanded fishing footprint and total days fished. Consequence: negligible, relatively small physical impact of gears, without capture. Confidence score: high, underwater camera footage collected by AAD on HIMI fishery demonstrate minor impacts aside from capture.
	Incidental behaviour	0									
	Gear loss	1	3	1	Population size	Patagonian Toothfish (*Dissos-tichus elegi-noides*)	1.2	1	2	2	Gear loss is rare in this fishery and small number of gear was recorded lost in the 2019-2023 ERA period. Vessels fishing in the MITF are required to try to retrieve any lost gear whilst fishing in accordance with conservation management measures and SFR conditions as set by CCAMLR and AFMA. Operators will also retrieve illegal fishing gear they may come across as long as it is safe to do so. All gear lost, found or retrieved must be recorded in logbooks. Intensity negligible, only one vessel in the fishery, complete or fractional gear loss is rare. Consequence: minor, Integrated Weight Line (IWL) sinks to benthos and is rapidly removed from majority this species habitat. Confidence: high, 100% Observer coverage records all gear loss from MITF (except for 2020-21 season due to COVID-19 restrictions).
	Anchoring/ mooring	0									

Table 3.6: ***(continued)***

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	4	4	Population size	Patagonian Toothfish (*Dissos-tichus elegi-noides*)	1.2	2	1	2	Navigation/ steaming occurs up to 173 days per year. Intensity: minor, as population size not likely to be affected by collision of this species with vessel or gear. Consequence: negligible, unlikely for deepwater demersal species to collide with vessel or gear. Confidence: high, 100% Observer coverage (except for 2020-21 season due to COVID-19 restrictions) and logical consideration would indicate minimal impact.
Addition/ movement of biological material	Translocation of species	1	3	4	Population size	Patagonian Toothfish (*Dissos-tichus elegi-noides*)	1.2, 1.3	2	2	1	Translocation of species via ballast or hull-fouling could occur while vessel on the grounds up to 173 days per year. Population size impact plausible. Intensity: minor, based on days steaming in MITF, 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 highly unlikely. Low likelihood of temperate water species surviving and establishing in sub-Antarctic waters. In regard to transport of pathogens through the Macquarie Ridge, circumpolar currents facilitate wide distribution of Antarctic and sub-Antarctic species throughout region, vessel transport would be a minor vector by comparison. Consequence: minor, scored 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									

Table 3.6: *(continued)*

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
	Provisioning	1	3	4	Behaviour/ movement	Patagonian Toothfish (*Dissostichus eleginoides*)	6.1	3	1	2	Auto baiting ensures baited hooks enter below the waterline, removing much of bait loss to aerial scavengers. Possible that target species may remove portion of bait or catch from longline. Intensity: moderate, due to footprint of the fishery and days fishing. Consequence: negligible, bait input into system from loss is low. Confidence: high, 100% Observer coverage (except for 2020-21 season due to COVID-19 restrictions). Captain experience and crew training would ensure bait loss is minimised, through optimal bait attachment to hooks, as this is central to attaining desired catch rates.
	Organic waste disposal	0									
Addition of non-biological material	Debris	0									
	Chemical pollution	0									
	Exhaust	1	4	4	Behaviour/ movement	Patagonian Toothfish (*Dissostichus eleginoides*)	6.1	2	1	2	The Aurora Trough, Southern Ridge and the Northern Valleys fishing grounds are less than 100 nm wide. Exhaust emissions occurs daily during the season. Intensity: minor, the limited number of vessels (1) 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. Consequence: negligible, weather conditions in the region are frequently extreme, rapidly dispersing exhaust emissions. Confidence: high, due to depth of water column separating key commercial species from emissions.

Table 3.6: ***(continued)***

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	2	1	Population size	Patagonian Toothfish (*Dissostichus eleginoides*)	1.2	1	1	2	Gear loss in this fishery is rare and the impact on addition of non-biological material of the target species is small and therefore unlikely to population size of this species. Intensity: negligible, only one vessel in the fishery coupled with the type of gear in use. Consequence: negligible, rare incidence and sink rate of gears out of this species. Confidence: high, there is 100% Observer coverage (except for 2020-21 season due to COVID-19 restrictions). Small number of gear was recorded lost in the 2019-2023 ERA period. Vessels fishing in the MITF are required to try to retrieve any lost gear whilst fishing in accordance with conservation management measures and SFR conditions as set by CCAMLR and AFMA. Operators will also retrieve illegal fishing gear they may come across as long as it is safe to do so. All gear lost or retrieved must be recorded in logbooks.
	Navigation/ steaming	1	4	2	Behaviour/ movement	Patagonian Toothfish (*Dissostichus eleginoides*)	6.1	2	1	1	Navigation/ steaming occurs up to 173 days. Intensity: minor, due to the limited number of vessels in the fishery and the resultant fishing footprint. Consequence: negligible, target species likely too deep and mobile to be impacted by noise or echo sounding from vessel. Confidence low, observation or studies on vessel noise impacts on Patagonian Toothfish behaviour and movement not currently available.

Table 3.6: *(continued)*

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	4	Behaviour/ movement	Patagonian Toothfish (*Dissos-tichus elegi-noides*)	6.1	2	1	2	Intensity: minor, as only one vessel present and active daily up to 173 days. Consequence: negligible, vessel and gears occupy vanishingly small fraction of this species habitat. Target species is a slow moving bentho-pelagic predator, mostly likely too deep to be impacted by surface activity. Confidence: high, observation or studies on vessel on surface and impact on Patagonian Toothfish behaviour and movement not currently available. However, it is unlikely to have impact given scale of vessel and distance to target species.
Disturb physical processes	Bait collection	0									
	Fishing	1	2	4	Population size	Patagonian Toothfish (*Dissos-tichus elegi-noides*)	1.2	3	2	1	The three regions of the fishery are the Aurora Trough, Northern Macquarie Ridge and Southern Macquarie Ridge. All fishing grounds are less than 100 nm wide. Fishing occurs between 15 April and 30 August, and between 81 and 139 days per year. Intensity: moderate, 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 key commercial species habitat could affect distribution of habitat-dependent prey species. Confidence: low, due to lack of data from the Macquarie fishery regarding effects of this mode of disturbance.
	Boat launching	0									
	Anchoring/ mooring	0									

Table 3.6: *(continued)*

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	4	Behaviour/ movement	Patagonian Toothfish (*Dissostichus eleginoides*)	6.1	3	1	2	Navigation/ steaming occurs daily over up to 173 days. Intensity: moderate, due to fishing foot print from the limited number of vessels (1) in the fishery. Consequence: negligible, this species is too deep for vessel to alter relevant physical processes to be detectable beyond natural variation. Confidence: high, wave and vessels effects unlikely to impact behaviour of this bentho-pelagic species.
External Impacts	Other fisheries	1	4	1	Population size	Patagonian Toothfish (*Dissostichus eleginoides*)	1.2	1	1	2	No other fisheries operate in the Australian fishing zone (AFZ) at MITF. Intensity: negligible, only one alleged case of IUU fishing to have occurred in the AFZ in the early history of the fishery. However, Industry has reported finding IUU gears during this ERA period. Fishing outside AFZ (e.g., in adjacent New Zealand AFZ or in International waters) could cause impact on the same populations of this deepwater species listed as unit of analysis. Consequence: negligible, if IUU fishing is occurring within 2000 nm of fishing zone, there is likely to be some impact on the population of Patagonian Toothfish centred around Macquarie Ridge, given those vessels would most likely not be conforming to best practice in bycatch mitigation and handling. Confidence: high, 100% Observer coverage (except for 2020-21 season due to COVID-19 restrictions) while fishing is occurring. AFMA reports no IUU activity.
	Aquaculture	0									
	Coastal development	0									
	Other extractive activities	0									

Table 3.6: *(continued)*

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	3	3	Behaviour/ movement	Patagonian Toothfish (*Dissostichus eleginoides*)	6.1	2	1	2	Tourism (~150 days) and research vessel voyages (~ 60 days) occur over this spatial scale within the AFZ over the 2019-23 ERA period. Tourism vessels visit the area several times a year (e.g., https:// www.heritage-expeditions.com/ macquarie-island-cruises-gl/). AAD resupply occurs twice a year. There has been a single CSIRO led Investigator cruise in the ERA period (~ 20 days in Macquarie Island Marine Park in 2020). Distribution of this deepwater species make them unlikely impacted. Intensity: minor, due to small number of trips/ vessels involved. Consequence: negligible, limited activity overlap with species identified as units of analysis in this impact. Confidence: high, each vessel is bound by the same regulations as the commercial fishing vessels, and have specific permits and must abide by regulated approach distances to marine species and fishing grounds.

3.10.2 Byproduct/Bycatch Species Component

Table 3.7: Level 1 (SICA) Document 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									
	Fishing	1	3	4	Population size	Antarctic Sleeper Shark (*Somniosus antarcticus*); Deep Water Ghost Shark (*Chimaera fulva*)	1.3, 1.4	3	2	2	The three regions of the fishery are the Aurora Trough, the Northern Macquarie Ridge and the Southern Macquarie Ridge. All fishing grounds are less than 100 nm wide. Fishing occurs between 15 April and 30 August, and between 81 and 139 days per year. Population size most likely to be affected by capture fishing. Population size of Antarctic Sleeper Shark, Deep Water Ghost Shark and other deepwater shark species are most likely to be affected before other sub-components as growth, maturity rates and productivity are magnitudes lower than other bycatch species, not only for these species but many deepwater shark and ray species (Finucci et al., 2024). Post release mortality for deepwater shark species are thought to be high, estimated up to 100% in some species, greater work needed on Sleeper and Ghost sharks species (Talwar et al. (2017), Rodriguez-Cabello et al. (2017), Moura et al., (2018), Rigby et al. (2021)). Intensity: moderate, expanding fishing footprint and fishing days. Consequence: minor, minimal impact on stock structure or dynamics. Confidence: high, due to data collection by Observers and research conducted in the fishery to date and in other ocean basins where Sleeper and Chimaera are captured on longline.
	Incidental behaviour	0									
Direct impact without capture	Bait collection	0									

Table 3.7: ***(continued)***

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
	Fishing	1	3	4	Population size	Antarctic Sleeper Shark (*Somniosus antarcticus*); Deep Water Ghost Shark (*Chimaera fulva*)	1.3, 1.4	3	2	2	Population size most likely to be affected before other sub-components as productivity of Southern Sleeper Shark and Deepwater Ghost shark considered much lower than bycatch species and mortality, following interactions with fishing gears for many sharks can be high (Talwar et al. (2017), Rodriguez-Cabello et al. (2017), Moura et al. (2018), Rigby et al. (2021)). Intensity: minor, capture rates in fishery are low. Consequence: minor, although detection of impacts due to escapement by Sleeper Sharks and Chimaera is data deficient. Confidence: high, scores are based on data collection by Observers and research conducted in the fishery to date, and other ocean basins where Sleeper and Chimaera are captured on longline.
	Incidental behaviour	0									
	Gear loss	1	3	1	Population size	Antarctic Sleeper Shark (*Somniosus antarcticus*); Deep Water Ghost Shark (*Chimaera fulva*)	1.3, 1.4	1	2	2	Gear loss in the 2019-23 ERA period isolated to small number of recorded events. Intensity negligible, only one vessel in the fishery, complete or fractional gear loss is rare. Consequence: minor, as Integrated Weight Longline (IWL) is used in the fishery and sinks to benthos so is rapidly removed from majority deepwater shark habitat. Confidence: high, 100% Observer coverage records all gear loss from MITF (except for 2020-21 season due to COVID-19 restrictions).
	Anchoring/ mooring	0									

Table 3.7: *(continued)*

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	4	4	Population size	Antarctic Sleeper Shark (*Somniosus antarcticus*); Deep Water Ghost Shark (*Chimaera fulva*)	1.3, 1.4	2	1	2	Navigation/ steaming occurs up to 173 days per year. Intensity: minor, population size not likely to be affected by collision of fish with vessel or gear. Consequence: negligible, unlikely for deepwater demersal species to collide with vessel or gear. Confidence: high, 100% Observer coverage (except for 2020-21 season due to COVID-19 restrictions) and logical consideration would indicate minimal impact.
Addition/ movement of biological material	Translocation of species	1	3	4	Population size	Antarctic Sleeper Shark (*Somniosus antarcticus*); Deep Water Ghost Shark (*Chimaera fulva*)	1.3, 1.4	2	2	1	Translocation of species via ballast or hull-fouling could occur while vessel on the grounds up to 173 days per year. Population size impact plausible. Low likelihood of temperate water species surviving and establishing in sub-Antarctic waters. In regard to transport of pathogens through the Macquarie Ridge, circumpolar currents facilitate wide distribution of Antarctic and sub-Antarctic species throughout region, vessel transport would be a minor vector by comparison. Intensity: minor, remote likelihood of temperate water species surviving and establishing as a threat to Sleeper Shark or Ghost Shark in sub-Antarctic waters. Consequence: minor, scored to recognize the potential for the spread of fish borne disease. Confidence low, no data on susceptibility of deepwater sharks to fish borne diseases or evidence that translocation has occurred.
	On board processing	0									

Table 3.7: ***(continued)***

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
	Discarding catch	0									
	Stock enhancement	0									
	Provisioning	1	3	4	Behaviour/ movement	Antarctic Sleeper Shark (*Somniosus antarcticus*); Deep Water Ghost Shark (*Chimaera fulva*)	6.1	3	2	1	Auto baiting ensures baited hooks enter below the waterline, removing much of bait loss to aerial scavengers. Shark species may easily remove bait or catch from longline. Intensity: moderate due to footprint of the fishery and days fishing. Consequence: negligible, bait input into system from loss is low. Confidence: high, 100% Observer coverage (except for 2020-21 season due to COVID-19 restrictions). Captain experience and crew training would ensure bait loss is minimised as this is central to attaining desired catch rates.
	Organic waste disposal	0									
Addition of non-biological material	Debris	0									
	Chemical pollution	0									

Table 3.7: *(continued)*

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	4	4	Behaviour/ movement	Antarctic Sleeper Shark (*Somniosus antarcticus*); Deep Water Ghost Shark (*Chimaera fulva*)	6.1	2	1	2	The Aurora Trough, Southern Ridge and the Northern Valleys fishing grounds are less than 100 nm wide. Exhaust emissions occurs daily during the season. Intensity: minor, the limited number of vessels (1) in the fishery coupled with the depth at which these species are found makes it highly unlikely that exhaust gas emissions will have an affect on these species. Consequence: negligible, weather conditions in the region are frequently extreme, rapidly dispersing exhaust emissions. Confidence: high, due to depth of water column separating bycatch species from emissions.
	Gear loss	1	2	1	Population size	Antarctic Sleeper Shark (*Somniosus antarcticus*); Deep Water Ghost Shark (*Chimaera fulva*)	1.3, 1.4	1	1	2	Gear loss in this fishery is rare and the impact on these species small and therefore unlikely to impact population size. Intensity: negligible, only one vessel in the fishery coupled with the type of gear in use. Consequence: negligible, rare incidence and sink rate of gears out of deepwater shark primary habitat. Confidence: high, there is 100% Observer coverage (except for 2020-21 season due to COVID-19 restrictions). A small number of set of gear was recorded lost in the 2019-2023 ERA period. Vessels fishing in the MITF are required to try to retrieve any lost gear whilst fishing in accordance with conservation management measures and SFR conditions as set by CCAMLR and AFMA. Operators will also retrieve illegal fishing gear they may come across as long as it is safe to do so. All gear lost or retrieved must be recorded in logbooks.

Table 3.7: *(continued)*

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	4	2	Behaviour/ movement	Antarctic Sleeper Shark (*Somniosus antarcticus*); Deep Water Ghost Shark (*Chimaera fulva*)	6.1	2	1	1	Navigation/ steaming occurs up to 173 days per year. Intensity: minor, due to the limited number of vessels (1) in the fishery and the resulting fishing footprint. Consequence: negligible, Sleeper Shark and/ or Ghost Shark likely too deep and mobile to be impacted by noise or echo sounding from vessel. Confidence: low, studies on vessel noise on shark not available.
	Activity/ presence on water	1	3	4	Behaviour/ movement	Antarctic Sleeper Shark (*Somniosus antarcticus*); Deep Water Ghost Shark (*Chimaera fulva*)	6.1	2	1	1	Intensity: minor, only one vessel present and active daily up to 173 days per year. Consequence: negligible, vessel and gears occupy small fraction of deepwater shark area. Sleeper and Ghost sharks are too deep and mobile to be impacted by surface activity. Confidence: high, due to review of research on habitat use of similar species (Finucci et al., 2024).

Table 3.7: ***(continued)***

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	Bait collection	0									
	Fishing	1	2	4	Population size	Antarctic Sleeper Shark (*Somniosus antarcti-cus*); Deep Water Ghost Shark (*Chimaera fulva*)	1.3, 1.4	3	2	1	The three regions of the fishery are the Aurora Trough, Northern Macquarie Ridge and Southern Macquarie Ridge. All fishing grounds are less than 100 nm wide. Fishing occurs between 15 April and 30 August, and between 81 and 139 days per year. 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 fishery regarding effects of benthos disturbance.
	Boat launching	0									
	Anchoring/ mooring	0									

Table 3.7: *(continued)*

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	4	Behaviour/ movement	Antarctic Sleeper Shark (*Somniosus antarcticus*); Deep Water Ghost Shark (*Chimaera fulva*)	6.1	3	1	2	Navigation/ steaming occurs daily up to 173 days. Intensity: moderate, due to fishing foot print and the limited number of vessels (1) in the fishery. Consequence: negligible, deepwater sharks are too deep for vessel to alter relevant physical processes to be detectable beyond natural variation. Confidence: high, wave and vessels effects unlikely to impact behaviour/ movement of benthopelagic shark species.
External Impacts	Other fisheries	1	4	1	Population size	Antarctic Sleeper Shark (*Somniosus antarcticus*); Deep Water Ghost Shark (*Chimaera fulva*)	1.3, 1.4	1	1	2	No other fisheries operate in the Australian fishing zone (AFZ) at MITF. Intensity: negligible, only one alleged case of IUU fishing to have occurred in the AFZ in the early history of the fishery. However, Industry has reported finding IUU gears during this ERA period. Fishing outside AFZ (e.g., in adjacent New Zealand AFZ or in International waters) could cause impact on the same populations of the deepwater sharks listed as unit of analyses. Consequence: negligible, if IUU fishing is occurring within 2000 nm of fishing zone, there is likely to be some impact on deepwater shark species, given those vessels would most likely not be conforming to best practice in bycatch mitigation and handling. Confidence: high, 100% Observer coverage (except for 2020-21 season due to COVID-19 restrictions) while fishing is occurring. AFMA reports no IUU activity.
	Aquaculture	0									

Table 3.7: *(continued)*

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
	Coastal development	0									
	Other extractive activities	0									
	Other non extractive activities	0									
	Other anthropogenic activities	1	3	3	Behaviour/ movement	Antarctic Sleeper Shark (*Somniosus antarcticus*); Deep Water Ghost Shark (*Chimaera fulva*)	6.1	2	1	1	Tourism (~150 days) and research vessel voyages (~ 60 days) occur over this spatial scale within the AFZ over the 2019-23 ERA period. Tourism vessels visit the area several times a year (e.g., https:// www.heritage-expeditions.com/ macquarie-island-cruises-gl/). AAD resupply occurs twice a year. There has been a single CSIRO led Investigator cruise in the assessment period (~ 20 days in Macquarie Island Marine Park in 2020). Distribution of deepwater sharks make them unlikely impacted. Intensity: minor, due to small number of trips/ vessels involved. Consequence: negligible, limited activity overlap with species identified as units of analysis in this impact. Confidence: high, each vessel is bound by the same regulations as the commercial fishing vessels, and have specific permits and must abide by regulated approach distances to marine species and fishing grounds.

3.10.3 Protected Species Component

Table 3.8: Level 1 (SICA) Document L1.3 - Protected 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									

Table 3.8: *(continued)*

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
	Fishing	1	3	4	Population size	White-Chinned Petrel (*Procellaria aequinoctialis*); Porbeagle Shark (*Lamna nasus*)	1.1	3	3	2	The three regions of the fishery are the Aurora Trough, the Northern Macquarie Ridge and the Southern Macquarie Ridge. All fishing grounds are less than 100 nm wide. Fishing occurs between 15 April and 30 August, and between 81 and 139 days per year. The White-chinned Petrel population sizes are most likely to be affected before other sub-components, as the population trend is decreasing for this species (https:// www.iucnredlist.org/ species/ 22698140/ 132628887#population). ACAP website https:// www.acap.aq). The White-chinned Petrel (1 dead) that has interacted with the MITF-longline operation is part of a population that is listed as Vulnerable (IUCN Red list). Note that longline and trawl fishing remain a primary threat to Southern Ocean seabirds, including the the White-chinned Petrel (Phillips et al., 2016). Note only a single direct White-chinned Petrel fatal interaction was recorded in this ERA period (and one alive Giant Petrel: *Macronectes spp*). Also, the Porbeagle Shark population size most likely to be affected before other sub-components. Mortalities and interactions with the Porbeagle have continued in the fishery, although at a reduced number, and caution is still required, given IUCN listing as Vulnerable, as global stocks are declining, and some of the Northern sub-populations are listed as critically endangered (Hoyle et al., 2017). Noting that there is global concern in many shark populations and a call for a global standard for their conservation and management (Hyde et al., 2022). The Southern hemisphere population is genetically, biologically and geographically distinct from the Northern population - a clear indication that it is indeed an independent stock, or more likely a number of poorly mixed stocks in the Southern Ocean basins, all of which are not believed to be as heavily depleted as the Northern stocks (Hoyle et al., 2017). However, the Southern population are thought to take longer to grow and mature.

Table 3.8: ***(continued)***

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
	Fishing (continued)										In addition, this long lived shark has a long gestation and rears small litters (mean 3.7 pups). For both these reasons this species is highly vulnerable to depletion. Intensity: moderate, due to increasing fishery footprint and days of fishing. Consequence: moderate, while these species highly vulnerable to depletion, relatively few individuals impacted from this fishery in the ERA period. Confidence: high, 100% Observer coverage (except for 2020-21 season due to COVID-19 restrictions).
	Incidental behaviour	0									
Direct impact without capture	Bait collection	0									

Table 3.8: ***(continued)***

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
	Fishing	1	3	4	Population size	White-Chinned Petrel (*Procellaria aequinoctialis*); Porbeagle Shark (*Lamna nasus*)	1.1	3	3	2	The Porbeagle Shark population size most likely to be affected before other sub-components. Porbeagle Shark mortalities and interactions have continued in the fishery, although at a reduced intensity, however the high level of sensitivity in this required due to the extremely low productivity of the Southern population. Also, stock structure of the Southern hemisphere populations are still yet to be defined, although it is likely there are multiple poorly mixing stocks as in the Northern hemisphere (Hoyle et al., 2017). Also, the White-chinned Petrel (WCP) population size most likely to be affected before other sub-components as population trend is decreasing [https:// www.iucnredlist.org/ species/ 22698140/ 132628887] and any interactions resulting in injury or death may impact survival. The only interaction with the WCP resulted in a death over this 2019-2023 ERA period. Note that longline and trawl fishing remain a primary threat to Southern Ocean seabirds (Phillips et al., 2016). Intensity: moderate, due to the increasing fishery footprint and days of fishing. Consequence: moderate. Confidence: high, due to data collection by Observers and research conducted in the fishery to date.
	Incidental behaviour	0									

Table 3.8: ***(continued)***

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	1	Population size	White-Chinned Petrel (*Procellaria aequinoctialis*); Porbeagle Shark (*Lamna nasus*)	1.1	1	2	2	Gear loss in this fishery is rare and the impact on these species small and therefore unlikely to impact population size. Intensity: negligible, only one vessel in the fishery coupled with the type of gear in use and rare incidence of loss. Consequence: minor, very low number of baited hooks lost. Confidence: high, 100% Observer coverage (except for 2020-21 season due to COVID-19 restrictions) but no data on effect of gear loss on these species. Only a small number of gear was lost in the 2019-2023 ERA period. Vessels fishing in the MITF are required to try to retrieve any lost gear whilst fishing in accordance with conservation management measures and SFR conditions as set by CCAMLR and AFMA. Operators will also retrieve illegal fishing gear they may come across as long as it is safe to do so. All gear lost or retrieved must be recorded in logbooks.
	Anchoring/ mooring	0									

Table 3.8: *(continued)*

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	4	4	Population size	White-Chinned Petrel (*Procellaria aequinoctialis*); Northern Giant Petrel (*Macronectes halli*); Southern Giant Petrel (*Macronectes giganteus*)	1.1	2	2	2	Navigation/ steaming occurs daily up to 173 days per year. Population size most likely to be affected before other sub-components. Intensity: minor, due to presence of vessel and Observer data on seabirds around vessels. Seabirds have flown into vessels or fishing gear by accident. Consequence: minor, despite mitigating factors including reduced lighting, removal of protruding wires etc., and the estimated population levels of these species result in a minor consequence score. Confidence: high, due to data collection by Observers and research conducted in the fishery to date.

Table 3.8: *(continued)*

Direct impact of fishing	Fishing Activity	Presence (1) Absence (0)	Spatial scale of Hazard (1-6)	Temporal scale of Hazard (1-6)	Sub-component	Unit of analysis	Operational objective (S2.1)	Intensity Score (1-6)	Consequence Score (1-6)	Confidence Score (1-2)	Rationale
Addition/ movement of biological material	Translocation of species	1	3	4	Behaviour/ movement	White-Chinned Petrel (*Procellaria aequinoctialis*); Porbeagle Shark (*Lamna nasus*)	6.1	2	2	2	Translocation of temperate species from lower latitudes could occur in transit from home port. Species ranges are such that any species translocated would still be in natural range of these highly migratory species. Behaviour/ movement most likely to be affected. Intensity: minor, due to fishing foot print and number of days steaming in fishery area. Consequences minor, as the likelihood of the translocation 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. Confidence: high, logical consideration, any notable translocation of the protected species would have been noted via 100% Observer coverage (except for 2020-21 season due to COVID-19 restrictions). Ballast management would also be subject MARPOL regulations and Australian Marine Park requirements.
	On board processing	0									
	Discarding catch	0									
	Stock enhancement	0									

Table 3.8: *(continued)*

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
	Provisioning	1	3	4	Behaviour/ movement	White-Chinned Petrel (*Procellaria aequinoctialis*); Porbeagle Shark (*Lamna nasus*)	6.1	3	1	2	Auto baiting ensures baited hooks enter below the waterline, however, the White-chinned Petrel (WCP) are now known to dive to beyond 10 m meaning they can provision from baits or retrieved catch (Bentley et al., 2021; Frankish et al., 2021; Rollinson et al., 2014). Porbeagle Shark may also easily remove bait or catch from longline. Intensity: moderate, due to footprint of the fishery and days fishing. Consequence: negligible, bait input into system from loss is low. Confidence: high, 100% Observer coverage (except for 2020-21 season due to COVID-19 restrictions). Captain experience and crew training would ensure bait loss is minimised as this is central to attaining desired catch rates.
	Organic waste disposal	0									
Addition of non-biological material	Debris	0									
	Chemical pollution	0									

Table 3.8: ***(continued)***

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	4	4	Behaviour/ movement	White-Chinned Petrel (*Procellaria aequinoctialis*); Porbeagle Shark (*Lamna nasus*)	6.1	2	1	2	Exhaust emissions occurs daily during the season. Intensity: minor, due to the number of days operating in the fishery. Consequence: negligible. Only one vessel in the fishery, and given the White-chinned Petrel mobility, and the depth at which the Porbeagle is found, it is unlikely that exhaust gas emissions will affect these species. Also, weather conditions in the region are frequently extreme, rapidly dispersing exhaust emissions. Confidence: high, 100% Observer coverage (except for 2020-21 season due to COVID-19 restrictions), logical consideration.
	Gear loss	1	2	1	Population size	White-Chinned Petrel (*Procellaria aequinoctialis*); Porbeagle Shark (*Lamna nasus*)	1.1	1	1	2	Gear loss in this fishery is rare and the impact on these species is considered small and therefore unlikely to impact their population size. Intensity: negligible, only one vessel in the fishery coupled with the type of gear in use and rate of loss in this ERA period. Consequence: negligible, the Integrated Weight Line (IWL) will sink to bottom when gear is lost, limiting entanglement with protected species as it moves outside of their habitat rapidly. Confidence: high, 100% Observer coverage (except for 2020-21 season due to COVID-19 restrictions). Small number of gear was lost in the 2019-2023 ERA period. Vessels fishing in the MITF are required to try to retrieve any lost gear whilst fishing in accordance with conservation management measures and SFR conditions as set by CCAMLR and AFMA. Operators will also retrieve illegal fishing gear they may come across as long as it is safe to do so. All gear lost or retrieved must be recorded in logbooks.

Table 3.8: *(continued)*

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	4	2	Behaviour/ movement	White-Chinned Petrel (*Procellaria aequinoctialis*); Northern Giant Petrel (*Macronectes halli*); Southern Giant Petrel (*Macronectes giganteus*)	6.1	2	1	2	Navigation/ steaming occurs daily up to 173 days/ year. Intensity: minor, due to the limited number of vessels days recorded in the fishery. Consequence: negligible, any changes in behaviour/ movement would be temporary due to mobility of birds. Confidence: high, likelihood of bird collisions with vessel being observed are high due to 100% Observer coverage (except for 2020-21 season due to COVID-19 restrictions).
	Activity/ presence on water	1	3	4	Behaviour/ movement	White-Chinned Petrel (*Procellaria aequinoctialis*); Porbeagle Shark (*Lamna nasus*)	6.1	2	1	2	Intensity: minor, only one vessel present and active in fishing zone up to 173 days per year. Consequence: negligible, any change in distribution and freedom of movement of birds and sharks only temporary. Confidence: high, logical consideration. Any notable interactions are recorded by AFMA Observer, and in the case of the White-chinned Petrel, there was only single interaction (1 dead) recorded during the 2019-2023 ERA period.

Table 3.8: *(continued)*

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	Bait collection	0									
	Fishing	1	2	4	Population size	White-Chinned Petrel (*Procellaria aequinoctialis*); Porbeagle Shark (*Lamna nasus*)	1.1	3	1	1	White-chinned Petrel and Porbeagle Shark chosen as most likely protected species as they are likely to interact with deepwater longlines. However, the impact the vessel or longline is likely to have on physical processes relevant to these species is likely to be very low, given the scale of the physical processes that these species navigate in their normal transit through space. Intensity: moderate, with expanding footprint of the fishery, even with the low numbers of vessels (1) in fishery. Consequence: negligible, while the vessel and gear do represent a physical obstacle, it is a small one and easy to avoid. Confidence: low, due to lack of targeted studies on the physical disturbance of vessels on the selected species.
	Boat launching	0									
	Anchoring/ mooring	0									

Table 3.8: *(continued)*

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	4	Population size	White-Chinned Petrel (*Procellaria aequinoctialis*); Northern Giant Petrel (*Macronectes halli*); Southern Giant Petrel (*Macronectes giganteus*)	1.1	3	1	2	Navigation/ steaming occurs daily during season. Surface orientated protected species most susceptible to disturbance by navigation/ steaming, such as Petrels - all direct protected species interactions are recorded by 100% Observer coverage (except for 2020-21 season due to COVID-19 restrictions). Note that indirect impacts from vessel noise/ presence is difficult to quantify and report on. Intensity: moderate, with increase in total days in the vicinity of known foraging locations. Consequence: negligible, only one vessel involved. Confidence: high, 100% Observer coverage and data on interactions suggests impact minimal.

Table 3.8: ***(continued)***

Direct impact of fishing	Fishing Activity	Presence (1) Absence (0)	Spatial scale of Hazard (1-6)	Temporal scale of Hazard (1-6)	Sub-component	Unit of analysis	Operational objective (S2.1)	Intensity Score (1-6)	Consequence Score (1-6)	Confidence Score (1-2)	Rationale
External Impacts	Other fisheries	1	4	1	Population size	Southern Giant Petrel (*Macronectes giganteus*); Northern Giant Petrel (*Macronectes halli*)	1.1	1	2	2	No other fisheries operate in the Australian fishing zone (AFZ) at MITF. Intensity: negligible, only one alleged case of IUU fishing to have occurred in the AFZ in the early history of the fishery. However, Industry has reported finding IUU gears during this ERA period. Fishing outside AFZ (e.g., in adjacent New Zealand AFZ or in International waters) could cause impact on breeding birds at Macquarie Island (i.e., Southern Giant Petrel; Northern Giant Petrel). Consequence: minor, if IUU fishing is occurring within 2000 nm of fishing zone, there is likely to impact *Macronectes giganteus* and *Macronectes halli* , given those vessels would most likely not be conforming to best practice in bird bycatch mitigation. Confidence: high, 100% Observer coverage (except for 2020-21 season due to COVID-19 restrictions) while fishing is occurring. AFMA reports no IUU activity.
	Aquaculture	0									
	Coastal development	0									
	Other extractive activities	0									
	Other non extractive activities	0									

Table 3.8: ***(continued)***

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	3	3	Behaviour/ movement	Southern Giant Petrel (*Macronectes giganteus*); Northern Giant Petrel (*Macronectes halli*)	6.1	2	2	2	Tourism (~150 days) and research vessel voyages (~ 60 days) occur over this spatial scale within the AFZ over this 2019-2023 ERA period. Tourism vessels visit the area several times a year (e.g., https:// www.heritage-expeditions.com/ macquarie-island-cruises-gl/). The Australian Antarctic Division (AAD) resupply occurs twice a year. There has been a single CSIRO led Investigator cruise in the 2019-23 ERA period (~ 20 days in Macquarie Island Marine Park in 2020). Intensity: minor, due to small number of trips/ vessels involved. Consequence: minor. Confidence: high, each vessel is bound by the same regulations as the commercial fishing vessels, have specific permits and must abide by regulated approach distances to protected species.

3.10.4 Habitats Component

The habitats component was not assessed in this report.

3.10.5 Communities Component

Table 3.9: Level 1 (SICA) Document L1.5 - Communities 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	4	Species composition	Demersal: Upper mid-slope 250 – 1100 m	1.1	3	3	2	The three regions of the fishery are the Aurora Trough, the Northern Macquarie Ridge and the Southern Macquarie Ridge. All fishing grounds are less than 100 nm wide. Fishing occurs between 15 April and 30 August, and operates between 81 and 139 days per year. Fishing can alter community species composition. Fishing footprint has expanded since the last ERA with and increase in fishing days and broader effort. The concentration of effort is still consistently present at Aurora Trough while there was also concentration of effort in the Northern Macquarie Ridge through the first two years of this ERA focus period. In the last two years of the ERA period there has been an increase in North South extent of the fishing footprint. These expansions of fishing will have increased the impact on the slow growing benthic substrate and the communities it supports. Intensity: moderate, increased fishing footprint means broader impacts on communities. Consequence: moderate, the Integrated Weight Line (IWL) interacts with communities that consist of organisms that are often fragile and slow to grow and recover following disruption. Confidence: high, while research efforts into benthic communities at Macquarie Island are ongoing, sufficient research has been conducted into cold deepwater communities to support these scores.
	Incidental behaviour	0									

Table 3.9: *(continued)*

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	4	Species composition	Demersal: Upper mid-slope 250 – 1100 m	1.1	3	2	1	Post-capture mortality resulting from escapement of species from longline gears could affect species composition of community without capture on fishing grounds. Intensity: minor, only one vessel in fishery. Consequence: minor, bycatch is low and relatively small area is affected. Confidence: low, disruption of communities from removal of mid to high trophic levels has not yet been determined, further research required.
	Incidental behaviour	0									
	Gear loss	1	3	1	Species composition	Demersal: Upper mid-slope 250 – 1100 m	1.1	1	2	2	Gear loss is rare. Only small number of gear was lost in the 2019-2023 ERA period. Gear loss has potential to alter species composition by direct interactions with species particularly benthic species. Intensity: negligible, limited numbers of vessels in fishery, and management controls designed to reduce/ monitor interactions with non-target 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 (except for 2020-21 season due to COVID-19 restrictions) and report all gear lost.
	Anchoring/ mooring	0									

Table 3.9: *(continued)*

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	4	4	Species composition	Pelagic: Oceanic 0 – 1600 m	1.1	2	1	2	Navigation/ steaming has potential to alter species composition by direct impact with rare/ endangered species. Intensity: minor, increased fishing foot print even with limited numbers of vessels in fishery, and management controls designed to reduce/ monitor interactions with these species. Consequence: negligible, 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: high, as the data on population sizes and incidents is well documented.
Addition/ movement of biological material	Translocation of species	1	3	4	Species composition	Demersal: Upper mid-slope 250 – 1100 m	1.1	2	2	2	Translocation of species via ballast or hull-fouling could occur while vessel on the grounds (up to 173 days per year) species composition most likely to be affected. Intensity: minor, low likelihood of temperate water species surviving and establishing in sub-Antarctic waters. In regard to movement through the Macquarie Ridge, circumpolar currents facilitate wide distribution of Antarctic and sub-Antarctic species throughout region vessel transport would be a minor vector by comparison. Consequence: minor, due to wide distribution of Antarctic and sub-Antarctic species through region. Confidence: high, as successful translocations involve species already adapted to particular environments and climatic regimes. However, in the context of climate change and the associated shift in marine systems, baseline community research at Macquarie Island Marine Park is an area of interest.
	On board processing	0									
	Discarding catch	0									
	Stock enhancement	0									

Table 3.9: *(continued)*

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
	Provisioning	1	3	4	Distribution of community	Pelagic: Oceanic 0 – 1600 m	3.1	3	1	2	Provisioning occurs through use of bait and discarding. Intensity: negligible, unlikely to be detectable at spatial temporal scale. Consequence: negligible, waste expected to be taken up quickly by opportunistic scavengers or sink to benthos and scavenged by benthic species. Confidence: high, 100% Observer coverage (except for 2020-21 season due to COVID-19 restrictions). Captain experience and crew training would ensure bait loss is minimised as this is central to attaining desired catch rates.
	Organic waste disposal	0									
Addition of non-biological material	Debris	0									
	Chemical pollution	0									
	Exhaust	1	4	4	Distribution of community	Pelagic: Oceanic 0 – 1600 m	3.1	2	1	2	Exhaust emissions occurs daily during the season. Intensity: minor, limited vessel steaming days in the fishing zone (up to 173 days). Consequence: 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 frequently extreme, rapidly dispersing exhaust emissions. Confidence: high, 100% Observer coverage (except for 2020-21 season due to COVID-19 restrictions), logical consideration.

Table 3.9: *(continued)*

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	2	1	Species composition	Demersal: Upper mid-slope 250 – 1100 m	1.1	1	1	2	Gear loss is rare. However, gear loss has potential to alter species composition by direct impact with rare/ endangered species. Intensity: negligible, limited numbers of vessels (1) in fishery and small number of gear lost in the five year (2019-2023) ERA period. Consequence: negligible, detail of gear recorded as lost are either small or have a minimal risk of entangling species or altering habitat of habitat-dependent species. Confidence: high, 100% Observer coverage (except for 2020-21 season due to COVID-19 restrictions).
	Navigation/ steaming	1	4	2	Distribution of community	Pelagic: Oceanic 0 – 1600 m	3.1	2	1	2	Navigation/ steaming has the potential to alter community distributions by attracting species to the vessel and alter foraging patterns. Intensity: minor, increasing fishing footprint and vessel days actively fishing (up to 173 days). Consequence: negligible, small number of vessels involved. Confidence: high, due to Observer data on interactions with vessels navigating/ steaming in the fishery.
	Activity/ presence on water	1	3	4	Distribution of community	Pelagic: Oceanic 0 – 1600 m	3.1	2	1	2	Activity/ presence has the potential to alter community distributions by attracting species to the vessel and alter foraging patterns. Intensity: minor, due to increasing vessel fishing days and expanded fishing gear footprint. Consequence: negligible, due to the small number of vessels involved. Confidence: high, 100% Observer coverage (except for 2020-21 season due to COVID-19 restrictions) recorded interactions with vessels and VMS records tracks of vessels steaming in the fishery, providing accurate maps of impact.
Disturb physical processes	Bait collection	0									

Table 3.9: *(continued)*

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
	Fishing	1	2	4	Distribution of community	Demersal: Upper mid-slope 250 – 1100 m	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, core fishing grounds are consistently targeted once identified as productive. Consequence: minor, as area is relatively small and gears have a reduced footprint relative to the trawl gears that pioneered the core fishing grounds. Confidence: low, due to insufficient data. Research into the benthic impacts of the fishery is recognised as a current priority.
	Boat launching	0									
	Anchoring/ mooring	0									
	Navigation/ steaming	1	3	4	Distribution of community	Pelagic: Oceanic 0 – 1600 m	3.1	3	1	2	Navigation/ steaming has the potential to alter community distributions by wake mixing of the pelagic community. Intensity: minor, due to increasing activity and footprint of small number of vessels involved. Consequence: negligible, only small number of vessels (1) involved and known wind mixing depths exceeding wake mixing. Confidence: high, due to logical consideration of physical processes.

Table 3.9: *(continued)*

Direct impact of fishing	Fishing Activity	Presence (1) Absence (0)	Spatial scale of Hazard (1-6)	Temporal scale of Hazard (1-6)	Sub-component	Unit of analysis	Operational objective (S2.1)	Intensity Score (1-6)	Consequence Score (1-6)	Confidence Score (1-2)	Rationale
External Impacts	Other fisheries	1	4	1	Species composition	Demersal: Upper mid-slope 250 – 1100 m	1.1	1	2	2	No other fisheries operate in the Australian fishing zone (AFZ) at MITF. Intensity: negligible; only one alleged case of IUU fishing to have occurred in the AFZ in the early history of the fishery. However, Industry has reported finding IUU gears during this ERA period. Fishing outside AFZ (e.g., in adjacent New Zealand AFZ or in International waters) could cause impact on locally breeding birds. Consequence: minor, if IUU fishing is occurring within 2000 nm of fishing zone, there is likely to be an impact on avian communities, given those vessels would most likely not be conforming to best practice in bird bycatch mitigation. Confidence: high, 100 % Observer coverage (except for 2020-21 season due to COVID-19 restrictions) while fishing is occurring. AFMA reports no IUU activity.
	Aquaculture	0									
	Coastal development	0									
	Other extractive activities	0									
	Other non extractive activities	0									

Table 3.9: ***(continued)***

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	3	3	Distribution of community	Coastal pelagic	3.1	2	2	1	Tourism (~150 days) and research vessel voyages (~ 60 days) occur over this spatial scale within the AFZ over this 2019-23 ERA period. Tourism vessels visit the area several times a year (e.g., https:// www.heritage-expeditions.com/ macquarie-island-cruises-gl/). AAD resupply occurs twice a year. There has been a single CSIRO led Investigator cruise during the ERA period (~ 20 days in Macquarie Island Marine Park in 2020). Distribution of the coastal pelagic community thought to be most likely impacted. Intensity: minor, due to small number of trips/ vessels involved. Consequence: minor. Confidence: high, each vessel is bound by the same regulations as the commercial fishing vessels, and have specific permits and must abide by regulated approach distances to sensitive communities.

3.11 Summary of SICA Results

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 (shaded) and differentiating those that did so with high confidence (in bold) is outlined in Table 3.10.

Table 3.10: Level 1 (SICA) Document L1.6.
Summary table of consequence scores for all activity/component combinations. Internal activities that scored 3 or more are coloured light blue and bold if high confidence. * existing stock assessment for all species within component. Therefore, assessment not required. n.a.: component not assessed. Note: external hazards are not considered at Level 2.

Impact	Activity	Key/ secondary commercial species	Bycatch/ byproduct species	Protected species	Habitats	Communities
Capture	Bait collection	0	0	0	n.a	0
	Fishing	*	**2**	**3**	n.a	**3**
	Incidental behaviour	0	0	0	n.a	0
Direct impact without capture	Bait collection	0	0	0	n.a	0
	Fishing	**1**	**2**	**3**	n.a	2
	Incidental behaviour	0	0	0	n.a	0
	Gear loss	**2**	**2**	**2**	n.a	**2**
	Anchoring/ mooring	0	0	0	n.a	0
	Navigation/ steaming	**1**	**1**	**2**	n.a	**1**
Addition/ movement of biological material	Translocation of species	2	2	**2**	n.a	**2**
	On board processing	0	0	0	n.a	0
	Discarding catch	0	0	0	n.a	0
	Stock enhancement	0	0	0	n.a	0
	Provisioning	**1**	2	**1**	n.a	**1**
	Organic waste disposal	0	0	0	n.a	0
Addition of non-biological material	Debris	0	0	0	n.a	0
	Chemical pollution	0	0	0	n.a	0
	Exhaust	**1**	**1**	**1**	n.a	**1**
	Gear loss	**1**	**1**	**1**	n.a	**1**
	Navigation/ steaming	1	1	**1**	n.a	**1**
	Activity/ presence on water	**1**	1	**1**	n.a	**1**
Disturb physical processes	Bait collection	0	0	0	n.a	0
	Fishing	2	2	1	n.a	2
	Boat launching	0	0	0	n.a	0
	Anchoring/ mooring	0	0	0	n.a	0
	Navigation/ steaming	**1**	**1**	**1**	n.a	**1**
External Impacts	Other fisheries	**1**	**1**	**2**	n.a	**2**
	Aquaculture	0	0	0	n.a	0
	Coastal development	0	0	0	n.a	0
	Other extractive activities	0	0	0	n.a	0
	Other non extractive activities	0	0	0	n.a	0
	Other anthropogenic activities	**1**	1	**2**	n.a	2

Figure 3.1 to Figure 3.4 show the frequency distribution of consequence scores for all components that were assessed.

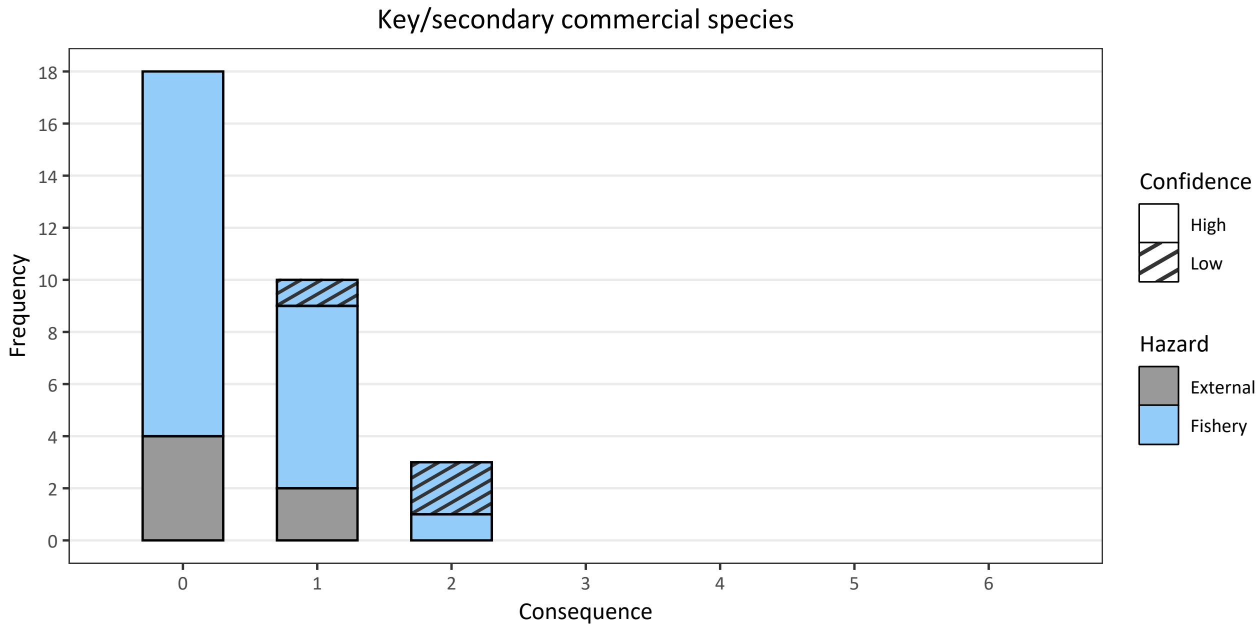

Figure 3.1: Key/secondary commercial species component: Frequency of consequence score by high and low confidence.

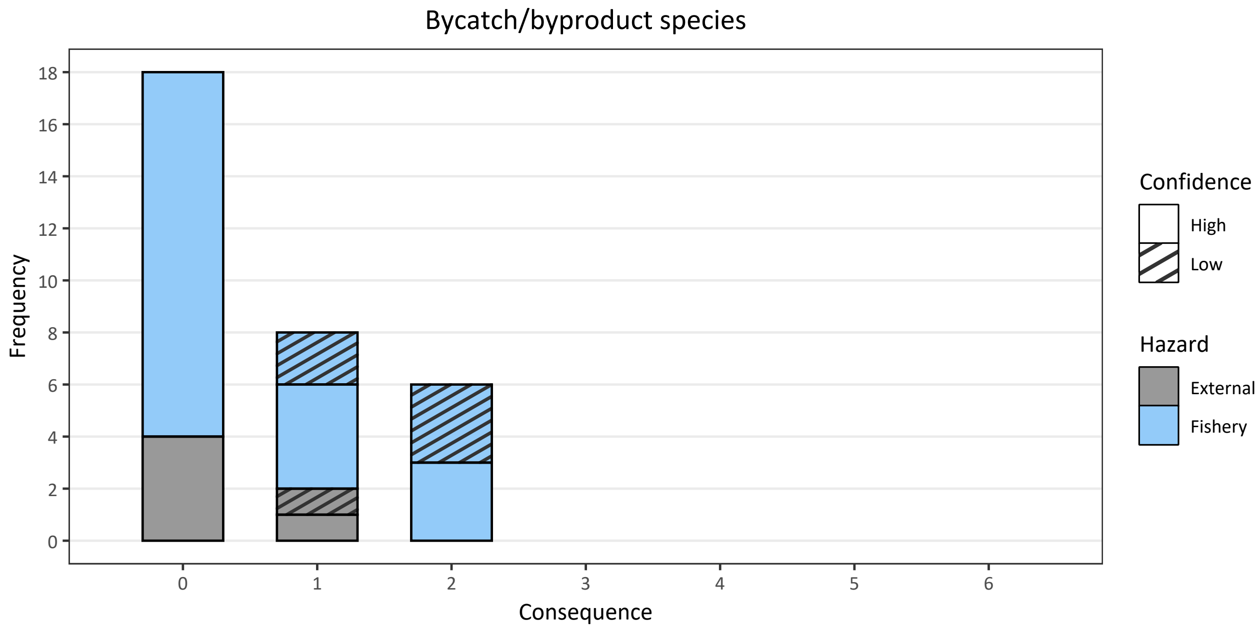

Figure 3.2: Bycatch/byproduct species component: Frequency of consequence score by high and low confidence.

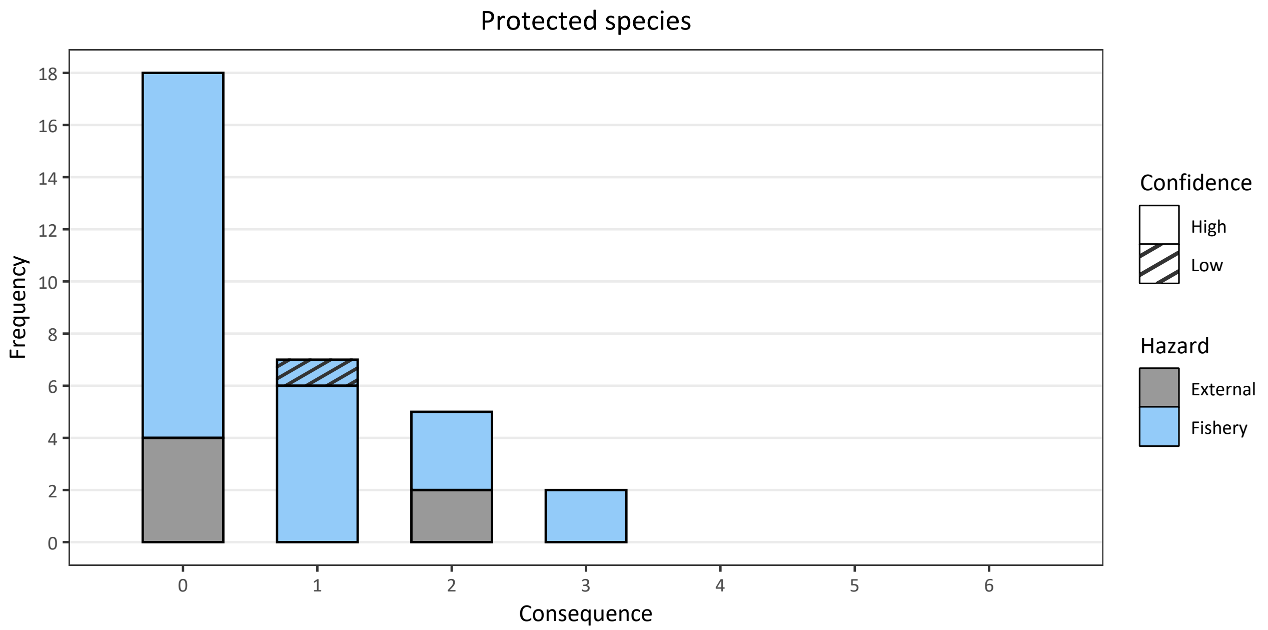

Figure 3.3: Protected species component: Frequency of consequence score by high and low confidence.

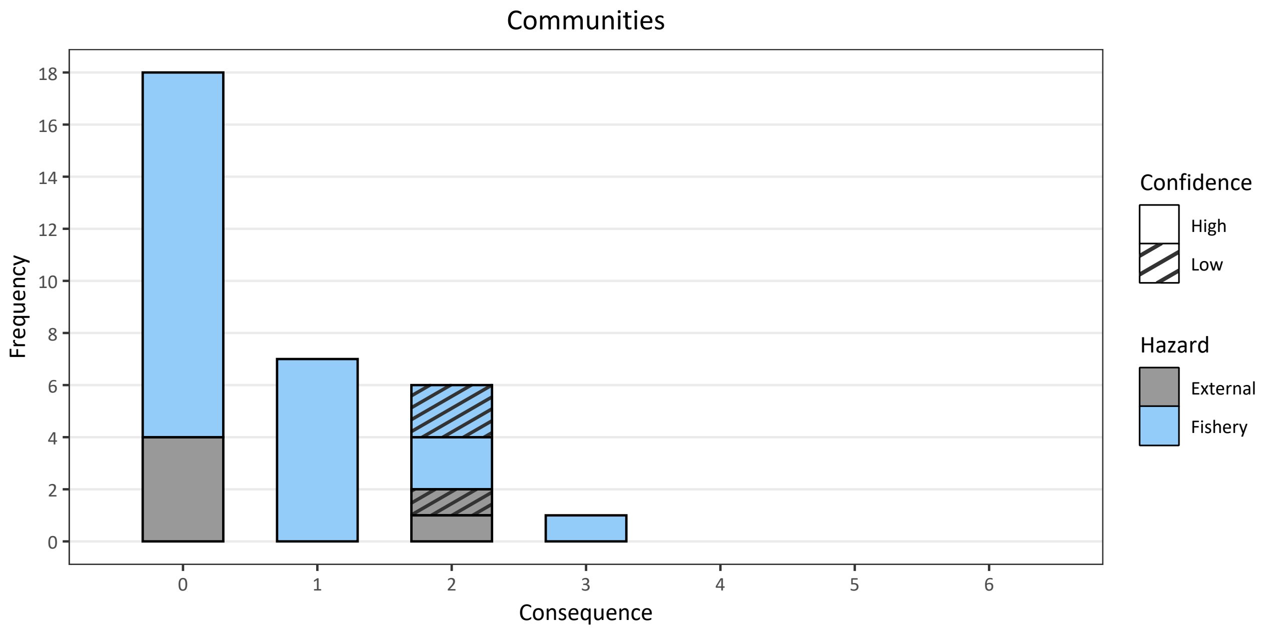

Figure 3.4: Communities component: Frequency of consequence score by high and low confidence.

3.12 Evaluation/Discussion of Level 1

Most hazards (fishing activities) were eliminated at Level 1 (risk scores 1 or 2; Table 3.10); Figure 3.1-Figure 3.4). Those remaining consist of:

- Direct impact/capture from fishing (protected species and communities)
- Direct impact/without capture from fishing (protected species)

The most vulnerable species that triggered a Level 2 analysis were the protected White-chinned Petrel *Procellaria aequinoctialis* and the Porbeagle Shark *Lamna nasus* with and without capture from fishing. For the latter species, the moderate risk score from the capture from fishing was due to (i) the number of interactions with MITF-Longline operations (42: 12 alive, 29 dead, 1 injured), (ii) low productivity (slow growth rate, late maturing and low fecundity) of the southern population and (iii) the southern population being genetically, biologically and geographically distinct from the northern population.

Fishing by direct capture was considered a moderate risk (3) to communities (i.e., Demersal: Upper mid-slope 250-1100 m), due to the potential for the Integrated Weight Line (IWL) to interact with communities that consist of organisms that are often fragile and slow to grow and recover following disruption. The communities component triggered a Level 2 analysis but was not analysed in this assessment. Also, a Level 1 for the habitats component was not assessed, as it was outside the project scope.

3.13 Components to be Examined at Level 2

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

- Protected species
- Communities

A SICA for the habitats component was not conducted for this sub-fishery, as it was outside the project scope.

In addition, it was not possible to conduct a Level 2 ERA for the communities component, as it is outside the project scope.

4 Level 2

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.

A residual risk (RR) analysis was undertaken for species at high risk in PSA and for any species at high risk in bSAFE (Table 4.1). There may be instances where a RR analysis may be required for medium risk species resulting from a PSA and/or bSAFE.

Table 4.1: Residual risk guidelines drawn from document "Revision of residual risk guidelines to reflect updated Ecological Risk Assessment Methodology – version Oct 12, 2016.

1	Risk rating due to missing, incorrect or out of date information
2	At risk due to external factors (cumulative risks)
3	At risk in regards to level of interaction/capture with a zero or negligible level of susceptibility
4	Effort and catch management arrangements for target and byproduct species
5	Management arrangements to mitigate against the level of bycatch
6	Management arrangements relating to seasonal, spatial and depth closures

4.1 Level 2 Productivity and Susceptibility Analysis (PSA)

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 4.1.1 and 4.1.2 of this report measure risk of direct impacts of fishing only. 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 essentially measures potential for risk, hereafter denoted as "risk". A measure of absolute risk requires some direct measure of abundance or mortality rate for the unit in question, and this information is generally lacking at Level 2.

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

Species

Table 4.2 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.

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

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

Encounterability is the likelihood that a species will encounter fishing gear deployed within its range.

Table 4.2: Attributes that measure productivity and susceptibility.

Category	Attribute	Description
Productivity	Average age at maturity	
	Average size at maturity	
	Average maximum age	
	Average maximum size	
	Fecundity	
	Reproductive strategy	
	Trophic level	
Susceptibility	Availability	Overlap of fishing effort with a species distribution
	Encounterability	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	The potential of the gear to capture or retain species
	Post capture mortality	The condition and subsequent survival of a species that is captured and released (or discarded)

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

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

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

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

Habitats

Similar to species, PSA methods for habitats are based around a set of attributes that measure productivity and susceptibility. Productivity attributes include speed of regeneration of fauna, and likelihood of natural disturbance. The susceptibility attributes for habitats are described in Table 4.3.

Communities

There are seven steps for the PSA undertaken for each component brought forward from Level 1 analysis (see Hobday et al., 2007 for full details).

- Step 1. Identify the units excluded from analysis and document the reason for exclusion (see Table 2.20)
- 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 of each unit
- Step 6. Evaluation of the PSA results
- Step 7. Decision rules to move from Level 2 to Level 3

Table 4.3: Description of susceptibility attributes for habitats.

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
	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			
	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

4.1.1 Level 2 PSA (Steps 2 and 3)

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. For species assessed at Level 2, no account is taken of the level of catch, the size of the population, or the likely exploitation rate. To assess actual risk for any species requires a Level 3 assessment which does account for these factors. However, recent fishing effort distributions are considered when calculating the availability attribute for the Level 2 analysis, whereas the entire jurisdictional range of the fishery is considered at Level 1.

The PSA 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 *Risk Score following Residual Risk* 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.

Observer data and observer expert knowledge are important sources of information in the PSA, particularly for the bycatch and protected components. The level of observer data for this fishery is regarded as high, due to 100% Observer coverage (or 50% during the 2020-21 due to COVID-19 restrictions) over this assessment period. Information on target and byproduct species is well collected, and bycatch attempts are made, but may be compromised by taxonomic difficulties. Interactions with protected species are recorded, although again, taxonomic resolution may be weaker for some taxa (e.g., seabirds).

Summary of Habitats PSA results

The habitats component was not assessed at Level 2 as it was outside the project scope.

Summary of Communities PSA results

The communities component was not assessed at Level 2 as it was outside the project scope.

4.1.2 PSA Results for Individual Units of Analysis (Step 4-6)

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).

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 of an individual unit will depend on the level of impact as well its productivity and susceptibility.

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 described above.

4.1.3 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 protected) 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.

4.1.4 PSA Results and Discussion

Productivity Attributes

Available productivity attributes for each species used in a PSA and corresponding risk scores are listed in Table 4.4.

Table 4.4: Productivity attribute names and cutoff scores for the ERAF L2 PSA method. These cutoff scores have been determined from analysis of the distribution of attribute values for species in the ERAF database, and are intended to divide the attribute values into low, medium and high productivity categories.

Attribute number	Attribute name	Low productivity (risk score: 3)	Medium productivity (risk score: 2)	High productivity (risk score: 1)
P1	Average age at maturity	> 15 years	5 – 15 years	< 5 years
P2	Average max age	> 25 years	10-25 years	< 10 years
P3	Fecundity	< 100 eggs per year	100-20,000 eggs per year	> 20,000 eggs per year
P4	Average max size	> 300 cm	100-300 cm	< 100 cm
P5	Average size at Maturity	> 200 cm	40-200 cm	< 40 cm
P6	Reproductive strategy	Taxa is *Marine Bird* OR *Marine Mammal*	(Family is *Syngnathidae* OR *Solenostomidae*) OR (Reproductive Strategy is *Demersal Spawner* OR *Brooder*)	Reproductive Strategy is *Broadcast Spawner*
P7	Trophic level	> 3.25	2.75-3.25	< 2.75

Table 4.5: Susceptibility attribute names and cutoff scores for the ERAF L2 PSA method. These cutoffs have been determined from analysis of the distribution of attribute values for species in the ERAF database, and are intended to divide the attribute values into low, medium and high susceptibility categories.

Attribute number	Attribute name	Low susceptibility (risk score: 1)	Medium susceptibility (risk score: 2)	High susceptibility (risk score: 3)
S1	Availability	< 10% overlap	Continuous [1,3]	> 30% overlap
S2	Encounterability (habitat and bathymetry based)	Fishery Specific	Fishery Specific	Fishery Specific
S3	Selectivity (size based)	Fishery Specific	Fishery Specific	Fishery Specific
S4	Post-Capture Mortality (role in fishery based, protected Species based)	Some Protected (Live)	Byproduct or bycatch; Some protected (generally alive)	Key or secondary commercial; Some protected (likely to be dead)

Susceptibility Attributes

Available susceptibility attributes for each species used in a PSA and corresponding risk scores are listed in Table 4.5.

Post Capture Mortality

The following rules were used to assign a risk score to Post Capture Mortality (PCM), based on each species ERAEF classification (see also Table 4.6):

- Commercial, secondary commercial, commercial bait or byproduct species: score is 3.
- Bycatch species: score is 2
- Protected species (which are discarded), PCM is based on taxa, i.e.,
  - marine birds and marine reptiles: score is 3
  - marine mammals and chondrichthyans: score is 2
  - syngnathids: score is 1

Table 4.6: Post capture mortality attribute risk score for the Macquarie Island Toothfish Fishery - Automatic Longline for the ERAEF L2 PSA and bSAFE methods. High: H; medium: M; Low: L. Risk scores that are not assigned by taxa (not specific) for each ERAEF classification are in italics.

Role in fishery	Taxa	Rationale	Risk category	Risk score
Key commercial	*Not specific*	Retained, therefore dead	H	3
Secondary commercial	*Not specific*	Retained, therefore dead	H	3
Commercial bait	*Not specific*	Retained, therefore dead	H	3
Byproduct	*Not specific*	Retained, therefore dead	H	3
Bycatch	*Not specific*	Discarded alive or dead	M	2
Protected Species	Marine birds	long duration set, if caught, highly likely to drown	H	3
	Marine reptiles	long duration set, if caught, highly likely to drown	H	3
	Marine mammals	large enough/strong swimming to have a chance of survival	M	2
	Chondrichthyans	large enough/strong swimming to have a chance of survival	M	2
	All others (e.g., syngnathids, invertebrates (if any))	Do not get hooked	L	1

Key Commercial Species

Under the revised ERAEF (AFMA, 2017), key commercial species were not assessed at Level 2.

Secondary Commercial Species

The secondary commercial species component was not evaluated in this assessment since it was eliminated at Level 1.

Commercial Bait Species

The commercial bait species component was not evaluated in this assessment since it was eliminated at Level 1.

Byproduct Species

The byproduct species component was not evaluated in this assessment since it was eliminated at Level 1.

Bycatch Species

The bycatch species component was not evaluated in this assessment since it was eliminated at Level 1.

Protected Species

A total of three out of four protected species were assessed in the PSA. All three species were found to be at medium risk (Figure 4.1 and Table 4.7). Of these, none were non-robust (i.e., data deficient) species (Figure 4.1).

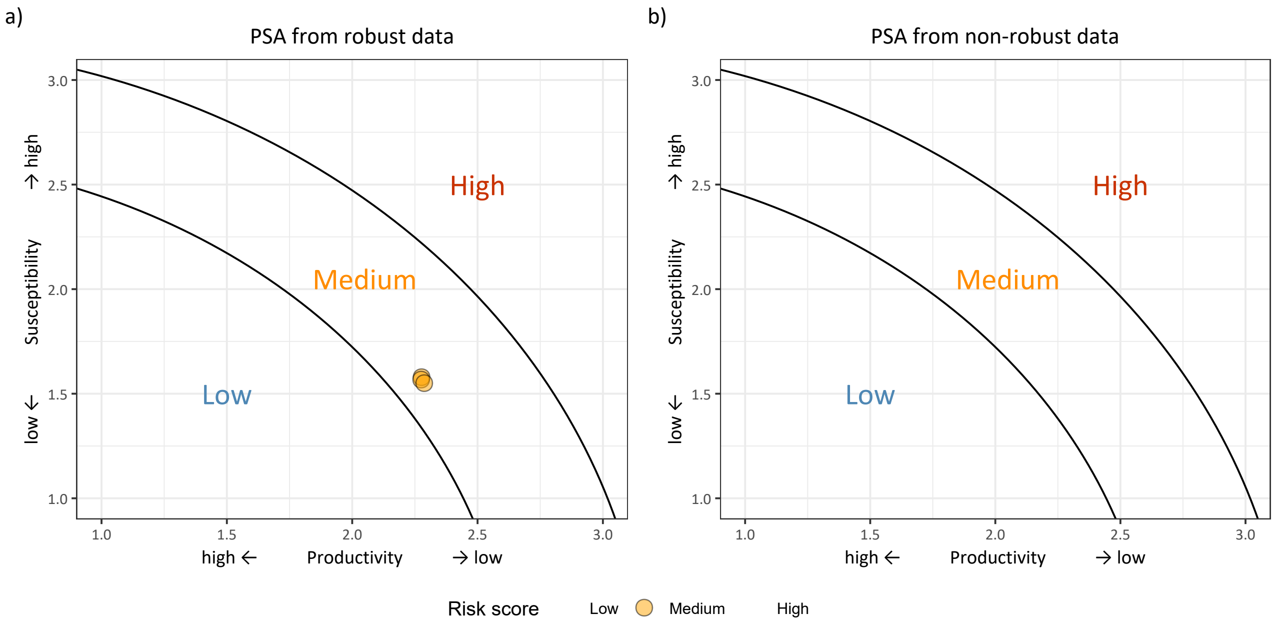

Figure 4.1: PSA plot for protected species in the Macquarie Island Toothfish Fishery - Automatic Longline for (a) robust [left, less than three missing attributes] and (b) data deficient species [right, three or more missing attributes].

Table 4.7: Summary of the regular PSA scores on the set of productivity and susceptibility attributes for protected species and residual risk (RR) for high risk species. Productivity attributes (P1-P7) are listed in Table 4.4. Susceptibility attributes (S1-S4) are listed in Table 4.5. Missing attributes are highlighted (red). Productivity score (Prod. score); Susceptibility score (Susc. score).

CAAB code	Scientific name	Common name	P1	P2	P3	P4	P5	P6	P7	S1	S2	S3	S4	Prod. score	Susc. score	Missing attributes	PSA 2D	Risk category
40041007	*Macronectes giganteus*	Southern Giant Petrel	1	3	3	1	2	3	3	1	1	2	3	2.29	1.57	0	2.78	Medium
40041008	*Macronectes halli*	Northern Giant Petrel	1	3	3	1	2	3	3	1	1	2	3	2.29	1.57	0	2.78	Medium
40041018	*Procellaria aequinoctialis*	White-Chinned Petrel	1	3	3	1	2	3	3	1	1	2	3	2.29	1.57	0	2.78	Medium

4.2 bSAFE Results and Discussion

Each of the reference points (MSM, LIM, and CRASH) were evaluated. If the biological reference point mean was higher than the estimated F attributed to this sub-fishery, then the species was categorised as *Below*. When the biological reference point mean was lower than the estimated F attributed to the sub-fishery, then the species was categorised as *Above* for that species and reference point measure. The overall risk is a summary of the three reference point measures (Table 4.8). If all reference points are categorised as *Below*, then the overall risk is low.

Table 4.8: Overall risk summary against each of the three reference point measures.

MSM	LIM	CRASH	Overall risk
Below	Below	Below	Low
Above	Below	Below	Medium
Above	Above	Below	High
Above	Above	Above	Extreme

4.2.1 bSAFE – Key Commercial Species

Under the revised ERAEF (AFMA, 2017), key commercial species were not assessed at Level 2.

4.2.2 bSAFE - Secondary Commercial Species

The secondary commercial species component was not evaluated in this assessment since it was eliminated at Level 1.

4.2.3 bSAFE - Commercial Bait Species

The commercial bait species component was not evaluated in this assessment since it was eliminated at Level 1.

4.2.4 bSAFE - Byproduct Species

The byproduct species component was not evaluated in this assessment since it was eliminated at Level 1.

4.2.5 bSAFE - Bycatch Species

The bycatch species component was not evaluated in this assessment since it was eliminated at Level 1.

4.2.6 bSAFE - Protected Species

There was one out of four protected species assessed in the bSAFE (Figure 4.2 and Table 4.9). No species were above the limit (bSAFE-MSM and bSAFE-LIM) reference points (Table 4.9), i.e., it was assessed at low risk.

Table 4.9: bSAFE risk categories for protected species ecological component for F_{MSM}, F_{Lim}, and F_{Crash}.

CAAB code	Scientific name	Common name	Susceptibility	F MSM	F MSM risk	F Lim	F Lim risk	F Crash	F Crash risk	F overall risk
37010004	*Lamna nasus*	Porbeagle Shark	<0.001	0.0566	Below	0.0849	Below	0.1132	Below	Low

While a SAFE analysis was previously conducted it did not include the Porbeagle Shark (Zhou & Fuller, 2011).

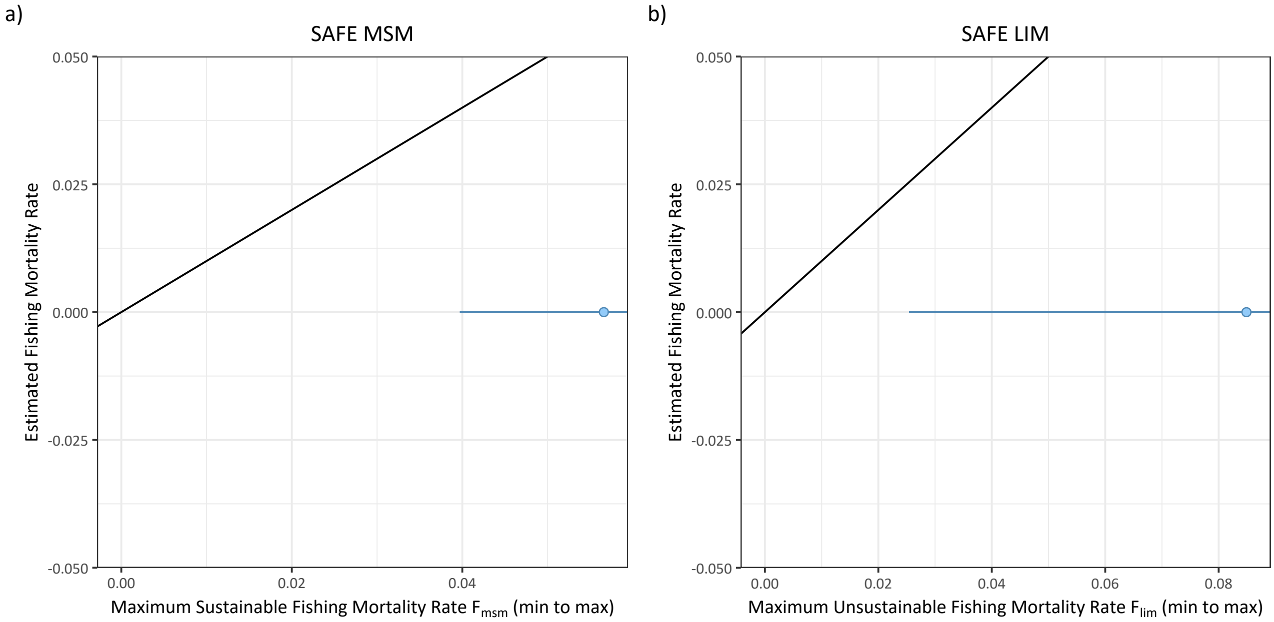

Figure 4.2: SAFE plot for protected species in the Macquarie Island Toothfish Fishery - Automatic Longline for (a) bSAFE-MSM reference point [left] and (b) bSAFE limit (LIM) [right] reference point. Red: Best estimate of mortality rate is above reference point; orange: best estimate of mortality rate is below reference point, but the top of the uncertainty range is above the reference point; blue: mortality rate is below reference point for the given uncertainty.

4.3 Habitats Component

The habitats component was not assessed at Level 2 as it was outside the project scope.

4.4 Communities Component

The communities component was not assessed at Level 2 as it was outside the project scope.

4.5 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. For the SAFE method, species that fall above the SAFE-MSM or limit reference point (SAFE-LIM) are considered to be at risk of overfishing (Table 4.8). Species identified from either method 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. PSA-units at low risk, (i.e., in the lower third), or at SAFE where units were below the overfishing limit point (i.e., SAFE-LIM) will be deemed not at risk from the sub-fishery and the assessment is concluded for these units.

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

- The risk of 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 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 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 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 the conclusion of the 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 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 (Figure 4.3). 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.

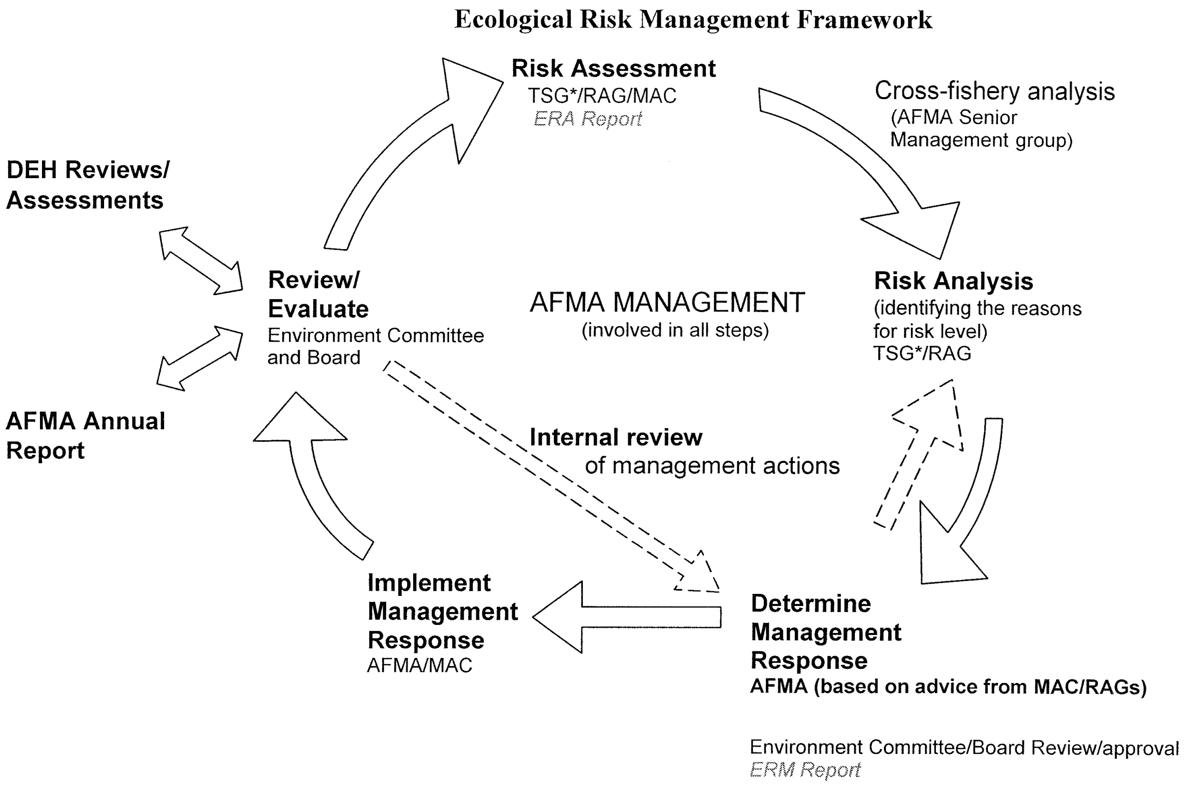

Figure 4.3: Schematic of the Ecological risk management cycle. TSG – Technical Support Group.

4.6 High and Medium Risk Categorisation (Step 8) Update with Residual Risk Information

4.6.1 PSA

Byproduct species

The byproduct species component was not evaluated in this assessment since it was eliminated at Level 1.

Bycatch species

The bycatch species component was not evaluated in this assessment since it was eliminated at Level 1.

Protected species

All three protected species were medium risk following a PSA, so no residual risk analysis was conducted (Table 4.7).

4.6.2 bSAFE

Byproduct species

The byproduct species component was not evaluated in this assessment since it was eliminated at Level 1.

Bycatch species

The bycatch species component was not evaluated in this assessment since it was eliminated at Level 1.

Protected species

The one protected species was low risk following a bSAFE analysis, so no residual risk analysis was conducted (Table 4.9).

5 General Discussion and Research Implications

5.1 Level 1

Most hazards (fishing activities) were eliminated at Level 1 (risk scores 1 or 2; Table 3.10; Figure 3.1-Figure 3.4). Those remaining consist of:

- Direct impact/capture from fishing (protected species and communities)
- Direct impact/without capture from fishing (protected species)

The most vulnerable species that triggered a Level 2 analysis were the protected White-chinned Petrel *Procellaria aequinoctialis* and the Porbeagle Shark *Lamna nasus* with and without capture from fishing. For the latter species, the moderate risk score from the capture from fishing was due to (i) the number of interactions with MITF-Longline operations (42: 12 alive, 29 dead, 1 injured), (ii) low productivity (slow growth rate, late maturing and low fecundity) of the southern population and (iii) the southern population being genetically, biologically and geographically distinct from the northern population.

Fishing by direct capture was considered a moderate risk (3) to communities (i.e., Demersal: Upper mid-slope 250-1100 m), due to the potential for the Integrated Weight Line (IWL) to interact with communities that consist of organisms that are often fragile and slow to grow and recover following disruption. The communities component triggered a Level 2 analysis but was not analysed in this assessment. Also, a Level 1 for the habitats component was not assessed, as it was outside the project scope.

This is the first Level 1 analysis (i.e., SICA) conducted, since the commencement of this sub-fishery. A Level 2 assessment was undertaken for protected species and reported in the next section.

5.2 Level 2

5.2.1 Species at Risk

PSA and Residual Risk

Protected species: All three protected species were medium risk following a PSA. Therefore, no residual risk analysis was conducted.

bSAFE and Residual Risk

Protected species: The Porbeagle Shark *Lamna nasus* was assessed at low risk within the assessment period.

5.2.2 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 and SAFE) 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 L2 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, in particular, there will be a tendency to overestimate absolute levels of risk from fishing.

In moving from ERA to ERM, AFMA will focus 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. 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, 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 as it becomes available.

5.2.3 Habitats at Risk

No Level 2 assessment was conducted for this sub-fishery, as it was outside the project scope.

5.2.4 Community Assemblages at Risk

It was not possible to conduct a Level 2 ERA for communities, as it was outside the project scope.

5.3 Key Uncertainties/Recommendations for Research and Monitoring

In assessing risk to byproduct, bycatch and protected species, it is not possible to assess absolute risk without supplementary information on either abundance or total mortality rates, and such data are not available for the vast majority of such species. However it may be possible to draw inferences from information that may be available for some species, either from catch records of occurrence from other fisheries, from fishery independent survey data, or from examination of trends in CPUE from Observer data.

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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 and references within).
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).
Fishing mortality

- F_{MSM}: Maximum sustainable fishing mortality.
- F_{Lim}: Limit fishing mortality which is half of the maximum sustainable fishing mortality.
- F_{Crash}: minimum unsustainable fishing mortality rate that may lead to population extinction in the longer term.

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 foodweb.
Unit of analysis The entities for which attributes are scored in the Level 2 analysis. For example, the units of

analysis for the Key Commercial Species component are individual “species”, while for Habitats, they are “biotypes”, and for Communities the units are “assemblages”.

A APPENDIX Examples of Fishing Activities

Table A.1: 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.

Table A.1: *(continued)*

Direct impact of Fishing	Fishing Activity	Examples of activities include
	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	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.
	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	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.

Table A.1: *(continued)*

Direct impact of Fishing	Fishing Activity	Examples of activities include
	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.
	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.

Table A.1: *(continued)*

Direct impact of Fishing	Fishing Activity	Examples of activities include
	Other extractive activities	Oil and gas pipelines, drilling, seismic activity.
	Other non-extractive activities	Defense, 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.

B APPENDIX Level 1 Description of Consequences for Each Component

Table B.1: Key/secondary commercial 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)	Score/level 2 (Minor)	Score/level 3 (Moderate)	Score/level 4 (Major)	Score/level 5 (Severe)	Score/level 6 (Intolerable)
Population size	Insignificant change to population size/growth rate (r). Unlikely to be detectable against background variability for this population.	Possible detectable change in size/growth rate (r) but minimal impact on population size and none on dynamics.	Full exploitation rate but long-term recruitment dynamics not adversely damaged.	Affecting recruitment state of stocks and/or their capacity to increase.	Likely to cause local extinctions if continued in longer term.	Local extinctions are imminent/immediate.
Geographic range	No detectable change in geographic range. Unlikely to be detectable against background variability for this population.	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.	Change in geographic range up to 10 % of original.	Change in geographic range up to 25 % of original.	Change in geographic range up to 50 % of original.	Change in geographic range > 50 % of original.
Genetic structure	No detectable change in genetic structure. Unlikely to be detectable against background variability for this population.	Possible detectable change in genetic structure. Any change in frequency of genotypes, effective population size or number of spawning units up to 5%.	Change in frequency of genotypes, effective population size or number of spawning units up to 10%.	Change in frequency of genotypes, effective population size or number of spawning units up to 25%.	Change in frequency of genotypes, effective population size or number of spawning units, change up to 50%.	Change in frequency of genotypes, effective population size or number of spawning units > 50%.
Age/size/sex structure	No detectable change in age/size/sex structure. Unlikely to be detectable against background variability for this population.	Possible detectable change in age/size/sex structure but minimal impact on population dynamics.	Impact on population dynamics at maximum sustainable level, long-term recruitment dynamics not adversely affected.	Long-term recruitment dynamics adversely affected. Time to recover to original structure up to 5 generations free from impact.	Long-term recruitment dynamics adversely affected. Time to recover to original structure up to 10 generations free from impact.	Long-term recruitment dynamics adversely affected. Time to recover to original structure > 100 generations free from impact.

Table B.1: ***(continued)***

Sub-component	Score/level 1 (Negligible)	Score/level 2 (Minor)	Score/level 3 (Moderate)	Score/level 4 (Major)	Score/level 5 (Severe)	Score/level 6 (Intolerable)
Reproductive capacity	No detectable change in reproductive capacity. Unlikely to be detectable against background variability for this population.	Possible detectable change in reproductive capacity but minimal impact on population dynamics.	Impact on population dynamics at maximum sustainable level, long-term recruitment dynamics not adversely affected.	Change in reproductive capacity adversely affecting long-term recruitment dynamics. Time to recovery up to 5 generations free from impact.	Change in reproductive capacity adversely affecting long-term recruitment dynamics. Time to recovery up to 10 generations free from impact.	Change in reproductive capacity adversely affecting long-term recruitment dynamics. Time to recovery > 100 generations free from impact.
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.	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.	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.	Change in behaviour/ movement with impacts on population dynamics. Time to return to original behaviour/ movement on the scale of months to years.	Change in behaviour/ movement with impacts on population dynamics. Time to return to original behaviour/ movement on the scale of years to decades.	Change to behaviour/ movement. Population does not return to original behaviour/ movement.

Table B.2: Bycatch species. Description of consequences for each component and each sub-component. Use table as a guide for scoring the level of consequence for by-catch/byproduct species (Modified from Fletcher et al., 2002).

Sub-component	Score/level 1 (Negligible)	Score/level 2 (Minor)	Score/level 3 (Moderate)	Score/level 4 (Major)	Score/level 5 (Severe)	Score/level 6 (Intolerable)
Population size	Insignificant change to population size/growth rate (r). Unlikely to be detectable against background variability for this population.	Possible detectable change in size/growth rate (r) but minimal impact on population size and none on dynamics.	No information is available on the relative area or susceptibility to capture/ impact or on the vulnerability 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%.	Relative state of capture/susceptibility suspected/known to be greater than 50% and species should be examined explicitly.	Likely to cause local extinctions if continued in longer term.	Local extinctions are imminent/immediate.
Geographic range	No detectable change in geographic range. Unlikely to be detectable against background variability for this population.	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.	Change in geographic range up to 10 % of original.	Change in geographic range up to 25 % of original.	Change in geographic range up to 50 % of original.	Change in geographic range > 50 % of original.

Table B.2: *(continued)*

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

Table B.2: ***(continued)***

Sub-component	Score/level 1 (Negligible)	Score/level 2 (Minor)	Score/level 3 (Moderate)	Score/level 4 (Major)	Score/level 5 (Severe)	Score/level 6 (Intolerable)
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.	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.	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.	Change in behaviour/ movement with impacts on population dynamics. Time to return to original behaviour/ movement on the scale of months to years.	Change in behaviour/ movement with impacts on population dynamics. Time to return to original behaviour/ movement on the scale of years to decades.	Change to behaviour/ movement. Population does not return to original behaviour/ movement.

Table B.3: Protected species. Description of consequences for each component and each sub-component. Use table as a guide for scoring the level of consequence for protected species (Modified from Fletcher et al., 2002).

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

Table B.3: *(continued)*

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

Table B.3: ***(continued)***

Sub-component	Score/level 1 (Negligible)	Score/level 2 (Minor)	Score/level 3 (Moderate)	Score/level 4 (Major)	Score/level 5 (Severe)	Score/level 6 (Intolerable)
Interaction with fishery	No interactions with fishery.	Few interactions and involving up to 5% of population.	Moderate level of interactions with fishery involving up to10 % of population.	Major interactions with fishery, interactions and involving up to 25% of population.	Frequent interactions involving ~ 50% of population.	Frequent interactions involving the entire known population negatively affecting the viability of the population.

Table B.4: 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)	Score/level 2 (Minor)	Score/level 3 (Moderate)	Score/level 4 (Major)	Score/level 5 (Severe)	Score/level 6 (Intolerable)
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.	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.	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%.	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.	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.	The dynamics of the entire habitat is in danger of being changed in a major way, or > 90% of habitat destroyed.

Table B.4: ***(continued)***

Sub-component	Score/level 1 (Negligible)	Score/level 2 (Minor)	Score/level 3 (Moderate)	Score/level 4 (Major)	Score/level 5 (Severe)	Score/level 6 (Intolerable)
Water quality	No direct impact on water quality. Impact unlikely to be detectable. Time taken to recover to pre-disturbed state on the scale of hours.	Detectable impact on water quality. Time to recover from local impact on the scale of days to weeks, at larger spatial scales recovery time of hours to days.	Moderate impact on water quality. Time to recover from local impact on the scale of weeks to months, at larger spatial scales recovery time of days to weeks.	Time to recover from local impact on the scale of months to years, at larger spatial scales recovery time of weeks to months.	Impact on water 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.	The dynamics of the entire habitat is in danger of being changed in a major way, or > 90% of habitat destroyed.
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.	Detectable impact on air quality. Time to recover from local impact on the to recover to pre-disturbed state on the scale of hours.	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.	Time to recover from local impact on the scale of months to years, at larger spatial scales recovery time of weeks to months.	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.	The dynamics of the entire habitat is in danger of being changed in a major way, or > 90% of habitat destroyed.

Table B.4: *(continued)*

Sub-component	Score/level 1 (Negligible)	Score/level 2 (Minor)	Score/level 3 (Moderate)	Score/level 4 (Major)	Score/level 5 (Severe)	Score/level 6 (Intolerable)
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.	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.	Impact reduces distribution of habitat types. Time to recover from local impact on the scale of weeks to months, at larger spatial scales recovery time of months to < one year.	The reduction of habitat type areal extent may threaten ability to recover adequately, or cause strong downstream effects in habitat distribution and extent. Time to recover from impact on the scale of > one year to < decadal timeframes.	Impact on relative abundance of habitat types resulting in severe changes to ecosystem function. Recovery period likely to be > decadal.	The dynamics of the entire habitat is in danger of being changed in a catastrophic way. The distribution of habitat types has been shifted away from original spatial pattern. If reversible, will require a long-term recovery period, on the scale of decades to centuries.

Table B.4: *(continued)*

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

Table B.5: ***(continued)***

Sub-component	Score/level 1 (Negligible)	Score/level 2 (Minor)	Score/level 3 (Moderate)	Score/level 4 (Major)	Score/level 5 (Severe)	Score/level 6 (Intolerable)
Distribution of the community	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/de-clining/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	Interactions which affect the internal dynamics unlikely to be detectable against natural variation.	Change in mean trophic level, biomass/ number in each size class up to 5%.	Changes in mean trophic level, biomass/ number in each size class up to 10%.	Changes in mean trophic level. Ecosystem function altered measurably and some function or components are locally missing/de-clining/increasing outside of historical range and/or allowed/facilitated new species to appear. Recovery period measured in years to decades.	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.	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.

Table B.5: ***(continued)***

Sub-component	Score/level 1 (Negligible)	Score/level 2 (Minor)	Score/level 3 (Moderate)	Score/level 4 (Major)	Score/level 5 (Severe)	Score/level 6 (Intolerable)
Bio-geochemical cycles	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.

C APPENDIX Reproducibility Details

C.1 Date and time of execution

2026-04-10 14:36:59.296536

C.2 Version Control

C.2.1 Bitbucket

Repository: https://bitbucket.csiro.au/scm/era/eraef-ar_macquarie-island-toothfish-fishery.git

Branch: MIF_Autoline

Commit Number: 818419c70a8ef962da140e86e1df5218dbfbd400

C.2.2 Data Sources

Table C.1: Version control for data sources.

Item No.	Aspect	Version No./Git ID	Comments
1.	Bioregionalization information	2023	
1.1	New species distribution information added manually	08/03/2024	Date of last added species
2	Update of species attributes from FishBase	Jan. 2024	
3	Manual updates to ERAEF species attributes	08/03/2024	Date of last added species
4	Database snapshots for fishery ERAEF extracts	10/03/2024	Fishery species table, species table and species attributes
5	Version front end tables snapshot	01/03/2022	Scoring tables - calculate productivity, susceptibility for each sub-fishery Intermediate information used for PSA and SAFE plots
6	PLSQL for generating PSA and SAFE calculations	v1.3, git commit: 3er330fdskek	
7	Effort overlaps	12/10/2023; 16/02/2024	

C.2.3 Excel templates

Table C.2: Version control for Excel templates. Lists current version of Excel files with a 'Changelog' sheet.

File	Version	Date
ManualInput/Appendix/Appendices.xlsx	1.2.1	2024-03-04
ManualInput/Level1/HazardsTemplateAFMA.xlsm	1.2	2024-06-05
ManualInput/Level1/SICA.xlsm	1.1	2023-09-04
ManualInput/Level1/SICA_20260402.xlsm	1.1	2023-09-04

Table C.2: *(continued)*

File	Version	Date
ManualInput/Level1/SICA_OLD.xlsm	1.1	2023-09-04
ManualInput/Scoping/GeneralFisheryCharacteristics.xlsx	1.2.1	2024-03-04
ManualInput/Scoping/GeneralFisheryCharacteristicsOLD.xlsx	1.2.1	2024-03-04

C.3 Parameters

C.3.1 index.Rmd

```
## [1,1] ---
## [2,1]
## [3,1] params:
## [4,1]   subfishery_id: 53
## [5,1]   assessment_year: "`r format(Sys.Date(), '%Y')`"
## [6,1]   data_from: 2019
## [7,1]   data_to: 2023
## [8,1]   needs_client_review: false
## [9,1]   sql:
## [10,1]     value:
## [11,1]       run_sql: false
## [12,1]
## [13,1]       dsn: "aqua"
## [14,1]
## [15,1]   evaluation:
## [16,1]     value:
## [17,1]       scoping: true
## [18,1]
## [19,1]
## [20,1]
## [21,1]       level1: true
## [22,1]       level2: true
## [23,1]       level3: false
## [24,1]   recreateScopingRmdFile: true
## [25,1]
## [26,1]
## [27,1]
## [28,1]   recreateAppendixRmdFile: true
## [29,1]
## [30,1]
## [31,1]   show_warnings: true
## [32,1]
## [33,1]
## [34,1]
## [35,1]   show_messages: true
## [36,1]   dev_mode: false
## [37,1]
## [38,1]
## [39,1]
## [40,1]
## [41,1]
## [42,1]
```

```
## [43,1] draft: true
## [44,1] documentclass: CSIROerareport2021
## [45,1] hyperrefoptions: "linktoc = all"
## [46,1] mainfont: Calibri
## [47,1] sansfont: Calibri
## [48,1] urlcolor: blue
## [49,1] linkcolor: black
## [50,1] citecolor: black
## [51,1] link-citations: yes
## [52,1] bibliography: [ERAEF.bib, Fishery.bib]
## [53,1]
## [54,1] csl: apa_mod.csl
## [55,1] always_allow_html: true
## [56,1] csirocolour: blueberry
## [57,1] site: bookdown::bookdown_site
## [58,1]
## [59,1]
## [60,1] title: "Ecological Risk Assessment for the Effects of Fishing"
## [61,1] author: "M. Sporcic, M. Fuller, C. Gerber, J. Dell"
## [62,1] date: "`r paste(format(Sys.Date(), ifelse(rmarkdown::metadata$draft, '%d %B
## [62,2]  %Y', '%d %B %Y')), ifelse(rmarkdown::metadata$draft, ifelse(!knitr::is_lat
## [62,3] ex_output(),ifelse(knitr::is_html_output(),'<br>Commercial in Confidence',
## [62,4] '  \\n Commercial in Confidence'),'') ,''))`"
## [63,1] year: "`r format(Sys.Date(), '%Y')`"
## [64,1] subtitle: "Report for the Macquarie Island Toothfish Fishery: Automatic Lon
## [64,2] gline Sub-fishery, 2019 - 2023"
## [65,1] citation: "Sporcic, M., Fuller, M., Gerber, C., Dell, J. (`r format(Sys.Dat
## [65,2] e(), '%Y')`). `r rmarkdown::metadata$title`. `r rmarkdown::metadata$subtitl
## [65,3] e`. Report for the Australian Fisheries Management Authority."
## [66,1] description: This is a technical report detailing an ecological risk assess
## [66,2] ment for the effects of fishing.
## [67,1] ---
## [68,1]
## [69,1]
## [70,1] NULL
```

C.3.2 _bookdown.yml

```
##  [1] "book_filename: \"ERAEF-AR\""     "delete_merged_file: false "
##  [3] "                          "      "language:"
##  [5] "  ui:"                           "    appendix_name: \"Chapter \""
##  [7] "    "                            ""
##  [9] ""                                ""
## [11] ""                                ""
## [13] ""                                ""
## [15] ""                                ""
## [17] ""                                ""
## [19] ""                                ""
## [21] ""                                ""
## [23] ""                                "rmd_files: "
## [25] "- index.Rmd"                     "- 01-frontmatters.Rmd"
## [27] "- 03-executivesummary.Rmd"       "- 04-overview.Rmd"
## [29] "- 05-scoping.Rmd"                "- 06-results-level1.Rmd"
## [31] "- 07-results-level2.Rmd"         "- 08-discussion.Rmd"
```

```
## [33] "- 09-references.Rmd"            "- 10-glossary.Rmd"
## [35] "- 11-appendix-automated.Rmd"     "- 12-appendix-manual.Rmd"
## [37] "- 13-backmatters.Rmd"
```

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