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# Ecological Risk Assessment for the Effects of Fishing

## Final report for the Heard Island and McDonald Islands fishery: Midwater trawl sub-fishery 2010/11 to 2014/15

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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 (2016).

> Australian Fisheries Management Authority (2016). Draft Guide to AFMA's Ecological Risk Management. 130 pp. (Commonwealth of Australia, Canberra).

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# Acknowledgments

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# Executive summary

The “Ecological Risk Assessment for Effect of Fishing” ERAEF was developed jointly by CSIRO Marine and Atmospheric Research and the Australian Fisheries Management Authority. This assessment of the ecological impacts of the Heard Island and McDonald Islands Fishery: midwater trawl sub-fishery was undertaken using the ERAEF method version 9.2, with some additional modifications currently in 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 new ecological components – key commercial and secondary commercial species; byproduct and bycatch species; protected species; habitats; and (ecological) communities (see ERM Guide; AFMA (2016b)).

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

Application of the ERAEF methods to a fishery 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 SAFE. The Level 2 methods do not provide absolute measures of risk. Instead they combine information on productivity and exposure to fishing to assess potential risk – the term used at Level 2 is risk. Because of the precautionary approach to uncertainty, there will be more false positives than false negatives at Level 2, and the list of high risk species or habitats should not be interpreted as all being at high risk from fishing. Level 2 is a screening process to identify species or habitats that require further investigation. Some of these may require only a little further investigation to identify them as a false positive; for some of them managers and industry may decide to implement a management response; others will require further analysis using Level 3 methods, which do assess absolute levels of risk.

This 2010/11-2014/15 assessment of the Heard Island and McDonald Islands Fishery: midwater trawl sub-fishery includes:

- Scoping
- Level 1 results for all components

**Fishery Description**

| | |
|---|---|
| Gear: | Midwater trawl (90 mm mesh size for mackerel icefish) |
| Area: | Heard and McDonald Islands midwater Trawl Fishery |
| Depth range: | 62 – 707 m when targeting mackerel icefish. *cf.* 30 to 400 m (2005) |
| Fleet size: | 1-2 vessels *cf*. 1 vessel (2005) |
| Effort: | 19.5 $km^2$ swept area (AFMA Observer data); 5 shots (2013/14; AFMA logbook) *cf.* approximately 100 shots per year (2002-05) |
| Landings: | 17.8 t in 2013/14 (AFMA Observer data) *cf.* 709 t (2004/05) |
| Discard rate: | 2.78 kg mackerel icefish; 1.04 t bycatch (Observer data includes codes "mealed" and dead overboard"; 2013/14). No offal or bycatch is permitted to be discharged from fishing vessels within fishery area. Instead, it is discharged outside EEZ *cf.* Quota species 8%; non-quota species 92% mealed (2002-05) |
| Key commercial species: | Mackerel icefish |
| Management: | Quota management system for two species/stocks. Catch limits for six bycatch species/groups |
| Observer program: | Observer program operating since beginning of fishery in 1997. Two observers on all fishing trips. Observers conduct 12 hour shifts, so an observer is on shift during all fishing operations. |

**Ecological Units Assessed**

**Table ES2.1 Ecological units assessed in 2016 and 2006.**

| Ecological component | Units assessed in 2016 | Units assessed in 2006 |
|---|---|---|
| **Key/secondary commercial species** | 1 | 2 |
| **Byproduct and bycatch species** | 1 byproduct; 12 bycatch | 21 byproduct; 3 bycatch |
| **Protected species** | 8 | 80 |
| **Habitats** | 1 pelagic | - |
| **Communities** | 2 (1 demersal; 1 pelagic) | 2 (1 demersal; 1 pelagic) |

**Level 1 Results**

All hazards (fishing activities) were eliminated at Level 1 (risk scores 1 or 2; Table 2.19; Figure 2.2-Figure 2.6). This is due to low fishing levels by midwater trawl (i.e. 4 days in the 2013/14 season). By contrast, all ecological components were completed at Level 2 (except communities) in the previous assessment (Table ES2.2; Table ES2.4). Of the external impacts, other fisheries in the region capturing the same key/secondary commercial species present a moderate risk. The benthic habitat component was not assessed because a higher level habitat assessment was

conducted (Welsford et al. 2014) but pelagic habitats were. Results of this ERA assessment have been presented and discussed with stakeholders, an important step in the ERAEF process.

**Table ES2.2. Outcomes of assessments for ecological components conducted or *triggered in 2016 and 2006.**

| Ecological component | Level attained in 2016 | Level attained in 2006 |
|---|---|---|
| **Key/secondary commercial species** | Level 1 | Level 2 |
| **Byproduct and bycatch species** | Level 1 | Level 2 |
| **Protected species** | Level 1 | Level 2 |
| **Habitats** | Level 1[#] | - |
| **Communities** | Level 1 | Level 2* |

[#]Partial assessment-pelagic only (Benthic habitat assessment previously conducted; Welsford et al. 2015)

- no habitat assessments were conducted in 2006

*triggered but due to lack of methodology available in 2006 and ecosystem modelling projects underway in 2016 this component was not assessed at L2 in the ERA process.

**Table ES2.3. Stock and related assessments including status detail (where available) of key commercial and bycatch species in the HIMI fishery.**

| Role in fishery | Common name, scientific name | Stock status[1] | Year last assessed | Data included and/or Source |
|---|---|---|---|---|
| *Key commercial* | Mackerel icefish, *Champsocephalus gunnari* | Not subject to overfishing. Not overfished. | 2015 | RSTS 2014/2015; 2006-2014 fishery data. CCAMLR 2015a |
| *Byproduct* | Patagonian toothfish, *Dissostichus eleginoides* | Not subject to overfishing. Not overfished. | 2015 | RSTS 2014/15; 2009-2014 fishery data. CCAMLR 2015b |
| *Bycatch* | Unicorn icefish, *Channichthys rhinoceratus* | | 2015 | RSTS 2013/14 WG-FSA-15/50 |
| | Grey rockcod, *Lepidonotothen squamifrons* | | 1998 | SC-CAMLR-XVII, Annex 5, 4.204 to 4.206. |
| | Grey rockcod, *Lepidonotothen squamifrons* | | 2015 | Maschette 2015; Maschette et al. 2015; Maschette et al. (in prep) |
| | Skates and rays | | 1997 | SC-CAMLR-XVI, 5.119 to 5.122. |
| | Skates and rays | | 2017 | Nowara et al. 2017 |
| | *Macrourus caml* and *M. whitsoni* | | 2015 | RSTS 2013/14 WG-FSA-15/50 and 15/63 |
| | *M. halotrachys* and *M. carinatus* | | 2003 | CCAMLR 2015a, 2015b |

[1] Patterson and Skirtun 2015

**Table ES2.4 Comparison of vulnerable analysis units for each ecological component which had a risk score >2 in 2016 and 2006. Numbers in parentheses represent consequence/confidence scores (e.g. (3/1)).**

| Year assessed | Fishing activity | Ecological component | | | |
|---|---|---|---|---|---|
| | | Key/secondary commercial species | Byproduct/ Bycatch species | Protected species | Communities |
| **2016** | **Fishing with capture** | - | - | - | - |

| | | | | | |
|---|---|---|---|---|---|
| **2006** | **Fishing with capture** | Mackerel icefish (3/1) | Porbeagle (3/1) | Black-browed albatross (3/1) | Heard Plateau 0 – 1000 m (3/1) |

# 1 Overview

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

### 1.1.1 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.

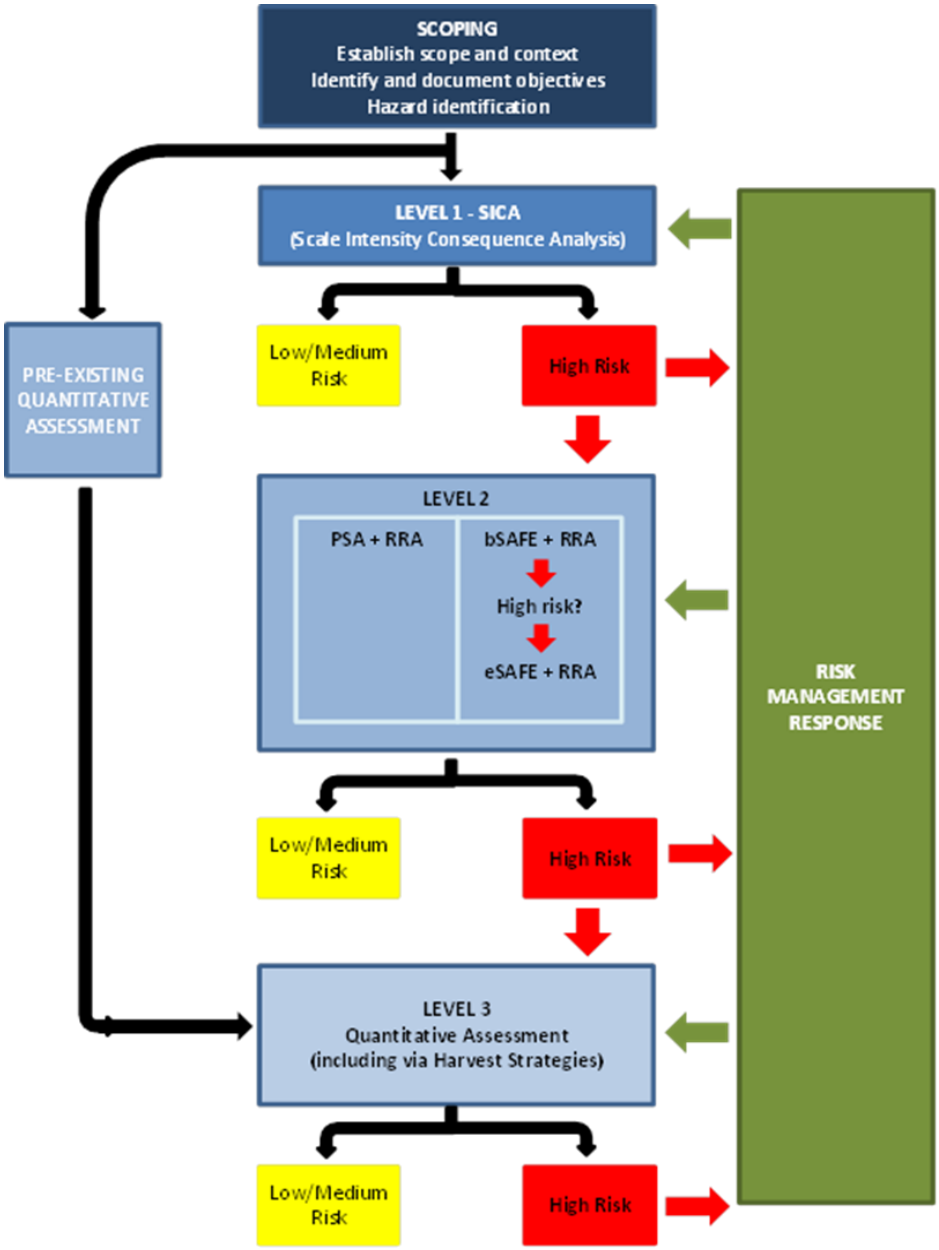



**Figure 1.1. Structure of the 3 level hierarchical ERAEF methodology. SICA – Scale Intensity Consequence Analysis; PSA – Productivity Susceptibility Analysis; SAFE – Sustainability Assessment for Fishing Effects; RRA – Residual Risk Analysis. T1 – Tier 1. eSAFE may be used for species classified as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

## Conceptual Model

The approach makes use of a general conceptual model of how fishing impacts on ecological systems, which is used as the basis for the risk assessment evaluations at each level of analysis (Levels 1-3). For the ERAEF approach, five general ecological component are evaluated, corresponding to five areas of focus in evaluating 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 achievement of management objectives.

[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).

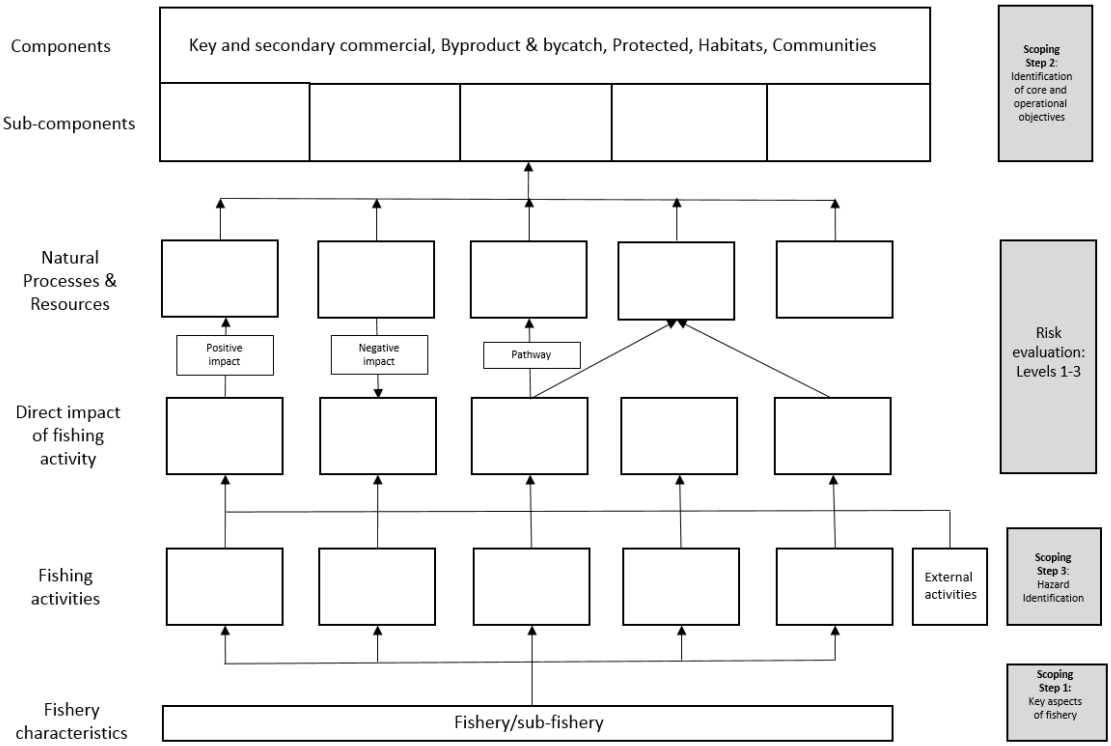



**Figure 1.2. Generic conceptual model used in ERAEF.**

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

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

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

### 1.1.2 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.

### 1.1.3 Scoping

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

1. Identification of units of analysis (species, habitats and communities) potentially impacted by fishery activities (Section 2.2.2; Scoping Documents S2A, S2B1, S2B2 and S2C1, S2C2).
2. Selection of objectives (Section 2.2.3; 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 (ERM Guide; AFMA (2016b)). 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 (eg: tables 5A-C in Hobday et al. 2007).
3. Selection of activities (hazards) (Section 2.2.4; Scoping Document S4) that occur in the sub-fishery is made using a checklist of potential activities provided. The checklist was developed following extensive review, and allows repeatability between fisheries. Additional activities raised by the stakeholders can be included in this checklist (and would feed back into the original checklist). The background information and consultation with the stakeholders is used to finalize the set of activities. Many activities will be self-evident (e.g. fishing, which obviously occurs), but for others, expert or anecdotal evidence may be required.

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

The SICA analysis evaluates the risk to ecological components resulting from the stakeholder-agreed set of activities. Evaluation of the temporal and spatial scale, intensity, sub-component, unit of analysis, and credible scenario (consequence for a sub-component) 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 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 result in the elimination of activities (hazards) and in some cases whole components. Any SICA element that scores 2 or less is documented, but not considered further for analysis or management response.

### 1.1.5 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 (2016b)).

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

Level 2 was originally designed to rely on a single risk assessment methodology, the Productivity-Susceptibility Analysis (PSA) (see Chapter 4.8.3 of AFMA ERM Guide, AFMA (2016b)), however a more quantitative method called the Sustainability Assessment for Fishing Effects (SAFE) (see Chapter 4.8.4 of AFMA ERM Guide, AFMA (2016b)) 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 chondricthyan 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 to take more immediate management action to reduce the risk. The types of considerations required in making that choice (ie: moving up the ERAEF assessment hierarchy or taking direct management action) are outlined in Chapter 5.5 of the AFMA ERM Guide (AFMA, 2016b).

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.

### 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 2016b). Stakeholders can provide input and 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, 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.

### 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 (see below) to assist in making accurate judgments 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 which underpin the residual risk guidelines and should be understood before the guidelines are applied:

- All assessments and management measures used within the residual risk assessment 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 facilitating 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 publically available documents.

### 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 and Griffiths, 2008; Zhou et al. 2011):

- is a more quantitative approach (analogous to stock assessment) that is able to provide absolute measures of risk by estimating fishing mortality rates relative to fishing mortality rate reference points (based on life history parameters);
- requires less productivity data than the PSA;
- is able to account for cumulative risk and
- potentially out performs PSA in several areas, including 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 (eg: 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. And;
- 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 target species MSY.
- **$F_{LIM}$** – instantaneous fishing mortality rate that corresponds to the limit biomass $B_{LIM}$ where $B_{LIM}$ is a 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) are 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 is able to 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 suggest 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).

- 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 (ie: populations rapidly mix between fished and unfished areas). The fishing mortality will likely be overestimated if this assumption is not satisfied (ERA TWG 2015)[4].
- The method also assumes that the mean fish density does not vary between 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 habitat, while risk would be under-estimated for species that prefer fished habitat (ERA TWG 2015)[4].
- 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.

### 1.1.6 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. It will be both time and data-intensive. Individual stakeholders are engaged as required in a

[4] ERA Technical Working Group, September 2015

more intensive and directed fashion. Results are presented to the stakeholder group and feedback incorporated, but live modification is not considered likely.

### 1.1.7 Conclusion and final risk assessment report

The conclusion of the stakeholder consultation process has resulted 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 Department of the Environment and Energy.

### 1.1.8 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[5] 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 Fisheries Management Strategy (FMS).

For byproduct and bycatch species, in the periods between scheduled 5 year ERA reviews[6], AFMA will develop and monitor a set of fishery indicators and triggers, on an annual basis, so as to detect any changes (increase or decrease) in the level of risk

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

[6] 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.

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.
- 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 2 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 Table 8 in AFMA ERM Guide, AFMA (in prep)). 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)[7]. 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.

[7] ERA TWG recommendation, September 2015

# 2 Results

The focus of analysis is the fishery as identified by the responsible management authority. The assessment area is defined by the fishery management jurisdiction within the Australian Fisheries Zone (AFZ). The fishery may also be divided into sub-fisheries on the basis of fishing method and/or spatial coverage. These sub-fisheries should be clearly identified and described during the scoping stage. Portions of the scoping and analysis at Level 1 and beyond 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 midwater trawl sub-fishery of the Heard Island and McDonald Islands (HIMI) Fisheries.

A full description of the ERAEF method is provided in the methodology document (Hobday et al. 2007; Hobday et al. 2011b). This fishery report contains figures and tables with numbers that correspond to this methodology document. Thus, table and figure numbers within this fishery ERAEF report are not sequential, as not all figures and tables are relevant to the fishery risk assessment results.

## 2.1 Stakeholder Engagement

**Table 2.1. Summary Document SD1. Summary of stakeholder involvement for sub-fishery: Heard Island and McDonald Islands: midwater trawl sub-fishery.**

| Fishery ERA Report stage | Type of stakeholder interaction | Date of stakeholder interaction | Composition of stakeholder group (names or roles) | Summary of outcome |
|---|---|---|---|---|
| Scoping | Phone calls and emails | July/Aug. 2016 | Jo Fisher (AFMA), Natalie Rivero (AFMA), Tim Lamb (AAD), Phillipe Ziegler (ADD), Industry | Discussion, information supplied and reports sent to ERA Team |
| Level 1 (SICA) | Phone calls and emails | July/Aug. 2016 | AFMA contacts<br>Industry | Draft Level 1 completed |
| Draft report | Presenatation at SARAG meeting | 8 Sep. 2016 | SARAG members and invited participants | Comments species lists, scoping and SICA |
| Draft report | Draft review | 13 Oct. 2016 | Gabrielle Nowara (AAD) | Reviewed document |
| Draft report | Draft review | 26 Apr. 2017 | Jo Fisher (AFMA), Martin Exel (Industry), Rhys Arangio (Industry) | Reviewed document |
| Draft final report | Draft final review | May 2017 | Jo Fisher (AFMA) | Reviewed document |
| Final report | | Feb. 2018 | Jo Fisher (AFMA) | Submitted report; Reviewed document |

## 2.2 Scoping

The aim in 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 on the basis of 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.

**Scoping Document S1 General Fishery Characteristics**

Fishery Name: Heard Island and McDonald Islands – Midwater Trawl

Assessment date: August 2016

Assessor: M. Sporcic (CSIRO)

**Table 2.2. General fishery characteristics.**

| General Fishery Characteristics | |
|---|---|
| **Fishery Name** | Heard Island and McDonald Islands Fishery |
| **Sub-fisheries** | *Identify sub-fisheries on the basis of fishing method/area.*<br>There are currently four sub-fisheries based on fishing methods, the first of which could be considered as two sub-fisheries because two species are targeted:<br>1. **Demersal otter board trawling** for Patagonian toothfish (*Dissostichus eleginoides*) and mackerel icefish (*Champsocephalus gunnari*).<br>2. **Midwater trawling** for mackerel icefish (*C. gunnari*). This method has had limited application over the past few years. When operating it targets large midwater schools.<br>3. **Demersal longlining** for Patagonian toothfish (*D. eleginoides*) began in May 2003 season under scientific permits. |

| | |
|---|---|
| | 4. **Pot and trap fishing.** Although a permitted method in the HIMI Fishery, pot fishing has not been used recently and therefore hasn't been included in the current ERA process. |
| **Sub-fisheries assessed** | *The sub-fisheries to be assessed on the basis of fishing method/area in this report.*<br><br>This assessment only considers midwater trawling for mackerel icefish (*Champsocephalus gunnari*). NB: Patagonian toothfish are caught incidentally and are not targeted. |
| **Start date/ history** | *Provide an indication of the length of time the fishery has been operating.*<br><br>Fishing activity in the region had been sparse until recently. There are records of Soviet and Polish vessels fishing mackerel icefish (*Champsocephalus gunnari*) in the region in the 1970s and some research surveys were conducted by AAD in the early 1990s, before the establishment of the EEZs of Australia and France.<br><br>The Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR) came into force in 1982, as part of the Antarctic Treaty System, with the aim of regulating exploitation rather than outright protection. CCAMLR was established at a time when commercial interests in krill were growing rapidly; it began to be truly effective as a management regime in 1991 when the first catch limits were set.<br><br>From the outset CCAMLR was based on the principle that management of fisheries should include not just the target species but also dependent and associated species and their ecological relationships. CCAMLR and AFMA are committed to minimise impacts on the marine environment from fishing in the Heard Island and McDonald Islands area and strict environmental management measures have been in place since access to the fishery was first granted in 1995. These measures are incorporated in the Heard Island and McDonald Islands Fishery Management Plan 2002 (the HIMI Plan) and supporting legislative instruments, developed under the Fisheries Management Act 1991.<br><br>Commercial fishing for mackerel icefish (*C. gunnari*) by Australian operators commenced in March 1997 using demersal and midwater trawls in accordance with CCAMLR Conservation Measures 109/XV and 110/XV (1996) respectively (now CM 41-08 and 42-02). Subsequently, licensed Australian vessels have attempted to take the TAC set by CCAMLR each year but due to fluctuations in abundances, they have not always caught the icefish limit (Williams et al. 2002).<br><br>A pot fishing trial was undertaken during the 2005/06, 2008/09, 2009/10, 2010/11 and 2012/13 seasons with low Patagonian toothfish catch (~35.9 t in 2010/11; 43.84 t in 2012/13). Pot fishing is very selective with very little bycatch (~4 t (mostly starfishes – unidentified in 2010/11) and 0.5 t (2012/13)) and there is less impact than demersal trawl on the benthic habitats.<br><br>The HIMI Fishery Direction which prohibited fishing methods other than trawling and longlining expired November 2010 and was not renewed. The SFR conditions for the fishery were amended to limit permitted fishing methods to trawl, longline and pot fishing.<br><br>The HIMI Fishery was the first Commonwealth fishery to be accredited for export approval/accreditation under the EPBC Act. The initial accreditation was granted in May 2002 for a period of 5 years. A further two 5 year exemption periods were granted, and more recently a ten year exemption was granted with the current period expiring on 9 October 2026.<br>The HIMI fishery was certified as sustainable in March 2012 by the Marine Stewardship Council both trawling and longlining Patagonian toothfish and has re-entered re-assessment in July 2016 (https://www.msc.org/track-a-fishery/fisheries-in-the-program/certified/southern-ocean/heard_island_and_mcdonald_islands_himi_toothfish). The HIMI Mackerel icefish fishery was certified in 2011.<br><br>Illegal, unregulated or unreported (IUU) fishing is of concern because it has the potential to undermine attempts to manage fish stocks. In 1999, CCAMLR adopted a catch |

| | |
|---|---|
| | documentation scheme (CDS) which has helped prevent illegally caught fish entering the markets of CCAMLR nations. The CDS was implemented in 2000.<br><br>No illegal foreign fishing vessels have been detected inside the Australian Fishing Zone of the HIMI area since 2007 (CCAMLR Fishery Report 2015). There were 142 surveillance patrol days by Australian Government vessels in 2014-15 in the southern ocean (against a target of 172 days) (Australian Customs and Borders Protection Service 2015). There are cooperative arrangements with the French Government. Electronic surveillance methods and range of other approaches are also used to combating risks from IUU fishing in areas outside Australia's jurisdiction (SCS Global Services; https://www.msc.org/track-a-fishery/fisheries-in-the-program/certified/southern-ocean/heard_island_and_mcdonald_islands_himi_toothfish/assessment-downloads-1/20150901_SR_TOO227.pdf).<br><br>Source: CCAMLR., 2015c; http://www.afma.gov.au/fisheries |
| **Geographic extent of fishery** | *The geographic extent of the managed area of the fishery. Maps of the managed area and distribution of fishing effort should be included.*<br><br>The fishery operates in sub-Antarctic waters adjacent to Heard Island and the McDonald Islands. Heard Island and McDonald Islands (HIMI) are external territories of Australia located in the Southern Indian Ocean about 4,000 km south-west of Perth. The islands lie south of the Polar Front. The Islands are listed on the Register of the National Estate as the only unmodified example of a sub-Antarctic island ecosystem. In addition, the Islands and the 12 nautical mile territorial sea around them are on the World Heritage List and form part of the current HIMI Marine Reserve (declared in 2014; Fig. 6 below). This Reserve was extended to include areas of an existing Conservation Zone (Fig. A below) and is categorised as an International Union for Conservation of Nature Category 1a: Strict Nature Reserve. It is managed by the Australian Antarctic Division (AAD), is closed to commercial fishing but limited scientific research and monitoring is permitted.<br><br>In recognition of the Islands' importance, fishing is prohibited within 13 nautical miles of the Islands, providing a buffer zone of one nautical mile between the territorial sea and the area of the fishery. The fishery extends from 13 nautical miles offshore to the edge of the 200 nautical mile Australian Economic Exclusive Zone (EEZ) around the Islands and is managed by the Australian Fisheries Management Authority. The fishery lies in CCAMLR Statistical Division 58.5.2. |

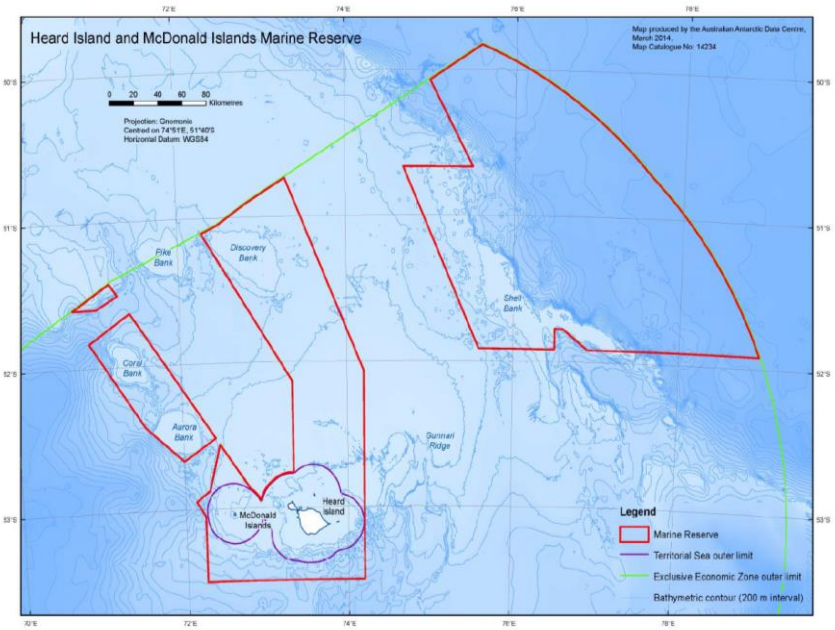



**Figure 6: The HIMI Fishery including the Marine Reserve and Conservation Zones**

Source : Figure 6: AFMA 2014 - HIMI Fishery Status Report 2014

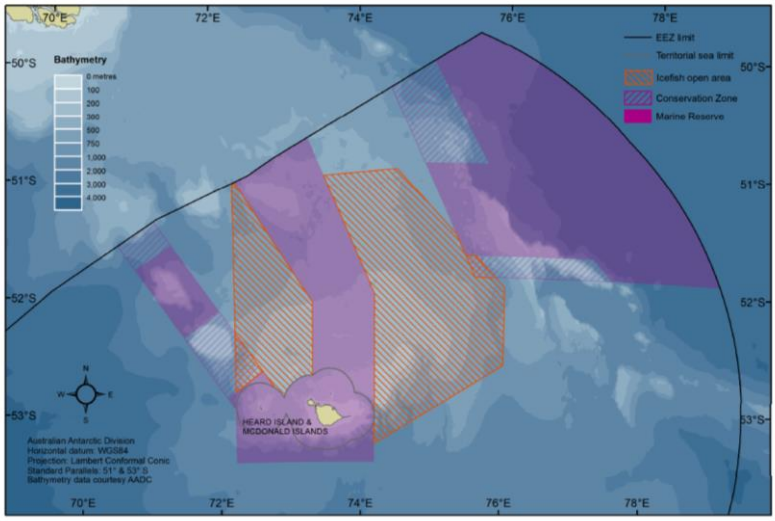



**Figure A: HIMI Reserve before the newly declared (2014) HIMI Marine Reserve (i.e. Fig. 6 above).**

Source: Welsford et al. 2014

**Regions or Zones within the fishery**

*Any regions or zones used within the fishery for management purposes and the reason for these zones if known.*

Mackerel icefish are fished on the shallower parts of the Heard Island plateau particularly on the southeast slope and Gunnari Ridge between 450 m and 700 m deep (CCAMLR CM42-02, Meyer et al. 2000). Outside of the Heard Island Plateau there is a closure to mackerel icefish fishing (see figure above). Until 1998 they were abundant on Shell Bank (Williams et al. 2002) but this area has been closed since then due to concern that it was not able to sustain a fishery and to the potential for overlap between the icefish fishery and the foraging activities of icefish predators (Meyer et al. 2000). In contrast to the reports of the early 1970s, they are now found rarely on the other shallow banks i.e. Pike and Aurora, and other parts of the Plateau (Williams et al. 2002).

| | |
|---|---|
| **Fishing season** | *What time of year does fishing in each sub-fishery occur?*<br><br>The fishing season for mackerel icefish (*Champsocephalus gunnari*) is from 1 December to 30 November each year. |
| **Key/second-ary commercial species and stock status** | *Species targeted and where known, stock status.*<br><br>**Key commercial species**<br><br>• Mackerel icefish (*Champsocephalus gunnari*)<br><br>Mackerel icefish is found in the Atlantic and Indian sectors of the Southern Ocean. It is a semi-pelagic species confined to waters less than 500m, but is most abundant at depths of less than 350m in shelf waters surrounding Heard Island (Williams et al. 2002). In this area they grow to a maximum length of around 40-45 cm and have a maximum reported age of 6 years. Size at first maturity for females is 26.5 cm and for males is 28.5 cm total length (Williams et al. 2002). The average fished length is 25-35 cm and 100-200 grams. Older juveniles and adults form large aggregations predominantly in the demersal or midwater range of the water column. They are mostly present from January through to July.<br><br>**Stock status**<br><br>The 2014 stock assessment for mackerel icefish in the HIMI fishery estimated the biomass at 6457 t (Welsford 2014). Yields of 309 t for the 2014/15 season and 275 t for the 2015/16 season were estimated to allow for 75% escapement over two years and to satisfy the CCAMLR decision rules. A TAC of 309 t was set for the 2014/15 season and endorsed by the CCAMLR (Patterson and Skirtun, 2015).<br><br>Based on the 2015 survey and fixed model parameters, a short-term stock assessment was conducted for mackerel icefish which led to an estimated biomass of 3048 t. The working group recommended a TAC of 482 t in 2015/16 to allow 75% escapement of biomass after two years.<br><br>The mackerel icefish assessment is generally updated annually using results from the annual RSTS. As such, the stock assessment for 2016/17 was updated, based on the 2016 survey, and recommended a TAC of 561 t, which was endorsed by both CCAMLR and the AFMA Commission.<br><br>The stock status of mackerel icefish is not overfished (Biomass) and not subject to overfishing based on current levels of fishing mortality (Patterson and Skirtun, 2015; ABARES Fishery Status Report 2015). |
| **Bait collection and usage** | *Identify bait species and source of bait used in the sub-fishery. Describe methods of setting bait and trends in bait usage.*<br><br>Not applicable |
| **Current entitlements** | *The number of current entitlements in the fishery. Note latent entitlements. Licences/ permits/ boats and number active*<br><br>Access to the fishery is limited and strict operating conditions are imposed to minimise negative effects on the environment, including effects on non-targeted species. Only one midwater trawler in any given year has operated since the 2000 season with no trawlers operating in 2009 and during the period 2011-2013.<br><br>Source: AFMA Annual Report 2014-2015 and Department of the Environment and Energy website |
| **Current and recent TACs, quota trends by method** | *Summary of the most recent catch quota levels in the fishery by fishing method (sub-fishery) in table form.*<br><br>TAC for target species (mackerel icefish) in Division 58.5.2 (CCAMLR code for the region including HIMI) are tabulated below. Note: Separate TACs are not specified for each method. |

**Total Allowable Catch (TAC) for mackerel icefish across all methods spanning fishing seasons 2010/11 – 2015/16. *: 30 t research/bycatch limit.**

| | Mackerel icefish | |
|---|---|---|
| Year | Survey abundance estimates (t) | Agreed TAC (t) |
| 2010/11 | 5123 | 78 |
| 2011/12 | 983 | 0* |
| 2012/13 | 3987 | 679 |
| 2013/14 | 6098 | 1267 |
| 2014/15 | 4861 | 309 |
| 2015/16 | Not available | 482 |

Agreed TAC for mackerel icefish ranged from <30 t in 2011/12 to 1267 t for the 2013/14 season.

**Bycatch limits (t) for main bycatch species taken in the HIMI fishery.**

| Common name | Scientific name | Bycatch limit (t) fishing season | |
|---|---|---|---|
| | | 2014/15 | 2015/16 |
| Unicorn icefish | *Channichthys rhinoceratus* | 150 | 1663 |
| Grey rockcod | *Lepidonotothen squamifrons* | 80 | 80 |
| Skates and rays | Skates and rays | 120 | 120 |
| *Macrourus* spp. | *Macrourus* spp. | 360 | |
| *Macrourus* spp. | *Macrourus caml* and *M. whitsoni* | - | 409 |
| *Macrourus* spp. | *M. halotrachys* and *M. carinatus* | - | 360 |
| Other species | Other species | 50 | 50 |

Bycatch or byproduct is not considered a major issue in Antarctic fisheries. There are two observers on all trips to the regions, which has resulted in accurate catch and bycatch reporting. The major bycatch species are skates and rays, and macrourids**.** Catch limits are set for by-catch species groups (see TACs). No by-catch species was caught in quantities approaching the catch limit (CCAMLR 2015).

In the past, non-target fishes were retained for milling into meal which was sold ashore or dumped on return to port but this practice no longer occurs and bycatch is macerated and then discarded at sea outside the EEZ.

Bycatch limits have changed for the 2015/16 fishing season for macrourids, dividing them into two morphs, and increased for unicorn icefish (SouthMAC Nov. 2015). Prior to this, these limits did not change for more than 10 years. The fishery is closed if bycatch limits are reached. Source: CCAMLR 2015/16 Schedule of Conservation Measures (CCAMLR 2015c).

The reported catch for skates and rays do not include animals that have been tagged or returned to the sea in a live and vigorous state, which is an approved CCAMLR protocol.

**Current and recent fishery effort trends by method**

*Summary of the most recent effort levels in the fishery by fishing method (sub-fishery) in table form.*

**Total swept area (km$^2$) made during each fishing season targeting mackerel icefish. Source: AFMA Observer data.**

| Fishing season | Total swept area (km$^2$) |
|---|---|
| 2010/11 | |
| 2011/12 | |
| 2012/13 | |
| 2013/14 | 19.538 |
| 2014/15 | |

**Current and recent fishery catch trends by method**

*Summary of the most recent estimate of catch levels in the fishery by fishing method (sub-fishery).*

**Annual total reported catch (t) of mackerel icefish in the midwater trawl sub-fishery. Source: AFMA Observer data.**

| Fishing season | 2010/11 | 2011/12 | 2012/13 | 2013/14 | 2014/15 |
|---|---|---|---|---|---|
| Mackerel icefish (t) | | | | 17.785 | |

**Current and recent value of fishery ($)**

*Note current and recent value trends by sub-fishery.*

**Mackerel icefish:** Conservative estimates of mackerel icefish in the midwater trawl sub-fishery are approximately $35,570 in 2013/14 (estimated using average value ex-vessel at $2 kg). In order to maintain operator confidentiality, actual GVP estimates were unavailable to be released by AFMA and therefore not incorporated in this report. However, it is likely that more than $2 per kg is being achieved (AFMA).

Source: Catarci, 2004; AFMA, http://www.afma.gov.au/fisheries/heard-island-mcdonald-island-fishery/

**Relationship with other fisheries**

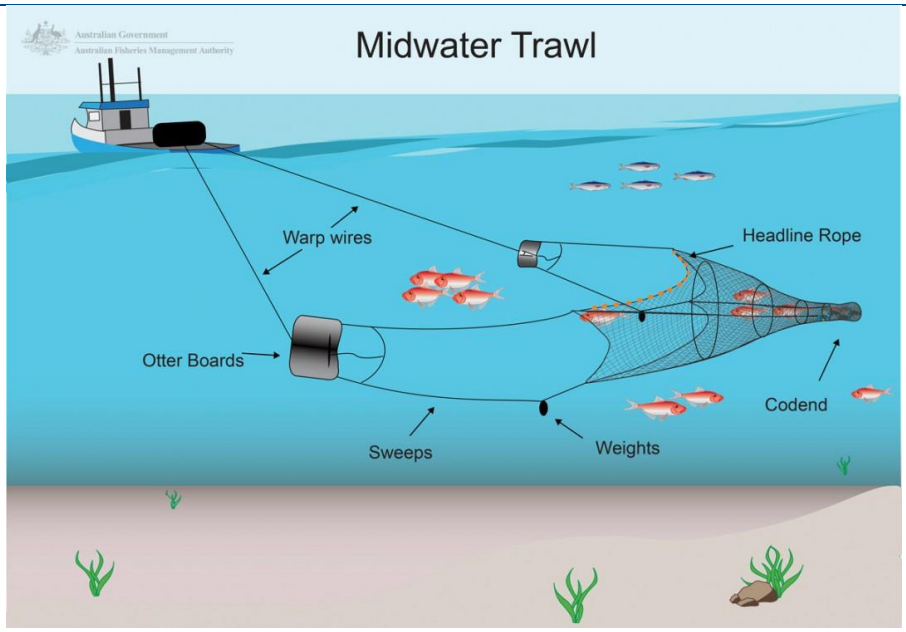
*Commercial and recreational, state, national and international fisheries. List other fisheries operating in the same region any interactions*

The Antarctic Fisheries (HIMI and Macquarie Island Toothfish Fishery (MITF)) are both managed within the context of the Australian Government's policy position within CCAMLR. Accordingly the fishery is more stringently managed than CCAMLR regulations. CCAMLR is the International Convention for the Conservation of Antarctic Marine Living Resources and Australia is one of the 24 member nations. CCAMLR is charged with ensuring the conservation and sustainable use of Antarctic living marine resources, with the exception of whales (ICRW) and seals (CCS).

**Demersal trawl sub-fishery:** occurs on the fishing grounds targeting both Patagonian toothfish and mackerel icefish. Demersal trawling generally occurs in deeper water than midwater trawling. Total catch and effort are higher in this sub-fishery compared to the midwater trawl sub-fishery. Demersal trawl has greater impact on benthic habitats compared to mid-water trawl. See also ERAF-HIMI demersal trawl report Sporcic et al. 2017.

**IUU:** Illegal fishing has been a concern in the Toothfish fishery but not the icefish fishery. In the past, IUU has targeted the northern and central part of the Kerguelen Plateau and the north-eastern part of the HIMI AFZ. Since 2005, there has been no illegal foreign fishing

| | |
|---|---|
| | vessels have been detected inside the Australian Fishing Zone of the HIMI area. However remnants of IUU fishing for toothfish persists on the high seas areas in the Southern Ocean.<br><br>Source: Commonwealth of Australia, 2014; CCAMLR: http://ccamlr.org<br><br>**Longline sub-fishery:** Demersal longlining for Patagonian toothfish began in 2002/3. Longlining operations generally occur on the deeper slope where larger fish occur and does not impact icefish. Longline fishing is thought to have less impact on benthic habitats than bottom trawling, although it may have greater impacts on the bycatch of some non-target species, such as skates (Rajiformes spp.) and rat-tails (*Macrourus* spp.), as well as bycatch of seabirds and mammals. See also ERAF-HIMI longline report Bulman et al. 2017.<br><br>**Longline fisheries of other nations:** Adjacent to the HIMI fishery, longlining is conducted in the French EEZ around the Îles Kerguelen for Patagonian toothfish. Australian and French scientists are conducting joint research to determine the extent the toothfish stock is shared on the Kerguelen Plateau. The recent Patagonian Toothfish catches from the French zone around Kerguelen Island (CCAMLR Statistical Area 58.5.1), as reported by CCAMLR, are 5235 t (2010/11), 4897 t (2011/12) and 5341 t (2012/13).<br><br>Source: http://ccamlr.org |
| **Gear** | |
| **Fishing methods and gear** | *Description of the methods and gear in the fishery, average number days at sea per trip.*<br><br>When midwater trawling, a net similar to, but typically larger than, a demersal trawl is towed in the midwater column. The net is spread horizontally and vertically, similar to demersal trawling operations. However, it does not have the same ground gear as it is not designed to touch the seafloor. Midwater trawl nets are also equipped with electronic units to allow monitoring of the net in the water column, fishing takes place between 62-707 m and an average of 339 m.<br><br>Like demersal trawling, midwater trawling relies on the herding of fish inward toward the mouth of the net where they are scooped up and are ultimately trapped in the codend.<br><br>The horizontal opening is maintained either by otter boards or by towing the net by two boats (pair trawling). Floats on the headline and weights on the groundline often maintain the vertical opening. Modern large midwater trawls, however, are rigged in such a way that floats are not required, relying on downward forces from weights to keep the vertical opening during fishing. No additional net specifications are available. |

| | |
|---|---|
| |  <br>Source: AFMA, http://www.afma.gov.au/portfolio-item/trawling/ |
| **Fishing gear restrictions** | *Any restrictions on gear*<br><br>Trawl nets are limited to a mesh size of not less than 90 mm when targeting mackerel icefish to enable juvenile fish to escape.<br><br>Source: CCAMLR Schedule of Conservation Measures in force 2015/16 season (CCAMLR, 2015c) |
| **Selectivity of fishing methods** | *Description of the selectivity of the sub-fishery methods*<br><br>Trawl nets for mackerel icefish have minimum mesh size of 90 mm. Midwater trawling generally results in little or no bycatch. |
| **Spatial gear zone set** | *Description where gear set i.e continental shelf, shelf break, continental slope (range nautical miles from shore)*<br><br>Midwater trawling is conducted on the upper Heard Plateau. |
| **Depth range gear set** | *Depth range gear set at in metres*<br><br>When targeting mackerel icefish, fishing takes place between 62-707 m and an average of 339 m. |
| **How gear set** | *Description how set, pelagic in water column, benthic set (weighted) on seabed*<br><br>Nets are set in midwater column approximately 100-200 m above bottom. The average net wing spread is estimated at 43.9 m (Zhou et al. 2009). |
| **Area of gear impact per set or shot** | *Description of area impacted by gear per set (square metres)*<br><br>Not applicable. |
| **Capacity of gear** | *Description number hooks per set, net size weight per trawl shot*<br><br>Vessel size in the HIMI range from 44-91 m. Catches are monitored to maximum capacity of 15 t. |

**Effort per annum all boats**

*Description effort per annum of all boats in fishery by shots or sets and hooks, for all boats*

**Total number of fishing hours, days and shots made during the fishing period based on CCAMLR seasons (12-month period from 1 December to 30 November of the following year) in the midwater trawl sub-fishery targeting mackerel icefish. Source: AFMA logbook data.**

| Fishing season | Fishing Hours | Fishing Days | Shots |
|---|---|---|---|
| 2010/11 | | | |
| 2011/12 | | | |
| 2012/13 | | | |
| 2013/14 | 13.63 | 4 | 5 |
| 2014/15 | | | |

**Total swept area ($km^2$) by fishing season in the midwater trawl sub-fishery targeting mackerel icefish (*Champsocephalus gunnari*). Source: AFMA Observer data.**

| Fishing season | Total swept area ($km^2$) |
|---|---|
| 2010/11 | |
| 2011/12 | |
| 2012/13 | |
| 2013/14 | 19.538 |
| 2014/15 | |

**Lost gear and ghost fishing**

*Description of how gear is lost, whether lost gear is retrieved, and what happens to gear that is not retrieved, and impacts of ghost fishing.*

Lost trawl gear occurs rarely and operators are required to attempt to retrieve it. Operators also recover illegal fishing gear. No gear reported lost during midwater operations.

Source: SARAG Minutes 2010-2015

Issues

**Key/second-ary commerical species issues and Interactions**

*List any issues, including biological information such as spawning season and spawning location, major uncertainties about biology or management, interactions etc.*

There were no future research requirements recommended at the WG-FSA-15 for mackerel icefish. However, better estimates of key biological characteristics including growth, mortality and reproduction rates for mackerel icefish are needed, in addition to population dynamics and stock structure.

There are some uncertainties concerning mackerel icefish particularly in relation to prey-predator interactions and extended ecological risk related to the fishery such as corresponding alteration of food webs. Drawing on results elsewhere (e.g. Baum and Worm 2009), effects on top predators from fishing may come from competition for and reduced availability of preferred prey species, and altered ecosystem structure and functions, with concomitant cascading effects of reduced top predator species. There is also a need to better understand the effects of bycatch removals on ecosystem dynamics and population dynamics of target species. Lastly, there is an increasing need to understand any potential effects of habitat disturbance brought about by climate change and ocean acidification.

**Byproduct and bycatch**

*List any issues, as for the target species above*

**issues and interactions**

**Bycatch (kg) of bycatch species caught in the mackerel icefish (*Champsocephalus gunnari*) HIMI mid-water trawl sub-fishery. Source: Observer data**

| Fishing season | Scientific name | Common name | Bycatch (kg) |
|---|---|---|---|
| 2013/14 | Asteroidea | Sea stars | 0.40 |
| | *Bathyraja eatonii* | Eaton's Skate | 15.96 |
| | *Bathyraja murrayi* | Murray's Skate | 2.04 |
| | *Channichthys rhinoceratus* | Unicorn icefish | 967.79 |
| | *Gobionotothen acuta* | Triangular rockcod | 0.18 |
| | *Lepidonotothen squamifrons* | Grey rockcod | 0.78 |
| | *Macrourus whitsoni* | Whitson's grenadier | 0.18 |
| | Medusae | Jellyfish | 51.59 |
| | Myctophidae | Lanternfish | 0.07 |
| | Octopodidae | Octopus | 0.40 |
| | Squid Indet | Squids | 0.45 |

Eleven bycatch taxa were caught in the midwater trawl sub-fishery targeting mackerel icefish in the 2013/14 season. The principal bycatch species were unicorn icefish (968 kg), jellyfish (52kg) and Eaton's skate (16kg), with all other species accounting < 2kg.

The midwater trawl sub-fishery poses limited impact on bottom habitats and bottom structures. Bycatch levels continue to be monitored by observers (who are present on all fishing trips) and reported to CCAMLR. Fishing shall cease if the bycatch of any species, as set out in CM 33-02, is reached (Source: CCAMLR Document WG-FSA-03/73; CCAMLR, 2015c)

**Protected species issues and interactions**

*List any issues. This section should consider all TEP species groups: marine mammals, chondrichthyans (sharks, rays etc.), marine reptiles, seabirds, teleosts (bony fishes), include any key spawning/breeding/aggregation locations that might overlap with the fishery/sub-fishery.*

**Marine mammals and chondrichtyans:**

**Protected species interactions in the HIMI midwater trawl sub-fishery targeting mackerel icefish (MI)) over the 2010-2015 period. PIN: Pinniped; CHN- chondrichthyans; Life status: No damage: no apparent damage; Minor injury: possible minor injury; Major injury: possible major injury; Dead: dead; UnK: unknown. Source: AFMA Observer data.**

| | | | | Life status | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Species targeted | Fishing season | Taxa | Common name | No damage | Minor injury | Major injury | Dead | UnK | Total |
| **MI** | 2013/14 | PIN | Seal | | | 1 | | | 1 |
| **MI** | 2013/14 | CHN | Porbeagle shark^ | | | 1 | | | 1 |

^ listed as a Migratory species under the EPBC Act.

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| | There has been reported interactions with one seal (species undifferentiated) and one porbeagle shark, *Lamna nasus*, interaction during the 2013/14 season, based on AFMA Observer data. In addition, there have been no reported marine mammals or chondrichthyans.<br><br>**Seabirds:**<br><br>There were no recorded interactions with seabirds in the observer data for the 2013/2014 season. There were however, 611 sightings (observations) of 9 different seabird species, predominantly Southern black browed albatross, White chinned petrel and Cape petrel. |
| **Habitat issues and interactions** | *List any issues for any of the habitat units identified in **Scoping Document S1.2**. This should include reference to any protected, threatened or listed habitats*<br><br>**Benthic damage by trawl gear:** Midwater fishing takes place between 62-707 m and nets are set in midwater column approximately 100-200 m above bottom. Midwater trawl would not impact benthic habitats unless gear is lost or hits the bottom. A comprehensive assessment of the vulnerability of benthic habitats to impact by demersal fishing gear has recently been undertaken in the HIMI and surrounding Southern Ocean (Welsford et al. 2014).<br><br>**Habitat Protection:** The Heard Island and McDonald Islands Marine Reserve was as established in 2003 with the boundaries expanded in March 2014 following scientific assessment of a Conservation Zone adjoining the Reserve. The scientific assessment recommended that 6200 square kilometres of the Conservation Zone be added to the Reserve on the basis that its waters were of high conservation value. The Reserve's area subsequently increased to 71,000 square kilometres. The Reserve is a declared IUCN Category 1a Strict Nature Reserve meaning that all fishing activities are prohibited unless for scientific research or management purposes in accordance with the Reserve Management Plan 2014-2024. It is thought that 40% of the biomass of potentially vulnerable benthic organisms are within the Marine Reserve (Welsford et al. 2014).<br>Source: https://www.legislation.gov.au/Details/F2014L01346/Html/Volume_2<br><br>**Pollution and invasive species:** Marine and terrestrial species that inhabit the HIMI fishery area are susceptible to marine pollution events (HIMI Marine Reserve Management Plan 2014-2024).Fishing operations (including for commercial, tourism, scientific reasons) in and around the HIMI are a key source of plastic debris in the Southern Ocean that can entangle or be consumed by wildlife (Woehler et al. 2014). Shipping operations can also disturb wildlife. Marine debris has been identified as a problem in the HIMI Fishery and the surrounding sub-Antarctic island basin (Eriksson et al. 2013). After a series of surveys over a five year period, most of the 6389 items collected at Heard and Macquarie Islands were plastic (94% at Heard) and discarded or lost fishing gear comprised 22% of those plastic items. Impacts upon fauna, including waste ingestion or entanglement and disease introduction, are of key concern that are as yet unknown for the Southern Ocean (Woehler et al. 2014). Anti-fouling toxins applied on ship hulls may also have adverse effects on marine species and ecosystems.<br><br>All efforts are made not to dispose of rubbish at sea in the demersal trawl sub-fishery. MARPOL regulations are strongly adhered to (Observer data records). Furthermore there isa plastic packaging ban which prohibits the use of plastic packaging bands, unless the bands are an essential part of the boat's gear, to avoid injury or death, through ingestion or entanglement, of wildlife. There is also a prohibition on the disposal of poultry products and vegetable scraps to minimise the possibility of the introduction of disease or pests on the Islands.<br><br>Source(s): Woehler et al. 2014; HIMI Marine Reserve Management Plan 2014-2024 (Commonwealth of Australia, 2014).<br><br>**Climate change:** Climate change has emerged as a key issue for biodiversity and environmental management. The effects of climate change are apparent in the HIMI Reserve. Increased warming has led to glacial retreat (Thost and Truffer 2007), changes in weather |

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| | patterns (Thost and Allison 2005) and the formation of lagoons and freshwater lakes. The Reserve's ecosystems and landscape are vulnerable to further climate change impacts, including: sea level rise; changes to ocean water chemistry; increases in sea surface temperature; and the arrival and establishment of invasive species (Chown et al. 2007). If such changes occur this will affect regional biodiversity. If change is detected or is of concern, the Management Plan Director will decide on further monitoring requirements, and whether protective, rehabilitation or adaptation measures are feasible.<br>Source: HIMI Marine Reserve Management Plan 2014-2024 (Commonwealth of Australia, 2014) |
| **Community issues and interactions** | *List any issues for any of the community units identified in **Scoping Document S1.2**.*<br><br>No specific issues identified. Aside from intermittent visits by Australian Government personnel, scientists and tourists, the Territory is devoid of human habitation. A low number of private yachts and commercial tourist vessels have visited Heard Island, although few successful landings have been made due to poor weather.<br><br>The importance of the Antarctic community is recognised by the CCAMLR approach to ecosystem-based management. AFMA has recognised and incorporated this approach in their management strategies for the HIMI fishery. To enable formulation of management strategies for the HIMI region, ongoing assessments of the ecosystem are needed.<br><br>Two recent initiatives are being undertaken by the SCAR community: ICED is organising a conference in 2018 (www.MEASO2018.aq) with a principle focus on assessing the status and trends of habitats, species and foodwebs in the Southern Ocean; and SOOS is designing the biological component of its observing system to be complementary to the CCAMLR Ecosystem Monitoring Program and is in the process of developing an initiative to undertake a circumpolar benchmarking of the Southern Ocean ecosystem. These initiatives are been undertaken within a project in the AAD Science Program Stream 3.1 Marine Ecosystem Change. This project aims "to develop a quantitative framework for assessing change in ecosystems (habitats, species and foodwebs) and, in conjunction with the international program Integrating Climate and Ecosystem Dynamics of the Southern Ocean, undertake the first assessment within that framework, focussing on the Indian Sector " https://secure3.aad.gov.au/public/projects/report_project_public.cfm?project_no=4343&season=1415.<br><br>Also providing fundamental information into this stream, is an ensemble of ecosystem models – together with a set of targeted models for particular ecological processes – that are currently being developed for the region. These include and implementation of the Atlantis model (as part of Australian Antarctic Science project #4347 (https://secure3.aad.gov.au/public/projects/report_project_public.cfm?project_no=4347&season=1516), an implementation of the SEAPODYM model (a stage-based model for fish-based ecosystems (Lehodey 2005) development of size-based models (AAS project #4366: https://secure3.aad.gov.au/public/projects/report_project_public.cfm?project_no=4366&season=1415) and implementations of Ecopath with Ecosim. Process modelling for the region includes individual-based modelling for predator species (http://soki.aq/x/EYArAQ), and larval transport modelling for Patagonian Toothfish (Mori et al. 2016). This suite of research will be important for assessing current and future status and trends of the ecosystem in the Kerguelen region.<br><br>A recent MSC certification audit (SCS 2015) found it "highly unlikely that current catch levels will have any adverse effect on the impacts of the fishery on, or the status of, retained species, bycatch, ETP species, or trophic function."<br><br>In addition, the (i) management of the HIMI Marine Reserve by the AAD; (ii) prohibition on fishing within 13 nautical miles of the islands; (iii) establishment of the HIMI Marine Reserve in 2002 and (iv) continued monitoring of top predators both in terms of diet, reproductive rates and overall abundance are seen as key actions in the preservation of community ecosystems. A specific allowance is made for predator needs by adopting a limit reference |

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| | point for the fishery of not less than 75% median escapement of the spawning biomass over a two year projection. However, this assumes that the biomass is known and that it does not fall below a sustainable level.<br><br>The information available on each species will be reviewed annually by the Antarctic Fishery Assessment Group (SAFAG) and CCAMLR with the aim of continuing to develop specific bycatch limits based on population assessments with the possible use of Potential Biological Removal levels. This review will incorporate data from the monitoring program including observer data and shot-by-shot logbook information recorded by industry, and will include information learned from fisheries in other parts of the world (e.g. sleeper sharks). AFMA, in conjunction with SAFAG, monitored the tag and release of sleeper sharks, investigated the use of new monitoring technologies and conducted a risk assessment for sleeper sharks. |
| **Discarding** | *Summary of discarding practices by sub-fishery, including bycatch, juveniles of target species, high-grading, processing at sea.*<br><br>Under the Antarctic Bycatch Plan (2003), AFMA requires that all bycatch is retained (with some exceptions) in order to limit possible interactions with marine mammals and seabirds. All retained bycatch is processed into fish meal with the exception of Grey Rockcod and Unicorn Icefish, which are generally retained whole. Skates, sharks, jellyfish, sponges, crabs and coral are returned to the ocean as these species either have a high chance of survival, do not attract seabirds and marine mammals when discarded, or cannot be effectively processed through the meal plant (if present on a vessel). |
| **Management: planned and those implemented** | |
| **Management objectives** | *The management objectives from the most recent management plan*<br><br>The objectives of the *Heard Island and McDonald Islands Fishery Management Plan 2002* (amended in May 2016) assessed under the Environmental Protection and Biodiversity Act 1999 are:<br><br>a) to manage the Fishery efficiently and cost effectively for the Commonwealth,<br>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,<br>c) to maximise economic efficiency in the exploitation of the resources of the Fishery,<br>d) to ensure AFMA's accountability to the fishing industry and to the Australian community in management of the resources of the Fishery,<br>e) to reach Government targets for the recovery of the costs of AFMA in relation to the Fishery,<br>f) to ensure, through proper conservation and management, that the living resources of the Australian Fishing Zone (AFZ) are not endangered by over-exploitation,<br>g) to achieve the best use of the living resources of the AFZ, and<br>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.<br>Source : https://www.legislation.gov.au/Details/F2005B02477<br><br>The *Heard Island and McDonald Islands Marine Reserve Management Plan for 2014-2024,* signed October 2014, is the second management plan for the Reserve established in October 2002 under the EPBC Act 1999. The reserve is 71000 km$^2$ in area, possesses an incredibly dynamic natural environment, and is an important breeding and foraging ground for many bird and mammal species, some listed as threatened or migratory species under the EPBC Act. The reserve contains important benthic habitats and is part of Australia's National Representative System of Marine Protected Areas.<br><br>Source: https://www.legislation.gov.au/Details/F2014L01346/Html/Volume_2 |

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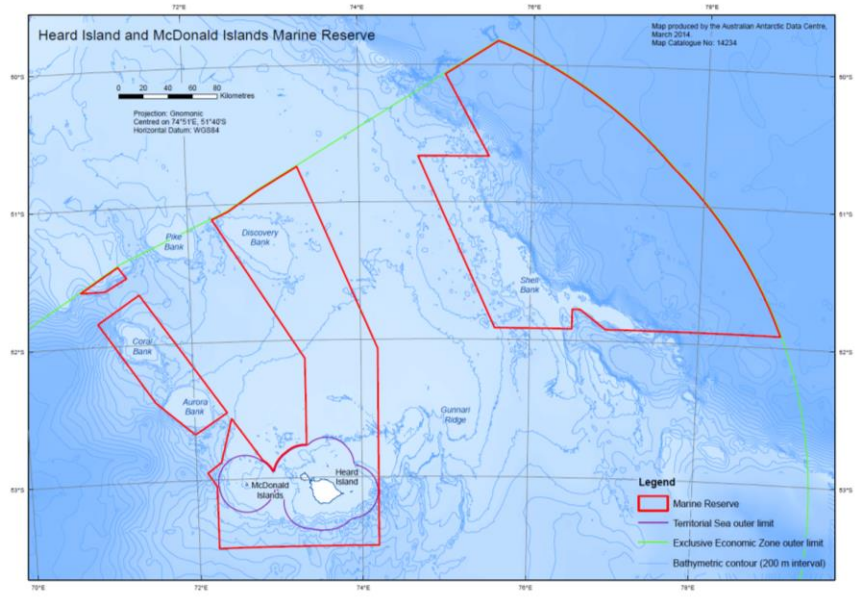
| | The consultative forums include the Sub-Antarctic Fisheries Management Advisory Committee (SouthMAC) and the Sub-Antarctic Resource Assessment Group (SARAG) which meet annually. |
| **Fishery management plan** | *Is there a fisheries management plan? Is it in the planning stage or implemented what are the key features*<br><br>The HIMI fishery was first managed under the HIMI Exploratory Fishery Interim Management Policy November 1996 to August 1997. This was replaced by the HIMI Management Policy 1998 to 2000, which was extended to November 2001. Now the fishery is managed under the HIMI Fishery Management Plan 2002 and supporting legislative instruments developed under the Fisheries Management Act 1991. The HIMI fishery falls within the area covered by CCAMLR and is managed by AFMA in close cooperation with the AAD in accordance with the Conservation Measures set by CCAMLR.<br><br>**Seasonal and area closures:** There is a closure of the area outside of the Heard Island Plateau to mackerel icefish fishing (*Direction No. HIMIFD-10*) that was repealed in May 2014 by the *Heard Island and McDonald Islands Fishery (Closures) Direction No. 1 2014*. This states:<br><br>(i) 6.1 No fishing is to be engaged in that targets mackerel icefish in the area of the fishery that is the outside of the Heard Island Plateau, as defined in Schedule 1.<br>(ii) 6.2 Any incidental take of mackerel icefish in the area of the fishery referred to in clause 6.1 will be decremented from a person's quota holdings for that species in the same manner as it would be if mackerel icefish were a target species in that area.<br>Source: https://www.legislation.gov.au/Series/F2009L01240<br><br>The fishery takes a precautionary approach to management which considers the effects of harvesting on target, dependent and associated species, and ecological relationships, to ensure sustainability of target species stocks and the broader marine environment.<br><br>In November 2006, the HIMI mackerel icefish was the first fish in Australia to be certified as sustainable by the MSC and has passed certification reassessments in 2011 with the second re-assessment commencing in June 2015. The HIMI Patagonian toothfish also receive MSC's sustainable status in March 2012. |
| **Input controls** | *Summary of any input controls in the fishery, e.g. limited entry, area restrictions (zoning), vessel size restrictions and gear restrictions. Primarily focused on target species as other species are addressed below.*<br><br>HIMI Demersal Trawl Fisheries is managed under a system of input and output controls designed to manage catches of the target and non-target species. The key input controls are:<br><br>• Area closures defined under include:<br>  - Heard Island Plateau to mackerel icefish fishing (CM 42-02)<br>• 'move-on' provisions such that vessels are required to move away from certain areas should a defined level of bycatch be taken in one fishing shot (CM 33-02);<br>• gear restrictions for trawl, including:<br>  - Bobbin diameter<br>  - Mesh size is restricted to > 120 mm for Patagonian toothfish fishery and > 90 mm for mackerel icefish fishery (CM 22-02 and 22-01)<br>• Limits on the number of trawlers than can operate to a maximum of three at any one time.<br>Source: CCAMLR, 2015c; Patterson and Skirtun, 2015<br><br>There are also area closures to protect areas (i.e. HIMI Marine Reserve with a buffer zone of 1 nm; see below). The Reserve was declared by Proclamation for the purpose of '*protecting the conservation values of Heard Island and McDonald Islands and the adjacent unique and vulnerable marine ecosystems*'. |

**Heard Island and McDonald Islands Marine Reserve**

In October 2002 the Heard Island and McDonald Islands (HIMI) Marine Reserve was declared under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). In 2014, the Reserve was expanded to cover 71 200 km$^2$ by proclamation after scientific assessment. It includes Heard Island and the McDonald Islands, the surrounding 12 nautical mile territorial sea, plus an extended marine area which extends in parts to the 200 nautical mile Exclusive Economic Zone (EEZ) boundary. The *Heard Island and McDonald Islands Marine Reserve management plan 2014–24*, provides the management regime for the reserve.




Source: July 2016, http://heardisland.antarctica.gov.au/about/maps

Classified as an IUCN Category 1a Strict nature reserve managed primarily for scientific research or environmental monitoring, the Reserve comprises the world's largest fully protected marine Reserve.

The management objectives for the Reserve outlined in the Reserve proposal were to:

- protect conservation values of Heard Island and McDonald Islands (HIMI), the territorial sea and the adjacent EEZ including:
    - the World Heritage and cultural values of the HIMI Territory;
    - the unique features of the benthic and pelagic environments;
    - representative portions of the different marine habitat types; and
    - marine areas used by land-based marine predators for local foraging activities.
- provide an effective conservation framework which will contribute to the integrated and ecologically sustainable management of the HIMI region as a whole;
- provide a scientific reference area for the study of ecosystem function within the HIMI region; and
- add representative examples of the HIMI EEZ to the National Representative System of Marine Protected Areas.

Source: July 2016 http://heardisland.antarctica.gov.au/protection-and management/marine-reserve

*Management of the HIMI Marine Reserve*

Administration of the HIMI Marine Reserve is the responsibility of the Australian Antarctic Division (AAD). The EPBC Act requires that management must be based on IUCN category Ia

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| | reserve management principles, and be not inconsistent with Australian World Heritage management principles. The Management Plan for the HIMI Marine Reserve was enacted in 2005 and addresses a broad range of management issues. It includes a similarly broad range of measures to address these issues, such as from the cleaning of clothing and gear to prevent unwanted 'alien' species, to where and how visitors can go to the toilet. The new management plan replaces the previous Heard Island Wilderness Reserve Management Plan (PDF) in force for the HIMI Territory since 1996 under the Environment Protection and Management Ordinance 1987.<br><br>Source: http://www.heardisland.aq/protection/management_plan/index.html |
| **Output controls** | *Summary of any output controls in the fishery, e.g. quotas. Effort days at sea. Primarily focused on target species as other species are addressed below.*<br><br>Output controls are the primary means of controlling the level of catch, and are set as annual TACs or catch limits for target and bycatch species. The TACs for the target species are divided among SFR holders in proportion to their holdings for each species. The main output controls are:<br><br>• Annual review and setting of total allowable catches (TAC) 2015/2016 and 2016/17 seasons for Patagonian toothfish is limited to 3405 t (Conservation Measure 41-08) and in the 2015/16 season for mackerel icefish is limited to 482 t (Conservation Measure 42-02).<br>• Move–on provisions if, in hauls larger than 100 kg of icefish, more than 10% of the fish are less than legal limits (240mm) (Conservation Measure 42-02).<br>• catch limits of bycatch species: fishing shall cease if bycatch of any species reaches its bycatch limit as specified in CM 33-02 (in CM 41-08 and 42-02).<br>• if 50% of catch limit is reached for any non-target species, AFMA will review operating practices with SFR holders.<br><br>Source: CCAMLR 2015/16 Schedule of Conservation Measures (CCAMLR, 2015c)<br><br>**Precautionary harvest strategies** are adopted for both target species:<br>Patagonian toothfish – that the probability that spawning biomass will fall below 20% of the pre exploitation level over the 35 year projection period must not exceed 0.1 and the median escapement for the Fishery of the spawning biomass shall not be less than 50% over a 35 year projection.<br><br>Mackerel icefish – that the probability that spawning biomass will fall below 20% of the pre exploitation level over the two year projection period must not exceed 0.1 and the median escapement for the Fishery of the spawning biomass shall not be less than 75% over a two year projection. |
| **Technical measures** | *Summary of any technical measures in the fishery, e.g. size limits, bans on females, closed areas or seasons. Gear mesh size, mitigation measures such as TEDs. Primarily focused on target species as other species are addressed below.*<br><br>**Mesh size** (Conservation Measures 22-01 and 22-01, 2015)<br><br>Under AFMA requirements the mesh-size of the trawl nets used must not be less than<br><br>• 120 mm for targeting Patagonian toothfish and<br>• 90 mm for targeting mackerel icefish.<br><br>See also Conservation Measures in “Regulations” section below.<br><br>Source: CCAMLR 2015/16 Schedule of Conservation Measures |

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| **Regulations** | *Regulations regarding species (bycatch and by-product, Protected species), habitat, and communities; MARPOL and pollution; rules regarding activities at sea such as discarding offal and/ or processing at sea.*<br><br>The Conservation Measures (CM) that apply to the HIMI Fishery are:<br><br>10-01 to 10-10 Compliance<br>22-01 Regulation on mesh size measurements<br>22-02 Mesh size<br>23-02 Ten-day catch and effort reporting<br>23-04 Fine-scale catch and effort data<br>23-06 Fine-scale biological data<br>24-01 and 24-02 Research and Experiments<br>25-01 and 25-03 Minimisation of Incidental Mortality of bycatch, seabirds and marine mammals<br>26-01 General environmental protection during fishing<br>31-02 General measure for the closure of all fisheries<br>32-01 Fishing seasons<br>33-02 Limitation of bycatch in Division 58.5.2<br>41-08 Limits on the fishery for *Dissostichus eleginoides* in Division 58.5.2<br>42-02 Limits on the fishery for *Champsocephalus gunnari*in Statistical Division 58.5.2<br><br>Details of the three most pertinent conservation measures are given here:<br>**Conservation measures 33-02** (CCAMLR 2015c) Limitation of bycatch in Statistical Division 58.5.2 in the 2015/16 season:<br>1. There shall be no directed fishing for any species other than *Dissostichus eleginoides* and *Champsocephalus gunnari*in Statistical Division 58.5.2 in the 2015/16 fishing season.<br>2. In directed fisheries in Statistical Division58.5.2 in the 2015/16 season, the bycatch of *Channichthys rhinoceratus* shall not exceed 1663 t, the bycatch of *Lepidonotothen squamifrons* shall not exceed 80 t, the bycatch of *Macrourus caml* and *Macrourus whitsoni* combined shall not exceed 409 t, the bycatch of *Macrourus holotrachys* and *Macrourus carinatus* combined shall not exceed 360 t, and the bycatch of skates and rays shall not exceed 120 t. For the purposes of this measure 'skates and rays' should be counted as a single species.<br>3. The bycatch of any fish species not mentioned in paragraph 2, and for which there is no other catch limit in force, shall not exceed 50 t in Statistical Division 58.5.2.<br>4. If, in the course of a directed fishery, the bycatch in any one haul is equal to, or greater than, 5 t for *Channichthys rhinoceratus*, 3 t for all *Macrourus* spp. combined, or 2 t for *Lepidonotothen squamifrons*, or 2 t of *Somniosus* spp., or 2 t of skates and rays, then the fishing vessel shall not fish using that method of fishing at any point within 5 nmof the location where the bycatch limit is exceeded for a period of at least five days. The location where the bycatch limit is exceeded is defined as the path followed by the fishing vessel.<br>5. If, in the course of a directed fishery, the bycatch in any one haul of any other bycatch species for which bycatch limitations apply under this conservation measure is equal to, or greater than, 1 t, then the fishing vessel shall not fish using that method of fishing at any point within 5 nm of the location where the bycatch exceeded 1 t for a period of at least five days. The location where the bycatch exceeded 1 t is defined as the path followed by the fishing vessel.<br><br>**Conservation measures 41-08** (2015) Limits on the fishery for *Dissostichus eleginoides* in Statistical Division 58.5.2 in the 2015/16 and 2016/17 seasons and Annex 41-08/A:<br>1. Access. The fishery for *Dissostichus eleginoides* in Statistical Division 58.5.2 shall be conducted by vessels using trawls, pots or longlines only. |

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| | 2. Catch limit. The total catch of *Dissostichus eleginoides* in Statistical Division 58.5.2 in the 2015/16 and 2016/17 seasons shall be limited to 3405 t in each season west of 79°20'E.<br>3. Season. For the purpose of the trawl and pot fisheries for *Dissostichus eleginoides* in Statistical Division 58.5.2, the 2015/16 and 2016/17 seasons are defined as the period from 1 December to 30 November in each season, or until the catch limit is reached, whichever is sooner. For the purpose of the longline fishery for *Dissostichus eleginoides* in Statistical Division 58.5.2, the 2015/16 and 2016/17 seasons are defined as the period from 1 May to 14 September in each season, or until the catch limit is reached, whichever is sooner. The season for longline fishing operations may be extended from 1 April to 30 April and 15 September to 30 November for any vessel which has demonstrated full compliance with Conservation Measure 25-02 in the previous season. These extensions to the season will also be subject to a total catch limit of three (3) seabirds per vessel. If three (3) seabirds are caught during the season extension, fishing throughout the season extensions shall cease immediately for that vessel for the remainder of that fishing season.<br>4. Bycatch. Fishing shall cease if the bycatch of any species reaches its bycatch limit as set out in Conservation Measure 33-02.<br>5. Mitigation. The operation of the trawl fishery shall be carried out in accordance with Conservation Measure 25-03 so as to minimise the incidental mortality of seabirds and mammals through the course of fishing. The operation of the longline fishery shall be carried out in accordance with Conservation Measure 25-02.During the periods 1 April to 30 April in the 2015/16 and 2016/17 seasons, vessels shall use IWL gear in conjunction with paired streamer lines.<br>6. Observers. Each vessel participating in this fishery shall have at least one scientific observer, and may include one appointedin accordance with the CCAMLR Scheme of International Scientific Observation, on board throughout all fishing activities within the fishing period, with the exception of the period 1 April to 30 April when two scientific observers shall be carried.<br>7. Data: catch/effort. For the purpose of implementing this conservation measure, the following shall apply: (i) the Ten-day Catch and Effort Reporting System set out in Annex 41-08/A; (ii) the Monthly Fine-scale Catch and Effort Reporting System set out in Annex 41-08/A. Fine-scale data shall be submitted on a haul-by-haul basis.<br>8. For the purpose of Annex 41-08/A, the target species is *Dissostichus eleginoides* and bycatch species are defined as any species other than *Dissostichus eleginoides*.<br>9. The total number and weight of *Dissostichus eleginoides* discarded, including those with the 'jellymeat' condition, shall be reported. These fish will count towards the total allowable catch.<br>10. Data: biological. Fine-scale biological data, as required under Annex 41-08/A, shall be collected and recorded. Such data shall be reported in accordance with the CCAMLR Scheme of International Scientific Observation.<br>11. Environmental protection. Conservation Measure 26-01 applies.<br><br>**Conservation measures 42-02** (2015) Limits on the fishery for *Champsocephalus gunnari*in Statistical Division 58.5.2 in the 2015/16 season and Annex42-02/A and Annex42-02/B.<br>1. Access. The fishery for *Champsocephalus gunnari* in Statistical Division 58.5.2 shall be conducted by vessels using trawls only.<br>2. For the purpose of this fishery for *Champsocephalus gunnari*, the area open to the fishery is defined as that portion of Statistical Division58.5.2that lies within the area enclosed by a line: …<br>3. A chart illustrating the above definition is appended to this conservation measure (Annex 42-02/A). Areas in Statistical Division 58.5.2 outside that defined above shall be closed to directed fishing for *Champsocephalus gunnari*.<br>4. Catch limit. The total catch of *Champsocephalus gunnari* in Statistical Division 58.5.2 in the 2015/16 season shall be limited to 482 t.<br>5. Where any haul contains more than 100 kg of *Champsocephalus gunnari*, and more than 10% of *Champsocephalus gunnari* by number are smaller than the specified |

minimum legal total length, the fishing vessel shall move to another fishing location at least 5 nm distant. The fishing vessel shall not return to any point within 5 nm of the location where the catch of small *Champsocephalus gunnari* exceeded 10% for a period of at least five days. The location where the catch of small *Champsocephalus gunnari* exceeded 10% is defined as the path followed by the fishing vessel from the point at which the fishing gear was first deployed from the fishing vessel to the point at which the fishing gear was retrieved by the fishing vessel. The minimum legal total length shall be 240 mm.

6. Season. For the purpose of the trawl fishery for *Champsocephalus gunnari* in Statistical Division 58.5.2, the 2015/16 season is defined as the period from 1 December 2015 to 30 November 2016, or until the catch limit is reached, whichever is sooner.
7. Bycatch. Fishing shall cease if the bycatch of any species reaches its bycatch limit as set out in CM 33-02.
8. Mitigation. The operation of this fishery shall be carried out in accordance with CM 25-03 so as to minimise the incidental mortality of seabirds in the course of fishing.
9. Observers. Each vessel participating in this fishery shall have at least one scientific observer, and may include one appointed in accordance with the CCAMLR Scheme of International Scientific Observation, on board throughout all fishing activities within the fishing period.
10. Data: catch/effort. For the purpose of implementing this conservation measure in the 2015/16 season, the following shall apply: (i) the Ten-day Catch and Effort Reporting System set out in Annex 42-02/B; (ii) the Monthly Fine-scale Catch and Effort Reporting System set out in Annex 42-02/B. Fine-scale data shall be submitted on a haul-by-haul basis.
11. For the purpose of Annex 42-02/B, the target species is *Champsocephalus gunnari* and 'bycatch species' are defined as any species other than *Champsocephalus gunnari*.
12. Data: biological. Fine-scale biological data, as required under Annex 42-02/B, shall be collected and recorded. Such data shall be reported in accordance with the CCAMLR Scheme of International Scientific Observation.
13. Environmental protection13.Conservation Measure 26-01 applies.

Source: CCAMLR Conservation Measures 2015/16 (CCAMLR., 2015c); https://www.ccamlr.org/en/data/data-forms

Under the EPBC Act 1999, interactions with a protected species must be reported within seven days of the incident occurring to the Department of Environment. A Memorandum of Understanding between AFMA and the Department for the Reporting of Fisheries Interactions with Protected Species (Reporting MOU) streamlines those reporting requirements (http://www.afma.gov.au/wp-content/uploads/2010/06/mou.pdf). AFMA reports its protected species interactions to the Department on a quarterly basis.

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). Garbage is all kinds of food wastes including brassicas, domestic wastes and operational wastes, all plastics, cargos residues, incinerator ashes, cooking oil, fishing gear, and animal carcasses generated during the normal operation of the ship and liable to be disposed of continuously or periodically except those substances which are defined or listed in other Annexes to the present Convention but not fish as a results of fishing or aquaculture activities. https://www.amsa.gov.au/environment/regulations/garbage-management-plans/sample.asp. Fishing gear is included in the definition of 'garbage' for the Convention (http://www.environment.gov.au/system/files/resources/d945695b-a3b9-4010-91b4-914efcdbae2f/files/tap-review-marine-debris.pdf.) Vessels of over 100 gross tonnage or which carries over 15 persons must have a Garbage Management Plan. Compliance by fishing

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| | vessels with the requirements of MARPOL Annex V and domestic marine pollution legislation on Commonwealth-licensed Australian fishing boats is monitored through the observer program (AFMA). Fishers must record loss of gear in vessel logbooks under the management of the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR). |
| **Initiatives, strategies and incentives** | *BAPs; TEDs; Industry codes of conduct*<br><br>The objective of the ***Antarctic Fisheries Bycatch Action Plan 2003*** is:<br>To ensure that the impacts of the fishery's bycatch on the ecosystem are sustainable and consistent with legislative requirements.<br><br>Six strategies have been developed to achieve this objective:<br>1 Develop and review non-target species catch limits to ensure catches are within sustainable limits<br>2 Minimise the bycatch of non-target species, including sharks , skates and rays,<br>3 Evaluate any fishing impacts on seabirds and marine mammals<br>4 Develop mitigation measures to minimise seabird and marine mammal catches in the longline fishery<br>5 Develop mitigation measures to minimise seabird and marine mammal interaction in the trawl fishery<br>6 Assess the benthic/ecological impacts of fishing on habitats.<br><br>Source: AFMA Antarctic Fisheries Bycatch Action Plan 2003 (AFMA 2003).<br><br>Also, the **Catch Documentation Scheme** (CDR) implemented in 2000 by CCAMLR tracks catches of toothfish sold in participating countries and is used to estimate IUU catch.<br><br>**FAO *Code of Conduct*** *for Responsible Fisheries* (adopted in 1995) sets out principles and international standards of behaviour for responsible fishing practices to enable effective conservation and management of living aquatic organisms, whilst considering impacts on the ecosystem and biodiversity. International Plans of Actions (IPOAs) are voluntary instruments elaborated within the framework of the Code with four currently developed:<br><br>• IPOA to prevent, deter and eliminate illegal, unreported and unregulated (IUU) fishing<br>• IPOA for Reducing Incidental Catch of Seabirds in Longline Fisheries<br>• IPOA for the Conservation and Management of Sharks, and<br>• IPOA for the Management of Fishing Capacity<br><br>Source: http://www.agriculture.gov.au/fisheries/legal-arrangements/code-conduct<br><br>In addition to the previous controls and regulations, further conditions accompany the statutory fishing rights:<br><br>• Boat eligibility<br>• Personal consumption and jellymeat (in the toothfish fishery)<br>• VMS requirements<br>• Boat marking<br>• Transhipping and carrying<br>• Product labelling<br>• Notification requirements<br>• CCAMLR inspection<br>• Carriage of observers<br>• Data collection officers<br>• Safety assessment |

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| | • Contingency arrangements for breakdown of the meal plant and disposal of fish meal<br><br>Source: MSC Assessment Report HIMI mackerel icefish 2006 |
| **Enabling processes** | *Monitoring, logbooks, observer data, scientific surveys); assessment stock assessments); performance indicators (decision rules, processes, compliance; education; consultation process.*<br><br>There are detailed management plans for Patagonian toothfish and mackerel icefish. Catches and landings are monitored by logbooks and observer data. This includes the:<br><br>• Ten-day Catch and Effort Reporting System set out in Annex 42-02/B;<br>• Monthly Fine-scale Catch and Effort Reporting System set out in Annex 42-02/B. Fine-scale data shall be submitted on a haul-by-haul basis.<br><br>Stock assessments on target (icefish: annual; toothfish: bi-annual) and some non-target species are conducted less frequently by SAFAG. The Bycatch Action Plan is reviewed biannually and outcomes are reported against performance indicators.<br><br>Random stratified trawl surveys are conducted annually to ensure that reliable stock assessments can be made for each target species and for monitoring the direct impact of the fishery on non-target species and ecosystem.<br><br>Australia, through its work in CCAMLR, has undertaken assessments on potentially commercial bycatch species (i.e. grey rockcod (*Lepidonotothen squamifrons*) and unicorn icefish (*Channichthys rhinoceratus)*) based on the results of random stratified trawl surveys. Based on these assessments, bycatch limits have been set even though they are presently non-target species. CCAMLR has also agreed to apply a general precautionary catch limit for other non-target species for which no assessment has been undertaken.<br><br>The status and management of the fisheries is reviewed annually by the Scientific Committee and its specialist working groups using the best available science and information, including detailed data from the fisheries and fishery surveys, and the CCAMLR Scheme of International Scientific Observation. |
| **Other initatives or agreements** | *State, national or international conventions or agreements that impact on the management of the fishery/sub-fishery being evaluated.*<br><br>The declaration and ongoing management of the Heard Island and McDonald Islands (HIMI) Marine Reserve contributes to the implementation of several international conservation agreements, including:<br><br>• World Heritage Convention<br>• Ramsar Wetlands Convention<br>• Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention)<br>• China/Australia Migratory Birds Agreement (CAMBA)<br>• Japan/Australia Migratory Birds Agreement (JAMBA)<br>• Australia/France Treaty on Maritime Cooperation<br>• France/Australia Agreement on Cooperative Enforcement Laws<br>• Convention on Biological Diversity<br>• Agreement on the Conservation of Albatrosses and Petrels (ACAP)<br>• Convention on the Conservation of Antarctic Marine Living Resources<br>• International Convention for the Prevention of Pollution from Ships (MARPOL)<br>• Convention on the International Trade in Endangered Species (CITES) |

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| | • International Convention for the Regulation of Whaling<br>• United Nations Convention on the Law of the Sea (UNCLOS)<br><br>Source: HIMI Marine Reserve Management Plan 2014-2024 (Commonwealth of Australia, 2014) |
| **Data** | |
| **Logbook data** | *Verified logbook data; data summaries describe programme*<br><br>All Australian operators are required to complete electronic shot by shot catch and effort logbooks with total coverage, including details of interactions with marine mammals and seabirds. The vessel's master is required to record an estimated weight of each species caught in each fishing operation. Data verified through observer program and catch documentation scheme.<br><br>Under the Fisheries Management Act 1991, the General Conditions 2014/15 require that the SFR holder to complete:<br><br>• CCAMLR data form C1v2015b: electronic fine-scale catch and effort data for trawl fisheries.<br>• CCAMLR data form CEv2014b: daily, 5-day, 10-day, monthly catch and effort report<br>• ANT04-VG (electronic logbook Antartic waters and for trawl vessels and gear details log)<br>• ANT02-LF: Antarctic waters length frequency log.<br><br>CCAMLR publish catch statistics for all Antarctic fisheries in their jurisdiction annually in the Statistical Bulletin series.<br><br>Source: Heard Island and McDonald Islands Management Plan 2002 (AFMA 2016a) |
| **Observer data** | *Objective observer programme; describe parameters, how many years run; coverage – random or full coverage; comments on interactions with species; observer training, species identification, and length of service; data summaries*<br><br>The purpose of the Observer Program is to "provide fisheries managers, research organizations, environmental agencies, the fishing industry and the wider community with independent, reliable, verified and accurate information on the fishing catch, effort and practice of a wide range of boats operating inside, and periodically outside, the Australian Fishing Zone" (AFMA http://www.afma.gov.au/fisheries-services/observer-services/: accessed 29 June 2016).<br><br>AFMA observers are highly experienced in fishery observer work in Australia. They:<br><br>• collect data on independent boat activity and catch data (not recorded in official logbooks)<br>• collect data and samples for research programs, supporting marine management and other issues relevant to environmental awareness and fisheries management and<br>• monitor compliance of the boat with its fishing concession.<br><br>Observer data is collated in AFMA's centralised database and data have been made available outside AFMA in the form of observer trip reports and as raw data.<br><br>There are two observers present on all fishing trips to HIMI. Each observer carries out 12 hour shifts, so that an observer is on shift during all fishing operations. All wildlife interactions are also monitored. Observer data are maintained by AAD and a copy held by AFMA. |

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| **Other data** | *Studies, surveys*<br><br>**Surveys:** Random Stratified Trawl Surveys (RSTS) have been conducted annually since 1998 to assess the juvenile stocks of Patagonian toothfish and mackerel icefish in the HIMI Fishery. The information collected on the population structure and abundance of Patagonian toothfish and mackerel icefish during these surveys is a critical input to stock assessments of these species, the last one being in 2016.<br><br>Fishing Vessels participated in the 8-year benthic camera project for the AAD. This now completed project was designed to assess if fishing operations are negatively impacting the seabed (Welsford et al. 2014).<br><br>The HIMI mackerel icefish Fishery is certified by the Marine Stewardship Council (MSC). As part of this certification, a consulting company (SCSglobal) undertakes annual surveillance audits to check if both target species continues to comply with the MSC Requirements for Continued Certification. Annual reports are made available to the public and summarise the current status of the fishery based on recent documentation received.<br><br>**Ageing programs (AAD):** There is no ageing program for mackerel icefish.<br><br>**Tagging program(s):** There is no tagging program for mackerel icefish.<br><br>**International scientific collaborations:** Australian and French scientists have been closely cooperating on complementary research on Kerguelen Plateau including on toothfish. There is a formal data sharing agreement between Australia and France signed in 2013. A joint meeting of scientists from Australia and France was held in May 2008, with a follow up workshop in May 2009, a symposium in April 2010 which focussed on marine ecosystems and fisheries, and a further workshop in June 2011 aimed at progressing work on toothfish and on Marine Protected Areas. The 2010 symposium resulted in a published document: The Kerguelen Plateau Marine Ecosystems and Fisheries, edited by Guy Duhamel and Dirk Welsford. Cooperative work has continued between Australia and France with a focus on improving toothfish assessments and other aspects of the fisheries and ecosystem in the Kerguelen region. |

### 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**

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| Key commercial and secondary species: | 1 key commercial species |
| Byproduct and bycatch species: | 1 byproduct; 12 bycatch |
| Protected species: | 8 |
| Habitats: | 1 pelagic |
| Communities: | 2 (1 demersal; 1 pelagic) |

## Scoping Document S2A. Species

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

**Key commercial/secondary commercial species for the Heard Island and McDonald Islands midwater trawl sub-fishery**

- *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.

**Table 2.3. Key commercial (C1) and secondary commercial (C2) species list for the HIMI midwater trawl sub-fishery.**

| ERA species ID | Role in fishery | Taxa name | Family name | CAAB code | Scientific name | Common name | Source |
|---|---|---|---|---|---|---|---|
| | C1 | Teleost | Channichthyidae | 37407791 | *Champsocephalus gunnari* | Mackerel icefish | AFMA |

**Byproduct species for the Heard Island and McDonald Islands midwater trawl sub-fishery**

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.

Table 2.4. Byproduct (BP) species list for the HIMI midwater trawl sub-fishery.

| ERA species ID | Role in fishery | Taxa name | Family name | CAAB code | Scientific name | Common name | Source(s) |
|---|---|---|---|---|---|---|---|
| | BP | Teleost | Nototheniidae | 37404792 | *Dissostichus eleginoides* | Patagonian toothfish | AFMA |

**Bycatch (discard) species for the Heard Island and McDonald Islands midwater trawl sub-fishery**

**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 effected) 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. Bycatch species are divided, for management purposes, into:

- *General bycatch species* (i.e. species of fish, sharks, invertebrates, etc. that are never retained for sale).

The initial list was obtained by AFMA which was subsequently reviewed using Commonwealth Logbooks and Observer data extracts and fisheries literature. Protected species were excluded. The total bycatch was 6.8% of total catch (mostly teleosts and chondrichthyans). The invertebrate bycatch comprised 0.66% of total catch the majority being medusa, and none of these groups were expanded.

Table 2.5. Bycatch (BC) species list for the HIMI midwater trawl sub-fishery.

| ERA species ID | Role in fishery | Taxa name | Family name | CAAB code | Scientific name | Common name | Source(s)^ |
|---|---|---|---|---|---|---|---|
| | BC | Chondrichthyan | Rajidae | 37031048 | *Bathyraja murrayi* | Murray's skate | AFMA; Logbook; Observer data |

| ERA species ID | Role in fishery | Taxa name | Family name | CAAB code | Scientific name | Common name | Source(s)^ |
|---|---|---|---|---|---|---|---|
| | BC | Chondrichthyan | Rajidae | 37031750 | *Bathyraja eatonii* | Eaton's skate | AFMA; Logbook; Observer data |
| | BC | Teleost | Macrouridae | 37232753 | *Macrourus whitsoni* | Whitson's grenadier | AFMA; Logbook; Observer data |
| | BC | Teleost | Channichthyidae | 37407792 | *Channichthys rhinoceratus* | Unicorn icefish | Observer data |
| | BC | Teleost | Nototheniidae | 37404793 | *Lepidonotothen squamifrons* | Grey rockcod | AFMA; Logbook; Observer data |
| | BC | Teleost | Nototheniidae | - | *Notothenia (Gobionotothen) acuta* | Triangular rockcod | AFMA; Logbook; Observer data |
| | BC | Invertebrate | | 14410000 | Actiniaria | Sea anemones | AFMA; logbook; Observer data |
| | BC | Invertebrate | | 25102000 | Asteroidea | Seastars | AFMA; logbook; Observer data |
| | BC | Invertebrate | | 23650000 | Octopodidae | Octopus | AFMA; logbook; Observer data |
| | BC | Invertebrate | | 23615000 | Teuthoidea - undifferentiated | Squid unidentified | AFMA; logbook; Observer data |
| | BC | Teleost | Myctophidae | 37122104 | Myctophidae | Lanternfishes | AFMA; logbook; Observer data |
| | BC | Invertebrate | Cnidaria | 11000000 | Hydrozoa | Medusae | Observer data |

**Protected species for the Heard Island and McDonald Islands midwater trawl sub-fishery**

A protected species[2] refers to all species listed/covered under the EPBC Act 1999, which include Protected[3] 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 has been generated using the Department of Environment and Eneregy home page **http://www.environment.gov.au/** as well as by reviewing all available fishery literature. Species considered to have potential to interact with fishery (based on geographic range & proven/perceived susceptibility to the fishing gear/methods and examples from other similar fisheries across the globe) should also be included. Highlighted in red are protected species that have interacted in the HIMI.

**Table 2.6. Protected species (PS) list for the HIMI midwater trawl sub-fishery. Obs-WI: Observer wildlife interactions; Obs-WO: Observer wildlife obseravtions.**

| ERA species ID | Role in fishery | Taxa | Family name | CAAB code | Scientific name | Common name | Source(s) |
|---|---|---|---|---|---|---|---|
| | PS | Marine mammal | Phocidae | 41136001 | *Hydrurga leptonyx* | Leopard seal | Expanded from Seals; Obs-WI |
| | PS | Marine mammal | Phocidae | 41136002 | *Leptonychotes weddelli* | Weddell seal | Expanded from Seals; Obs-WI |
| | PS | Marine mammal | Phocidae | 41136003 | *Lobodon carcinophagus* | Crabeater seal | Expanded from Seals; Obs-WI |
| | PS | Marine mammal | Phocidae | 41136004 | *Mirounga leonina* | Elephant seal | Expanded from Seals; Obs-WI |

[2] 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.

[3] 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).

| ERA species ID | Role in fishery | Taxa | Family name | CAAB code | Scientific name | Common name | Source(s) |
|---|---|---|---|---|---|---|---|
| | PS | Marine mammal | Phocidae | 41136005 | *Ommatophoca rossii* | Ross seal | Expanded from Seals; Obs-WI |
| | PS | Marine mammal | Otariidae | 41131002 | *Arctocephalus gazella* | Antarctic fur seal | Expanded from Seals; Obs-WI |
| | PS | Marine mammal | Otariidae | 41131004 | *Arctocephalus tropicalis* | Subantarctic fur seal | Expanded from Seals; Obs-WI |
| | PS | Chondrichthyan | Lamnidae | 37010004 | *Lamna nasus* | Porbeagle shark | Observer |
| **Observed, not interacted** | | | | | | | |
| | PS | Marine bird | Diomedeidae | 40040006 | *Diomedea exulans* | Wandering albatross | AFMA; Obs-WO |
| | PS | Marine bird | Diomedeidae | 40040007 | *Thalassarche melanophrys* | Black-browed albatross | AFMA; Obs-WO |
| | PS | Marine bird | Hydrobatidae | 40042002 | *Fregetta tropica* | Black-bellied storm-petrel | Expanded from Storm petrel; Obs-WO |
| | PS | Marine bird | Hydrobatidae | 40042003 | *Garrodia nereis* | Grey-backed storm petrel | Expanded from Storm petrel; Obs-WO |
| | PS | Marine bird | Hydrobatidae | 40042004 | *Oceanites oceanicus* | Wilson's storm petrel (subantarctic) | Expanded from Storm petrel; Obs-WO |
| | PS | Marine bird | Procellariidae | 40041003 | *Daption capense* | Cape petrel | AFMA; Obs-WO |
| | PS | Marine bird | Procellariidae | 40041004 | *Fulmarus glacialoides* | Southern fulmar | AFMA; Obs-WO |
| | PS | Marine bird | Procellariidae | 40041007 | *Macronectes giganteus* | Southern giant petrel | Expanded from Giant petrels; Obs-WO |
| | PS | Marine bird | Procellariidae | 40041008 | *Macronectes halli* | Northern giant petrel | Expanded from Giant petrels; Obs-WO |
| | PS | Marine bird | Procellariidae | 40041010 | *Pachyptila* crassirostris | Fulmar prion | Expanded from Prion; Obs-WO |
| | PS | Marine bird | Procellariidae | 40041011 | *Pachyptila desolata* | Antarctic prion | Expanded from Prion; Obs-WO |
| | PS | Marine bird | Procellariidae | 40041018 | *Procellaria aequinoctialis* | White-chinned petrel | AFMA; Obs-WO |
| | PS | Marine bird | Procellariidae | 40041048 | *Thalassoica antarctica* | Antarctic petrel | AFMA; Obs-WO |

## Scoping Document S2B1. Benthic Habitats

Risk assessment for benthic habitats considers both the seafloor structure and its attached invertebrate fauna. A comprehensive assessment of the vulnerability of benthic habitats to impact by demersal fishing gear has been undertaken in the HIMI and surrounding Southern Ocean (Welsford *et al.* 2014). Consequently, at SARAG's September 2016 meeting, it was greed that to avoid duplication and benthic habitats will not be assessed further.

**Table 2.7. Benthic habitats that occur within the jurisdictional boundary of the HIMI Fishery. Shading denotes habitats over which no effort occurs.**

| ERAEF record No. | ERAEF Habitat Number | Sub-biome | Feature | Habitat type | Depth (m) |
|---|---|---|---|---|---|
| | | | | | |

## Scoping Document S2B2. Pelagic Habitats

**Table 2.8. Pelagic habitats for the HIMI midwater trawl sub-fishery. Shading denotes habitats occurring within the jurisdictional boundary of the fishery that are not subject to effort from midwater trawl methods. Bolded text refers to pelagic habitats where fishing effort has has occurred.**

| ERAEF Pelagic Habitat No. | Pelagic Habitat type | Depth (m) | Comments | Source |
|---|---|---|---|---|
| **P1** | Eastern Pelagic Province - Coastal | 0 – 200 | | ERA pelagic habitat database based on pelagic communities definitions |
| **P2** | Eastern Pelagic Province - Oceanic | 0 – > 600 | this is a compilation of the range covered by Oceanic Community (1) and (2) | ERA pelagic habitat database based on pelagic communities definitions |
| **P3** | Heard/ McDonald Islands Pelagic Provinces - Oceanic | 0 - >1000 | this is a compilation of the range covered by Oceanic Community (1) and (2) | ERA pelagic habitat database based on pelagic communities definitions |

| ERAEF Pelagic Habitat No. | Pelagic Habitat type | Depth (m) | Comments | Source |
|---|---|---|---|---|
| **P4** | North Eastern Pelagic Province - Oceanic | 0 – > 600 | this is a compilation of the range covered by Oceanic Community (1) and (2) | ERA pelagic habitat database based on pelagic communities definitions |
| **P5** | Northern Pelagic Province - Coastal | 0 – 200 | | ERA pelagic habitat database based on pelagic communities definitions |
| **P6** | North Western Pelagic Province - Oceanic | 0 – > 800 | this is a compilation of the range covered by Oceanic Community (1) and (2) | ERA pelagic habitat database based on pelagic communities definitions |
| **P7** | Southern Pelagic Province - Coastal | 0 – 200 | this is a compilation of the range covered by Coastal pelagic Tas and GAB | ERA pelagic habitat database based on pelagic communities definitions |
| **P8** | Southern Pelagic Province - Oceanic | 0 – > 600 | this is a compilation of the range covered by Oceanic Communities (1, 2 and 3) | ERA pelagic habitat database based on pelagic communities definitions |
| **P9** | Southern Pelagic Province - Seamount Oceanic | 0 – > 600 | this is a compilation of the range covered by Seamount Oceanic Communities (1), (2), and (3) | ERA pelagic habitat database based on pelagic communities definitions |
| **P10** | Western Pelagic Province - Coastal | 0 – 200 | | ERA pelagic habitat database based on pelagic communities definitions |
| **P11** | Western Pelagic Province - Oceanic | 0 – > 400 | this is a compilation of the range covered by Oceanic Community (1) and (2) | ERA pelagic habitat database based on pelagic communities definitions |
| **P12** | Eastern Pelagic Province - Seamount Oceanic | 0 – > 600 | this is a compilation of the range covered by Seamount Oceanic Communities (1) and (2) | ERA pelagic habitat database based on pelagic communities definitions |
| **P13** | Heard/ McDonald Islands Pelagic Provinces - Plateau | 0 -1000 | this is a the same as community Heard Plateau 0-1000m | ERA pelagic habitat database based on pelagic communities definitions |
| **P14** | North Eastern Pelagic Province - Coastal | 0 – 200 | | ERA pelagic habitat database based on pelagic communities definitions |

| ERAEF Pelagic Habitat No. | Pelagic Habitat type | Depth (m) | Comments | Source |
|---|---|---|---|---|
| **P15** | North Eastern Pelagic Province - Plateau | 0 – > 600 | this is a compilation of the range covered by the Northeastern Seamount Oceanic (1) and (2) | ERA pelagic habitat database based on pelagic communities definitions |
| **P16** | North Eastern Pelagic Province - Seamount Oceanic | 0 – > 600 | | ERA pelagic habitat database based on pelagic communities definitions |
| **P17** | Macquarie Island Pelagic Province - Oceanic | 0 – 250 | | ERA pelagic habitat database based on pelagic communities definitions |
| **P18** | Macquarie Island Pelagic Province - Coastal | 0 - > 1500 | this is a compilation of the range covered by Oceanic Community (1) and (2) | ERA pelagic habitat database based on pelagic communities definitions |

## Scoping Document S2C1. Demersal Communities

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

**Table 2.9. Demersal communities that underlie the pelagic communities in which fishing activity can occur in the HIMI fishery (x). Shaded cells indicate all communities within the province. Bold crosses refer to communities that underlie where fishing occurred in the HIMI.**

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

| Demersal community | PROVINCE | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cape | North Eastern Transition | North Eastern | Central Eastern Transition | Central Eastern | South Eastern Transition | Central Bass | Tasmanian | Western Tas Transition | Southern | South Western Transition | Central Western | Central Western Transition | North Western | North Western Transition | Timor | Timor Transition | Heard & McDonald Is | Macquarie Is |
| Seamount 0 – 110m | | | | | | | | | | | | | | | | | | | |
| Seamount 110- 250m | | | | | | | | | | | | | | | | | | | |
| Seamount 250 – 565m | | | | | | | | | | | | | | | | | | | |
| Seamount 565 – 820m | | | | | | | | | | | | | | | | | | | |
| Seamount 820 – 1100m | | | | | | | | | | | | | | | | | | | |
| Seamount 1100 – 3000m | | | | | | | | | | | | | | | | | | | |
| Plateau 0 – 110m | | | | | | | | | | | | | | | | | | | |
| Plateau 110- 250m[4] | | | | | | | | | | | | | | | | | | X | |
| Plateau 250 – 565m[4] | | | | | | | | | | | | | | | | | | | |
| Plateau 565 – 820m[5] | | | | | | | | | | | | | | | | | | | |
| Plateau 820 – 1100m[5] | | | | | | | | | | | | | | | | | | | |

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

X: The only demersal community underlying the midwater activity is the Outer Heard Plateau (100-500m).

## Scoping Document S2C2. Pelagic Communities

**Table 2.10. Pelagic communities in which fishing activity occurs in the HIMI (black; x). Shaded cells indicate all communities that exist in the province.**

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

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

X: Pelagic community in which fishing activity occurred was the Heard Plateau (0-1000 m).

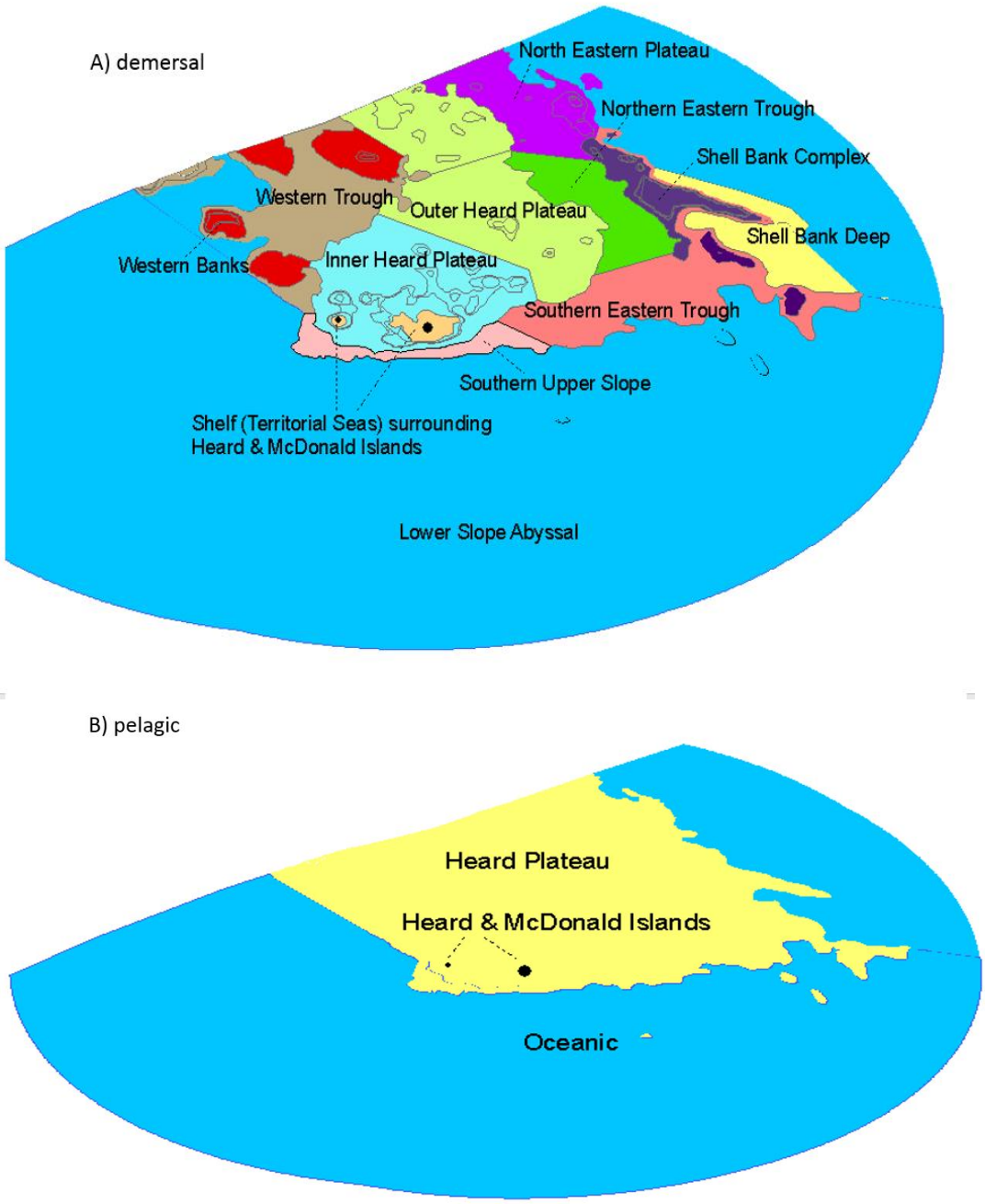


**Figure 2.1(a) Demersal and (b) pelagic communities in the Heard and McDonald Islands Fisheries.**

### 2.2.3 Identification of objectives for components and sub-components (Step 3)

Objectives are identified for each sub-fishery for the five ecological components (target, bycatch/byproduct, 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:

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

For fisheries that have completed 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; EMOs), those should be used (e.g. Strategic Assessment Reports). The objectives need not be exactly specified, with regard to numbers or fractions of removal/impact, but should indicate that an impact in the sub-component is of concern/interest to the sub-fishery. The rationale for including or discarding an operational objective is a crucial part of the table and must explain why the particular objective has or has not been selected for in the (sub) fishery. Only the operational objectives selected for inclusion in the (sub) fishery are used for Level 1 analysis (**Level 1 SICA Document L1.1**).

## Scoping Document S3. Components and sub-components identification of objectives

### Table 2.11. Components and sub-components identification of operational objectives and rationale. Operational objectives that are eliminated are shaded out. EMO: Existing Management Objective; AMO: Existing AFMA Objective

| Component | Core Objective | Sub-component | Example Operational Objectives | Example Indicators | Rationale |
|---|---|---|---|---|---|
| | *What is the general goal?* | | *"What you are specifically trying to achieve"?* | *"What you are going to use to measure performance?* | *Rationale flagged as 'EMO' where Existing Management Objective in place, or 'AMO' where there is an existing AFMA Management Objective in place for other Commonwealth fisheries (assumed that squid fishery will fall into line).* |
| Key Commercial and secondary commercial species | Avoid recruitment failure of the key/secondary commcercial species<br><br>Avoid negative consequences for species or population sub-components | 1. Population size | 1.1 No trend in biomass<br><br>1.2 Maintain biomass above a specified level<br><br>1.3 Maintain catch at specified level<br><br>1.4 Species do not approach extinction or become extinct | Biomass, numbers, density, CPUE, yield | 1.1 Increases in biomass of the key/secondary commcerical species would be acceptable.<br><br>1.2. To ensure that population at acceptable level by the assessment.<br><br>1.3. TAC levels are specified.<br><br>1.4. This is a general objective for all AFMA fisheries as per Fisheries Management Act 1991 (objective (b)).<br><br>In general these objectives underlie the sustainable management of the Fishery, for both target bait and target 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 the known distribution range | 2.1 Not currently monitored. No specific management objective based on the geographic range of key/secondary commercial species. |
| | | 3. Genetic structure | 3.1 Genetic diversity does not change outside acceptable bounds | Frequency of genotypes in the population, effective population size ($N_e$), number of spawning units | 3.1 Genetic studies have identified multiple stocks of striped marlin in Pacific Ocean. Stock assessment split by north and south Pacific Ocean. |
| | | 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<br><br>Biomass of spawners<br><br>Mean size, sex ratio | 4.1 Covered in general by 1.2 EMO and AMO.<br><br>The size range of Patagonian toothfish suggests that the fishery is not targeting recruitment or spawning grounds. |

| Component | Core Objective | Sub-component | Example Operational Objectives | Example Indicators | Rationale |
|---|---|---|---|---|---|
| | | 5. Reproductive Capacity | 5.1 Fecundity of the population does not change outside acceptable bounds (e.g. more than X% of reference population fecundity)<br>2 Recruitment to the population does not change outside acceptable bounds | Egg production of population<br>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.<br>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 behavior that are deleterious to the species and populations are to be avoided.<br>Covered by 1.2 EMO and AMO. However the possible links between the HIMI, Kerguelen and Crozet stocks and their respective degree of independence from each other require further investigation. |
| Byproduct and Bycatch | Avoid recruitment failure of the byproduct and bycatch species<br>Avoid negative consequences for species or population sub-components | 1. Population size | 1.1 No trend in biomass<br>1.2 Species do not approach extinction or become extinct<br>1.3 Maintain biomass above a specified level<br>1.4 Maintain catch at specified level | Biomass, numbers, density, CPUE, yield | 1.1 Increases in biomass of the key/secondary commcerical species would be acceptable.<br>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.<br>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. Use of 'move on provisions' to limit exploitation of bycatch stocks in localised areas.<br>1.4. This is a general objective for all AFMA fisheries as per Fisheries Management Act 1991 (objective (b)). Maintaining bycatch/byproduct levels not a specific objective. The protection of bycatch by TACs based on precautionary principles is the preferred method. "Move on provisions" are enforced if bycatch exceeds set limits. |
| | | 2. Geographic range | 2.1 Geographic range of the population, in terms of size and continuity does not change outside | Presence of population across space | 2.1 Not currently monitored. No specific management objective based on the geographic range of byproduct/bycatch species. No specific management objective based on the geographic range of bycatch/byproduct species. |

| Component | Core Objective | Sub-component | Example Operational Objectives | Example Indicators | Rationale |
|---|---|---|---|---|---|
| | | | acceptable bounds | | |
| | | 3. Genetic structure | 3.1 Genetic diversity does not change outside acceptable bounds | Frequency of genotypes in the population, effective population size ($N_e$), number of spawning units | 3.1 Not currently monitored. No reference levels established. No specific management objective based on the genetic structure of bycatch species. |
| | | 4. Age/size/sex structure | 4.1 Age/size/sex structure does not change outside acceptable bounds (e.g. more than X% from reference structure) | Biomass, numbers or relative proportion in age/size/sex classes<br>Biomass of spawners<br>Mean size, sex ratio | 4.1 |
| | | 5 Reproductive Capacity | 5.1 Fecundity of the population does not change outside acceptable bounds (e.g. more than X% of reference population fecundity)<br>Recruitment to the population does not change outside acceptable bounds | Egg production of population<br>Abundance of recruits | 5.1 Beyond the generality of the EMO "Fishing is conducted in a manner that does not threaten stocks of byproduct / bycatch species", reproductive capacity is not currently measured for bycatch/byproduct species and is largely covered by other objectives. |
| | | 6. Behaviour /Movement | 6.1 Behaviour and movement patterns of the population do not change outside acceptable bounds | Presence of population across space, movement patterns within the population (e.g. attraction to bait, lights) | 6.1 |
| Protected species | Avoid recruitment failure of protected species<br>Avoid negative consequences for protected species or population sub-components | 1. Population size | 1.1 Species do not further approach extinction or become extinct<br>1.2 No trend in biomass<br>1.3 Maintain biomass above a specified level<br>1.4 Maintain catch at specified level | Biomass, numbers, density, CPUE, yield | 1.1 EMO - The fishery is conducted in a manner that avoids mortality of, or injuries to, endangered, threatened or protected species.<br>1.2 A positive trend in biomass is desirable for protected species.<br>1.3 Maintenance of protected species biomass above specified levels not currently a fishery operational objective.<br>1.4 The above EMO states '.must avoid mortality/injury to protected species. |

| Component | Core Objective | Sub-component | Example Operational Objectives | Example Indicators | Rationale |
|---|---|---|---|---|---|
| | Avoid negative impacts on the population from fishing | 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 GAB | 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. |
| | | 3. Genetic structure | 3.1 Genetic diversity does not change outside acceptable bounds | Frequency of genotypes in the population, effective population size ($N_e$), number of spawning units | 3.1 Because population size of 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<br>Biomass of spawners<br>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)<br>Recruitment to the population does not change outside acceptable bounds | Egg production of population<br>Abundance of recruits | 5.1 The reproductive capacity of protected species is of concern to the HIMI Fishery because potential fishery induced changes in reproductive ability (e.g. reduction in prey items may critically affect seabird brooding success) may have immediate impact on the population size of 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 Survival after interactions is maximised | Survival rate of species after interactions | 7.1, 7.2, EMO – The fishery is conducted in a manner that avoids mortality of, or injuries to, endangered, threatened or protected species. Includes the prohibition on discarding offal (bycatch, fish processing waste, unwanted dead |

| Component | Core Objective | Sub-component | Example Operational Objectives | Example Indicators | Rationale |
|---|---|---|---|---|---|
| | | | 7.2 Interactions do not affect the viability of the population or its ability to recover | Number of interactions, biomass or numbers in population | fish), gear restrictions and reduced lighting levels to minimise interactions and attraction of the vessel to protected species. |
| Habitats | Avoid negative impacts on quality of environment<br><br>Avoid reduction in the amount and quality of habitat | 1. Water quality | 1.1 Water quality does not change outside acceptable bounds | Water chemistry, noise levels, debris levels, turbidity levels, pollutant concentrations, light pollution from artificial light | 1.1 EMO control the discharge or discarding of waste (fish offal) and 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, longlining operations not believed to strongly influence air quality. |
| | | 3. Substrate quality | 3.1 Sediment quality does not change outside acceptable bounds | Sediment chemistry, stability, particle size, debris, pollutant concentrations | 3.1 EMO – The fishery is conducted, in a manner that minimises the impact of fishing operations on benthic habitat The current MPA and conservation areas reserve large areas of the known habitat types from fishing disturbance. |
| | | 4. Habitat types | 4.1 Relative abundance of habitat types does not vary outside acceptable bounds | Extent and area of habitat types, % cover, spatial pattern, landscape scale | 4.1 Trawling activities is not likely to result in changes to the local habitat types on fishing grounds.<br>The current MPA and conservation areas reserve large areas of the known habitat types from fishing disturbance. |
| | | 5. Habitat structure and function | 5.1 Size, shape and condition of habitat types does not vary outside acceptable bounds | Size structure, species composition and morphology of biotic habitats | 5.1 Trawling activities may result in local disruption to pelagic and benthic processes. |
| Communities | Avoid negative impacts on the composition/function/distribution/structure of the community | 1. Species composition | 1.1 Species composition of communities does not vary outside acceptable bounds | Species presence/absence, species numbers or biomass (relative or absolute)<br>Richness<br>Diversity indices Evenness indices | 1.1 EMO – The fishery is conducted, in a manner that minimises the impact of fishing operations on the ecosystem generally. |
| | | 2. Functional group composition | 2.1 Functional group composition does not change outside acceptable bounds | Number of functional groups, species per functional group<br>(e.g. autotrophs, filter feeders, herbivores, | 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. |

| Component | Core Objective | Sub-component | Example Operational Objectives | Example Indicators | Rationale |
|---|---|---|---|---|---|
| | | | | omnivores, carnivores) | |
| | | 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 Trawling operations have unknown impacts on the benthos in the 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<br>Number of octaves, Biomass/number in each size class<br>Mean trophic level<br>Number of trophic levels | 4.1 Trawling activities 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, carbon, nitrogen, phosphorus flux | 5.1 Trawling operations not perceived to have a detectable effect on bio and geochemical cycles. |

### 2.2.4 Hazard Identification (Step 4)

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

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

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

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

## Scoping Document S4. Hazard Identification Scoring Sheet

This table is completed once for each sub-fishery. See Table 2.13 provides a set of examples of fishing activities for the effects of fishing to be used as a guide to assist in scoring the hazards.

Fishery name: Heard Island and McDonald Islands (HIMI)
Sub-fishery name: Midwater trawl
Date completed: September 2016

**Table 2.12. Hazard identification, score and rationale(s) for the HIMI midwater trawl sub-fishery.**

| Direct impact of Fishing | Fishing Activity | Score (0/1) | Documentation of Rationale |
|---|---|---|---|
| Capture | Bait collection | 0 | No baits used in trawl fishery |
| | Fishing | 1 | Occurs, resulting in capture of animals |
| | Incidental behaviour | 0 | No ports, no landings, no recreational fishing recorded. |
| Direct impact without capture | Bait collection | 0 | No baits used in trawl fishery |
| | Fishing | 1 | Capture of organisms due to gear deployment, retrieval and actual fishing. This includes organisms caught but not landed. |
| | Incidental behaviour | 0 | |
| | Gear loss | 0 | No gear lost. |
| | Anchoring/ mooring | 0 | Not recorded |
| | Navigation/steaming | 1 | Occurs throughout the fishery grounds. |
| Addition/ movement of biological material | Translocation of species | 1 | Translocation of species via ballast water or as hull or organisms fouling sea water piping systems is a potential risk. Movement of species due to movement of boats between areas of the fishery is a possibility. |
| | On board processing | 0 | Fish processed on-board but discarding of offal and unwanted bycatch prohibited within fishery jurisdiction. |
| | Discarding catch | 0 | Target and byproduct species are occasionally discarded. Bycatch species are discarded outside the fishery area, as discarding is not permitted. |
| | Stock enhancement | 0 | Does not occur in this fishery |
| | Provisioning | 0 | No bait or berley used in fishery |
| | Organic waste disposal | 0 | Disposal of certain food scraps, brassicas and poultry products prohibited, other food scraps disposed of according to MARPOL regulations. |
| Addition of non-biological material | Debris | 0 | Debris from non-fishing activities e.g. Crew rubbish – discarding regulations, plastics must be retained under MARPOL Convention. Other items (e.g. |

| | | | |
|---|---|---|---|
| | | | poultry and brassicas are incinerated and ash stored in impermeable bags in a rubbish locker located on deck. All non-burnable rubblish is bagged and retained in rubber locker and locked on deck. |
| | Chemical pollution | 0 | Possible oil spills, detergents other cleaning agents or chemicals. However, regulated by MARPOL. |
| | Exhaust | 1 | Occurs through steaming and engine operations. Types of fuels being burnt e.g.: MDO (marine diesel oils) vs HFO (heavy fuel oil). |
| | Gear loss | 0 | Major gear loss: none reported. |
| | Navigation/ steaming | 1 | Trawling operations involves navigating to and from fishing grounds. Navigation/steaming introduces noise to environment. Depth sounders/ acoustic net positioning systems have potential to disturb marine species. |
| | Activity/ presence on water | 1 | Noise and movement, visual stimuli may be a cue to some species attracting them to the vessel or a part of the fishing operation. |
| Disturb physical processes | Bait collection | 0 | No bait used in trawl fishery. |
| | Fishing | 1 | Fishing gear may disturb benthos by nets. Also, trawling unlikely to disturb/disrupt local physical water flow patterns, e.g. vertical mixing. |
| | Boat launching | 0 | Vessels operate from designated ports. |
| | Anchoring/ mooring | 0 | No records of vessels anchoring in sub-Antarctic AFZ. |
| | Navigation/ steaming | 1 | Trawling operations involves navigating to and from fishing grounds. Due to depth benthos unlikely to be affected. Wake mixing of surface waters does occur. |
| External Hazards (specify the particular example within each activity area) | Other capture fishery methods | 1 | Longline fisheries for Patagonian toothfish. Demersal trawl fishery for Patagonian toothfish and mackerel icefish. Area too remote for indigenous or recreational fishers. |
| | Aquaculture | 0 | None |
| | Coastal development | 0 | None |
| | Other extractive activities | 0 | Not known |
| | Other non-extractive activities | 0 | Not known |
| | Other anthropogenic activities | 1 | Tourist shipping and landings by tourists. Other scientific voyages. |

**Table 2.13. 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. |

| 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 (boat movements, reballasting) | 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. |

| Direct Impact of Fishing | Fishing Activity | Examples of Activities Include |
|---|---|---|
| | Debris | Non-biological material may be introduced in the form of debris from fishing vessels or mother ships. This includes debris from the fishing process: e.g. cardboard thrown over from bait boxes, straps and netting bags lost.<br>Debris from non-fishing activities can also contribute to this e.g. Crew rubbish – discarding or food scraps, plastics or other rubbish. Discarding at sea is regulated by MARPOL, which forbids the discarding of plastics. |
| | Chemical pollution | Chemicals can be introduced to water, sediment and atmosphere through: oil spills, detergents other cleaning agents, any chemicals used during processing or fishing activities. |
| | Exhaust | Exhaust can be introduced to the atmosphere and water through operation of fishing vessels |
| | Gear loss | The loss of gear will result in the addition of non-biological material, this includes hooks, line, sinkers, nets, otter boards, light sticks, buoys etc. |
| | Navigation /steaming | The navigation and steaming of vessels will introduce noise and visual stimuli into the environment.<br>Boat collisions and/or sinking of vessels.<br>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. |

| Direct Impact of Fishing | Fishing Activity | Examples of Activities Include |
|---|---|---|
| | | Impacts of boat launching that occurs within established marinas are outside the scope of this assessment. |
| | Anchoring /mooring | Anchoring/mooring may affect the physical processes in the area that anchors and anchor chains contact the seafloor. |
| | Navigation /steaming | Navigation /steaming may affect the physical processes on the benthos and the pelagic by turbulent action of propellers or wake formation. |
| External hazards | | Any outside activities that will result in an impact on the component in the same location and period that the fishery operates. The particular activity as well as the mechanism for external hazards should be specified. |
| | Other capture fishery methods | Take or habitat impact by other commercial, indigenous or recreational fisheries operating in the same region as the fishery under examination |
| | Aquaculture | Capture of feed species for aquaculture. Impacts of cages on the benthos in the region |
| | Coastal development | Sewage discharge, ocean dumping, agricultural runoff |
| | Other extractive activities | Oil and gas pipelines, drilling, seismic activity |
| | Other non-extractive activities | 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.<br>Shipping, oil spills |

### 2.2.5 Bibliography (Step 5)

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

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

- HIMI Status Assessment Report 2013
- HIMI Fishery Management Plan 2002 (amended 04/05/2016)
- HIMI Fishery Regulations 2002
- Management Plan and Regulation Guidelines
- AFMA At a glance web page http://www.afma.gov.au/fisheries/heard-island-mcdonald-island-fishery/
- Bycatch Action Plans
- Data Summary Reports (logbook and observer)

Other publications that may have provided information include

- ABARES Fishery Status Reports
- Strategic Plans

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

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

In this case, 9 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 11 activity-component scenarios will be considered at Level 1. This results in 33 total scenarios (of 160 possible) to be developed and evaluated using the unit lists (byproduct/bycatch, protected species, communities).

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

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

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

Step1: Record the hazard identification score (absence (0) presence (1) scores) identified at step 3 at the scoping level (Scoping Document S3) onto the SICA table
Step 2: Score spatial scale of the activity
Step 3: Score temporal scale of the activity
Step 4: Choose the sub-component most likely to be affected by activity
Step 5: Choose the most vulnerable unit of analysis for the component e.g. species, habitat type or community assemblage
Step 6: Select the most appropriate operational objective
Step 7: Score the intensity of the activity for that sub-component
Step 8: Score the consequence resulting from the intensity for that sub component
Step 9: Record confidence/uncertainty for the consequence scores
Step 10: Document rationale for each of the above steps
Step 11: Summary of SICA results
Step 12: Evaluation/discussion of Level 1
Step 13: Components to be examined at Level 2

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

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

### 2.3.2 Score spatial scale of activity (Step 2)

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

**Table 2.14. Spatial scale score of activity.**

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

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

### 2.3.3 Score temporal scale of activity (Step 3)

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

Table 2.15. Temporal scale score of activity.

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

It may be more logical for some activities to consider the aggregate number of days that an activity occurs. For example, if the activity "fishing" was undertaken by 10 boats during the same 150 days of the year, the score is 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 that a score of 3 is appropriate.

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

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

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

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

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

combination, and recorded in the 'unit of analysis' column of the SICA Document. The justification is recorded in the rationale column.

### 2.3.6 Select the most appropriate operational objective (Step 6)

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

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

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

**Table 2.16. Intensity score of activity (Modified from Fletcher et al. 2002).**

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

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

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

The consequence of the activity is a measure of the likelihood of not achieving the operational objective for the selected sub-component and unit of analysis. It considers the flow on effects of the direct impacts from Step 7 for the relevant indicator (e.g. decline in biomass below the selected threshold due to direct capture). Activities are scored as per consequence scores defined below. 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 (Table 2.17).

**Table 2.17. 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 key/secondary commercial species). |
| Major | 4 | Wider and longer term impacts (e.g. long-term decline in CPUE) |
| Severe | 5 | Very serious impacts now occurring, with relatively long time period likely to be needed to restore to an acceptable level (e.g. serious decline in spawning biomass limiting population increase). |
| Intolerable | 6 | Widespread and permanent/irreversible damage or loss will occur-unlikely to ever be fixed (e.g. extinction) |

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

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

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

documented. The confidence will reflect the levels of uncertainty for each score at steps 2, 3, 7 and 8 (see description; Table 2.18).

**Table 2.18. Description of Confidence scores for Consequences. The confidence score appropriate to the rationale is used, and documented on the SICA Document.**

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

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

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

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

## Level 1 (SICA) Document L1.1 Key commercial and secondary commercial species.

The direct impact of fishing hazard (i.e. Capture:Fishing) for mackerel icefish is not assessed at L1 since it undergoes a stock assessment and therefore does not go to the next level (L2).

| 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 | 2 | Population size | Mackerel icefish | 1.2 | 2 | | | Given that this species is assessed, this hazard is not assessed at L1 and negates the need for the next Level (L2) analysis. |
| | Incidental behaviour | 0 | | | | | | | | | |
| **Direct impact without capture** | Bait collection | 0 | | | | | | | | | |
| | Fishing | 1 | 3 | 2 | Population size | Mackerel icefish | 1.2 | 2 | 2 | 2 | Population size of mackerel icefish most likely to be affected before other sub-components if fish escaping from net have reduced survival rates. However, mesh sizes prescribed to allow 75% escapement to ensure stock maintenance and food supply for foraging birds. Intensity: minor because occurring irregularly in localised area. Consequence: minor overall catches very variable due to variability in recruitment. TAC levels being annually reviewed and adjusted to maintain fishery and 75 % escapement prescription. Confidence: high 100% observer coverage and research conducted in the fishery to date. |
| | Incidental behaviour | 0 | | | | | | | | | |

| Direct impact of fishing | Fishing Activity | Presence (1) Absence (0) | Spatial scale of Hazard (1-6) | Temporal scale of Hazard (1-6) | Sub-component | Unit of analysis | Operational objective (S2.1) | Intensity Score (1-6) | Consequence Score (1-6) | Confidence Score (1-2) | Rationale |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gear loss | 0 | | | | | | | | | |
| | Anchoring/ mooring | 0 | | | | | | | | | |
| | Navigation/ steaming | 1 | 3 | 2 | Population size | Mackerel icefish | 1.2 | 1 | 1 | 2 | Navigation/steaming occurred up to 10 days over the 2013/14 fishing season. Population size most likely to be affected by collision of fish with vessel. Intensity: negligible depth of icefish preclude collision with vessel. Consequence: negligible. Confidence: high logic would indicate minimal impact. |
| **Addition/ movement of biological material** | Translocation of species | 1 | 3 | 2 | Population size | Mackerel icefish | 1.2 | 1 | 2 | 1 | Translocation of species could occur via ballast, hull fouling. Population size most likely to be affected before major changes in geographic range or genetic structure. Intensity: negligible because the likelihood of temperate water species surviving and establishing as a threat to Mackerel icefish in sub-antarctic waters is considered negligible. However, consequence scored as minor due to the potential for the spread of fishborne disease. Confidence: low due absence of data on susceptability of Mackerel icefish to fishborne diseases. |
| | On board processing | 0 | | | | | | | | | |
| | Discarding catch | 0 | | | | | | | | | |
| | Stock enhancement | 0 | | | | | | | | | |
| | Provisioning | 0 | | | | | | | | | |
| | Organic waste disposal | 0 | | | | | | | | | |
| **Addition of non-biological material** | Debris | 0 | | | | | | | | | |
| | Chemical pollution | 0 | | | | | | | | | |
| | Exhaust | 1 | 3 | 2 | Population size | Mackerel icefish | 1.2 | 1 | 1 | 2 | Fishing therefore exhaust emissions occurred up to 10 days during 2013/14. Intensity and consequence are both scored as negligible. The limited number of vessels in the fishery coupled with the depth at which target species are found makes it highly unlikely that exhaust gas emissions will have an affect on the target species. Further weather conditions in the region are frequently extreme, rapidly dispersing exhaust emissions. Confidence: high due to depth of water column separating target species from emissions. |
| | Gear loss | 0 | 0 | 0 | | | | | | | |

| Direct impact of fishing | Fishing Activity | Presence (1) Absence (0) | Spatial scale of Hazard (1-6) | Temporal scale of Hazard (1-6) | Sub-component | Unit of analysis | Operational objective (S2.1) | Intensity Score (1-6) | Consequence Score (1-6) | Confidence Score (1-2) | Rationale |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Navigation/ steaming | 1 | 3 | 2 | Behaviour/movement | Mackerel icefish | 6.1 | 1 | 1 | 2 | Navigation/steaming introduces noise from engines and sounders electronic equipment which may affect behaviour of fish. Intensity: negligible due to the limited number of vessels in the fishery. Consequence: negligible, as only a small area is affected and target species mobility and depth locations seen as mitigating factors. Confidence: high, logical consideration. |
| | Activity/ presence on water | 1 | 3 | 2 | Behaviour/movement | Mackerel icefish | 6.1 | 1 | 1 | 2 | Behaviour of Mackerel icefish could be affected by presence of vessel by attraction or repulsion. Intensity: negligible due to the limited number of vessels in the fishery. Consequence: negligible as only a small area is affected temporarily and target species mobility and depth locations seen as mitigating factors. Confidence: high, logical consideration. |
| **Disturb physical processes** | Bait collection | 0 | | | | | | | | | |
| | Fishing | 1 | 3 | 2 | Behaviour/movement | Mackerel icefish | 6.1 | 1 | 1 | 2 | Mackerel icefish as a mid-water/pelagic species most likely to be affected by disturbance of water column. Intensity: negligible as disturbance to the water column is a frequent event in the Southern Ocean. Consequence: negligible. Only a small area is affected. Separating trawl disturbance from the effects of wind mixing in the Southern Ocean would not be possible. Confidence: recorded as high due to constraints imposed by logical consideration. |
| | Boat launching | 0 | | | | | | | | | |
| | Anchoring/ mooring | 0 | | | | | | | | | |
| | Navigation/ steaming | 1 | 3 | 2 | Behaviour/movement | Mackerel icefish | 6.1 | 1 | 1 | 2 | Mackerel icefish can be affected by wake mixing. Intensity: negligible due to the limited number of vessels in the fishery and disturbance to the water column is a frequent event in the Southern Ocean. Consequence: negligible, as only a small area is affected, and unable to detect against natural variation. Confidence: high, logical consideration. |
| **External Impacts** | Other fisheries: HIMI demersal trawl | 1 | 4 | 3 | Population size | Mackerel icefish | 1.2 | 3 | 3 | 2 | Demersal trawling catches mackerel icefish in larger numbers than midwater trawling. Intensity: moderate. Consequence: moderate as TACs limit catches to sustainable level of impact. Confidence: high (observers present on all fishing trips). |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Aquaculture | 0 | | | | | | | | | |
| | Coastal development | 0 | | | | | | | | | |
| | Other extractive activities | 0 | | | | | | | | | |
| | Other non extractive activities | 0 | | | | | | | | | |
| | Other anthropogenic activities | 1 | 3 | 2 | Behaviour/movement | Mackerel icefish | 6.1 | 2 | 1 | 2 | Research and tourism and the passage of research/tourist vessels. Intensity: minor due to the limited number of vessels/visits/groups per year. Consequence: is seen as negligible, as only a small area is affected and target species mobility and depth locations seen as mitigating factors. Confidence: high, due to data regarding numbers and activities indicates target species not at risk. |

## 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 | 0 | 0 | | | | | | | |
| | Fishing | 1 | 3 | 2 | Population size | Unicorn icefish | 1.3 | 2 | 2 | 2 | Midwater trawling occurred in a small area on the southern outer Heard Plateau (~25nm x 25nm). Fishing occured ~ 10 days (CCAMLR) or ~ 4 days (AFMA logbook) during 2013/14 fishing season. This correspnds to 1-2 days per year over the 2010/11 - 2014/15 period. Population size most likely to be affected before other sub-components as more unicorn icefish (~1 t) was caught compared to other bycatch species. Intensity: minor because occurring irregularly in localised area. Consequence: moderate as bycatch levels being monitored and annually reviewed. Confidence: high due data collection by observers and research conducted in the fishery to date. |
| | Incidental behaviour | 0 | 0 | 0 | | | | | | | |
| **Direct impact without capture** | Bait collection | 0 | 0 | 0 | | | | | | | |
| | Fishing | 1 | 3 | 2 | Population size | Unicorn icefish | 1.3 | 2 | 2 | 2 | Population size most likely to be affected before other sub-components by post-capture survival being affected. Intensity: minor because fising occurring irregularly in localised area and bycatch low. Consequence: minor. Confidence: high, based on data collected by observers and bycatch levels being monitored and annually reviewed. |
| | Incidental behaviour | 0 | 0 | 0 | | | | | | | |
| | Gear loss | 0 | 0 | 0 | | | | | | | |
| | Anchoring/ mooring | 0 | 0 | 0 | | | | | | | |

| 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 | 2 | Behaviour/movement | Unicorn icefish | 6.1 | 1 | 1 | 2 | Population size could be affected by collision with vessel. Intensity: negligible as thought unlikely to occur. Consequence: negligible. Confidence: high. Logical constraints would suggest impact is minimal. |
| **Addition/ movement of biological material** | Translocation of species | 1 | 3 | 2 | Population size | Unicorn icefish | 1.3 | 1 | 2 | 1 | Translocation of species could occur via ballast, hull fouling. Population size most likely to be affected before major changes in geographic range or genetic structure. Intensity: negligible because the likelihood of temperate water species surviving and establishing as a threat to fish in sub-antarctic waters is considered negligible. However consequence scored as minor due to the potential for the spread of fishborne disease. Confidence: low due absence of data on susceptability of species to fishborne diseases. |
| | On board processing | 0 | 0 | 0 | | | | | | | |
| | Discarding catch | 0 | 0 | 0 | | | | | | | |
| | Stock enhancement | 0 | 0 | 0 | | | | | | | |
| | Provisioning | 0 | 0 | 0 | | | | | | | |
| | Organic waste disposal | 0 | | | | | | | | | |
| **Addition of non-biological material** | Debris | 0 | | | | | | | | | |
| | Chemical pollution | 0 | | | | | | | | | |
| | Exhaust | 1 | 3 | 2 | Population size | Unicorn icefish | 1.3 | 1 | 1 | 2 | Exhaust emissions during fishing operations occurred up to 10 days during 2013/14 fishing season. Intensity and consequence are both scored as negligible. The limited number of vessels in the fishery coupled with the depth at which target species are found makes it highly unlikely that exhaust gas emissions will have an affect on the species. Further, weather conditions in the region are frequently |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | extreme, rapidly dispersing exhaust emissions. Confidence: high due to depth of water column separating target species from emissions. |
| | Gear loss | 0 | 0 | 0 | | | | | | | |
| | Navigation/ steaming | 1 | 3 | 2 | Behaviour/movement | Unicorn icefish | 6.1 | 1 | 1 | 2 | Navigation/steaming introduces noise from engines and sounders electronic euipment which may affect behaviour of fish. Intensity: negligible due to the limited number of vessels in the fishery. Consequence: negligible, as only a small area is affected and this species mobility and depth locations seen as mitigating factors. Confidence high, logical consideration. |
| | Activity/ presence on water | 1 | 3 | 2 | Behaviour/movement | Unicorn icefish | 6.1 | 1 | 1 | 2 | Behaviour of this species could be affected by presence of vessel by attraction or repulsion. Intensity: negligible due to the limited number of vessels in the fishery. Consequence: negligible as only a small area is affected temporarily and this species mobility and depth locations seen as mitigating factors. Confidence high, logical consideration. |
| **Disturb physical processes** | Bait collection | 0 | 0 | 0 | | | | | | | |
| | Fishing | 1 | 3 | 2 | Behaviour/movement | Unicorn icefish | 6.1 | 1 | 1 | 2 | Unicorn icefish may be affected by mixing effects of water through nets. Intensity: negligible as disturbance to the water column is a frequent event in the Southern Ocean. Consequence: negligible. Only a small area is affected. Separating trawl disturbance from the effects of wind mixing in the Southern Ocean would not be possible. Confidence: high due to constraints imposed by logical consideration. |
| | Boat launching | 0 | 0 | 0 | | | | | | | |
| | Anchoring/ mooring | 0 | 0 | 0 | | | | | | | |

| Direct impact of fishing | Fishing Activity | Presence (1) Absence (0) | Spatial scale of Hazard (1-6) | Temporal scale of Hazard (1-6) | Sub-component | Unit of analysis | Operational objective (S2.1) | Intensity Score (1-6) | Consequence Score (1-6) | Confidence Score (1-2) | Rationale |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Navigation/steaming | 1 | 3 | 2 | Behaviour/movement | Unicorn icefish | 6.1 | 1 | 1 | 2 | Unicorn icefish can be affected by wake mixing. Intensity: negligible as disturbance to the water column is a frequent event in the Southern Ocean. Consequence: negligible. Only a small area is affected. Separating wake mixing from the effects of wind mixing in the Southern Ocean would not be possible. Confidence: high due to constraints imposed by logical consideration. |
| **External Impacts** | Other fisheries: HIMI demersal trawl | 1 | 3 | 2 | Population size | Unicorn icefish | 1.3 | 3 | 2 | 2 | Some demersal trawling in similar areas to midwater trawling and also adjacent might also capture unicorn icefish. Intensity: moderate. Consequence: minor as bycatch limits are applied, and an average of ~10 t caught per year over the five year period. Confidence: high (observers present on all fishing trips and logbook data). |
| | Aquaculture | 0 | 0 | 0 | | | | | | | |
| | Coastal development | 0 | 0 | 0 | | | | | | | |
| | Other extractive activities | 0 | 0 | 0 | | | | | | | |
| | Other non-extractive activities | 0 | 0 | 0 | | | | | | | |
| | Other anthropogenic activities | 1 | 3 | 2 | Behaviour/movement | Unicorn icefish | 6.1 | 2 | 1 | 2 | Research and tourism and the passage of research/tourist vessels. Intensity: minor due to the limited number of vessels/visits/groups per year. Consequence: negligible as only a small area is affected and species mobility and midwater habit seen as mitigating factors. Confidence: high due to data regarding numbers and activities. |

## 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 | 0 | 0 | | | | | | | |
| | Fishing | 1 | 3 | 2 | Population size | Porbeagle shark | 1.1 | 2 | 1 | 2 | Midwater trawling occurs in a small area on the southern outer Heard Plateau (~25nm x25nm). Fishing has occurred up to 10 days during the 2013/14 season. Population size of the Porbeagle most likely to be affected before other sub-components since it is listed as migratory under the EPBC Act 1999, is long lived and has low fecundity. The population status is unknown. Only one porbeagle caught in midwater trawling operations in the season. Intensity: minor because midwater trawling occurring irregularly in localised area. Consequence: negligible. Confidence: high due data collection by observers and research conducted in the fishery to date. |
| | Incidental behaviour | 0 | 0 | 0 | | | | | | | |
| **Direct impact without capture** | Bait collection | 0 | 0 | 0 | | | | | | | |
| | Fishing | 1 | 3 | 2 | Population size | Porbeagle shark | 1.1 | 2 | 1 | 2 | Mitigating factors including reduced lighting, bans on net-sonde cables, removal of protruding wires and now night setting of trawls are applied. Population size most likely to be affected before other sub-components. Population status is unknown. Intensity: minor because trawling occurring irregularly in localised area. Consequence: negligible as shark mortality appear to be unaltered. Confidence: high due data collection by observers and research conducted in the fishery to date. |
| | Incidental behaviour | 0 | 0 | 0 | | | | | | | |
| | Gear loss | 0 | 0 | 0 | | | | | | | |
| | Anchoring/ mooring | 0 | 0 | 0 | | | | | | | |

| Direct impact of fishing | Fishing Activity | Presence (1) Absence (0) | Spatial scale of Hazard (1-6) | Temporal scale of Hazard (1-6) | Sub-component | Unit of analysis | Operational objective (S2.1) | Intensity Score (1-6) | Consequence Score (1-6) | Confidence Score (1-2) | Rationale |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Navigation/steaming | 1 | 3 | 2 | Population size | Porbeagle shark | 1.1 | 2 | 1 | 2 | Population size most likely to be affected before other sub-components. Only one porbeagle has interacted, which was injured. Intensity: minor. Consequence: negligible. Confidence: high due data collection by observers and research conducted in the fishery to date. |
| **Addition/ movement of biological material** | Translocation of species | 1 | 3 | 2 | Population size | Porbeagle shark | 1.1 | 1 | 1 | 1 | Translocation of species could occur via ballast, hull fouling. Population size most likely to be affected before major changes in geographic range or genetic structure. Intensity: negligible because the likelihood of temperate water species surviving and establishing as a threat to fish in sub-antarctic waters is considered negligible. However, consequence scored as negligible due to the potential for the spread of disease. Confidence: low due absence of data on susceptibility of species to fishborne diseases. The potential for the spread of disease deserves future consideration. The ban on discharge of poultry products is a mitigating factor. |
| | On board processing | 0 | 0 | 0 | | | | | | | |
| | Discarding catch | 0 | 0 | 0 | | | | | | | |
| | Stock enhancement | 0 | 0 | 0 | | | | | | | |
| | Provisioning | 0 | 0 | 0 | | | | | | | |
| | Organic waste disposal | 0 | | | | | | | | | |
| **Addition of non-biological material** | Debris | 0 | | | | | | | | | |
| | Chemical pollution | 0 | 0 | 0 | | | | | | | |

| Direct impact of fishing | Fishing Activity | Presence (1) Absence (0) | Spatial scale of Hazard (1-6) | Temporal scale of Hazard (1-6) | Sub-component | Unit of analysis | Operational objective (S2.1) | Intensity Score (1-6) | Consequence Score (1-6) | Confidence Score (1-2) | Rationale |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Exhaust | 1 | 3 | 2 | Population Size | Porbeagle shark | 1.1 | 1 | 1 | 2 | Exhaust emissions occur daily during the season. Intensity and consequences rated as negligible. The limited number of vessels in the fishery coupled with the local weather conditions makes it highly unlikely that exhaust gas emissions will have an affect on protected species. Weather conditions in the region are frequently extreme, rapidly dispersing exhaust emissions. Confidence: high, logical consideration. |
| | Gear loss | 0 | 0 | 0 | | | | | | | |
| | Navigation/ steaming | 1 | 3 | 2 | Behaviour/movement | Porbeagle shark | 1.1 | 2 | 1 | 1 | Distribution of sharks might be disturbed by noise or radio signals. Intensit: minor due to the limited number of vessels in the fishery. Consequence: negligible effects temporary and local. Confidence: low. |
| | Activity/ presence on water | 1 | 3 | 2 | Behaviour/movement | Porbeagle shark | 6.1 | 1 | 1 | 2 | Vessel present and active daily during season and may affect behaviour/movement of sharks by attracting or repelling. Intensity: negligible due to the limited number of vessels in the fishery. Consequence: negligible as any alteration to behaviour is temporary. Confidence: high due to data from the HIMI fishery on shark interactions. |
| **Disturb physical processes** | Bait collection | 0 | 0 | 0 | | | | | | | |
| | Fishing | 1 | 3 | 2 | Behaviour/movement | Porbeagle shark | 6.1 | 1 | 1 | 2 | These sharks may be affected by mixing effects of water through nets. Itensity negligible as disturbance to the water column is a frequent event in the Southern Ocean. Consequence: negligible. Only a small area is affected. Separating trawl disturbance from the effects of wind mixing in the Southern Ocean would not be possible. Confidence: high due to constraints imposed by logical consideration. |
| | Boat launching | 0 | 0 | 0 | | | | | | | |
| | Anchoring/ mooring | 0 | 0 | 0 | | | | | | | |

| Direct impact of fishing | Fishing Activity | Presence (1) Absence (0) | Spatial scale of Hazard (1-6) | Temporal scale of Hazard (1-6) | Sub-component | Unit of analysis | Operational objective (S2.1) | Intensity Score (1-6) | Consequence Score (1-6) | Confidence Score (1-2) | Rationale |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Navigation/steaming | 1 | 3 | 2 | Behaviour/movement | Porbeagle shark | 6.1 | 1 | 1 | 2 | Navigation/steaming introduces noise from engines and sounders electronic euipment which may affect behaviour of sharks. Intensity: negligible as disturbance to the water column is a frequent event in the Southern Ocean. Consequence: negligible. Only a small area is affected. Separating wake mixing from the effects of wind mixing in the Southern Ocean would not be possible. Confidence: high due to constraints imposed by logical consideration. |
| **External Impacts** | Other fisheries: HIMI demersal trawl | 1 | 3 | 2 | Population size | Porbeagle shark | 1.1 | 2 | 2 | 2 | Some demersal trawling in similar areas to midwater trawling and also adjacent areas might also impact sharks. Intensity: minor as only one porbeagle captured during fishing operations. Consequence: minor as unlikely to be detectable Confidence: high, observers present on all fishing trips |
| | Aquaculture | 0 | 0 | 0 | | | | | | | |
| | Coastal development | 0 | 0 | 0 | | | | | | | |
| | Other extractive activities | 0 | 0 | 0 | | | | | | | |
| | Other non-extractive activities | 0 | 0 | 0 | | | | | | | |
| | Other anthropogenic activities | 1 | 3 | 2 | Population size | Porbeagle shark | 1.1 | 2 | 1 | 2 | Research and tourism and the passage of research/tourist vessels occurs several times at most in a year. Population size most likely to be affected before other sub-components as some albatross numbers are critically low. Intensity: minor due to the limited number of vessels/visits/groups per year. Consequence: negligible as only a small area is affected and vessels not conducting activities likely to attract trap or injure sharks. Confidence: high as activities of these vessels/groups are generally carefully planned and monitored. |

## Level 1 (SICA) Document L1.4 - Habitat Component (pelagic)

Only impacts on pelagic habitat assessments are displayed as benthic habitats have been assessed by Welsford et al. (2014).

| Direct impact of fishing | Fishing Activity | Presence (1) Absence (0) | Spatial scale of Hazard (1-6) | Temporal scale of Hazard (1-6) | Sub-component | Unit of analysis | Operational objective (S2.1) | Intensity Score (1-6) | Consequence Score (1-6) | Confidence Score (1-2) | Rationale |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Capture** | Bait collection | 0 | 0 | 0 | | | | | | | |
| | Fishing | 1 | 3 | 2 | Habitat structure and function | Heard/ McDonald Islands Pelagic Provinces - Plateau | 5.1 | 1 | 1 | 2 | Midwater trawling occurs in a small area on the southern Heard Plateau (~25nm x 25nm). Fishing occured on 4 days (5 tows: AFMA logbook) during 2013/14 fishing season only. Mid-water trawl gear has potential to alter habitat structure and function by disrupting pelagic processes. Intensity negligible (1 tow per year). Consequence: negligible. Confidence: high, logical as water disruption epehemeral and indistinguishable from water circualation processes. |
| | Incidental behaviour | 0 | 0 | 0 | | | | | | | |
| **Direct impact without capture** | Bait collection | 0 | 0 | 0 | | | | | | | |
| | Fishing | 1 | 3 | 2 | Habitat structure and function | Benthic habitat | 5.1 | | | | Habitat assessment negate the need for assessment -no further action required |
| | Incidental behaviour | 0 | 0 | 0 | | | | | | | |
| | Gear loss | 0 | 0 | 0 | | | | | | | |
| | Anchoring/ mooring | 0 | 0 | 0 | | | | | | | |
| | Navigation/steaming | 1 | 3 | 2 | Habitat structure and function | Heard/ McDonald Islands Pelagic Provinces - Plateau | 5.1 | 1 | 1 | 2 | Mid-water trawl gear has potential to alter habitat structure and function by disrupting pelagic processes. Intensity: negligible (1 tow per year) unlikley to ditinguish between fishing disruption and normal turbulence effects on physical processes due to the depth and scale of wind mixing of pelagic waters in the Southern Ocean. Consequence negligible. Confidence: high, logical |

| Direct impact of fishing | Fishing Activity | Presence (1) Absence (0) | Spatial scale of Hazard (1-6) | Temporal scale of Hazard (1-6) | Sub-component | Unit of analysis | Operational objective (S2.1) | Intensity Score (1-6) | Consequence Score (1-6) | Confidence Score (1-2) | Rationale |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Addition/ movement of biological material** | Translocation of species | 0 | | | | | | | | | |
| | On board processing | 0 | 0 | 0 | | | | | | | |
| | Discarding catch | 0 | 0 | 0 | | | | | | | |
| | Stock enhancement | 0 | 0 | 0 | | | | | | | |
| | Provisioning | 0 | 0 | 0 | | | | | | | |
| | Organic waste disposal | 0 | 0 | 0 | | | | | | | |
| **Addition of non-biological material** | Debris | 0 | 0 | 0 | | | | | | | |
| | Chemical pollution | 0 | 0 | 0 | | | | | | | |
| | Exhaust | 1 | 3 | 2 | Air quality | Heard/ McDonald Islands Pelagic Provinces - Plateau | 2.1 | 1 | 1 | 2 | Exhaust from running engines may impact the air quality of the species within habitat (e.g. birds). Intensity: negligible, vessel present 4 days in one year. Consequence: negligible due to rapid dispersal of pollutants in winds. Confidence: high because effect of exhaust was considered to be very localised, and logical consideration. |
| | Gear loss | 0 | 0 | 0 | | | | | | | |
| | Navigation/ steaming | 1 | 3 | 2 | Water quality | Heard/ McDonald Islands Pelagic Provinces - Plateau | 1.1 | 1 | 1 | 2 | Navigation/steaming has the potential to alter water quality by introducing noise and visual stimuli to the environment. Intensity: negligible, vessel present 4 days in one year and effects of noise and visual stimuli were considered to be temporary. Consequence: negligible. Confidence: high, logical. |
| | Activity/ presence on water | 1 | 3 | 2 | Water quality | Heard/ McDonald Islands Pelagic Provinces - Plateau | 1.1 | 1 | 1 | 2 | Activity/ presence on water has the potential to alter water quality by introducing noise and visual stimuli to the environment. Intensity: negligible; vessel present only 4 days in one yearand the affect of noise was considered to be temporary. Consequence: negligible. Confidence: high, logical. |
| **Disturb physical processes** | Bait collection | 0 | 0 | 0 | | | | | | | |

| Direct impact of fishing | Fishing Activity | Presence (1) Absence (0) | Spatial scale of Hazard (1-6) | Temporal scale of Hazard (1-6) | Sub-component | Unit of analysis | Operational objective (S2.1) | Intensity Score (1-6) | Consequence Score (1-6) | Confidence Score (1-2) | Rationale |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fishing | 1 | 3 | 2 | Habitat structure and function | Benthic habitat | 5.1 | | | | Habitat assessment negate the need for assessment -no further action required |
| | Boat launching | 0 | 0 | 0 | | | | | | | |
| | Anchoring/ mooring | 0 | 0 | 0 | | | | | | | |
| | Navigation/ steaming | 1 | 3 | 2 | Habitat structure and function | Heard/ McDonald Islands Pelagic Provinces - Plateau | 5.1 | 1 | 1 | 2 | Navigation/steaming has the potential to impact habitat by disturbing physical processes by wake mixing of surface waters.Turbulence and disturbance unlikely to affect normal water column processes for long. Any disruption to these processes can therefore be expected to alter habitat function only briefly for macroscopic fauna. Intensity: negligble, vessel present only 4 days in one year. Consequence: negligible unlikley to distinguish between wake mixing of surface waters and normal turbulence effects on physical processes due to the depth and scale of wind mixing of pelagic waters in the Southern Ocean. Confidence: high, logical. |
| **External Impacts** | Other fisheries: HIMI longlining, HIMI demersal trawl | 1 | 4 | 3 | Habitat structure and function | Benthic habitat | 5.1 | | | | Habitat assessment negate the need for assessment -no further action required |
| | Aquaculture | 0 | 0 | 0 | | | | | | | |
| | Coastal development | 0 | 0 | 0 | | | | | | | |
| | Other extractive activities | 0 | 0 | 0 | | | | | | | |
| | Other non extractive activities | 0 | 0 | 0 | | | | | | | |
| | Other anthropogenic activities | 1 | 3 | 2 | Water quality | Heard/ McDonald Islands Pelagic Provinces - Plateau | 1.1 | 1 | 1 | 1 | Tourism and research vessel voyages occur over this spatial scale within the AFZ. Tourism/research vessels visit the area several times a year. Water quality thought to be most likely impacted by noise, debris pollutants, light. Intensity: negligible due to small number of trips/vessels |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | involved and MARPOL regulations controlling discharge of wastes. Consequence: negligible. Confidence: low, no data as specific operations conducted by each vessel may vary. |

## Level 1 (SICA) Document L1.5 - Community Component.

| Direct impact of fishing | Fishing Activity | Presence (1) Absence (0) | Spatial scale of Hazard (1-6) | Temporal scale of Hazard (1-6) | Sub-component | Unit of analysis | Operational objective (S2.1) | Intensity Score (1-6) | Consequence Score (1-6) | Confidence Score (1-2) | Rationale |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Capture** | Bait collection | 0 | 0 | 0 | | | | | | | |
| | Fishing | 1 | 3 | 2 | Species composition | Heard Plateau 0-1000m pelagic | 1.1 | 3 | 2 | 1 | Midwater trawling occurs in a small area on the southern outer Heard Plateau (~25nm x 25nm). Fishing occured ~ 10 days (CCAMLR) or ~ 4 days (AFMA logbook) during 2013/14 fishing season. This correspnds to 1-2 days per year over the 2010/11 - 2014/15 period. Mid-water trawl gear has potential to alter community species composition on fishing grounds. Intensity: rated as moderate as while there are limited numbers of vessels in fishery. Consequence: minor, as only a small area is affected and catch rates for midwater fishery are relatively low and variable. TAC levels for targeted and non-targeted species being annually reviewed and adjusted to maintain fishery. Escapement for icefish set for 75% to allow maintenance of food supply for predators. Whether mid-water trawling may alter pelagic community structure significantly has not been determined but possible if functional groups are removed. Confidence: low due to lack of data. |
| | Incidental behaviour | 0 | 0 | 0 | | | | | | | |
| **Direct impact without capture** | Bait collection | 0 | 0 | 0 | | | | | | | |
| | Fishing | 1 | 3 | 2 | Species composition | Heard Plateau 0-1000m pelagic | 1.1 | 3 | 2 | 1 | Mid-water trawling has potential to alter community species composition on fishing grounds by reducing survival of escaped fish. Intensity: moderate as while there are limited numbers of vessels in fishery and variable effort, specific grounds are targetted. Consequence: minor, as only a small area is affected and catch rates for midwater fishery are low and variable. TAC levels for key/secondary commercial species being annually reviewed and adjusted to maintain fishery. Escapement for icefish set for 75% to allow maintenance of food supply for predators. Whether mid-water trawling may |

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

| Direct impact of fishing | Fishing Activity | Presence (1) Absence (0) | Spatial scale of Hazard (1-6) | Temporal scale of Hazard (1-6) | Sub-component | Unit of analysis | Operational objective (S2.1) | Intensity Score (1-6) | Consequence Score (1-6) | Confidence Score (1-2) | Rationale |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Organic waste disposal | 0 | | | | | | | | | |
| **Addition of non-biological material** | Debris | 0 | | | | | | | | | |
| | Chemical pollution | 0 | | | | | | | | | |
| | Exhaust | 1 | 3 | 2 | Distribution of community | Heard Plateau 0-1000m pelagic | 1.1 | 1 | 1 | 2 | Exhaust emissions occurred up to 10 days during the 2013/14 fishing season. Intensity and consequences both rated as negligible. The limited number of vessels in the fishery coupled with the local weather conditions makes it highly unlikely that exhaust gas emissions will have an affect distribution of community. Weather conditions in the region are frequently extreme, rapidly dispersing exhaust emissions. Confidence: high, logical consideration. |
| | Gear loss | 0 | | | | | | | | | |
| | Navigation/ steaming | 1 | 3 | 2 | Distribution of community | Heard Plateau 0-1000m pelagic | 3.1 | 2 | 1 | 1 | Distribution of community may be disturbed by noise or radio signals. Intensity: minor due to the limited number of vessels in the fishery. Consequence: negligible effects temporary and local. Confidence: low, no data on effect of oceanic community. |
| | Activity/ presence on water | 1 | 3 | 2 | Distribution of community | Heard Plateau 0-1000m pelagic | 3.1 | 1 | 1 | 2 | Vessel present and active daily during season and may affect distribution of community members. Intensity: negligible due to the limited number of vessels in the fishery. Consequence: negligible as any alteration to distribution is temporary. Confidence: high (logic and observer records). |
| **Disturb physical processes** | Bait collection | 0 | 0 | 0 | | | | | | | |

| Direct impact of fishing | Fishing Activity | Presence (1) Absence (0) | Spatial scale of Hazard (1-6) | Temporal scale of Hazard (1-6) | Sub-component | Unit of analysis | Operational objective (S2.1) | Intensity Score (1-6) | Consequence Score (1-6) | Confidence Score (1-2) | Rationale |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fishing | 1 | 3 | 2 | Distribution of community | Heard Plateau 0-1000m pelagic | 3.1 | 1 | 1 | 1 | The distribution of the community members may be affected by mixing effects of water through nets. Intensity: negligible as disturbance to the water column is a frequent event in the Southern Ocean. Consequence: is negligible. Only a small area is affected. Separating trawl disturbance from the effects of wind mixing in the Southern Ocean would not be possible. Confidence: low. |
| | Boat launching | 0 | 0 | 0 | | | | | | | |
| | Anchoring/ mooring | 0 | 0 | 0 | | | | | | | |
| | Navigation/ steaming | 1 | 3 | 2 | Distribution of community | Heard Plateau 0-1000m pelagic | 3.1 | 1 | 1 | 2 | Navigation/steaming has the potential to alter community distributions by wake mixing of the pelagic community. Intensity rated as negligible due to small number of vessels involved and known wind mixing depths exceeding wake mixing. Consequence: negligible, due to the small number of vessels involved. Confidence: high due consideration of logical constraints. |
| **External Impacts** | Other fisheries: HIMI longlining, HIMI demersal trawl | 1 | 3 | 2 | Species composition | Heard Plateau 0-1000m pelagic | 1.1 | 3 | 2 | 2 | Longlining occurs in adjacent areas but unlikely to impact pelagic community. However demersal fishing in the area also targets icefish and some other non-target species and therefore likely to have greatest impact on pelagic plateau community. Intensity: moderate. Consequence: minor as TACs are applied to key/secondary commercial species anf bycatch limits applied to non-targeted species across all fishing methods. Confidence: high (high observer coverage). |
| | Aquaculture | 0 | 0 | 0 | | | | | | | |
| | Coastal development | 0 | 0 | 0 | | | | | | | |
| | Other extractive activities | 0 | 0 | 0 | | | | | | | |

| Direct impact of fishing | Fishing Activity | Presence (1) Absence (0) | Spatial scale of Hazard (1-6) | Temporal scale of Hazard (1-6) | Sub-component | Unit of analysis | Operational objective (S2.1) | Intensity Score (1-6) | Consequence Score (1-6) | Confidence Score (1-2) | Rationale |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Other non-extractive activities | 0 | 0 | 0 | | | | | | | |
| | Other anthropogenic activities | 1 | 3 | 2 | Distribution of community | Heard Plateau 0-1000m pelagic | 3.1 | 2 | 2 | 2 | Research and tourism and the passage of research/tourist vessels occurs several times at most in a year. Species composition may be affected by these activities. Intensity: minor due to the limited number of vessels/visits/groups per year. Consequence: minor as catches small and infrequent. Confidence: high, as activities of these vessels/groups are generally carefully planned and monitored. |

## 2.3.11 Summary of SICA results

**Table 2.19. Level 1 (SICA) Document L1.6. Summary table of consequence scores for all activity/component combinations. Those that scored >=3 (highlighted in green) and high confidence (in bold). * existing stock assessment –assessment not required.** existing benthic habitat assessment-assessment not required for benthic. Note: external hazards are not considered at Level 2.**

| DIRECT IMPACT | ACTIVITY | KEY/SECONDARY COMMERCIAL SPECIES | BYPRODUCT & BYCATCH SPECIES | PROTECTED SPECIES | HABITATS | COMMUNITIES |
|---|---|---|---|---|---|---|
| Capture | Bait collection | 0 | 0 | 0 | 0 | 0 |
| | Fishing | * | 2 | 1 | 1 | 2 |
| | Incidental behaviour | 0 | 0 | 0 | 0 | 0 |
| Direct impact without capture | Bait collection | 0 | 0 | 0 | 0 | 0 |
| | Fishing | 2 | 2 | 1 | ** | 2 |
| | Incidental behaviour | 0 | 0 | 0 | 0 | 0 |
| | Gear loss | 0 | 0 | 0 | 0 | 0 |
| | Anchoring/ mooring | 0 | 0 | 0 | 0 | 0 |
| | Navigation/ steaming | 1 | 1 | 1 | 1 | 1 |
| Addition/ movement of biological material | Translocation of species | 2 | 2 | 1 | 0 | 2 |
| | On board processing | 0 | 0 | 0 | 0 | 0 |
| | Discarding catch | 0 | 0 | 0 | 0 | 0 |
| | Stock enhancement | 0 | 0 | 0 | 0 | 0 |
| | Provisioning | 0 | 0 | 0 | 0 | 0 |
| | Organic waste disposal | 0 | 0 | 0 | 0 | 0 |
| Addition of non-biological material | Debris | 0 | 0 | 0 | 0 | 0 |
| | Chemical pollution | 0 | 0 | 0 | 0 | 0 |
| | Exhaust | 1 | 1 | 1 | 1 | 1 |
| | Gear loss | 0 | 0 | 0 | 0 | 0 |
| | Navigation/ steaming | 1 | 1 | 1 | 1 | 1 |
| | Activity/ presence on water | 1 | 1 | 1 | 1 | 1 |
| Disturb physical processes | Bait collection | 0 | 0 | 0 | 0 | 0 |
| | Fishing | 1 | 1 | 1 | ** | 1 |
| | Boat launching | 0 | 0 | 0 | 0 | 0 |
| | Anchoring/mooring | 0 | 0 | 0 | 0 | 0 |
| | Navigation/steaming | 1 | 1 | 1 | 1 | 1 |
| External Impacts | Other fisheries | **3** | 2 | 2 | ** | 2 |
| | Aquaculture | 0 | 0 | 0 | 0 | 0 |
| | Coastal development | 0 | 0 | 0 | 0 | 0 |
| | Other extractive activities | 0 | 0 | 0 | 0 | 0 |
| | Other non-extractive activities | 0 | 0 | 0 | 0 | 0 |
| | Other anthropogenic activities | 1 | 1 | 1 | 1 | 2 |

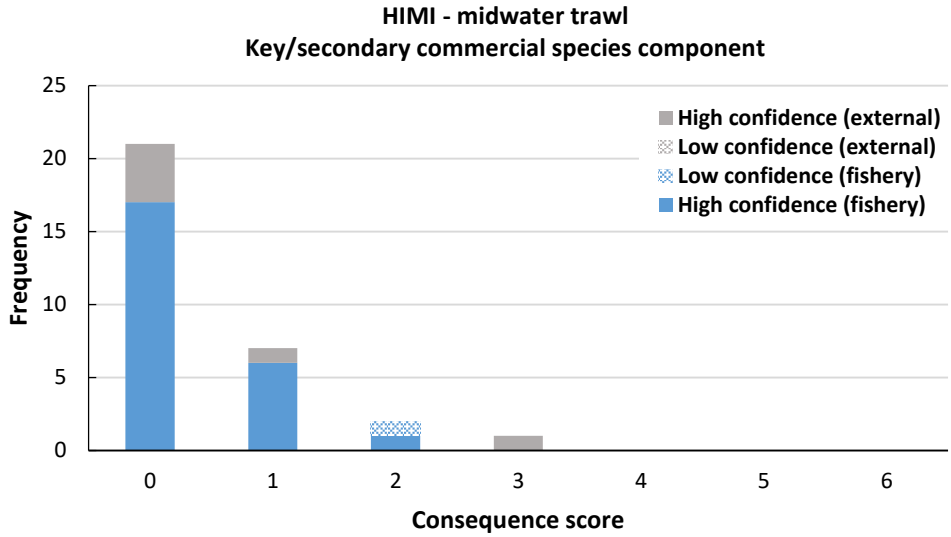


**Figure 2.2. Key commercial species: Frequency of consequence score by high and low confidence.**

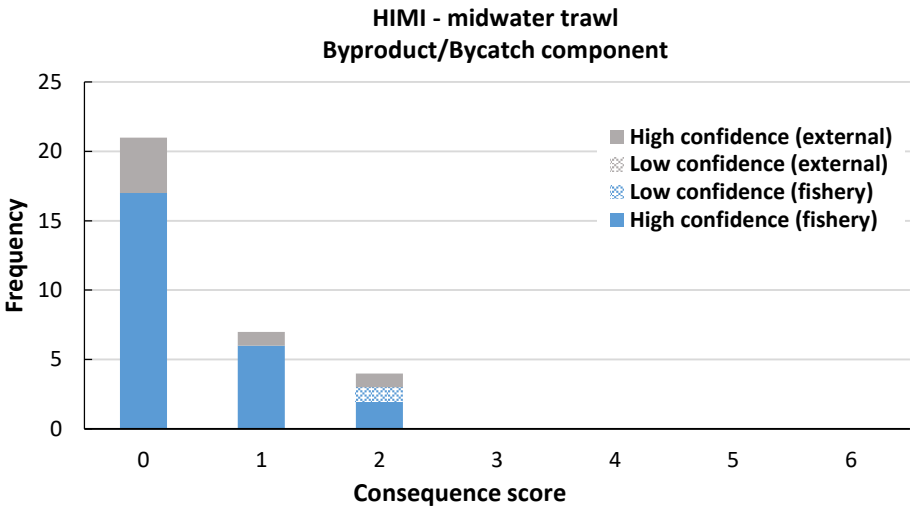


**Figure 2.3. Byproduct and bycatch species: Frequency of consequence score by high and low confidence.**

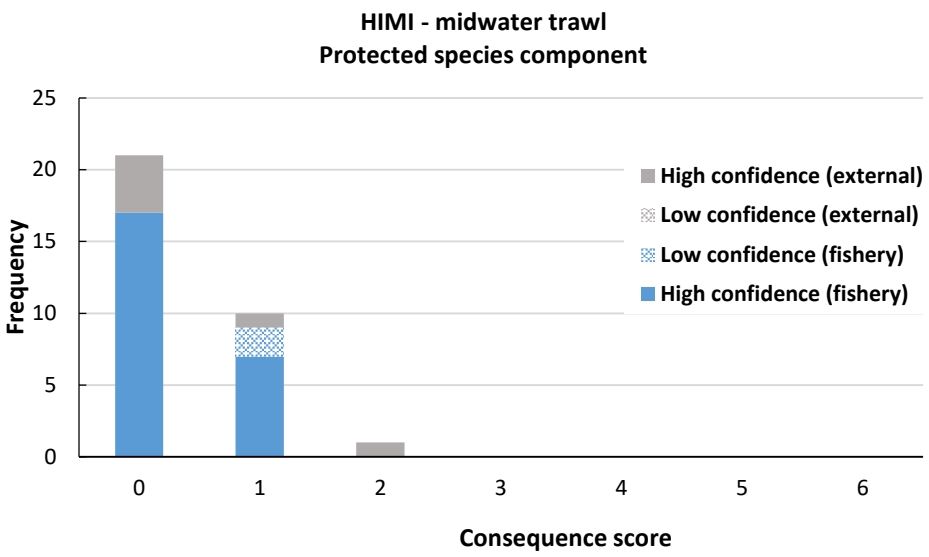


Figure 2.4. Protected species: Frequency of consequence score by high and low confidence.

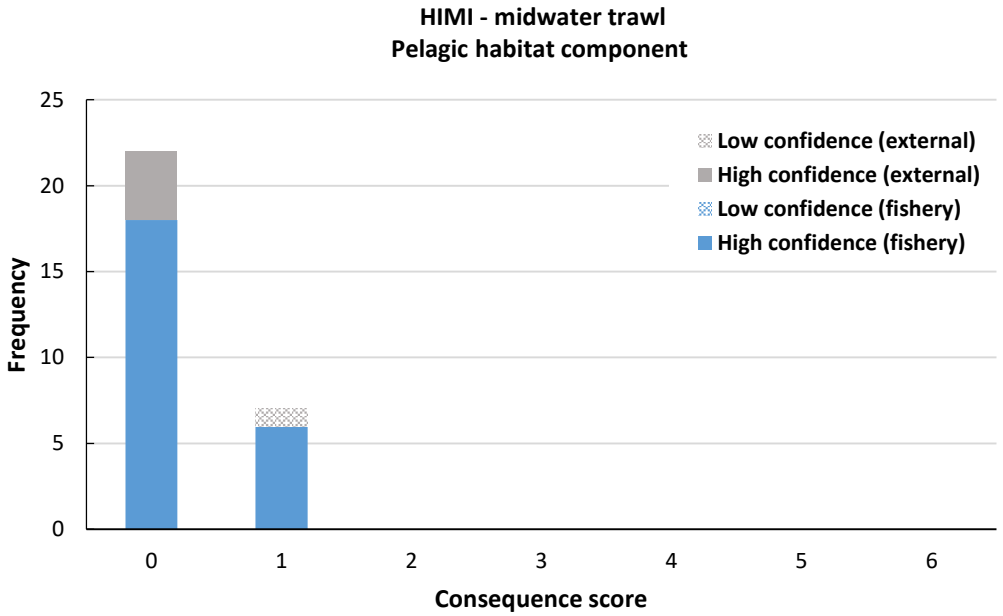


Figure 2.5.Habitats (pelagic): Frequency of consequence score by high and low confidence (not including activities impacting benthic habitats).

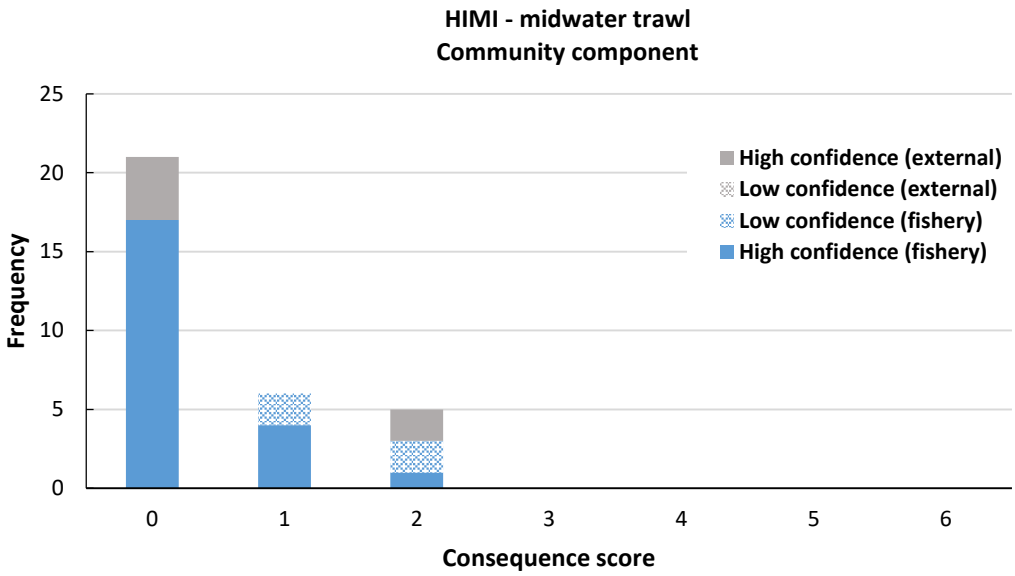


**Figure 2.6. Communities: Frequency of consequence score by high and low confidence.**

### 2.3.12 Evaluation/discussion of Level 1

All hazards (fishing activities) were eliminated at Level 1 (risk scores 1 or 2; Table 2.19; Figure 2.2 Three ecological communities were chosen as the most vulnerable component (risk score 2). The communities were scored 2, given that only a small area of each community was fished and two of these communities were also within the Marine Reserve. However, even though the removal of Patagonian toothfish from communities has been considered in the precautionary TAC setting process, there is still further work to do to understand the fishery dynamics at a community level. - Figure 2.6). Only one external impacts was scored as moderate (3) or above for any of the five ecological components: other fisheries on key commercial species.

The impacts on benthic habitats were not assessed due to a previous external assessment (Welsford et al. 2014), but wherever a pelagic habitat was most vulnerable unit of analysis the assessment was made. All activities impacting the pelagic habitat were negligible risk.

### 2.3.13 Components to be examined at Level 2

As a result of the SICA analysis, no ecological components are to be examined at Level 2.

# 3 General discussion and research implications

## 3.1 Level 1

All hazards (fishing activities) were eliminated at Level 1 (risk scores 1 or 2; Table 2.19; Figure 2.6). One external impact was scored as moderate or above for other fisheries on key commercial species. Pelagic habitats were assessed.

## 3.2 Level 2

### 3.2.1 Species at risk

A Level 2 analysis was not triggered for any ecological component: key/seconday commercial species, byproduct/bycatch species, protected species, habitats and communities.

#### Residual risk

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

In moving from ERA to ERM, AFMA will focus scarce resources on the highest priority species and habitats (those likely to be most at risk from fishing). To that end, and because Level 3 analyses are not yet available for most species, AFMA (with input from CSIRO and other stakeholders) has developed guidelines to assess “residual risk” for

those species identified as being at high potential risk based on the PSA analyses. The residual risk guidelines will be applied on a species by species basis, and include consideration of existing management measures not currently accounted for in the PSA analyses, as well as additional information about the levels of direct mortality. These guidelines will also provide a transparent process for including more precise or missing information into the PSA analysis as it becomes available.

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

# References


AFMA., 2003. Antarctic fisheries Bycatch Action Plan 2003, Commonwealth of Australia

AFMA., 2014. Status report Heard Island and McDonald Islands Fishery, Commonwealth of Australia

AFMA., 2016a. Heard Island and McDonald Islands Management Plan 2002

AFMA., 2016b. Draft Guide to AFMA's Ecological Risk Management. 130 pp.

Baum, J.K., Worm, B., 2009. Cascading top-down effects of changing oceanic predator abundances. Journal of Animal Ecology 78(4): 699-714.

Bulman, C.M., Sporcic, M., Pethybridge, H. & Hobday, A., 2016. Ecological Risk Assessment for Effects of Fishing. Report for the Demersal Longline Sub-fishery of the Heard and McDonald Islands Fishery. CSIRO/AFMA, Hobart). 130 pp.

Catarci, C., 2004. World markets and industry of selected commercially-exploited aquatic species with an international conservation profile. FAO Fisheries Circular 990, FAO, Rome. pp 186.

Condie, S., Ridgway, K., Griffiths, B., Rintoul, S. and Dunn, J. (2003). National Oceanographic Description and Information Review for National Bioregionalisation. Report for National Oceans Office.(CSIRO Marine Research: Hobart, Tasmania, Australia.)

CCAMLR., 2015a. Fishery Report 2015: *Champsocephalus gunnari* Heard Island Australian EEZ (Division 58.5.2)

CCAMLR., 2015b. Fishery Report 2015: *Dissostichus eleginoides* Heard Island Australian EEZ (Division 58.5.2)

CCAMLR., 2015c. Schedule of Conservation Measures in Force, 2015/16 season. CCAMLR, Hobart, Australia: 289 pp.

Cherel, Y., Duhamel, G., Gasco, N., 2004. Cephalopod fauna of subantarctic islands: new information from predators. Marine Ecology Progress Series, 266:143-156.

Chown, S.L., Slabber, S., McGeoch, M.A., Janion, C., Leinaas, H.P., 2007. Phenotypic plasticity mediates climate change responses among invasive and indigenous arthropods. Proceedings of the Royal Society of London B: Biological Sciences, 274(1625): 2531-2537.

Commonwealth of Australia., 2014. Heard Island and McDonald Islands Marine Reserve Management Plan 2014-2024, Department of the Environment, Canberra.

EPBC Act List of Threatened Fauna. http://www.environment.gov.au/cgi-bin/sprat/public/publicthreatenedlist.pl

Eriksson, C., Burton, H., Fitch, S., Schulz, M., van den Hoff, J., 2013. Daily accumulation rates of marine debris on sub-Antarctic island beaches. Marine Pollution Bulletin, 66(1): 199-208.

Fletcher, W. J., Chesson, J., Fisher, M., Sainsbury, K. J., Hundloe, T., Smith, A.D.M. and Whitworth, B. 2002. National ESD reporting framework for Australian Fisheries: The how to guide for wild capture fisheries. FRDC Report 2000/145, Canberra, Australia.

Hobday, A.J., Bulman, C.M., Williams, A., and Fuller, M., 2011a. Ecological risk assessment for effects of fishing on habitats and communities FRDC Report 2009/029. (Fisheries Research and Development Corporation and CSIRO Marine and Atmospheric Research: Hobart, Australia.)

Hobday, A. J., Smith, A.D.M., Stobutzki, I., Bulman, C.m Daley, R., Dambacher, J.M., Deng, R.A., Dowdney, J, Fuller, M., Furlani, D., Griffiths, S.P., Johnson, D., Kenyon, R., Knuckey, I.A., Ling, S.D., Pitcher, R., Sainsbury, K.J., Sporcic, M., Smith, T., Turnball, C., Walker, T.I., Wayte, S.E., Webb, H.,

Williams, A., Wise, B.S., Zhou, S., 2011b. Ecological risk assessment from the effects of fishing. *Fisheries Research* 108(2-3): 372-384.

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.

Interim Marine and Coastal Regionalisation for Australia Technical Group (1998). Interim Marine and Coastal Regionalisation for Australia: an ecosystem-based classification for marine and coastal environments. Version 3.3 (Environment Australia, Commonwealth Department of the Environment: Canberra, Australia.)

Last, P., Lyne, V., Yearsley, G., Gledhill, D., Gomon, M., Rees, T., and White, W. (2005). Validation of national demersal fish datasets for the regionalisation of the Australian continental slope and outer shelf (>40m depth). (National Oceans Office, Department of Environment and Heritage and CSIRO Marine Research, Australia.)

Lehodey, P. (2005) Reference Manual for the Spatial Ecosystem and Populations Dynamics Model — SEAPODYM. (WCPFC-SC1, ME IP-1.)

Lyne, V. and Hayes, D. (2004). Pelagic Regionalisation. National Marine Bioregionalisation Integration Project. 137 pp. (CSIRO Marine Research and NOO: Hobart, Australia).

Maschette, D., 2015. Exploring multi-decadal changes in population dynamics of a historically overfished sub-Antarctic fish species: The Grey Rockcod (Lepidonotothen squamifrons) on the Kerguelen Plateau. Honours Thesis, University of Tasmania. 120 p.

Maschette D., Welsford, D.C., Gardner, C., 2015. Exploring age and growth dynamics of a historically overfished Sub-Antarctic fish species: The grey rockcod (*Lepidonotothen squamifrons*) in the vicinity of Heard Island and McDonald Island. In: CCAMLR, WG-FSA-15/51, 24pp.

Maschette D., Welsford, D.C., Gardner, C., Woodcock, E., Farmer, B., Burch, P., Péron, C, in prep. First insights into population dynamics and spatial structure of a historically overfished subantarctic fish species: The grey rockcod (*Lepidonotothen squamifrons*).

Meyer, L., Constable, A., Williams, R., 2000. Conservation of marine habitats in the region of Heard Island and McDonald Islands. Australian Antarctic Division.

Mori, M., Corney, S.P., Melbourne-Thomas, J., Welsford, D.C., Klocker, A., and Ziegler, P.E. (2016) Using satellite altimetry to inform hypotheses of transport of early lifestage of Patagonian toothfish on the Kerguelen Plateau. *Ecological Modelling* **340**, 45-56.

Nowara, G.D., Burch, P., Gasco, N., Welsford, D.C., Lamb, T.D., Chazeau, C., Duhamel, G., Pruvost, P., Wotherspoon, S., Candy, S.G., 2017. Distribution and abundance of skates (*Bathraja* spp.) on the Kerguelen Plateau through the lens of the toothfish fisheries. Fisheries Research. 186: 65-81.

Patterson, H., and Savage, J., 2016. Heard Island and McDonald Islands Fishery. In 'Fishery status reports 2016.' (Eds. Patterson, H., Noriega, R., Georgeson, L., Stobutzki, I., and Curtotti, R.) pp. 421-431. (Australian Bureau of Agricultural and Resource Economics and Sciences: Canberra)

Patterson, H., Skirtun, M., 2015. Heard Island and McDonald Islands Fishery. pp 404-413 In: Georgeson, L, Stobutzki, I & Curtotti, R (eds), Fishery Status Reports 2014–15, Australian Bureau of Agricultural and Resource Economics and Sciences, Canberra, Australia.

SCS (2015) The Australian Heard Island and McDonald Islands patagonian Toothfish Fishery 2015 Third Annual Surveillance. (SCS: Emeryville, CA.).

Smith, A.D.M., Fulton, E.J., Hobday, A.J., Smith, D.C., and Shoulder, P. (2007) Scientific tools to support the practical implementation of ecosystem-based fisheries management. Ices Journal of Marine Science 64(4), 633-639.

Sporcic, M., Pethybridge, H., Bulman, C.M., Hobday, A., Fuller, M., 2017. Ecological Risk Assessment for the Effects of Fishing: Heard Island and McDonald Islands Fishery: Demersal trawl sub-fishery. Report for the Australian Fisheries Management Authority. 142 pp.

Thost, D., Allison, I., 2005. 'The Climate of Heard Island' In: Green, K., Woehler E.J., (eds), Heard Island: Southern Ocean Sentinel, Surrey Beatty and Sons, Chipping Norton, Australia.

Thost, D., Truffer, M., 2007. Glacier response to climate change on Heard Island, Southern Indian Ocean. Ice and Climate News 9:17.

Welsford, D.C., 2014. A preliminary assessment of Mackerel icefish (*Champsocephalus gunnari*) in Division 58.5.2, based on results from the 2014 random stratified trawl survey. WGFSA-14/44

Welsford, D.C., Candy, S.G., Lamb, T.D., Nowara, G.B., Constable, A.J., Williams, R., 2011. Habitat use by Patagonian toothfish (*Dissostichus eleginoides* Smitt 1898) on the Kerguelen Plateau around Heard Island and the McDonald Islands. Kerguelen Plateau Symposium. First International Scientific Symposium on the Kerguelen Plateau: Marine Ecosystem and Fisheries: 125-136.

Welsford, D., Ewing, G.P., Hibberd, T., Constable, A.J., Kilpatrick, R., 2014. Demersal fishing interactions with marine benthos in the Australian EEZ of the Southern Ocean: An assessment of the vulnerability of benthic habitats to impact by demersal gears. Final Report FRDC Project 2006/042. 258 pp.

Williams, R., Tuck, G.N., Constable, A.J., Lamb, T., 2002. Movement, growth and available abundance to the fishery of Dissostichus eleginoides Smitt, 1898 at Heard Island, derived from tagging experiments. CCAMLR Science 9:33-48.

Woehler, E.J., Ainley, D., Jabour, J., 2014. Human impacts to Antarctic wildlife: predictions and speculations for 2060. In: Antarctic Futures. Springer Netherlands. 27-60 pp.

Zhou, S., and Griffiths, S.P. (2008) Sustainability Assessment for Fishing Effects (SAFE): A new quantitative ecological risk assessment method and its application to elasmobranch bycatch in an Australian trawl fishery. Fisheries Research 91(1), 56-68.

Zhou, S., Fuller, M., Smith, T., 2009. Rapid quantitative risk assessment for fish species in seven Commonwealth fisheries. AFMA Report April 2009

Zhou, S.J., Smith, A.D.M., and Fuller, M. (2011) Quantitative ecological risk assessment for fishing effects on diverse data-poor non-target species in a multi-sector and multi-gear fishery. Fisheries Research 112(3), 168-178.

Zhou, S., Hobday, A.J., Dichmont, C.M., and Smith, A.D.M. (2016) Ecological risk assessments for the effects of fishing: A comparisonand validation of PSA and SAFE. Fisheries Research 112, 168-178.

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

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

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