SPRFMO
South Pacific Regional Fisheries Management Organisation

11th MEETING OF THE SCIENTIFIC COMMITTEE

11 to 16 September 2023, Panama City, Panama

SC11 – DW03
Australia FOP for an exploratory toothfish fishery on the Macquarie Ridge in the SPRFMO Area

Australia

Exploratory Fishing Application to fish for Toothfish on the Macquarie Ridge in the South Pacific Regional Fisheries Management Organisation 2024-2026

Contents

1 Purpose

The purpose of this paper is to provide information on the elements set out in *CMM 13-2021 Management of New and Exploratory Fisheries in the SPRFMO Convention Area* for an application for an Australian vessel to undertake exploratory fishing on the Macquarie Ridge for Toothfish species (*Dissostichus spp.*). As required by CMM 13-2021 the current paper contains a Fisheries Operational Plan outlining the target species, proposed fishing method and gear, proposed timeframe of fishing and a preliminary data collection plan for the proposed exploratory fishing.

Proposed activities will occur from 2024-2026 on the Macquarie Ridge Continuation Research Block (MRC RB), in the SPRMFO area between the Macquarie Island EEZ and the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) boundary (see Figure 1 – Map). The proposed fishing occurs outside the established SPRFMO bottom fishing footprint and contains a risk assessment of bottom fishing in the proposed area as required by *CMM 03-23 Bottom Fishing in SPRFMO Convention Area*.

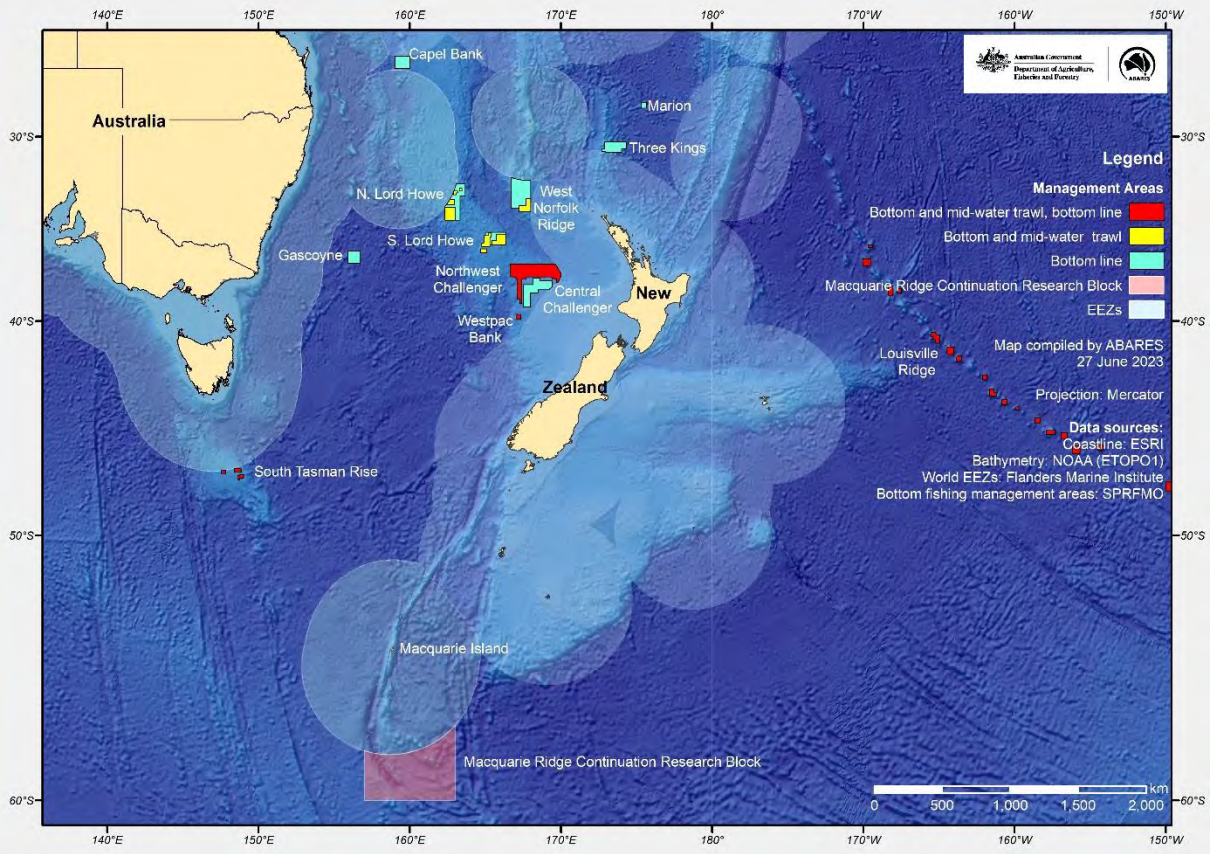


Figure 1 Proposed exploratory area in the Macquarie Ridge Continuation Research Block (MRC-RB). The SPRFMO Convention Area is delineated, as well as adjacent Economic Exclusion Zones (EEZs) and Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) Convention Area.

2 Introduction

This is the first proposal for exploratory fishing that Australia has submitted to the SPRFMO Scientific Committee, it is also the first exploratory fishing proposal to fish for Toothfish in this area. As it is a new area the proposed research block has been named Macquarie Ridge Continuation Research Block.

The proposal is to conduct exploratory fishing for Toothfish (*Dissostichus spp.*) over up to three seasons employing a Mustad Autoline System, demersal longlining using 12mm integrated weighted line (IWL), containing at least 50 grams of lead per meter of line. Fishing will occur on several seamounts in depths ranging from 600- 2,500m that could provide suitable habitat for Toothfish. Either Patagonian (*Dissostichus eliginoides*) or Antarctic (*Dissostichus mawsoni*) or a mixture of both species may be present in the MRC RB as it is adjacent to fisheries for both species.

The vessel proposed to undertake the exploratory fishing is the Antarctic Discovery, which has extensive experience and an exemplary record of operating in domestic Australian Toothfish fisheries and CCAMLR New and Exploratory fisheries in East Antarctica and the Ross and Amundsen Seas.

3 Vessel Details

3.1 Required Information

Requirement	Antarctic Discovery
A) Current vessel flag (using the codes indicated in Annex 2)	Australia (AUS)
B) Name of vessel	FV Antarctic Discovery
C) Registration number	861507
D) International radio call sign	VKAD
E) IMO number	9123219
F) Previous Names (if known)	Antarctic III and Argos Helena
G) Port of registry	Hobart
H) Previous flag (if any, and using the codes indicated in Annex 2)	Argentina and Norway
I) Type of vessel	LL 07.2.0
J) Type of fishing method(s)	LL 09.5.0
K) Length	55.3m
L) Length type e.g. "LOA", "LBP"	LOA
M) Gross Tonnage – GT	1545
N) Gross registered tonnage – GRT	AS ABOVE
O) Power of main engine(s) (kw)	Motors (Diesel Electric): Cummins KTA 38-Dm1 (2 Sets) and Caterpillar 34-12 (2 Sets)
P) Hold capacity (m3)	• Cargo Hold 790 cu m • Bait Hold 61 cu m • Fuel Oil 493 cu m • Fresh water 45 cu m
Q) Freezer type	Freon
R) Number of freezers units	2
S) Freezing capacity	• Cargo Hold 790 cu m • Bait Hold 61 cu m
T) Vessel communication types and numbers	1. Inmarsat C – 450371810 2. Inmarsat C – 450371811 3. Inmarsat C – 450371812 4. Inmarsat Fleet broadband
U) VMS system details (brand, model, features and identification);	See appendix 1.
V) Name of owner(s)	Antarctic longline Pty Ltd
W) Address of owner(s)	85 Macquarie Street, Hobart, Tasmania, 7000
X) Date of Inclusion into the SPRFMO record	July 2023

Y) Flag Authorisation end date	April 2027
Z) Flag Authorisation start date	April 2024

AA) Digital photos of Vessel

a. Stern Photograph

b. Starboard Side Photograph

c. Port Side Photograph

3.2 Additional information

A) External markings (such as vessel name, registration number or international radio call sign)	External Markings are *'Antarctic Discovery'*, *'VKAD'* and *'Hobart'*
B) Types of fish processing lines	The vessel processes Head Gut Trunk, Collars, Cheeks, Whole and GUT only.
C) When built	1995
D) Where built	Brattvag, Norway
E) Moulded depth	8.2m
F) Beam	12m
G) Electronic equipment on board	Radio UHF and VHF, Seaplot, Maxsea, 18 and 24khz echosounders, Electronic Monitoring (EM)
H) Name of license owner(s) (if different from vessel owner)	Australian Longline Fishing Pty Ltd
I) Address of license owner(s) (if different from vessel owner)	85 Macquarie street, Hobart, Tasmania, 7000
J) Name of operator(s) (if different from vessel owner)	Australian Longline Fishing Pty Ltd
K) Address of operator(s) (if different from vessel owner)	85 Macquarie street, Hobart, Tasmania, 7000
L) Name of vessel master	Trevor Tuson
M) Nationality of vessel master	New Zealand
N) Name of fishing master	Not Applicable
O) Nationality of fishing master	Not Applicable

4 Fisheries Operation Plan

4.1 Description of exploratory fishery

Information is vitally important in understanding and maintaining a sustainable fishing stock. The Macquarie Island Toothfish fishery has been operating for 28 years and is primarily based around the Macquarie ridge. During this time over 21,000 tags have been released to understand the movements of the stock and the toothfish recaptures form an important statistic along with the biological data in establishing a stock assessment (Hillary and Day 2021). The Macquarie Ridge is a complex underwater structure and has some complex oceanography the effects of this oceanography on the movement of toothfish is currently being examined by Australian scientists at CSIRO (AFMA pers com). Due to the incredible depths found between Macquarie Island and the Ross

Sea, it would make sense that seamounts found in the SPRFMO area, which we have dubbed MRC RB have the potential to sustain Patagonian or Antarctic Toothfish population.

The main objective of the exploratory fisheries survey will be to establish whether Patagonian and/or Antarctic Toothfish are in the area and if Patagonian Toothfish are captured, how closely related to the Macquarie Island Toothfish population. If Antarctic Toothfish are caught are they related to the CCAMLR population found in the adjacent 88.1. This will be achieved through the collection of biological information and tagging data of the target species.

Secondary objectives are to provide the SPRFMO SC, Australian Science organisation and Fisheries managers with new information on adjacent areas to Australian EEZs through fishery dependant data collection by implementing a research plan that samples bycatch species, accidental catches, Vulnerable Marine Ecosystems (VMEs) and other oceanographic data. The proposal is for up to three years of survey to occur, with the second and third years being contingent on toothfish being found in year one. At the conclusion of the three years Australia will assess the need for a more thorough research plan designed to assess the viability of an ongoing sustainable fishery in the area.

The proposed exploratory fisheries survey will maintain strict compliance with conservation measures regarding by-catch of mammals and VMEs (CMM 03-2023) and the protection of seabirds and marine mammals (CMM 09-2017).

The proposed study area has been named the *Macquarie Ridge Continuation Research Block* or MRC RB (with coordinates listed in Table 1), with fishing depths between 600 and 2500m. The total area is approximately ~55,257 km², the area within the fishable depth range 600-2500m equates to about 19% of the total fishable area at approximately ~10,370 km². The fishable depth area is calculated from the bathymetric information provided by SeaPlot (https://seaplot.net/index.html). However, it is suspected that there may well be inaccuracies, as survey activities in this region have been limited.

We consider the proposed annual Total Allowable Catch (TAC) of 40t to be precautionary. Based on the study area being ~55,257 km², this would mean the extraction rate would equate to 0.7kgs per km², this in comparison to the New Zealand of 0.4 kgs per km² (SPRFMO SC-04-DW-02) and the EU 0.34 km² (SC-08-DW-05)..

The Antarctic Discovery hauls on average about 20,000 hooks per day. Based on these figures it will take approximately 8-14 days fishing at an extraction rate between 15kg/100 hooks and 25kgs/100 hooks, if there are toothfish in this area. We think this is reasonable based on the MITF averaging 22kg/100 hooks in the past 5 years, the EU exploratory fishery averaging 55kgs/100 hooks in 2021 ((SC-08-DW-05) and NZ exploratory averaging 80kgs/100 hooks in their first year (SC05-DW-02).

4.2 Fishing gear

The FV Antarctic Discovery is a demersal longliner, considered as one of the most successful methods to catch toothfish with minimal interaction with the benthic habitat. Demersal longline is quite simple:

- Specially designed weighted line (50g/metre) which achieves a sink rate at approximately 0.24m/s and this is set horizontally on the sea floor (*Robertson et al, 2006*)
- Line can range anywhere from 3-11km in length
- Hooks are attached spaced 1.2m apart, as we are undertaking research lines we are proposing no more than 5000 hook lines
- each end is anchored by a large grapnel between 45kgs and 80kgs
- This is connected by a different rope, called downline (generally floating type of rope) which runs vertically to the surface
- The surface is marked by different sized buoys and a radio beacon for easy location and retrieval.

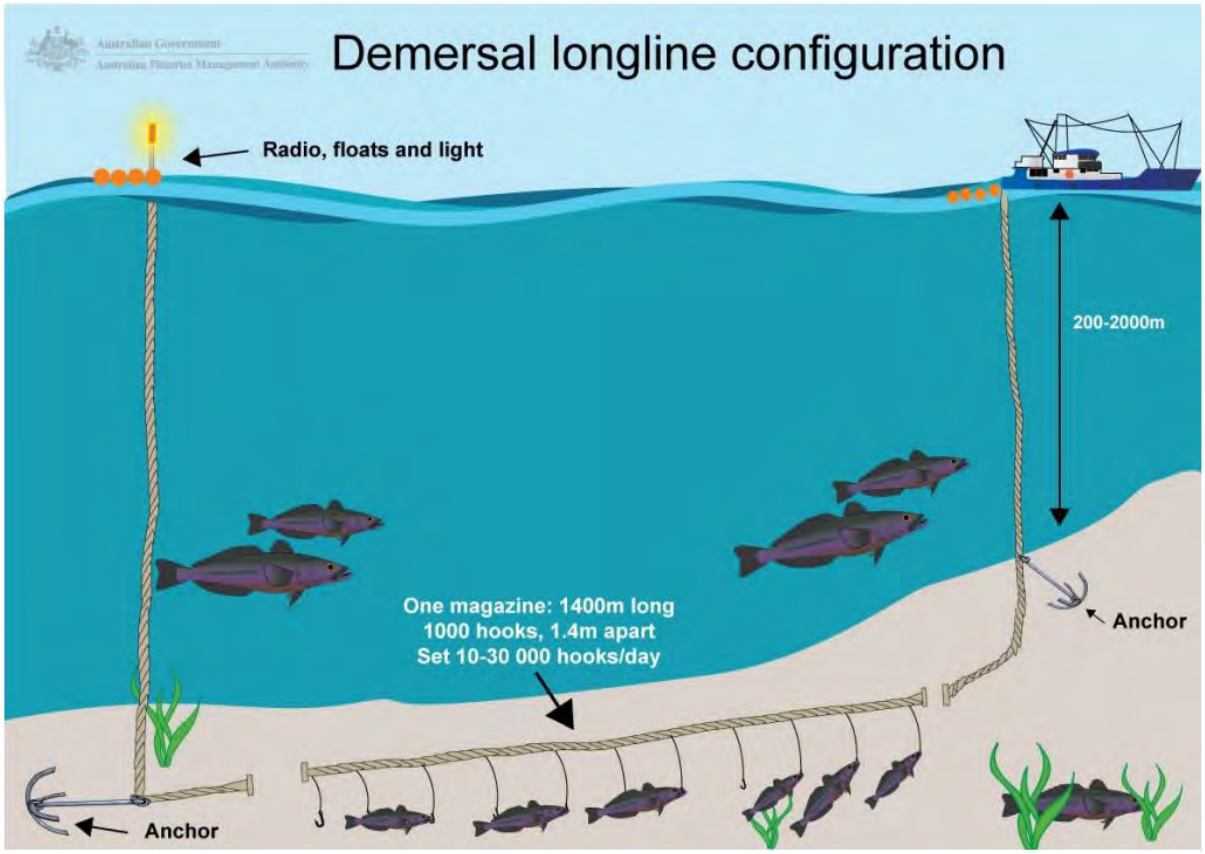


Figure 2: FV Antarctic Discovery line make up. Main line is weighted, with 14/0 hooks spaced 1.2m apart (source https://www.afma.gov.au/methods-and-gear/longlining).

The FV Antarctic Discovery is equipped with a 40,000 hook Mustad Autoline System including a Mustad 3000 Autobaiter baiting machine. The FV Antarctic Discovery is also fitted with SP2000 Mustad Autoline hook separators and Autoline Combi haulers. The vessel has the Mustad Line Controller system fitted which provides the fishing crew information on line tension, helping to reduce the chance of line breakage.

4.3 Time period

It is expected that the exploratory fishing may take up to three weeks each year and that fishing may occur in conjunction with a trip to either the adjacent Macquarie Island Toothfish Fishery or the CCAMLR New and Exploratory Fishery in the Ross Sea. As such it is expected that fishing will occur in

early April or late September each year, either immediately prior or after the Macquarie Island fishing season.

4.4 Biological information on toothfish

There is little information about toothfish for this region and we have been unable to find any records of Toothfish catches from this area. There is a Patagonian Toothfish Fishery in the Australian EEZ around Macquarie Island to the north and an Antarctic Toothfish fishery in the CCAMLR area to the South of the proposed area. Part of this exploratory fishing application is to determine which species (if any) of Toothfish occur here.

The biological characteristics and population dynamics of Patagonian Toothfish in the Adjacent Macquarie Island Toothfish Fishery are well understood. Tag recaptures in this fishery suggest limited movement amongst stock assessment areas with high site fidelity (Hillary and Day 2021), although recent tag recaptures by the exploratory fishery in the George V Fracture zone by EU exploratory fishing (https://www.sprfmo.int/assets/Meetings/SC/10th-SC-2022/SC10-DW08-Exploratory-toothfish-survey-report-EU.pdf) indicates that some longer range movement does occur.

Aging data is available from Macquarie Island from 1996 to 2019 with different growth rates observed for males and females, with females generally being longer at age than males (Hillary 2021). Von Bertalanffy growth parameters were estimated separately for males and females with females having a larger asymptotic length. This work at Macquarie Island also indicated that length and age at 50% female maturity are 97cm and 13-15 years respectively (Hillary 2021). The population status from the most recent stock assessment is estimated to be at 84% of unfished biomass (Hillary and Day 2021).

CCAMLR conducts regular stock assessments of Antarctic toothfish populations in the Ross Sea region, immediately to the south of the proposed exploratory fishing. An integrated stock assessment is conducted and presented to CCAMLR every second year with the most recent being Gruss et al. (2021). Estimates of age at maturity are 13 years for males and 17 years for females. Genetic studies have found there is no genetic differences and that a well mixed single gene pool with a circum-polar distribution exists (Choi et al. 2021). The current population status in the Ross Sea is estimated to be 66% of unfished biomass (Gruss et al. 2021).

4.5 Risk assessment of non-target bycatch

4.5.1 Methodology

The SPRFMO **Bottom Fishery Impact Assessment Standard** (BFIAS) (2019) was used as guidance for this risk assessment. As this is an exploratory fishery in an area not well understood in terms of the species presence or abundance, the expert judgment based Level 1 analysis (Scale Intensity Consequence Analysis; SICA) approach from the Ecological Risk Assessment for Effects of Fishing (ERAEF) (Hobday et al. 2007) was used.

Data on spatial overlap and catchability is evaluated and given qualitative assignments of ‘Low’, ‘Low-Med’, ‘Med’, ‘Med-High’ and ‘High’, and combined to form overall risk. Mitigation measures are applied and a residual risk analysis (RRA) was presented. The species’ International Union for Conservation of Nature’s (IUCN) Red List of Threatened Species conservation status was used to

inform decisions on triggers and actions to be taken to manage risk. A feedback process to incorporate new knowledge was considered to reduce risk through enhanced mitigation.

This assessment aims to identify the risk to:

- Target species
- Non–target species and bycatch species
- Seabirds, marine mammals, reptiles, and other species of concern
- Benthic habitats, biodiversity, and VMEs

In addition, consideration will be given to hazards caused by fishing, including impacts of gear and gear loss, as well as examining the potential for bird strike, discards, and other potential impactors.

As per recommended by the BFIAS, in areas where information was lacking on the likelihood of occurrence [of VMEs], other information that is relevant to inferring the likely presence of vulnerable populations, communities, and habitats was used.

This approach was taken for all species groups potentially impacted by fishing activities through using available information from the risk assessments conducted for the nearby Macquarie Island Toothfish Fishery (MITF) (Daley et al., 2007; Zhou & Fuller, 2011).

Data on species observation and predicted occurrences were gathered from multiple validated online and published sources. Data for taxonomic groups and species were cross validated between multiple sources. Online data was accessed on 26th May 2023.

- International Union for Conservation of Nature's (IUCN) Red List of Threatened Species (www.iucnredlist.org) was used to collect species distribution data using published spatial data, and the conservation status of the species.
- BirdLife International (www.birdlife.org) holds the IUCN distribution shape files and Threatened Species lists for birds.
- Rays of the World (Last et al., 2016).
- Sharks of the World (Ebert et al., 2013).
- Fish Base (www.fishbase.com). Global species database of fish species with mapped predicted distributions from Aquamaps (www.aquamaps.com).

The species catchability, that is the likelihood of the species susceptible to being caught during demersal longline fishing operations was assessed, assuming no mitigation.

For seabirds, the size, diving behaviour, and other characteristics were considered and gathered from various sources.

For species other than seabirds, catchability was considered relative to the species vertical distribution in the water column (either benthic or pelagic). For example, higher catchability sources were given to demersal/benthic species, compared to pelagic species that are more associated with water column. The fishing method in the proposed application is highly associated with benthic/demersal habitats for long periods of time (12 – 16 hours soak time), compared to the time spent in the water column and pelagic areas during setting and hauling of lines (approx. 6 hours).

The IUCN Red List of Threatened Species conservation status for the species was considered in the assessment, acting as a modifier to catchability. A more conservative approach to the species risk with critical conservation status (Critically Endangered [CR], Endangered [EN], or Vulnerable [VU]) was taken.

4.5.2 Ecological setting

The proposed area (MRC-RB) is the continuation of the Macquarie Ridge which is located with the SPRFMO Convention Area. Fishing will occur on several seamounts in depths ranging from 600 – 2,500 m that could provide suitable habitat for Toothfish.

Macquarie Ridge is one of the southernmost seamount ridges, extending ~1600 km that runs north to south and characterised by rugged bathymetry (Conway et al., 2012). Macquarie Ridge is one of three ridges which impedes the eastward flow the Antarctic Circumpolar Circulation across the Southern Ocean, with differences in the biological and physical oceanography to the west and east of the ridge (Sokolov and Rintoul 2009a). It is an area where three main bodies of water are separated by two oceanic fronts (Sub-Antarctic Front and Antarctic Polar Front) creating a complex range of habitats (Gordon, 1988). The ridge not only separates two hydrological regions, but also separates areas of distinctive marine life associations with representatives from south-east Australia, southern New Zealand and other regions of the Southern Ocean, many of which are at the southern or northern limit of their range (Butler et al., 2000). There is evidence for changes in community composition north to south, and it is likely that the ridge provides "stepping stones" linking Sub-Antarctic and polar faunas.

Species inventories for the benthic and pelagic habitats are absent for this region. Analyses of the benthic communities of the Macquarie Ridge, primarily focused near Macquarie Island, remain preliminary due to uneven sampling effort and incomplete analysis.

4.5.3 Non-target fish

Summary Risk

Group	Spatial Overlap	Catchability	Risk of mortality
Macrouridae, Moridae, Anguilliformes	High	High	High
Other species	Medium	Low	Low
Mitigation			
Precautionary bycatch limits Low effort proposed			
Residual risk after mitigation			
Macrouridae, Moridae, Anguilliformes - Low Other species - Low			

Mitigation measures

Precautionary catch limits for all bycatch species will meet and exceed **CCAMLR CMM 33-03 2022** and **SPRFMO CMM 02-2020 (Data Standard) Annex 14**. Once the limit has been reached, fishing will cease. The total catch of by-catch, excluding individuals released alive, shall not exceed the following limits:

- *Macrourus* spp.: 16% of the catch limit for *Dissostichus* spp.
- Other species: 16% of the catch limit for *Dissostichus* spp.
- One species: 1 tonne limit in any one haul or set and will trigger move-on rule as below.

As per **CCAMLR CMM 33-03 2022 paragraph 3 and 5,** if the by-catch of only one species is equal to, or greater than 1 tonne in any one haul or set, then the fishing vessel shall move to another location at least 5 nautical miles distant. '*Macrourus* spp.' will be counted as a single species. The fishing

vessel shall not return to any point within 5 nautical miles of the location where the bycatch exceed 1 tonne for a period of at least five days. The location where the bycatch exceed 1 tonne will be defined as the point at which the first anchor of a set was deployed to the point at which the last anchor of that set was deployed.

Trigger / Action

Bycatch limits and move-on-rules for bycatch species following **CCAMLR CMM 33-03**.

Data collection

Data collection requirements under **Annex 7, Section G of CMM 02-2022 (Data Standards)** will be met. Sufficient data will be collected in aim of establishing baselines to build future monitoring and mitigation, as required under **paragraphs 12 and 26 of CMM 13-2021 (Exploratory Fisheries)**. Additionally,

- Samples will be retained for specialist identification and museum curation.
- Samples for DNA analyses will be collected.

4.5.4 Chondrichthyans

Summary Risk

Group	Spatial Overlap	Catchability	Risk of mortality
Skates	Unknown	High	Low
Sharks	Medium	Medium	Medium
Mitigation			
Precautionary bycatch limits Skates and sharks (where possible) are to be released alive Safe handling practises Ban on wire traces			
Residual risk after mitigation			
Skates - Low			
Sharks - Medium			

Mitigation measures

Primary mitigation for reducing risk to chondrichthyans is through precautionary bycatch limits and gear restrictions, including ban on the use of wire traces. Catch limits for all bycatch species will meet and exceed **CCAMLR CMM 33-03 2022** and **SPRFMO CMM 02-2020 (Data Standard) Annex 14**. The total catch of by-catch, excluding individuals released alive, shall not exceed the following limits:

- Skates and rays: 5% of the catch limit for *Dissostichus* spp.
- Other species: 16% of the catch limit for *Dissostichus* spp.
- Species listed on CMM 02-2020 Annex 14: ban on retention of these species.

Chondrichthyans caught alive with high probability of survival should be recovered from the line and released alive, especially juveniles and gravid females. Skate can often be recovered and released alive. However the post-capture mortality of shark species is likely to be high based on studies of deepwater dogfish and shark species, particularly for larger species such as Somniosidae.

Safe handling practises will be used, including not bringing the animal on board the vessel and cutting the animal off at the water line to help ensure better post capture survival.

As per **CCMALR CMM 33-03 paragraph 3 and 5,** if the by-catch of only one species is equal to, or greater than 1 tonne in any one haul or set, then the fishing vessel shall move to another location at least 5 nautical miles distant. 'Skates and rays' will be counted as a single species. The fishing vessel shall not return to any point within 5 nautical miles of the location where the bycatch exceed 1 tonne for a period of at least five days. The location where the bycatch exceed 1 tonne will be defined as the point at which the first anchor of a set was deployed to the point at which the last anchor of that set was deployed.

Trigger / Action

Bycatch limits and move-on-rules for bycatch species.

Data Collection

Data collection requirements under **Annex 7, Sections E and F of CMM 02-2020** (Data Standards) will be met. Sufficient data will be collected with the aim of establishing baselines to build future monitoring and mitigation, as required under **paragraphs 10** and **24** of **CMM 13-2020.**

4.5.5 Seabirds

Summary

Group	Spatial Overlap	Catchability	Risk of mortality
Albatross & Fulmars	High	High	High
Cormorant & Shags	Medium	Low	Medium
Gulls, Terns & Skuas	High	Medium	Med-High
Penguins	High	Low	Medium
Petrels, Prions & Shearwaters	High	Medium	Med-High
Mitigation			
Meets and exceeds CMM-09-07 No offal discharge			
Residual risk after mitigation			
Albatross & Fulmars - Low Cormorant & Shags - Low Gulls, Terns & Skuas - Low Penguins - Low Petrels, Prions & Shearwaters - Low			

Mitigation measures

Mitigation measures adopted for seabirds in MITF have been successful in avoiding interactions with seabirds. Mitigation measures will meet **CCAMLR CMM 25-02 2018** and meet and exceed **SPRFMO Annex 1 CMM-09 2017**. Specifically for longline operation, the following mitigation measures will apply:

- **No offal discharge during fishing operations** – dumping of offal will be prohibited during the hauling and setting of gear. Any dumping of offal that is necessary will occur well away from fishing grounds in waters deeper than 2,500m.
- **Integrated weight line** – longline vessels use 12mm integrated weight line with at least 50g/m to sink the line quickly beyond the feeding range of seabirds.
- **Paired streamer lines** – two streamer lines (minimum of 150 m in length) are used to scare birds away from gear during line setting and to be attached to the vessel such that it is suspended from a point a minimum of 7 m above the water at the stern on the windward side of the point where the hook-lines enters the water.
- **Bird excluder device** – as adopted by CCAMLR to be deployed to discourage birds from accessing baits during line hauling.
- **Prohibition on the use of plastic packing bands** – to prevent ingestion of or entanglement in the debris by seabirds or marine mammals; and
- **Minimisation of lighting** – to reduce the risks of seabirds colliding with the vessel.
- **Bird scaring sound cannon**
- The **baiting machine is positioned towards the centre** of the vessel to enable the line to sink quickly within the downwash of the propeller.

The baiting machine has been repositioned towards the centre of the vessel to enable the line to sink quickly within the downwash of the propeller.

Trigger / Action

In line with the domestic Threat Abatement Plan for seabirds, future fishing will be reviewed if the interaction rate for seabirds must be less than 0.001 seabirds per 1000 hooks set.

Data collection

Data collection requirements under **Annex 7, Section G of CMM 02-2022 (Data Standards)** will be met. Sufficient data will be collected in aim of establishing baselines to build future monitoring and mitigation, as required under **paragraphs 12 and 26 of CMM 13-2021 (Exploratory Fisheries)**. Additional data collection protocols under **CMM 14-2021 paragraph 24** will be met or be exceed, including:

- As per CCAMLR and Australian sub-Antarctic fishery requirements, there must be 100% observer coverage of all shots for marine mammals, seabirds, and other species of concern.
- All dead seabirds must be retained for formal identification and necropsy.
- E-monitoring will also be employed to assist with seabird observations.

4.5.6 Mammals

Summary

Group	Spatial Overlap	Catchability	Risk of mortality

Whales	High	Low	Low
Dolphins	Medium	Low	Low
Seals, Sea lions	Medium	Medium	Medium
Mitigation			
Meets paragraph 24 of CMM 14b-2020 Avoidance of areas with visible mammal activity			
Residual risk after mitigation			
Whales - Low Dolphins - Low Seals, Sea lions - Low			

Mitigation measures

Few mitigation measures are available to reduce the risk of interactions with marine mammals. All reasonable steps must be taken to minimise the risk and incidental interactions with marine mammal. All reasonable steps must be taken that are necessary to ensure marine mammals are not attracted to the vessel. Due to depredation of toothfish by certain species, such as orcas and sperm whales, the Antarctic Discovery will naturally aim to avoid interactions with these species which may include steaming more than 90 nautical miles away, in accordance with guidance from recent toothfish depredation projects (Dr. Paul Tixier, pers. comm.).

Vessels shall take all reasonable steps to avoid losing any gear or non-biodegradable items from the boat to reduce entanglement risks. To prevent ingestion of or entanglement in the debris by marine mammals, there will be a prohibition on the use of plastic packaging bands.

Wildlife interaction reports are required to be completed and submitted within 24 hours of an interaction with a protected species (EPBC Act/CCAMLR), which must include detailed response to each wildlife interaction that must be implemented immediately by the fisher to minimise the likelihood of similar interactions.

Triggers

Any marine mammal bycatch will trigger a re-evaluation of fishing strategy and location, including potential move on measures.

Data collection

Data collection requirements under **Annex 7, Section G of CMM 02-2022 (Data Standards)** will be met. Sufficient data will be collected in aim of establishing baselines to build future monitoring and mitigation, as required under **paragraphs 12 and 26 of CMM 13-2021 (Exploratory Fisheries)**. E-monitoring will also monitor for marine mammal interactions.

4.5.7 VME Additional impacts of longline fishing

Summary Risk

Group	Spatial Overlap	Catchability	Risk of mortality
VME indicator species	Unknown	High (damage on seabed)	Medium
Mitigation			
Limited impact footprint			

Annual review of VME records and benthic camera records Any spatial overlap of line setting in subsequent years will be dependent on the previous year's review, with the aim of eliminating cumulative effects.
Residual risk after mitigation
VME indicator species - Low

Mitigation measures

As a precautionary measure, it should be assumed that there will be impact to VME indicator species when fishing on MCR–RB ridge from demersal longline fishing operations, through the impact from anchors, weights, hooks, and the line.

The footprint of a demersal longline is thought to be relatively low in comparison to demersal trawl (**BFIA SWG-10-DW-01A**). This combined with the low number of lines being set across a large spatial extent will ensure low local impact as well as ensure short-term recoverability of the impacted habitat. However, there are challenges in prescribing VME management tools for demersal longlines relating to the lack of comparative longline-derived VME catch and effort data, and the likely low detection rate of VME indicator species with demersal longline gear.

Lines set positions will not overlap previous line setting positions that year without review of the VME indicator species catch and evidence from seabed video monitoring This will ensure that there are no risks of cumulative impacts on VMEs as per **paragraph 20 of CMM 03-2020**.

Fishing gear has been developed so that all gear loss is minimised, this is continuously being achieved through gear strengthening, preventing line movement and recovery systems (larger floats and buoys and GPS systems, etc.) **Data collection**

All information specified in **CMM 03-2020** (Bottom fishing) and all data necessary to assess encounters with VMEs shall be collected to enable assessment and monitoring of the distribution of vulnerable marine ecosystems in the areas fished, including start and end positions of operations to monitor and analysis the spatial scale of fishing. Additionally,

- The vessel will record position, depth, type, and quantity of gear loss.
- Data will be collected to fill knowledge gaps as identified in **section 6 of SC6-DW09**, specifically the insufficient data from demersal longline fisheries to develop a data informed move-on rule for that method.
- VME data collection will help develop VME maps for the SPRFMO area as required under **CMM 03-18**.
- Environmental data will be collected (e.g. conductivity, temperature, depth,) for predictive modelling purposes, **as recommended by the BFIAS**.

5 Data collection plan

5.1 Standard SPRFMO data collection

During the fishing operations proposed in this application, data collection is proposed to be conducted in accordance with SPRFMO CMMs on data collection and any other elements suggested by the SPRFMO Scientific Committee during the consideration of this application.

Australia will ensure both the Antarctic Discovery and the observer on board comply with the relevant SPRFMO data collection requirements related to seabird and marine mammal observations as well as any other data recordings and opportunistic observations.

It is anticipated that the data collection described above should be adequate to establish baselines for future monitoring as required in CMM 13-2021. Should the first year of the exploratory fishing prove viable and three years of fishing are conducted, enough information should be collected to assist the Scientific Committee in providing future recommendations to the Commission about continued exploratory fishing proposals in this area or incorporating the area into management under CMMs 03-2023 and 03a-2023.

It is proposed that data will be collected as required by CMM 02-2022, specifically Annex 3 relating to long lining and Annex 7 relating to observer data.

The vessel will be required to complete the following information for each set, as required by Annex 3 of CMM 02-2022:

a) Vessel flag;

b) Vessel name;

c) Vessel call sign;

d) Registration number of vessel;

e) UVI (Unique Vessel Identifier)/IMO number;

f) Set start date and time (UTC format);

g) Set end date and time (UTC format);

h) Set start position (1/100th degree resolution – decimal format), latitude and longitude;

i) Set end position (1/100th degree resolution – decimal format), latitude and longitude;

j) Intended target species (FAO species code);

k) Number of hooks;

l) Bottom depth at start of set;

m) Incidental captures of species of concern (marine mammals, seabirds, reptiles or other species of concern6) or benthic taxa (Yes/No/Unknown);

n) FAO species code and estimated live weight of catch retained on board for all species caught by the set including target, bycatch and species of concern;

o) FAO species code and estimation of the amount7 of all living marine resources discarded by species to the extent practicable, including any marine mammals, seabirds, reptiles, species of concern, and benthic taxa.

Australia will ensure that the onboard observer completes the data related to the following sections of Annex 7 of CMM 2022-02 as per the requirements;

Section A: Vessel & Observer Data to be Collected for Each Observer Trip;

Section D: Catch & Effort Data to be Collected for Bottom Long Line Fishing Activity;

Section F: Length-Frequency Data to Be Collected;

Section G: Biological Sampling to be Conducted;

Section H: Data to be Collected on Incidental Captures of seabirds, mammals, reptiles (turtles) and other species of concern;

Section I: Detection of Fishing in Association with Vulnerable Marine Ecosystems (where relevant for long lining); and

Section J: Data to be collected for all Tag Recoveries.

5.2 Additional data collection for consistency with CCAMLR

Additional and/or more precise data will be collected, based on the research data collection plans specified for proximate CCAMLR surveys as described below. Data will be recorded and reported to SPRFMO and shared with CCAMLR upon request using the CCAMLR fine-scale catch and effort data (C2 longline fisheries) forms and CCAMLR observer forms and species codes for maximum consistency. This is critical, as it enables integration between the vessel catch-effort and observer biological data ensuring that the data can be prepared, error checked, and combined with CCAMLR data for use in CCAMLR and Australian stock assessment and reporting. The nominated vessel has demonstrated it is capable of reporting and electronically transmitting this information daily if necessary. Very similar information is regularly reported daily when this vessel is working within the CCAMLR Area.

5.3 Toothfish tagging

A minimum tagging rate of three fish of each Dissostichus species per green weight tonne retained will be implemented for consistency with research fishing requirements in the adjacent CCAMLR areas. These rules require a minimum tagging size overlap statistic (that is a comparison between the observed length frequency from vessel biological information and the size composition of fish returned alive with tags) of 60% once 30 or more Dissostichus have been successfully released with tags. The masters and crews of the Antarctic Discovery have experience working to catch limits and routinely closely monitor catch retained. As the catch limit is approached, the following measures will be used, as appropriate, to constrain the retained catch within the limit: shorter lines will be set; a seawater tank will be maintained on board such that live fish in good condition can be retained in case they need to be tagged and returned alive to stay within the catch limit; and the tagging rate may be progressively increased.

6 Post survey science reporting

The purpose of this exploratory fishing proposal is to determine the sustainable catch limit for toothfish in the MRC RB. As this proposal covers three years 2024-2026 it is anticipated that annual

reports will be presented to SPRFMO SC in 2025 and 2026 with a final, more detailed report presented in 2027.

If Antarctic toothfish are caught, these reports will also be provided to CCAMLR. Also, detailed information, including tag releases, recaptures and other associated data will be provided to the CCAMLR secretariat by the end of the current fishing month. In the event that Patagonian toothfish are caught all information will be shared with CSIRO, who conduct the Macquarie Island stock assessment , including AFMA, Australia's Commonwealth fisheries regulator, who manage the Macquarie Island Toothfish Fishery.

All mandatory reporting will be provided to SPRFMO within the relevant timeframes. Records of VME indictor taxa will be reported to SRPFMO and are likely to assist in the refinement of habitat suitability and abundance models. Environmental data will be collected (eg conductivity, temperature and depth) and be made available to CSIRO and SPRFMO.

7 Recommendations

It is recommended that the Scientific Committee:

a) **notes** Australia's proposal and its Fisheries Operation Plan to conduct exploratory demersal longline fishery for toothfish (limited at 40 tonnes green weight retained annually);

b) **recognises** the cautious, exploratory nature of the proposal especially with regard to minimising the risk to target species, non-target species and bycatch species, species of concern and VMEs.;

c) **recognises** the scientific benefits of the proposed data collection, especially for understanding the distribution, movement, spawning dynamics, and stock structure of toothfishes;

d) **approves or amends** the Data Collection Plan included in the proposal;

e) **advises** the Commission that the proposal is acceptable in terms of Articles 2 and 22, CMM-13-2021 (exploratory fisheries), CMM-03-2023 (bottom fisheries), and the BFIAS

8 References

Choi, H-K, Jang, J.E, Byeon, S.Y, Kim, Y.R, Machette, D, Chung, S, Choi, S-G, Kim H-W and Lee H. J. (2021) *Genetic diversity and population structure of the Antarctic Toothfish, Dissostichus Mawsoni, using mitochondrial and microsatellite DNA markers.* Frontiers in Marine Science 8 https://doi.org/10.3389/fmars.2021.666417

Gruss, A, Dunn, A and Parker, S 2021. *Assessment model for Antarctic toothfish (Dissostichus mawsoni) in the Ross Sea region to 2020-21.* Report to CCAMLR working group on Fish Stock Assessments WG- FSA-2021/26.

Hillary, R 2021, *Updated biological relationships for 2021 stock assessment of Macquarie Island Toothfish*, CSIRO Oceans and Atmosphere, Hobart.

Hillary, R & Day, J 2021, *Integrated stock assessment for Macquarie Island toothfish using data up to and including 2020,* CSIRO Oceans and Atmosphere, Hobart.

Robertson, Graham & McNeill, Malcolm & Smith, Neville & Wienecke, Barbara & Candy, Steven & Olivier, Frederique. (2006). *Fast sinking (integrated weight) longlines reduce mortality of White-chinned Petrels (Procellaria aequinoctialis) and Sooty Shearwaters (Puffinus griseus) in demersal longline fisheries*. Biological Conservation. 132. 458-471. 10.1016/j.biocon.2006.05.003.

9 Appendices

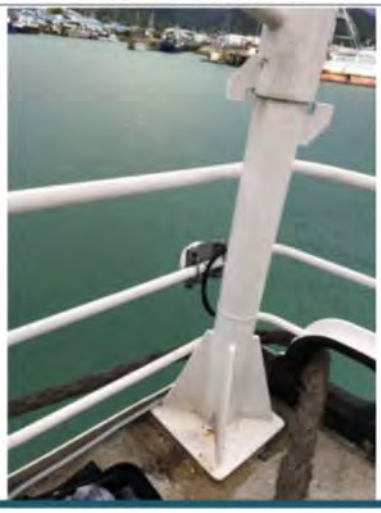
9.1 Appendix 1: VMS system details

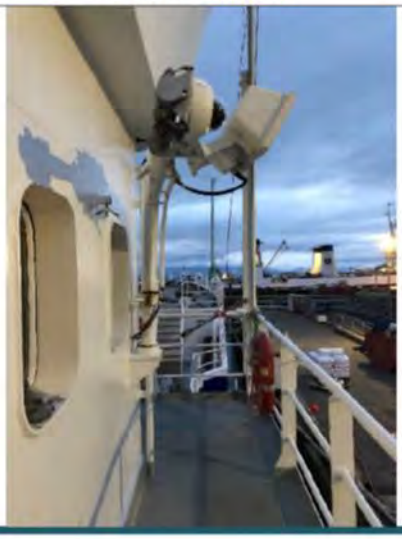
Manufacturer	Cobham Sailor
Model	3027 mini C terminal
Serial Number	15139826
Mobile Number	450371812
Service provider:	Inmarsat / SATCOM

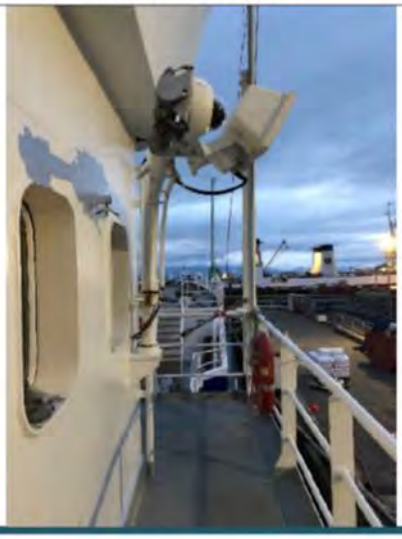
Manufacturer	CLS
Model	Triton Advanced
Serial Number	TM0000150583
Mobile Number	525024
Service provider:	CLS

9.2 Appendix 2: E-monitoring details

Camera Name	Tori Line	Camera Type	Vivotek FD9367-HV
Location	Aft-port rail	Trigger Settings	Auto-baiter/Tori winch
View/Purpose	Tori Line	Recording Exceptions	In Port
FPS	5	Run on Time	20min
		Image resolution	1920 x 1080

Camera View	Camera Location
	

Camera Name	BridgeWing	Camera Type	Vivotek FD9367-HTV
Location	Starboard mid-ship light boom	Trigger Settings	Pressure - Hauler
View/Purpose	Outboard hauling	Recording Exceptions	In Port
FPS	10	Run on Time	20min
		Image resolution	1920 x 1080
Camera View		**Camera Location**	
			

Camera Name	BridgeWing	Camera Type	Vivotek FD9367-HTV
Location	Starboard mid-ship light boom	Trigger Settings	Pressure - Hauler
View/Purpose	Outboard hauling	Recording Exceptions	In Port
FPS	10	Run on Time	20min
		Image resolution	1920 x 1080
Camera View		**Camera Location**	
			

9.3 Appendix 3: Bycatch Risk Assessment for exploratory demersal longline fishing: Macquarie Ridge continuation Research Block, South Pacific Regional Fisheries Management Organisation (SPRFMO) Convention area

Australian Government
Department of Agriculture, Fisheries and Forestry
ABARES

Risk assessment for exploratory toothfish demersal longline fishery:

Macquarie Ridge Continuation Research Block, South Pacific Regional Fisheries Management Organisation (SPRFMO) Convention Area

Brooke D'Alberto and Trent Timmiss

Research by the Australian Bureau of Agricultural and Resource Economics and Sciences

Technical Report 23.22
June 2023

© Commonwealth of Australia 2023

Ownership of intellectual property rights

Unless otherwise noted, copyright (and any other intellectual property rights) in this publication is owned by the Commonwealth of Australia (referred to as the Commonwealth).

Creative Commons licence

All material in this publication is licensed under a Creative Commons Attribution 4.0 International Licence except content supplied by third parties, logos and the Commonwealth Coat of Arms.

Cataloguing data

This publication (and any material sourced from it) should be attributed as: D'Alberto, B & Timmiss, T 2023, *Risk assessment for exploratory toothfish demersal longline fishery: Macquarie Ridge Continuation Research Block, South Pacific Regional Fisheries Management Organisation (SPRFMO) Convention Area*, ABARES Technical Report 23.22, Canberra, June, DOI: 10.25814/ybdd-ph05. CC BY 4.0.

ISSN 189-3128

Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES)
GPO Box 858 Canberra ACT 2601
Telephone 1800 900 090
Web agriculture.gov.au/abares

Disclaimer

The Australian Government acting through the Department of Agriculture, Fisheries and Forestry, represented by the Australian Bureau of Agricultural and Resource Economics and Sciences, has exercised due care and skill in preparing and compiling the information and data in this publication. Notwithstanding, the Department of Agriculture, Fisheries and Forestry, ABARES, its employees and advisers disclaim all liability, including liability for negligence and for any loss, damage, injury, expense or cost incurred by any person as a result of accessing, using or relying on any of the information or data in this publication to the maximum extent permitted by law.

Professional independence

The views and analysis presented in ABARES publications reflect ABARES professionally independent findings, based on scientific and economic concepts, principles, information and data. These views, analysis and findings may not reflect or be consistent with the views or positions of the Australian Government or of organisations or groups that have commissioned ABARES reports or analysis. Learn more about ABARES professional independence.

Acknowledgements

The authors thank Dave Galeano (DAFF) and Marty Johnson for their input with the report.

Acknowledgement of Country

We acknowledge the Traditional Custodians of Australia and their continuing connection to land and sea, waters, environment and community. We pay our respects to the Traditional Custodians of the lands we live and work on, their culture, and their Elders past and present.

Contents

Background

This risk assessment is prepared for the support of Australia's proposal for the new exploratory Toothfish species (*Dissostichus spp.*) fishing program in the new area, Macquarie Ridge Continuation Research Block (MRC-RB) within the South Pacific Regional Fisheries Management Organisation (SPRFMO) Convention Area (Figure 1). This assessment includes a mitigation strategy for minimising bycatch and overall impact on the marine environment.

There is little information about toothfish for this region and to the best of our knowledge, there has been no recorded toothfish fishing within MRC-RB. There is a Patagonian toothfish (*Dissostichus eleginoides*) fishery in the Australian Economic Exclusive Zone (EEZ) to the north at Macquarie Island and an Antarctic toothfish (*Dissostichus mawsoni*) fishery in the Conservation of Antarctic Marine Living Resources (CCAMLR) Convention Area to the South of the proposed area (Figure 1).

Data gathered and summarised in this report is aimed at providing the SPRFMO Scientific Committee (SC) with sufficient knowledge to make informed recommendations to the Commission, as required by **CMM 13 – 2021**.

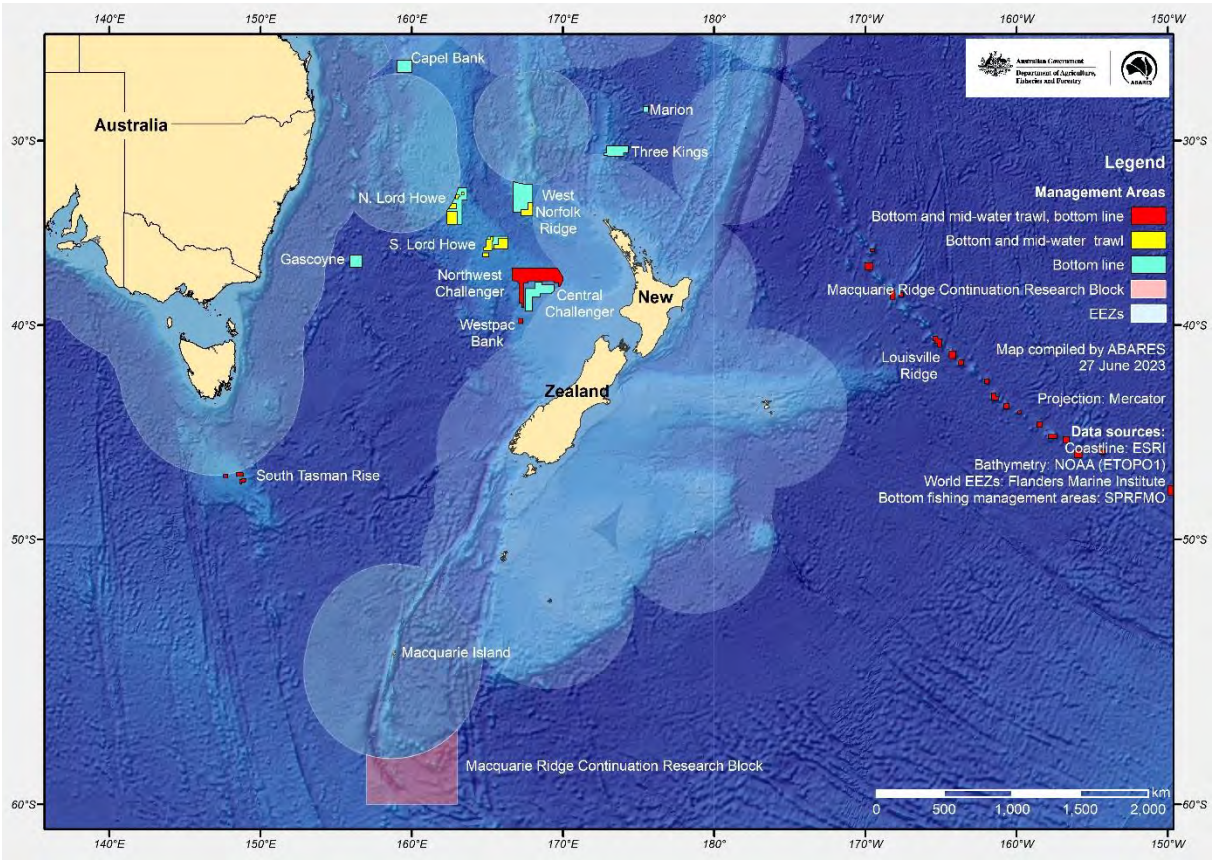


Figure 1 Proposed exploratory area in the Macquarie Ridge Continuation Research Block (MRC-RB). The SPRFMO Convention Area is delineated, as well as adjacent Economic Exclusion Zones (EEZs) and Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) Convention Area.

Methods

The aim is to undertake qualitative assessments that will incorporate key characteristics of the species, aiding the evaluation of likelihood and consequence of bycatch interactions in the case of demersal longline fishing for toothfish species in the proposed exploratory area, MCR–RB.

The SPRFMO **Bottom Fishery Impact Assessment Standard** (BFIAS) (2019) was used as guidance for this risk assessment. As this an exploratory fishery in an area not well understood in terms of species presence or abundance, the expert judgment based Level 1 analysis (Scale Intensity Consequence Analysis; SICA) approach from the Ecological Risk Assessment for Effects of Fishing (ERAEF) (Hobday et al. 2007) was used.

Data on spatial overlap and catchability was evaluated and given qualitative assignments of 'Low', 'Low-Med', 'Med', 'Med-High' and 'High', and combined to form overall risk. Mitigation measures were applied and a residual risk analysis (RRA) was presented. The species' International Union for Conservation of Nature's (IUCN) Red List of Threatened Species conservation status was used to inform decisions on triggers and actions to be taken to manage risk. A feedback process to incorporate new knowledge was considered to reduce risk through enhanced mitigation.

Scope of risk assessment

This assessment aims to identify the risk to:

- Target species
- Seabirds
- Marine mammals, reptiles, and other species of concern
- Non–target species and bycatch species
- Benthic habitats, biodiversity, and vulnerable marine ecosystems (VMEs)

In addition, consideration is given to hazards caused by fishing, including impacts of gear and gear loss, as well as examining the potential for bird strike, discards, and other potential impactors.

Spatial overlap

As per recommended by the BFIAS, in areas where information was lacking on the likelihood of occurrence [of VMEs], other information that is relevant to inferring the likely presence of vulnerable populations, communities, and habitats was used.

This approach was taken for all species groups potentially impacted by fishing activities through using available information from the risk assessments conducted for the nearby Macquarie Island Toothfish Fishery (MITF) (Daley et al., 2007; Zhou & Fuller, 2011).

Data sources

Data on species observation and predicted occurrences were gathered from multiple validated online and published sources. Data for taxonomic groups and species were cross validated between multiple sources. Online data was accessed on 26th May 2023.

- International Union for Conservation of Nature's (IUCN) Red List of Threatened Species (www.iucnredlist.org) was used to collect species distribution data using published spatial data, and the conservation status of the species.
- BirdLife International (www.birdlife.org) holds the IUCN distribution shape files and Threatened Species lists for birds.
- Rays of the World (Last et al., 2016).
- Sharks of the World (Ebert et al., 2013).
- Fish Base (www.fishbase.com). Global species database of fish species with mapped predicted distributions from Aquamaps (www.aquamaps.com).

Catchability

The species catchability, that is the likelihood of the species susceptible to being caught during demersal longline fishing operations was assessed, assuming no mitigation.

For seabirds, the size, diving behaviour, and other characteristics were considered and gathered from various sources.

For species other than seabirds, catchability was considered relative to the species vertical distribution in the water column (either benthic or pelagic). For example, higher catchability sources were given to demersal/benthic species, compared to pelagic species that are more associated with the water column. The fishing method in the proposed application is highly associated with benthic/demersal habitats for long periods of time (12 – 16 hours soak time), comparted to the time spent in the water column and pelagic areas during setting and hauling of lines (approx. 6 hours).

Conservation Status: IUCN

The IUCN Red List of Threatened Species conservation status for the species was considered in the assessment, acting as a modifier to catchability. A more conservative approach to the species risk with critical conservation status (Critically Endangered [CR], Endangered [EN], or Vulnerable [VU]) was taken.

Seasonality

Seasonality may affect species occurrence at the time of expected fishing within the MRC-RB area. In order to apply the most precautionary assessment and in the absence of species presence data, it was assumed that the likelihood of impact would remain the same in the region throughout the year and across all seasons.

Proposed mitigation and residual risk

Measures for reducing the occurrence of bycatch was provided and the residual impact after the mitigation measures were assessed to provide the residual risk of mortality.

Ecological setting

The proposed area (MRC-RB) is the continuation of the Macquarie Ridge which is located with the SPRFMO Convention Area. Fishing will occur on several seamounts in depths ranging from 600 – 2,500 m that could provide suitable habitat for Toothfish.

Macquarie Ridge is one of the southernmost seamount ridges, extending ~1600 km that runs north to south and characterised by rugged bathymetry (Conway et al., 2012). Macquarie Ridge is one of three ridges which impedes the eastward flow the Antarctic Circumpolar Circulation across the Southern Ocean, with differences in the biological and physical oceanography to the west and east of the ridge (Sokolov and Rintoul 2009a). It is an area where three main bodies of water are separated by two oceanic fronts (Sub-Antarctic Front and Antarctic Polar Front) creating a complex range of habitats (Gordon, 1988). The ridge not only separates two hydrological regions, but also separates areas of distinctive marine life associations with representatives from south-east Australia, southern New Zealand and other regions of the Southern Ocean, many of which are at the southern or northern limit of their range (Butler et al., 2000). There is evidence for changes in community composition north to south, and it is likely that the ridge provides “stepping stones” linking Sub-Antarctic and polar faunas.

The total proposed area for the exploratory fishing of MRC-RB is approximately ~55,257 km², the area within the fishable depth range 600 – 2500 m equates to about 19% of the total fishable area at approximately ~10,370 km². The fishable depth area is calculated from the bathymetric information provided by SeaPlot (https://seaplot.net/index.html). However, it is suspected that there may well be inaccuracies, as survey activities in this region have been limited.

Species inventories for the benthic and pelagic habitats are absent for this region. Analyses of the benthic communities of the Macquarie Ridge, primarily focused near Macquarie Island, remain preliminary due to uneven sampling effort and incomplete analysis.

Risk Assessment

Target species

Summary

Group	Spatial Overlap	Catchability	Risk of mortality
Toothfish	High	High	High
Mitigation			
Catch limit for target species Limited entry to the fishery *Caveat – unknown species composition of 2 toothfish species*			
Residual risk after mitigation			
Toothfish - High			

General Assessment

The main target species is toothfish, *Dissostichus spp.* (Patagonian toothfish *Dissostichus eleginoides* and/or Antarctic toothfish *Dissostichus mawsoni*), which are large (up to 2 m maximum length) and relatively long-lived species. Both species are benthopelagic and can be found at depths of 50 – 3000 meters.

The species composition and stock structure and of the proposed exploratory MCR–RB region is unknown. The closest spawning aggregation of Patagonian toothfish is around the nearby Macquarie Island (Gon & Heemstra, 1990; Peron et al., 2016), while Antarctic toothfish generally have a more southerly distribution and thought to be endemic to the waters around Antarctica (Maschette et al., 2023). The Patagonian toothfish stock at Macquarie Island is considered to be distinct from other regional toothfish populations in the Southern Ocean based on genetic studies and toothfish tagging programs (Appleyard et al. 2002; Williams et al. 2002) and assumed to be a single reproductive stock for stock assessment purposes (Hilary & Day, 2021).

Conservation status

Toothfish species have not been assessed by the IUCN Red List of Threatened Species.

Mitigation measures

There will be catch and effort limits for this proposed region MCR–RB. Input controls for the exploratory fishery will meet and exceed CCAMLAR standard input controls, including:

- Limited entry to the proposed region MCR–RB to 1 vessel (Antarctic Discovery)
- Carriage of full time observer
- Use of e-monitoring
- Vessel monitoring systems
- Annual target species catch limit of 40 t
- Spatial controls on fishing to avoid localised depletion

Data collection

Data collection requirements under **Annex 7, Section G of CMM 02-2022 (Data Standards)** will be met. Sufficient data will be collected in aim of establishing baselines to build future monitoring and mitigation, as required under **paragraphs 12 and 26 of CMM 13-2021 (Exploratory Fisheries)**. Additional data collection protocols under **CMM 14-2021 paragraph 24** will be met or be exceed, including:

- 100% observer coverage of shots, as per CCAMLR and Australian sub-Antarctic fishery requirements,
- Collection of length frequencies and otoliths for future analysis
- Collection of data that will facilitate assessment of any subsequent fishing.

Seabirds

Summary

Group	Spatial Overlap	Catchability	Risk of mortality
Albatross & Fulmars	High	High	High
Cormorant & Shags	Medium	Low	Medium
Gulls, Terns & Skuas	High	Medium	Med-High
Penguins	High	Low	Medium
Petrels, Prions & Shearwaters	High	Medium	Med-High
Mitigation			
Meets and exceeds CMM-09-07 No offal discharge			
Residual risk after mitigation			
Albatross & Fulmars - Low Cormorant & Shags - Low Gulls, Terns & Skuas - Low Penguins - Low Petrels, Prions & Shearwaters - Low			

General Assessment

A total of 58 seabird species were identified as overlapping or nearby the MCR–RB to varying degrees, based on the seabird species identified by the risk assessments for Macquarie Island sub-fisheries (Daley et al. 2007; Zhou & Fuller, 2011; Appendix 1).

Seabird interactions have been considered the principle ecological risk for Macquarie Island fisheries, including the nearby proposed region of MCR–RB, due to the particularly small population of wandering albatrosses on Macquarie Island. At the surface, birds are attracted to baited hooks during line setting and hauling, where some species may be caught at the surface (e.g. albatrosses)

or underwater if the species is able to dive to the baited hooks while descending (e.g. white chinned petrels). The seabirds at higher risk of interactions are the larger seabirds who are able to feed on the large squid and mackerel bait (e.g. petrels, shearwaters, albatrosses, and fulmars), while penguins considered to be at least at risk.

Seabird mortality mitigation measures have been successfully developed by the demersal longline fleet catching toothfish in Macquarie Island and CCAMLR. There have been no seabird interactions with longline fishing gear in the MITF since operations began in 1994 (AFMA 2013 Bycatch Discards Plan), including the proposed fishing vessel.

Conservation status and species at risk

Of the seabird species identified to be potentially encountered on the MCR–RB, 5 species were listed as EN, 9 species listed as VU, 9 species listed as Near Threatened (NT) and 35 species listed as Least Concern (LC), and 1 species has not assessed on the IUCN Red List of Threatened Species.

Macquarie Island supports a small and critical breeding population of Wandering albatrosses (listed as VU globally), with reported 5 breeding pairs (Cleeland et al. 2021).

Mitigation measures

Mitigation measures adopted for seabirds in MITF have been successful in avoiding interactions with seabirds. Mitigation measures will meet **CCMALR CMM 25-02 2018** and meet and exceed **SPRFMO Annex 1 CMM-09 2017**. Specifically for longline operation, the following mitigation measures will apply:

- Offal will not be dumped during fishing operations.
- Integrated weight line – longline vessels use 12 mm integrated weight line with at least 50 g/m to sink the line quickly beyond the feeding range of seabirds.
- Paired streamer lines – two streamer lines (minimum of 150 m in length) are used to scare birds away from gear during line setting and to be attached to the vessel such that it is suspended from a point a minimum of 7 m above the water at the stern on the windward side of the point where the hook-lines enters the water.
- Bird excluder device – as adopted by CCAMLR to be deployed to discourage birds from accessing baits during line hauling.
- Prohibition on the use of plastic packing bands – to prevent ingestion of or entanglement in the debris by seabirds or marine mammals; and
- Minimisation of lighting – to reduce the risks of seabirds colliding with the vessel.
- Bird scaring sound cannon
- Position of baiting machine – repositioning of the machine towards the centre of the vessel to enable the line to sink quickly within the downward wash of the propeller.

Trigger / Action

In line with the domestic Threat Abatement Plan for seabirds, future fishing will be reviewed if the interaction rate for seabirds must be less than 0.001 seabirds per 1000 hooks set.

Data collection

Data collection requirements under **Annex 7, Section G of CMM 02-2022 (Data Standards)** will be met. Sufficient data will be collected in aim of establishing baselines to build future monitoring and mitigation, as required under **paragraphs 12 and 26 of CMM 13-2021 (Exploratory Fisheries)**. Additional data collection protocols under **CMM 14-2021 paragraph 24** will be met or be exceed, including:

- As per CCAMLR and Australian sub-Antarctic fishery requirements, there must be 100% observer coverage of all shots for marine mammals, seabirds, and other species of concern.
- All dead seabirds must be retained for formal identification and necropsy.
- E-monitoring will also be employed to assist with seabird observations.

Marine Mammals

Summary

Group	Spatial Overlap	Catchability	Risk of mortality
Whales	High	Low	Low
Dolphins	Medium	Low	Low
Seals, Sea lions	Medium	Medium	Medium
Mitigation			
Meets paragraph 24 of CMM 14b-2020 Avoidance of areas with visible mammal activity			
Residual risk after mitigation			
Whales - Low Dolphins - Low Seals, Sea lions - Low			

General Assessment

A total of 32 marine mammals were identified as overlapping or nearby the MCR–RB to varying degrees, based on the marine mammal species identified by the risk assessments for Macquarie Island sub-fisheries (Daley et al. 2007; Zhou & Fuller, 2011; Appendix 2). No reptiles have a distribution within the proposed area.

The majority of whale species and half of dolphin species have a high degree of potential overlap with the MCR–RB region. Whales and dolphins are likely to be at risk at or near the surface during setting and hauling, where entanglement could result in injury or death. Catchability of whale and dolphins on the longlines is thought to be low, however it can vary between species (Werner et al., 2015).

Toothed whales and some dolphin species (orcas) have a high degree of association with toothfish longline vessels, with some seasonal and spatial patterns occurring (Clark & Agnew 2010; Richard et al. 2020). Interactions with sperm whales and orcas mainly involve depredation of catch off the line that can occur at any time during the fishing process (setting, soaking or hauling) and loss or damage

to gear (Tixier et al. 2019; Richards et al. 2020). Interactions that result in injury or death of toothed whales and dolphins may occur, with reported mortalities low-near-zero.

True seals, fur seals and sea lions have been associated with toothfish longline vessels, and have been observed to depredate on catch. There has been one fur seal interaction with the fishing gear in the MITF, where in 2008 a New Zealand fur seal was briefly hooked in a flipper when it swam into the 'moonpool' (seabird bycatch mitigation tool) on a longline fishing vessel. Toothfish fishing related mortalities and interactions with seals appear to be very rare at Macquarie Island.

Known interaction rates with marine mammals in nearby fisheries (MITF and CCAMLR) are low. The low number of reported incidents involving serious injury or death in the nearby fisheries and by the proposed vessels to the marine mammals is a positive factor.

Conservation status and species at risk

Of the marine mammal species identified to be potentially encountered on the MCR–RB, 3 species were listed as EN, 2 species listed as VU, 2 species listed as NT and 22 species listed as LC, and 3 species listed as Data Deficit (DD) on the IUCN Red List of Threatened Species.

Mitigation measures

Few mitigation measures are available to reduce the risk of interactions with marine mammals. All reasonable steps must be taken to minimise the risk and incidental interactions with marine mammal. All reasonable steps must be taken that are necessary to ensure mammals are not attracted to the vessel. Due to depredation of toothfish by certain species, such as orcas and sperm whales, vessels will naturally aim to avoid interactions with these species which may include steaming more than 90 n miles away, in accordance with guidance from recent toothfish depredation projects (Dr. Paul Tixier, pers. comm.).

Vessels shall take all reasonable steps to avoid losing any gear or non-biodegradable items from the boat to reduce entanglement risks. To prevent ingestion of or entanglement in the debris by marine mammals, there will be a prohibition on the use of plastic packaging bands.

Wildlife interaction reports are required to be completed and submitted within 24 hours of an interaction with a protected species (EPBC Act/CCAMLR), which must include detailed response to each wildlife interaction that must be implemented immediately by the fisher to minimise the likelihood of similar interactions.

Triggers

Any marine mammal bycatch will trigger a re-evaluation of fishing strategy and location, including potential move on measures.

Data collection

Data collection requirements under **Annex 7, Section G of CMM 02-2022 (Data Standards)** will be met. Sufficient data will be collected with the aim of establishing baselines to build future monitoring and mitigation, as required under **paragraphs 12 and 26 of CMM 13-2021 (Exploratory Fisheries)**. E-monitoring will also monitor for marine mammal interactions.

Non-target finfish

Summary Risk

Group	Spatial Overlap	Catchability	Risk of mortality
Macrouridae, Moridae, Anguilliformes	High	High	High
Other species	Medium	Low	Low
Mitigation			
Precautionary bycatch limits Low effort proposed			
Residual risk after mitigation			
Macrouridae, Moridae, Anguilliformes - Low Other species - Low			

General Assessment

There is poor knowledge of the fish taxonomy and biogeography of the area. As there were no historical fishing records available for the proposed region (MCR–RB), the assessments for non-target finfish were made in consideration for possible interactions with the demersal longline gear and known bycatch profiles based on other toothfish longline fisheries. The species identified in the sustainability assessment for fishing effects (SAFE) on fish bycatch species (Zhou & Fulller, 2011) and ecological risk assessment (ERA) for demersal trawl for MITF (Daley et al. 2007) was considered in this assessment.

A total of 136 non-target finfish species were identified in OBIS and by other risk assessments to have possible distributions over the proposed fished area of MCR–RB (Appendix 3). On the basis of previous experience on the MITF, and other toothfish fisheries, Macrouridae, Moridae, and the Anguilliformes likely to be caught as bycatch. Other groups have a low likelihood of being caught. On this basis, a catchability of ‘High’ was allocated to these groups, while the other species were assigned a catchability of ‘Medium’.

The principal bycatch species recorded in the nearby MITF for demersal longline are macrourid (*Macrourus carinatus*), blue antimoral (*Antimora rostrata*), and stonecrab (*Lithoides murrayi*). Given the general circumpolar distribution of most fish species at this latitude, and experience in other nearby fisheries, such as MITF, Heard & McDonald Islands and in CCAMLR, it is expected that bycatch will not exceed 10% of the total catch. For example, in MITF for 2021-22, 4% of the total retained catch accounted for by other species, primarily grenadier and violet cod, with 94% of the total retained catch was toothfish (Patterson & Curtotti 2022).

Conservation status and species at risk

No potential fish bycatch species are particularly at risk.

Mitigation measures

Precautionary catch limits for all bycatch species will meet and exceed **CCAMLR CMM 33-03 2022** and **SPRFMO CMM 02-2020 (Data Standard) Annex 14**. Once the limit has been reached, fishing will cease. The total catch of by-catch, excluding individuals released alive, shall not exceed the following limits:

- *Macrourus* spp.: 16% of the catch limit for *Dissostichus* spp.
- Other species: 16% of the catch limit for *Dissostichus* spp.
- One species: 1 tonne limit in any one haul or set and will trigger move-on rule as below.

As per **CCAMLR CMM 33-03 2022 paragraph 3 and 5,** if the by-catch of only one species is equal to, or greater than 1 tonne in any one haul or set, then the fishing vessel shall move to another location at least 5 n miles distant. '*Macrourus* spp.' will be counted as a single species. The fishing vessel shall not return to any point within 5 n miles of the location where the bycatch exceed 1 tonne for a period of at least five days. The location where the bycatch exceed 1 tonne will be defined as the point at which the first anchor of a set was deployed to the point at which the last anchor of that set was deployed.

Trigger / Action

Bycatch limits and move-on-rules for bycatch species following **CCAMLR CMM 33-03**.

Data collection

Data collection requirements under **Annex 7, Section G of CMM 02-2022 (Data Standards)** will be met. Sufficient data will be collected with the aim of establishing baselines to build future monitoring and mitigation, as required under **paragraphs 12 and 26 of CMM 13-2021 (Exploratory Fisheries)**. Additionally,

- Samples will be retained for specialist identification and museum curation.
- Samples for DNA analyses will be collected.

Chondrichthyans

Summary Risk

Group	Spatial Overlap	Catchability	Risk of mortality
Skates	Unknown	High	Low
Sharks	Medium	Medium	Medium
Mitigation			
Precautionary bycatch limits Skates and sharks (where possible) are to be released alive Safe handling practises Ban on wire traces			
Residual risk after mitigation			
Skates - Low			
Sharks - Medium			

General Assessment

The risk assessment for MITF (Zhou & Fulller, 2011) and for deepwater chondrichthyans in SC7-DW10-rev1 were considered in this risk assessment. This was done in a comparative way, as the qualitative assessments made in this report use similar concepts as the two quantitative, integrated assessments using the PSA and SAFE methods.

As there were no historical fishing records available for the proposed region (MCR–RB), the assessments for chondrichthyans were made in consideration for possible interactions with the demersal longline gear and known bycatch profiles based on other toothfish longline fisheries.

A total of 9 shark species were found to have possible distributions over the proposed fished area of MCR–RB (Appendix 4), with a mix of demersal and pelagic species identified. Catchability of the demersal species were considered 'High' and pelagic species were considered 'Medium' given the shorter amount of time that the line is suspended in the water column, compared to the time on the benthos. A base SAFE of MITF on nearby Macquarie Island demonstrated that the southern sleeper shark *Somniosus antarcticus* was the main bycatch species, had a high catchability with demersal longline gear and the most vulnerable discard species. As it unknown if the species of these groups are present on the MCR–RB, a level of precaution will be taken.

No skates (*Bathyraja* spp) were found to have possible distributions over the proposed MCR–RB (Last et al 2016). Skates (*Bathyraja* spp) have been recorded in the far northern area of Macquarie Island, where there is a connection with the New Zealand continental shelf (AFMA 2010). Skates have not been recorded to be caught on the Macquarie Ridge in MITF, in contrast to toothfish fisheries elsewhere (CCAMLAR – Heard Island and McDonald Island, Kerguelen, Ross Sea, South Georgia) (AFMA 2010). It is unknown if skates are present on the MCR–RB and a level of precaution will be taken.

As noted in SC7-DW10-rev1, 'false positives' and 'false negatives' can occur due to the lack of data through reporting, poor species identification, and/or assumption that the degree of interaction with the fishing gear is higher than what actually occurs. Due to the paucity of fishing interaction data from the proposed region, it is possible that the assessments here are over-precautionary.

Conservation Status and species at risk

Of the shark species identified to be potentially encountered on the MCR–RB, one species in listed as EN, two species listed as VU, 2 species listed as NT and one species listed as LC on the IUCN Red List of Threatened Species. One species was not assessed by the IUCN Red List.

One of the shark species, porbeagle (*Lamna nasus*) is listed on the **CMM 02-2020 (Data Standard) Annex 14** as other species of concern.

Mitigation measures

Primary mitigation for reducing risk to chondrichthyans is through precautionary bycatch limits and gear restrictions, including a ban on the use of wire traces. Catch limits for all bycatch species will meet and exceed **CCAMLR CMM 33-03 2022** and **SPRFMO CMM 02-2020 (Data Standard) Annex 14**. The total catch of by-catch, excluding individuals released alive, shall not exceed the following limits:

- Skates and rays: 5% of the catch limit for *Dissostichus* spp.
- Other species: 16% of the catch limit for *Dissostichus* spp.

- Species listed on CMM 02-2020 Annex 14: ban on retention of these species.

Chondrichthyans caught alive with high probability of survival should be recovered from the line and released alive, especially juveniles and gravid females. Skate can often be recovered and released alive. However the post-capture mortality of shark species is likely to be high based on studies of deepwater dogfish and shark species, particularly for larger species such as Somniosidae.

Safe handling practises will be used, including not bringing the animal on board the vessel and cutting the animal off at the water line to help ensure better post capture survival.

As per **CCMALR CMM 33-03 paragraph 3 and 5,** if the by-catch of only one species is equal to, or greater than 1 tonne in any one haul or set, then the fishing vessel shall move to another location at least 5 n miles distant. 'Skates and rays' will be counted as a single species. The fishing vessel shall not return to any point within 5 n miles of the location where the bycatch exceed 1 tonne for a period of at least five days. The location where the bycatch exceed 1 tonne will be defined as the point at which the first anchor of a set was deployed to the point at which the last anchor of that set was deployed.

Trigger / Action

Bycatch limits and move-on-rules for bycatch species.

Data Collection

Data collection requirements under **Annex 7, Sections E and F of CMM 02-2020** (Data Standards) will be met. Sufficient data will be collected with the aim of establishing baselines to build future monitoring and mitigation, as required under **paragraphs 10** and **24** of **CMM 13-2020.**

Vulnerable Marine Ecosystems

Summary Risk

Group	Spatial Overlap	Catchability	Risk of mortality
VME indicator species	Unknown	High (damage on seabed)	Medium
Mitigation			
Limited impact footprint Annual review of VME records and benthic camera records Any spatial overlap of line setting in subsequent years will be dependent on the previous year's review, with the aim of eliminating cumulative effects.			
Residual risk after mitigation			
VME indicator species - Low			

General Assessment

This exploratory fishing is outside the currently assessed area in Bottom Fishing Impact Assessment submitted by Australia and New Zealand.

Fishing has the potential to alter the distribution of communities through disturbing the seafloor and benthos, however the impacts of demersal longlines on benthic habitats is not completely understood. Demersal longline gear has a lesser impact on the benthic environment than demersal trawling. However, demersal longline fishing operations can catch benthic organisms, including vulnerable hard corals, gorgonians, and sponges. Demersal line operations can either directly catch benthic organisms on the hooks, or may cause damage to benthic communities as the lines are dragged laterally across the benthos, either by currents or during hauling. The extent of the impacts on the benthos will be limited to areas directly damaged by fishing gear.

Benthic taxa were found to be patchily distributed along the Macquarie Ridge, whereas areas of high taxa diversity occurred east of Macquarie Island (Dell et al. 2006). Sponges, octocorals and lophotrochoza (brachiopods and bryozoans) dominate the sparse benthic environments and large branching sessile epifauna form important habitat for other organisms (Dell et al. 2006). As there were no historical fishing records available for the proposed region (MCR–RB), the assessments for VME were made in consideration for possible interactions with the demersal longline gear and known VME profiles based on other toothfish longline fisheries.

No records of possible VME indicator species were found on OBIS.

In addition to the impact of demersal gear on the benthos, there is a risk of loss of bottom line fishing gear that can impact benthic communities and habitats. The greatest risk is the loss of weights, anchors, and gear that may be rigged with weak links to such gear to prevent the loss of catch and fishing components, if the anchors should become stuck. As the gear is weighted, it will remain at the site at which it was lost and is likely to take considerable length of time (years to decades) to degrade and become covered with benthic growth. There is not likely to be any additional impact on the benthic fauna once the gear is lost and the bait degrades within 1 year.

Conservation status

Specific species have not been identified as being at-risk, but broadly include those species that form hard structures or frameworks with slow recovery potential.

Mitigation measures

As a precautionary measure, it should be assumed that there will be impact to VME indicator species when fishing on MCR–RB ridge from demersal longline fishing operations, through the impact from anchors, weights, hooks, and the line.

The footprint of a demersal longline is thought to be relatively low in comparison to demersal trawl (**BFIA SWG-10-DW-01A**). This combined with the low number of lines being set across a large spatial extent will ensure low local impact as well as ensure short-term recoverability of the impacted habitat. However, there are challenges in prescribing VME management tools for demersal longlines relating to the lack of comparative longline-derived VME catch and effort data, and the likely low detection rate of VME indicator species with demersal longline gear.

Lines set positions will not overlap previous line setting positions that year without review of the VME indicator species catch and evidence from seabed video monitoring This will ensure that there are no risks of cumulative impacts on VMEs as per **paragraph 20 of CMM 03-2020**.

Fishing gear has been developed so that all gear loss is minimised, this is continuously being achieved through gear strengthening, preventing line movement and recovery systems (larger floats and buoys and GPS systems, etc.).

Data collection

All information specified in **CMM 03-2020** (Bottom fishing) and all data necessary to assess encounters with VMEs shall be collected to enable assessment and monitoring of the distribution of vulnerable marine ecosystems in the areas fished, including start and end positions of operations to monitor and analysis the spatial scale of fishing. Additionally,

- The vessel will record position, depth, type, and quantity of gear loss.
- Data will be collected to fill knowledge gaps as identified in **section 6 of SC6-DW09**, specifically the insufficient data from demersal longline fisheries to develop a data informed move-on rule for that method.
- VME data collection will help develop VME maps for the SPRFMO area as required under **CMM 03-18**.
- Environmental data will be collected (e.g. conductivity, temperature) for predictive modelling purposes, **as recommended by the BFIAS**.

Appendix 1: Seabirds

Group	Species	Common name	IUCN Status	Spatial Overlap	Catchability	Risk	Residual Risk	PSA MITF
Albatross & Fulmars	Phoebetria fusca	Sooty Albatross	EN	Medium	High	Med-High	Low	Medium
Albatross & Fulmars	Thalassarche chrysostoma	Grey-headed Albatross	EN	High	High	High	Low	Medium
Albatross & Fulmars	Diomedea amsterdamensis	Amsterdam Albatross	EU	Low	High	Medium	Low	Medium
Albatross & Fulmars	Diomedea sanfordi	Northern Royal Albatross	EU	High	High	High	Low	Medium
Penguins	Eudyptes sclateri	Erect-crested penguin	EU	Medium	Low	Low-Med	Low	Medium
Albatross & Fulmars	Thalassarche melanophrys	Black-browed Albatross	LC	High	High	High	Low	Medium
Albatross & Fulmars	Fulmarus glacialoides	Southern fulmar	LC	High	High	High	Low	Medium
Cormorant & Shags	Phalacrocorax carbo	Black cormorant	LC	Medium	Low	Low-Med	Low	Medium
Gulls, Terns & Skuas	Larus dominicanus	Kelp Gull	LC	High	Medium	Med-High	Low	Medium
Gulls, Terns & Skuas	Sterna vittata	Antarctic tern (NZ)	LC	High	Medium	Med-High	Low	High
Gulls, Terns & Skuas	Sterna paradisaea	Arctic tern	LC	High	Medium	Med-High	Low	Medium
Gulls, Terns & Skuas	Catharacta antarctica	Brown skua	LC	High	Medium	Med-High	Low	Medium
Penguins	Pygoscelis adeliae	Adelie penguin	LC	Low	Low	Low	Low	Medium
Penguins	Pygoscelis antarctica	Chinstrap penguin	LC	High	Low	Medium	Low	Medium
Penguins	Pygoscelis papua	Gentoo penguin	LC	High	Low	Medium	Low	Medium
Penguins	Aptenodytes patagonicus	King Penguin	LC	High	Low	Medium	Low	Medium
Penguins	Eudyptes schlegeli	Royal Penguins	LC	High	Low	Medium	Low	Medium
Petrels, Prions & Shearwaters	Pterodroma neglecta	Kermadec Petrel (western)	LC	Low	Medium	Low-Med	Low	Medium
Petrels, Prions & Shearwaters	Pachyptila belcheri	Thin billed prion	LC	Medium	Low	Low-Med	Low	Medium
Petrels, Prions & Shearwaters	Pachyptila desolata	Antarctic prion	LC	High	Low	Medium	Low	Medium
Petrels, Prions & Shearwaters	Pachyptila turtur	Fairy Prion	LC	High	Low	Medium	Low	Medium
Petrels, Prions & Shearwaters	Pachyptila crassirostris	Fulmar prion	LC	High	Low	Medium	Low	Medium
Petrels, Prions & Shearwaters	Puffinus gavia	Fluttering Shearwater	LC	High	Low	Medium	Low	Medium
Petrels, Prions & Shearwaters	Puffinus assimilis	Little Shearwater (Tasman Sea)	LC	High	Low	Medium	Low	Medium
Petrels, Prions & Shearwaters	Puffinus tenuirostris	Short-tailed Shearwater	LC	High	Low	Medium	Low	Medium

Petrels, Prions & Shearwaters	Thalassoica antarctica	Antarctic petrel	LC	High	Medium	Med-High	Low	Medium
Petrels, Prions & Shearwaters	Fregetta tropica	Black-bellied Storm-Petrel	LC	High	Medium	Med-High	Low	Medium
Petrels, Prions & Shearwaters	Halobaena caerulea	Blue Petrel	LC	High	Medium	Med-High	Low	Medium
Petrels, Prions & Shearwaters	Daption capense	Cape Petrel	LC	High	Medium	Med-High	Low	Medium
Petrels, Prions & Shearwaters	Pelecanoides urinatrix	Common Diving-Petrel	LC	High	Medium	Med-High	Low	Medium
Petrels, Prions & Shearwaters	Garrodia nereis	Grey-backed storm petrel	LC	High	Medium	Med-High	Low	Medium
Petrels, Prions & Shearwaters	Lugensa brevirostris	Kerguelen Petrel	LC	High	Medium	Med-High	Low	Medium
Petrels, Prions & Shearwaters	Macronectes halli	Northern Giant-Petrel	LC	High	Medium	Med-High	Low	Medium
Petrels, Prions & Shearwaters	Pelecanoides georgicus	South Georgian diving petrel	LC	High	Medium	Med-High	Low	Medium
Petrels, Prions & Shearwaters	Fulmarus glacialoides	Southern fulmar	LC	High	Medium	Med-High	Low	Medium
Petrels, Prions & Shearwaters	Macronectes giganteus	Southern Giant-Petrel	LC	High	Medium	Med-High	Low	Medium
Petrels, Prions & Shearwaters	Pterodroma lessoni	White-headed petrel	LC	High	Medium	Med-High	Low	Medium
Petrels, Prions & Shearwaters	Oceanites oceanicus	Wilson's storm petrel (subantarctic)	LC	High	Medium	Med-High	Low	Low
Petrels, Prions & Shearwaters	Pterodroma macroptera	Great-winged Petrel	LC	High	Medium	Med-High	Low	Medium
Petrels, Prions & Shearwaters	Pterodroma mollis	Soft-plumaged Petrel	LC	High	Medium	Med-High	Low	Medium
Cormorant & Shags	Leucocarbo atriceps purpurascens	Imperial shag (Macquarie Island)	-	High	Low	Medium	Low	High
Albatross & Fulmars	Thalassarche cauta	Shy Albatross	NT	Low	High	Medium	Low	Medium
Albatross & Fulmars	Thalassarche bulleri	Buller's Albatross	NT	High	High	High	Low	Medium
Albatross & Fulmars	Phoebetria palpebrata	Light-mantled Albatross	NT	High	High	High	Low	Medium
Gulls, Terns & Skuas	Sterna striata	White-fronted Tern	NT	Medium	Medium	Medium	Low	Medium
Penguins	Aptenodytes forsteri	Emperor Penguin	NT	Medium	Low	Low-Med	Low	Medium
Penguins	Eudyptes pachyrhynchus	Fiordland Penguin	NT	High	Low	Medium	Low	Medium
Petrels, Prions & Shearwaters	Puffinus griseus	Sooty Shearwater	NT	High	Low	Medium	Low	Medium
Petrels, Prions & Shearwaters	Procellaria cinerea	Grey petrel	NT	High	Medium	Med-High	Low	Medium
Petrels, Prions & Shearwaters	Pterodroma inexpectata	Mottled petrel	NT	High	Medium	Med-High	Low	Medium
Albatross & Fulmars	Thalassarche eremita	Chatham albatross	VU	Medium	High	Med-High	Low	Medium
Albatross & Fulmars	Thalassarche impavida	Campbell Albatross	VU	High	High	High	Low	Medium
Albatross & Fulmars	Thalassarche salvini	Salvin's albatross	VU	High	High	High	Low	Medium
Albatross & Fulmars	Diomedea epomophora	Southern Royal Albatross	VU	High	High	High	Low	Medium
Albatross & Fulmars	Diomedea exulans	Wandering Albatross	VU	High	High	High	Low	Medium

Penguins	Eudyptes chrysolophus	Macaroni penguin	VU	Medium	Low	Low-Med	Low	Medium
Penguins	Eudyptes robustus	Snares Penguin	VU	High	Low	Medium	Low	Medium
Penguins	Eudyptes chrysocome	Southern Rockhopper Penguin	VU	High	Low	Medium	Low	Medium
Petrels, Prions & Shearwaters	Procellaria aequinoctialis	White-chinned petrel	VU	High	Medium	Med-High	Low	Medium

Appendix 2: Marine Mammals

Group	Species	Common name	IUCN Status	Habitat	Spatial Overlap	Catchability	Risk	Residual Risk
Dolphins	Grampus griseus	Risso's dolphin	LC	Pelagic	Low	Low	Low	Low
Dolphins	Lagenorhynchus obscurus	Dusky dolphin	LC	Pelagic	Low	Low	Low	Low
Dolphins	Tursiops truncatus	Bottlenose dolphin	LC	Pelagic	Low	Low	Low	Low
Dolphins	Lagenorhynchus cruciger	Hourglass dolphin	LC	Pelagic	High	Low	Medium	Low
Dolphins	Lissodelphis peronii	Southern right whale dolphin	LC	Pelagic	High	Low	Medium	Low
Dolphins	Orcinus orca	Killer whale	DD	Pelagic	High	Low	Medium	Low
Dolphins	Australophocoena dioptrica	Spectacled porpoise	LC	Pelagic	High	Low	Medium	Low
Seals, Sea lions	Hydrurga leptonyx	Leopard seal	LC	Pelagic	Low	Medium	Low-Med	Low
Seals, Sea lions	Leptonychotes weddelli	Weddell seal	LC	Pelagic	Low	Medium	Low-Med	Low
Seals, Sea lions	Lobodon carcinophagus	Crabeater seal	LC	Pelagic	Low	Medium	Low-Med	Low
Seals, Sea lions	Arctocephalus forsteri	New Zealand Fur-seal	LC	Pelagic	High	Medium	Med-High	Low
Seals, Sea lions	Arctocephalus gazella	Antarctic fur seal	LC	Pelagic	High	Medium	Med-High	Low
Seals, Sea lions	Arctocephalus tropicalis	Subantarctic fur seal	LC	Pelagic	High	Medium	Med-High	Low
Seals, Sea lions	Phocarctos hookeri	Hooker's sea lion	EN	Pelagic	High	Medium	Med-High	Low
Seals, Sea lions	Mirounga leonina	Elephant seal	LC	Pelagic	High	Medium	Med-High	Low
Whales	Mesoplodon densirostris	Blainville's beaked whale	LC	Pelagic	Low	Low	Low	Low
Whales	Ziphius cavirostris	Cuvier's beaked whale	LC	Pelagic	Low	Low	Low	Low
Whales	Eubalaena australis	Southern right whale	LC	Pelagic	High	Low	Low-Med	Low
Whales	Mesoplodon bowdoini	Andrew's beaked whale	DD	Pelagic	Medium	Low	Low-Med	Low
Whales	Mesoplodon hectori	Hector's beaked whale	DD	Pelagic	Medium	Low	Low-Med	Low
Whales	Balaenoptera acutorostrata	Minke whale	LC	Pelagic	High	Low	Medium	Low
Whales	Balaenoptera borealis	Sei whale	EN	Pelagic	High	Low	Medium	Low
Whales	Balaenoptera musculus	Blue whale	EN	Pelagic	High	Low	Medium	Low
Whales	Balaenoptera physalus	Fin whale	VU	Pelagic	High	Low	Medium	Low
Whales	Megaptera novaeangliae	Humpback whale	LC	Pelagic	High	Low	Medium	Low

Whales	Balaenoptera bonaerensis	Antarctic minke whale	NT	Pelagic	High	Low	Medium	Low
Whales	Globicephala melas	Long-finned Pilot Whale	LC	Pelagic	High	Low	Medium	Low
Whales	Physeter catodon	Sperm whale	VU	Pelagic	High	Low	Medium	Low
Whales	Berardius arnuxii	Arnoux's beaked whale	LC	Pelagic	High	Low	Medium	Low
Whales	Hyperoodon planifrons	Southern bottlenose whale	LC	Pelagic	High	Low	Medium	Low
Whales	Mesoplodon grayi	Gray's beaked whale	LC	Pelagic	High	Low	Medium	Low
Whales	Mesoplodon layardii	Strap-toothed Beaked Whale	LC	Pelagic	High	Low	Medium	Low

Appendix 3: Non-target finfish

Family	Species	Common name	Spatial Overlap	Catchability	Risk of mortality	Residual Risk
Achiropsettidae	Neoachiropsetta milfordi	Armless Deepsea Flounder	High	Medium	Med-High	Low
Achiropsettidae	Mancopsetta maculata	Spotted Deepsea Flounder	High	Medium	Med-High	Low
Achiropsettidae	Achiropsetta sp.	Southern flounder	High	Medium	Med-High	Low
Achiropsettidae	Mancopsetta sp.	Southern flounder	High	Medium	Med-High	Low
Alepocephalidae	Alepocephalus spp.	Slickhead	High	Medium	Med-High	Low
Anoplogastridae	Anoplogaster cornuta	Fangtooth	High	Medium	Med-High	Low
Anotopteridae	Anotopterus pharao	Daggerfish	High	Medium	Med-High	Low
Anotopteridae	Anotopterus vorax	Southern Daggertooth	High	Medium	Med-High	Low
Astronesthidae	Astronesthes sp.	Spangled trouble- shouter	High	Medium	Med-High	Low
Barbourisiidae	Barbourisia rufa	Redvelvet Whalefish	High	Medium	Med-High	Low
Bathydraconidae	Cygnodraco mawsoni	Antarctic dragonfish	High	Medium	Med-High	Low
Bathylagidae	Bathylagus antarcticus	Antarctic Deepsea Smelt	High	Medium	Med-High	Low
Bathylagidae	Bathylagus spp.	Bathylagus	High	Medium	Med-High	Low
Bothidae	Pseudoachiropsetta milfordi	Flounder	High	Medium	Med-High	Low
Carapidae	Echiodon cryomargarites	Pearlfish	High	Medium	Med-High	Low
Centriscidae	Centriscops humerosus	Banded Bellowsfish	High	Medium	Med-High	Low
Centrolophidae	Icichthys australis	Southern Ruffe	High	Medium	Med-High	Low
Ceratiidae	Ceratias tentaculatus	Southern Seadevil	High	Medium	Med-High	Low
Ceratiidae	Ceratias spp.	Ceratias	High	Medium	Med-High	Low
Congiopodidae	Zanclorhynchus spinifer	Horsefish	High	Medium	Med-High	Low
Cyclopteridae	Paraliparis gracilis	Snailfish/lumpfish	High	Medium	Med-High	Low
Engraulidae	Engraulidae	Anchovy spp.	High	Medium	Med-High	Low
Epigonidae	Epigonus robustus	Robust Deepsea Cardinalfish	High	Medium	Med-High	Low
Epigonidae	Rosenblattia robusta	Stout Cardinalfish	High	Medium	Med-High	Low
Evermannellidae	Evermannella balbo	Balbo Sabretooth	High	Medium	Med-High	Low

Gempylidae	Paradiplospinus gracilis	Snake mackerel/gemfish	High	Medium	Med-High	Low
Gempylidae	Paradiplospinus antarcticus	Slender Escolar	High	Medium	Med-High	Low
Gigantactinidae	Gigantactinidae	Whipnose anglerfishes spp.	High	Medium	Med-High	Low
Gigantactinidae	Gigantactis vanhoeffeni	Whipnose anglerfish	High	Medium	Med-High	Low
Gigantactinidae	Gigantactis meadi	Whipnose anglerfish	High	Medium	Med-High	Low
Gonostomatidae	Photichthys sp.	Bristlemouth	High	Medium	Med-High	Low
Gonostomatidae	Diplophos rebainsi	Rebains' Portholefish	High	Medium	Med-High	Low
Gonostomatidae	Cyclothone microdon	Smalltooth Bristlemouth	High	Medium	Med-High	Low
Gonostomatidae	Cyclothone pallida	Tanned Bristlemouth	High	Medium	Med-High	Low
Gonostomatidae	Sigmops bathyphilus	Deepsea Fangjaw	High	Medium	Med-High	Low
Halosauridae	Halosauropsis macrochir	Black Halosaur	High	Medium	Med-High	Low
Halosauridae	Aldrovandia phalacra	Baldhead Halosaur	High	Medium	Med-High	Low
Harpagiferidae	Harpagifer antarcticus	Barbled plunderfish	High	Medium	Med-High	Low
Harpagiferidae	Harpagifer bispinis	Barbled plunderfish	High	Medium	Med-High	Low
Harpagiferidae	Harpagifer macquariensis	Barbled plunderfish	High	Medium	Med-High	Low
Himantolophidae	Himantolophidae	Footballfishes	High	Medium	Med-High	Low
Himantolophidae	Himantolophus appelii	Prickly Footballfish	High	Medium	Med-High	Low
Himantolophidae	Himantolophus stewarti	Football fish	High	Medium	Med-High	Low
Himantolophidae	Himantolophus sp.	Football fish	High	Medium	Med-High	Low
Lampridae	Lampris immaculatus	Southern Moonfish	High	Medium	Med-High	Low
Liparidae	Paraliparis brunneocaudatus	Browntail Snailfish	High	Medium	Med-High	Low
Macrouridae	Coryphaenoides serrulatus	Serrulate Whiptail	High	High	High	Low
Macrouridae	Caelorinchus kaiyomaru	Whiptail	High	High	High	Low
Macrouridae	Caelorinchus kermadecus	Whiptail	High	High	High	Low
Macrouridae	Macrourus whitsoni	Whiptail	High	High	High	Low
Macrouridae	Coelorinchus innotabilis	Notable Whiptail	High	High	High	Low
Macrouridae	Coryphaenoides subserrulatus	Longray Whiptail	High	High	High	Low
Macrouridae	Macrourus carinatus	Ridgescale Whiptail	High	High	High	Low
Macrouridae	Idiolophorhynchus andriashevi	Pineapple Whiptail	High	High	High	Low
Macrouridae	Coryphaenoides dossenus	Humpback Whiptail	High	High	High	Low

Macrouridae	Coryphaenoides mcmillani	McMillan's Whiptail	High	High	High	Low
Macrouridae	Cynomacrurus piriei	Dogtooth Whiptail	High	High	High	Low
Macrouridae	Kuronezumia leonis	Snubnose Whiptail	High	High	High	Low
Macrouridae	Nezumia kapala	Kapala Whiptail	High	High	High	Low
Macrouridae	Trachonurus gagates	Velvet Whiptail	High	High	High	Low
Macrouridae	Coelorinchus trachycarus	Rough-head Whiptail	High	High	High	Low
Macrouridae	Coryphaenoides murrayi	Abyssal Whiptail	High	High	High	Low
Macrouridae	Macrourus holotrachys	Bigeye Grenadier	High	High	High	Low
Melamphaidae	Poromitra crassiceps	Bigscale	High	Medium	Med-High	Low
Melamphaidae	Poromitra atlantica	Crested Bigscale	High	Medium	Med-High	Low
Melanonidae	Melanonus gracilis	Pelagic Cod	High	Medium	Med-High	Low
Melanostomiidae	Melanostomias sp.	Scaleless dragonfish	High	Medium	Med-High	Low
Microstomatidae	Nansenia	*Nansenia* spp.	High	Medium	Med-High	Low
Moridae	Antimora rostrata	Violet Cod	High	High	High	Low
Moridae	Halargyreus johnsonii	Slender Cod	High	High	High	Low
Moridae	Lepidion microcephalus	Smallhead Cod	High	High	High	Low
Moridae	Guttigadus globosus	Tadpole Cod	High	High	High	Low
Moridae	Moridae	Morid cods	High	High	High	Low
Moridae	Paralaemonema sp.	Morid cod	High	High	High	Low
Muraenolepididae	Muraenolepis sp.	Eelcod	High	Medium	Med-High	Low
Myctophidae	Electrona subaspera	Rough Lanternfish	High	Medium	Med-High	Low
Myctophidae	Gymnoscopelus piabilis	Southern Blacktip Lanternfish	High	Medium	Med-High	Low
Myctophidae	Lampanyctus intricarius	Intricate Lanternfish	High	Medium	Med-High	Low
Myctophidae	Protomyctophum normani	Norman's Lanternfish	High	Medium	Med-High	Low
Myctophidae	Nannobrachium achirus	Cripplefin Lanternfish	High	Medium	Med-High	Low
Myctophidae	Protomyctophum parallelum	Parallel Lanternfish	High	Medium	Med-High	Low
Myctophidae	Electrona carlsbergi	Carlsberg's Lanternfish	High	Medium	Med-High	Low
Myctophidae	Gymnoscopelus microlampas	Minispotted Lanternfish	High	Medium	Med-High	Low
Myctophidae	Gymnoscopelus bolini	Lanternfish sp.	High	Medium	Med-High	Low
Myctophidae	Gymnoscopelus fraseri	Lanternfish sp.	High	Medium	Med-High	Low

Myctophidae	Hintonia candens	Lanternfish sp.	High	Medium	Med-High	Low
Myctophidae	Protomyctophum andriashevi	Lanternfish sp.	High	Medium	Med-High	Low
Myctophidae	Protomyctophum tenisoni	Lanternfish sp.	High	Medium	Med-High	Low
Myctophidae	Electrona antarctica	Lanternfish	High	Medium	Med-High	Low
Myctophidae	Gymnoscopelus braueri	Lanternfish sp.	High	Medium	Med-High	Low
Myctophidae	Gymnoscopelus nicholsi	Lanternfish sp.	High	Medium	Med-High	Low
Myctophidae	Krefftichthys anderssoni	Lanternfish sp.	High	Medium	Med-High	Low
Myctophidae	Protomyctophum bolini	Lanternfish sp.	High	Medium	Med-High	Low
Myctophidae	Protomyctophum spp.	Lanternfish spp.	High	Medium	Med-High	Low
Myctophidae	Gymnoscopelus opisthopterus	Lantern fish	High	Medium	Med-High	Low
Nemichthyidae	Labichthys yanoi	Yano's Snipe Eel	High	High	High	Low
Nemichthyidae	Nemichthyidae	Eel	High	High	High	Low
Notacanthidae	Notacanthus chemnitzii	Cosmopolitan Spineback	High	Medium	Med-High	Low
Notosudidae	Scopelosaurus hamiltoni	Smallscale Waryfish	High	Medium	Med-High	Low
Nototheniidae	Notothenia microlepidota	Black cod	High	Medium	Med-High	Low
Nototheniidae	Nototheniops larseni	Painted notie	High	Medium	Med-High	Low
Nototheniidae	Nototheniidae	Icefishes	High	Medium	Med-High	Low
Nototheniidae	Paranotothenia magellanica	Icefish sp	High	Medium	Med-High	Low
Nototheniidae	Trematomus nicolai	Icefish	High	Medium	Med-High	Low
Nototheniidae	Notothenia rossii	Icefish sp	High	Medium	Med-High	Low
Nototheniidae	Lepidonotothen squamifrons	Grey rockcod	High	Medium	Med-High	Low
Nototheniidae	Notothenia coriiceps	Icefish sp	High	Medium	Med-High	Low
Nototheniidae	Notothenia spp.	Icefishes	High	Medium	Med-High	Low
Oneirodidae	Chaenophryne longiceps	Longhead Dreamer	High	Medium	Med-High	Low
Oneirodidae	Oneirodes notius	Dreamer fish	High	Medium	Med-High	Low
Oneroididae	Oneirodes sp.	Dreamer fish	High	Medium	Med-High	Low
Oreosomatidae	Pseudocyttus maculatus	Smooth Oreodory	High	Medium	Med-High	Low
Oreosomatidae	Neocyttus sp.	Oreo dory	High	Medium	Med-High	Low
Paralepididae	Paralepididae	Barracudinas	High	Medium	Med-High	Low
Paralepididae	Magnisudis prionosa	Duckbill Barracudina	High	Medium	Med-High	Low

Psychrolutidae	Ebinania macquariensis	Macquarie Blobfish	High	Medium	Med-High	Low
Psychrolutidae	Ambophthalmos magnicirrus	Blobfish	High	Medium	Med-High	Low
Sternoptychidae	Sternoptyx pseudodiaphana	False Oblique Hatchetfish	High	Medium	Med-High	Low
Stomiidae	Stomias sp.	Scaleless dragonfish	High	Medium	Med-High	Low
Stomiidae	Astronesthes psychrolutes	Temperate Snaggletooth	High	Medium	Med-High	Low
Stomiidae	Borostomias antarcticus	Antarctic Snaggletooth	High	Medium	Med-High	Low
Stomiidae	Trigonolampa miriceps	Threelight Dragonfish	High	Medium	Med-High	Low
Stomiidae	Chauliodus sloani	Sloane's Viperfish	High	Medium	Med-High	Low
Stomiidae	Stomias gracilis	Scaly dragonfish	High	Medium	Med-High	Low
Stomiidae	Idiacanthus atlanticus	Common Black Dragonfish	High	Medium	Med-High	Low
Synaphobranchidae	Diastobranchus capensis	Basketwork Eel	High	High	High	Low
Trachichthyidae	Hoplostethus atlanticus	Orange Roughy	High	Medium	Med-High	Low
Zoarcidae	Melanostigma gelatinosum	Limp Eelpout	High	Medium	Med-High	Low
Zoarcidae	Melanostigma sp.	Eelpout (undifferentiated)	High	Medium	Med-High	Low
Macrouridae	Nezumia pudens	Atacam grenadier	High	High	High	Low
Psychrolutidae	Ebinania sp.	Deepwater sculpin	High	Medium	Med-High	Low
Epigonidae	Epigonus sp.	Cardinal fish	High	Medium	Med-High	Low
Nototheniidae	Pagothenia sp.	Icefish/notothen	High	Medium	Med-High	Low
Moridae	Mora moro	Ribaldo	High	High	High	Low
Macrouridae	Caelorinchus matamua	Blueband Whiptail	High	High	High	Low

Appendix 4: Chondrichthyans

Family	Species	Common name	IUCN Status	Habitat	Spatial Overlap	Catchability	Risk of mortality	Residual Risk
Alopiidea	Alopias vulpinus	Common thresher	VU	Pelagic	Low	Medium	Low-Med	Low
Carcharhinidae	Carcharodon carcharias	White shark	VU	Pelagic	Low	Medium	Low-Med	Low
Carcharhinidae	Prionace glauca	Blue shark	NT	Pelagic	Medium	Medium	Medium	Medium
Cetorhinidae	Cetorhinus maximus	Basking shark	EN	Pelagic	Low	Medium	Low-Med	Low
Etmopteridae	Etmopterus granulosus	Southern lantern shark	LC	Demersal	Medium	High	Medium	Medium
Lamnidae	Lamna nasus	Porbeagle	VU	Pelagic	High	Medium	Med-High	Medium
Somniosidae	Somniosus antarcticus	Southern sleeper shark	LC	Demersal	Medium	High	Med-High	Medium
Somniosidae	Centroscymnus crepidater	Deepwater Dogfish	NT	Demersal	Medium	High	Med-High	Medium
Triakidae	Mustelus antarcticus	Gummy Shark	--	Demersal	Medium	High	Med-High	Medium
Rajidae	Rajidae spp.	Skates	--	Demersal	Unknown	High	Low-Med	Low

-- Not assessed by the International Union for Conservation of Nature Red List of Threatened Species.

References

AFMA 2010, Assessment of longline fishing in the Macquarie Island Toothfish Fishery, Australian Fisheries Management Authority, Canberra.

Butler, A., Williams, A., Koslow, T., Gowlett-Holmes, K., Barker, B., Lewis M., and Reid., R. 2000. A Study of the Conservation Significance of the Benthic Fauna Around Macquarie Island and the Potential Impact of the Patagonian Toothfish Fishery. Final report to Environment Australia. CSIRO Marine Research.

Conway, C., Bostock, H., Baker, J., Wysoczanski, R. and Verdiet, A. 2012. Evolution of Macquarie Ridge Complex seamounts: Implications for volcanic and tectonic processes at the Australia–Pacific plate boundary south of New Zealand. Marine Geology, 295, 34-50.

Daley, R., Bulman, C., Stevenson, D., Hobday, A., Sporcic, M., and Fuller, M 2007. Ecological risk assessment for the effects of fishing, Report for the demersal trawl sub-fishery of the Macquarie Island Fishery. Report to Australian Fisheries Management Authority, Canberra, Australia.

Dell, J., Maschette, D., Sumner, M. and Welsford, D. 2016. Interactions between demersal fishing gears and macro-benthos around subantarctic Macquarie Island. Report by the Australian Antarctic Division (report also submitted to Marine Ecology Progress Series).

EA 2001. Macquarie Island Marine Park Management Plan, 2001, Environment Australia, Canberra.

Ebert, D., Fowler, S., Compagno, L. and Dando, M (eds) 2016. Sharks of the World: A fully illustrated guide. Wild Nature Press, Plymouth.

Gon, O. and Heemstra, P.C. eds., 1990. Fishes of the southern ocean (Vol. 1). Grahamstown: JLB Smith Institute of Ichthyology.

Gordon, A.L. 1988. "Spatial and temporal variability within the Southern Ocean," in Antarctic Ocean and Resources Variability, ed. D. Sahrhage. (Berlin: Springer-Verlag), 41-56.

Hillary, R. and Day, J. 2021. Integrated stock assessment for Macquarie Island toothfish using data up to and including 2020. Report to Australian Fisheries Management Authority, Canberra, Australia.

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

Last, P., White, W., de Carvalho, M., Séret, B., Stehmann, M. and Naylor, G 2016. Rays of the World. CSIRO Publishing Clayton, Victoria

Maschette, D., Wotherspoon, S., Polanowski, A. et al. Circumpolar sampling reveals high genetic connectivity of Antarctic toothfish across their spatial distribution. Rev Fish Biol Fisheries 33, 295–310 (2023). https://doi.org/10.1007/s11160-023-09756-9

Péron, C., Welsford, D.C., Ziegler, P., Lamb, T.D., Gasco, N., Chazeau, C., Sinègre, R. and Duhamel, G., 2016. Modelling spatial distribution of Patagonian toothfish through life-stages and sex and its implications for the fishery on the Kerguelen Plateau. Progress in Oceanography, 141, pp.81-95.

Sokolov, S., and Rintoul, S.R. 2009. Circumpolar structure and distribution of the Antarctic Circumpolar Current fronts. 1: Mean circumpolar paths. Journal of Geophysical Research: Oceans 114(C11018), 1-19. doi: 10.1029/2008JC005108.

Werner, T., Northridge, S., McClellan Press, K. and Young, N 2015. Mitigating bycatch and depredation of marine mammals in longline fisheries. ICES Journal of Marine Science, 72, pp. 576–1586.

Welsford D., Ewing, G., Constable, A., Hibberd, T., and 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. Edited by Dirk C. Welsford, Graeme P. Ewing, Andrew J. Constable, Ty Hibberd and Robert Kilpatrick.

Zhou, S and Fuller, M. 2011. Sustainability assessment for fishing effect on fish bycatch species in the Macquarie Island Toothfish Longline Fishery: 2007-2010. Report to the Australia Fisheries Management Authority, Canberra, Australia. June 2011.