SPRFMO

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Proposal for Exploratory Bottom Longlining for Toothfish in the SPRFMO Area

New Zealand

Proposal for exploratory bottom longlining for toothfish by New Zealand vessels, 2019–2021: Fisheries Operation Plan, suggested Data Collection Plan, and impact assessments

Prepared by the New Zealand Ministry for Primary Industries for the consideration of the Scientific Committee of the South Pacific Regional Fisheries Management Organization

11 July 2018

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1. Purpose of paper

This paper forms the first stage of an application for New Zealand vessels to extend the successful programme of exploratory fishing for toothfish. The proposed exploratory fishing will increase our understanding of the distribution, life history, and spawning dynamics of toothfish species and thereby increase the certainty of stock assessment models for Antarctic toothfish being developed by CCAMLR. This proposal is drafted to conform to Article 22 of the Convention and the requirements of CMM-13-2016 on the management of new and exploratory fisheries, CMM-03-2018 on bottom fisheries, and the Bottom Fishery Impact Assessment Standard (BFIAS). In accordance with CMM-13-2016, this proposal is provided for the consideration of the Scientific Committee meeting in September 2018 such that it can advise the Commission meeting in early 2019. It is proposed that exploratory fishing occurs in 2019, 2020, and 2021.

2. Requirements for a proposal

2.1. Requirements of Article 22 of the Convention

Article 22 in relation to NEW OR EXPLORATORY FISHERIES states that:

1. A fishery that has not been subject to fishing or has not been subject to fishing with a particular gear type or technique for ten years or more shall be opened as a fishery or opened to fishing with such gear type or technique only when the Commission has adopted cautious preliminary conservation and management measures in respect of that fishery, and, as appropriate, non-target and associated or dependent species, and appropriate measures to protect the marine ecosystem in which that fishery occurs from adverse impacts of fishing activities.

2. Such preliminary conservation and management measures, which may include requirements regarding notification of intention to fish, the establishment of a development plan, mitigation measures to prevent adverse impacts on marine ecosystems, use of particular fishing gear, the presence of observers, the collection of data, and the conduct of research or exploratory fishing, shall be consistent with the objective and the conservation and management principles and approaches of this Convention. The measures shall ensure that the new fishery resource is developed on a precautionary and gradual basis until sufficient information is acquired to enable the Commission to adopt appropriately detailed conservation and management measures.

3. The Commission may, from time to time, adopt standard minimum conservation and management measures that are to apply in respect of some or all new fisheries prior to the commencement of fishing for such new fisheries.

2.2. Relevant sections of CMM-13-2016 (exploratory fisheries)

2.2.1. Objective and Interpretation

1. This CMM details the framework which will govern the management of new and exploratory fisheries in the SPRFMO Convention Area. This CMM is intended to ensure that sufficient information is available to evaluate the long-term potential of new and exploratory fisheries, to assist the formulation of management advice, to evaluate the possible impacts on target stocks and non-target and associated and dependent species, to ensure new and exploratory fishery resources are developed on a precautionary and gradual basis and to promote the sustainable management of new and exploratory fisheries.

4. For the purposes of this CMM, a fishery is an “exploratory fishery”:

a) if it has not been subject to fishing in the previous ten years; or

b) for the purposes of fishing with a particular gear type or technique, if it has not been subject to fishing by that particular gear type or technique in the previous ten years; or

c) if fishing in that fishery has been undertaken in the previous ten years pursuant to this CMM, and a decision has not yet been taken in accordance with paragraph 23 or 24 of this CMM to either close or manage the fishery as an established fishery.

2.2.2. Requirements for exploratory fisheries

5. Any Member or CNCP seeking to permit a vessel that flies its flag to fish in an exploratory fishery, or to fish in an exploratory fishery with a gear type that has not been used in that fishery for the previous ten years; shall, not less than 60 days in advance of the next annual meeting of the Scientific Committee:

a) submit an application to the Commission to permit a vessel or vessels that fly its flag to fish in that exploratory fishery. This application shall include information that satisfies paragraphs 2 and 3 of Annex 1 of CMM 05-2016 (Record of Vessels);

b) prepare and submit a Fisheries Operation Plan to the Scientific Committee. The Fisheries Operation Plan shall include the following information, to the extent it is available:

i. a description of the exploratory fishery, including area, target species, proposed methods of fishing, proposed maximum catch limits and any apportionment of that catch limit among areas or species;

ii. specification and full description of the types of fishing gear to be used, including any modifications made to gear intended to mitigate the effects of the proposed fishing on non-target and associated or dependent species or the marine ecosystem in which the fishery occurs

iii. the time period the Fisheries Operation Plan covers (up to a maximum period of three years);

iv. any biological information on the target species from comprehensive research and/or survey cruises, such as distribution, abundance, demographic data and information on stock identity;

v. details of non-target and associated or dependent species and the marine ecosystem in which the fishery occurs, the extent to which these would likely be affected by the proposed fishing activity and any measures that will be taken to mitigate these effects;

vi. the anticipated cumulative impact of all fishing activity in the area of the exploratory fishery if applicable;

vii. information from other fisheries in the region or similar fisheries elsewhere that may assist in the evaluation of the relevant exploratory fishery's potential yield, to the extent the Member or CNCP is able to provide this information;

viii. if the proposed fishing activity is bottom fishing, as defined in CMM 03-2018 (Bottom Fishing), the assessment of the impact of their flagged vessels' bottom fishing activities, prepared pursuant to paragraphs 10 and 11 of CMM 03-2018, or paragraphs 16 and 17 of CMM 03-2018, as applicable; and

ix. where the target species is also managed by an adjacent Regional Fisheries Management Organisation or similar organisation, a description of that neighboring fishery sufficient to allow the Scientific Committee to formulate its advice in accordance with paragraph 8.

c) provide a commitment in its proposal to implement the Data Collection Plan for the exploratory fishery developed in accordance with paragraph 9, should the Commission approve fishing in accordance with the Fisheries Operation Plan.

6. The requirements in paragraphs 5 shall be considered as a proposal for the next annual meeting of the Commission and will be made available to all Members and CNCPs in accordance with the Rules of Procedure.

2.2.3. Scientific Committee Consideration

Fisheries Operation Plans

7. At its annual meeting, the Scientific Committee shall consider all Fisheries Operations Plans submitted pursuant to paragraph 5, all information provided in accordance with a Data Collection Plan and any other relevant information.

8. The Scientific Committee shall provide recommendations and advice to the Commission on each Fisheries Operation Plan on the following matters, as appropriate:

a) management strategies or plans for fishery resources;

b) reference points, including precautionary reference points as described in Annex II of the 1995 Agreement;

c) an appropriate precautionary catch limit;

d) the cumulative impacts of all fishing activity in the area of the exploratory fishery;

e) the impact of the proposed fishing on the marine ecosystem;

f) the sufficiency of information available to inform the level of precaution required and the degree of certainty with which the Scientific Committee's advice is provided;

g) the degree to which the approach outlined in the Fisheries Operation Plan is likely to ensure the exploratory fishery is developed consistently with its nature as an exploratory fishery, and consistently with the objectives of Article 2 of the Convention; and

h) in respect of a Fisheries Operation Plan that proposes any bottom fishing, advice and recommendations in accordance with paragraph 12 of CMM 03-2018 (Bottom Fishing).

Data Collection Plans

9. When considering a Fisheries Operation Plan submitted pursuant to paragraph 5 of this CMM in respect of an exploratory fishery that meets the definition of paragraph 4(a) or (b) of this CMM, the Scientific Committee shall develop a Data Collection Plan in respect of that exploratory fishery which should include research requirements, as appropriate. The Data Collection Plan shall identify and describe the data needed and any operational research actions necessary to obtain data from the exploratory fishery to enable an assessment of the stock, the feasibility of establishing a fishery and the impact of fishing activity on non-target, associated or dependent species and the marine ecosystem in which the fishery occurs. The Scientific Committee shall review and update the Data Collection Plan for each exploratory fishery annually as appropriate.

10. The Data Collection Plan shall require, as appropriate:

a) a description of the catch, effort and related biological, ecological and environmental data required to undertake the evaluations described in paragraph 24;

b) the dates by which the data must be provided to the Commission;

c) a plan for directing fishing effort in an exploratory fishery to allow for the acquisition of relevant data to evaluate the fishery potential and the ecological relationships among harvested, non-target and associated and dependent populations and the likelihood of adverse impact;

d) where appropriate, a plan for the acquisition of any other research data obtained by fishing vessels, including activities that may require the cooperative activities of scientific observers and the vessel, as may be required by the Scientific Committee to evaluate the fishery potential and the ecological relationships among harvested, non-target, associated and dependent populations and the likelihood of adverse impacts; and

e) an evaluation of the time scales involved in determining the responses of harvested, dependent and related populations to fishing activities.

2.3. Relevant sections of CMM-03-2018 (bottom fisheries)

2.3.1. Assessment of bottom fishing

10. No Member or CNCP shall authorize their flagged vessels to engage in any bottom fishing within the Convention Area unless they have undertaken an assessment of the impact of their flagged vessels' bottom fishing. Any assessment carried out after 2011 must be done in accordance with the FAO Deep-sea Fisheries Guidelines[1], and taking into account the SPRFMO BFIAS and areas identified where VMEs are known or suspected to occur in the area to be fished. When preparing assessments, Members and CNCPs will take into account the information provided pursuant to paragraph 23 of this CMM.

11. Assessments by Members or CNCPs shall also address whether the proposed activities achieve the objectives described in paragraph 1 of this CMM and Article 2 of the Convention.

12. The Scientific Committee shall:

(a) assess, on the basis of the best available scientific information, whether the proposed bottom fishing would have significant adverse impacts on VMEs and if it is assessed that these activities would have significant adverse impacts, recommend measures to prevent such impacts, or recommend that the proposed bottom fishing should not proceed.

(b) assess, taking into account, inter alia, the cumulative impacts of other fishing occurring in the region where such information is available, whether the proposed activities are consistent with paragraph 1 of this CMM and Article 2 of the Convention.

(c) provide recommendations and advice to the Commission on the assessment.

[1] https://www.sprfmo.int/assets/Meetings/Meetings-before-2013/Scientific-Working-Group/SWG-06-2008/SPRFMO6-SWG-INF01-FAO-Deepwater-Guidelines-Final-Sep20.pdf

2.3.2. Fishing outside the footprint or above reference period catch levels (including new and exploratory fisheries)

16. Notwithstanding paragraphs 8(c) and (d), a Member or CNCP may apply to the Commission to either:

    a. undertake bottom fishing in the Convention Area where they do not have a bottom fishing footprint;

    b. undertake bottom fishing in the Convention Area but outside their footprint established in accordance with paragraph 8(a); or

    c. exceed the average level of catch for bottom fishing established in accordance with paragraph 8(c).

17. The Member or CNCP shall prepare and submit to the Secretariat for consideration by the Scientific Committee 60 days in advance of a Scientific Committee meeting, an application outlining their proposal to commence bottom fishing or their proposal to fish outside their footprint or above reference year catch levels, in accordance with paragraphs 10 and 11. Such an application will take into account the results of any public consultation conducted by that Member or CNCP.

2.4. Bottom Fishery Impact Assessment Standard

The purpose of the Bottom Fishery Impact Assessment Standard (BFIAS) is to provide a minimum standard for assessing the potential impacts of proposed bottom fishing activities on VMEs and deep sea fish stocks. This standard is intended to guide SPRFMO participants in preparing the required bottom fishery impact assessments, and to guide the SWG when reviewing these assessments. It is intended to constitute the standardized approach to be taken by all participants when preparing risk and impact assessments for high seas bottom fishing activities in the SPRFMO area.

The BFIAS specifies that assessments should include the following sections:

2.4.1. Description of the Proposed Fishing Activities

(The BFIAS notes that, for exploratory fisheries, estimates of total catch and discard quantities may not be available given the nature of the fisheries and so estimates of the other factors, such as fishing duration, number of tows and potential catch rates should be provided. Once information is available from the new or exploratory fishery the impact assessment would be updated using this data.)

2.4.2. Mapping and Description of Proposed Fishing Areas

(The BFIAS provides substantial detail on potential approaches to mapping fisheries, benthic habitats and communities, underwater topographical features, evidence of vulnerable marine ecosystems (VMEs), and areas known or likely to contain VMEs.)

2.4.3. Impact Assessment

(The BFIAS notes that, for exploratory fisheries, little information may be available, and predictive approaches should be used to evaluate the likelihood of interaction with, and potential impact on, VMEs. All assumptions used in the impact assessment should be clearly stated. This section should include a trigger for when a new assessment should be completed.)

2.4.4. Information on Status of the Deepwater Stocks to be Fished

(The BFIAS notes that, for exploratory fisheries, predictive approaches and information from other fisheries should be used to inform the assessment of impact on deepwater stocks to be fished.)

2.4.5. Monitoring, Management and Mitigation Measures

(The BFIAS notes that, in situations where new or exploratory fisheries are being undertaken monitoring and precautionary measures are critical. As outlined in the FAO Guidelines:

> *65. Precautionary conservation and management measures, including catch and effort controls, are essential during the exploratory phase of a DSF, and should be a major component of the management of an established DSF. They should include measures to manage the impact of the fishery on low-productivity species, non-target species and sensitive habitat features. Implementation of a precautionary approach to sustainable exploitation of DSFs should include the following measures:*
>
> *i. precautionary effort limits, particularly where reliable assessments of sustainable exploitation rates of target and main by-catch species are not available;*
> *ii. precautionary measures, including precautionary spatial catch limits where appropriate, to prevent serial depletion of low-productivity stocks;*
> *iii. regular review of appropriate indices of stock status and revision downwards of the limits listed above when significant declines are detected;*
> *iv. measures to prevent significant adverse impacts on vulnerable marine ecosystems; and*
> *v. comprehensive monitoring of all fishing effort, capture of all species and interactions with VMEs (FAO 2008).*

Based on this, the BFIAS goes on to state that assessments for new or exploratory fisheries must include a description of the monitoring, mitigation and precautionary management measures that will be in place, as outlined above. Details regarding the reporting of evidence of a VME to the SPRFMO Secretariat should be included.)

The remainder of this paper includes the information specified in CMM-13-2016, CMM-03-2018, and the BFIAS, bearing in mind the requirements of Articles 2 and 22 of the Convention, for the consideration of the Scientific Committee.

3. Proposal

3.1. Proposed stratification of potential fishing areas for toothfish

Both species of toothfish[2] have broad, circumpolar distributions and some fish migrate over large distances. It is very likely that stocks of both species straddle SPRFMO and CCAMLR management boundaries and several EEZs. To ensure consistency and compatibility of exploratory fishing results and data with CCAMLR, it is proposed that SPRFMO adopts a spatial stratification consistent with that used by CCAMLR, and especially that adopted for the winter surveys in the northern parts of CCAMLR Areas 88.1 and 88.2 (Figure 1).

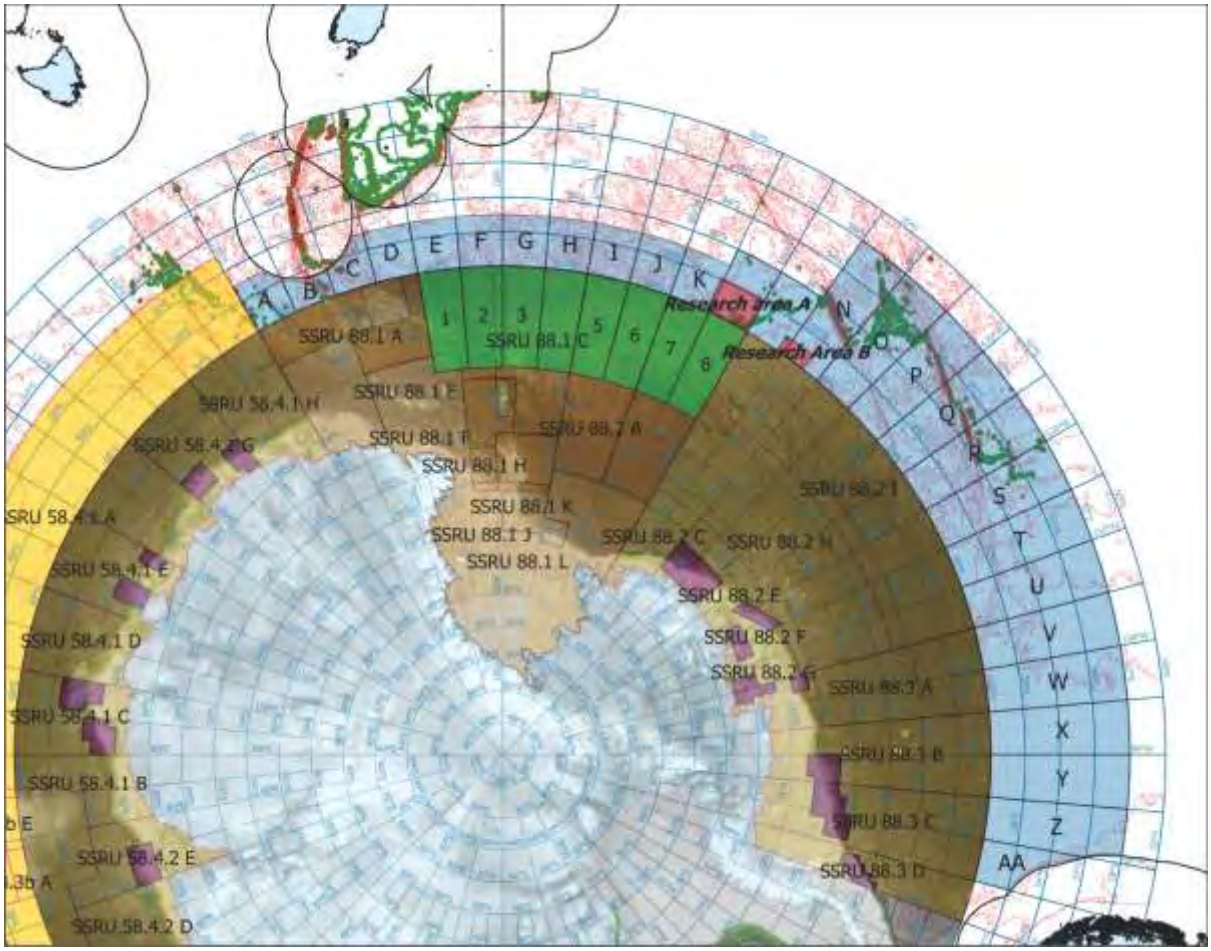

Figure 1. Proposed spatial stratification for toothfish in the SPRFMO Area (blue-shaded boxes labelled A–AA) showing consistency with CCAMLR Areas (winter survey strata shaded green and labelled 1–8. The 2016–2017 exploratory fishing research areas (shaded red), CCAMLR small-scale reporting units (SSRUs) and adjoining EEZs are also shown.

[2] Antarctic toothfish, *Dissostichus mawsoni*, and Patagonian toothfish, *Dissostichus eleginoides*

3.2. Objectives for New Zealand exploratory fishing

The exploratory fishing proposed is designed to cover key gaps in our knowledge of the distribution and life cycle of Antarctic toothfish in the South Pacific Ocean and Ross Sea to underpin understanding and management of those stocks. This work complements the exploratory fishing work in the winter longline survey of Antarctic toothfish in the northern region of CCAMLR Subareas 88.1 and 88.2 proposed by New Zealand (Appendix 2).

It is proposed that the exploratory fishery for toothfish successfully completed by New Zealand pursuant to CMM-4-14 in the southern part of the SPRFMO area be extended for an additional 3 years. The results of the initial exploratory fishing in 2016 and 2017 show that Antarctic toothfish, *Dissostichus mawsoni*, are dominant in the area, with a low number (two fish) of small Patagonian toothfish, *D. eleginoides* taken incidentally. This indicates that one or more stocks of Antarctic toothfish probably straddle the SPRFMO and CCAMLR Area boundaries. This result requires coordinated research and management by the two organisations. Exploratory fishing in the SPRFMO Area has, therefore, been designed to answer some key current questions related to the distribution, life cycle and spawning dynamics of Antarctic toothfish in the northern part of its distribution. Results will be directly relevant to CCAMLR's stock assessment efforts as well as understanding the distribution and abundance of toothfishes in the SPRFMO Area.

Broad objectives for the work are as follows

- Continue to map the bathymetry of the fishable area (shallower than about 2500 m) in mid-Pacific to the north of the SPRFMO-CCAMLR boundary;
- Document the spatial distribution, catch rates, and relative abundance of Antarctic and Patagonian toothfish in apparently suitable habitat to the north of CCAMLR Areas 88.1 and 88.2 by latitude, area, and depth;
- Characterise the biology, life history and spawning dynamics of toothfish in the area;
- Tag substantial numbers of toothfish for stock linkage and life history studies, and, potentially, for use in a multi-area CCAMLR stock assessment model and for biomass estimation;
- Collect information on distribution, relative abundance, and life history of bycatch and other associated or dependent species;
- Collect toothfish eggs using plankton net tows if practical;
- Conduct Continuous Plankton Recorder (CPR) tows for planktonic studies and potentially for fish eggs;
- Collect acoustic data using existing procedures as carried out within the CAMLR Convention area;

3.3. General approach to exploratory fishing

As with the initial exploratory fishing, there will be a stepwise process of ground location, observation for fishing feasibility, and structured fishing within the clustered design developed by CCAMLR for feature-based fisheries (CCAMLR document WG-FSA-14/61, see also the CCAMLR Gear Library). Contingent on the approval of the Scientific Committee and the SPRFMO Commission, fishing will take place in 2019, 2020 and 2021 with up to four trips each year. It is critical that some of these trips occur between August and October each year to characterise post-spawning dynamics, but trips at other

times of year during the period March to October, will provide additional information on spawning dynamics, distribution, and movement patterns.

Exploration will occur throughout the apparently suitable parts of a larger area than New Zealand's previous exploratory fishing, including strata L, M, N, and O of the proposed stratification of SPRFMO areas adjacent to the CCAMLR boundary (see section 3.1). Although this is an area of about 960 000 square kilometers, the fishable area (shallower than 2500 m) is very much smaller and poorly-known because of the scant bathymetry information for this area.

The structured approach will start with acoustic observation of bathymetry across the more promising parts of the exploratory fishing area. This will be followed by fishing using demersal longlines in a structured design. Fishing will be spread throughout suitable areas of the exploratory strata using the cluster design adopted by CCAMLR for winter surveys in the northern parts of CCAMLR Areas 88.1 and 88.2 — toothfish in these areas are found mainly on seamounts and other features where the bathymetry is not well known, making a stratified random survey approach unsuitable. Such cluster designs deliver multiple samples from discrete fishable areas while spreading fishing effort throughout larger strata. Cluster surveys are not ideal for "scaling up" samples to estimate total population size. Estimates of toothfish stock abundance are derived using mark and recapture methods. A catch limit of 220 tonnes per annum (live weight, both species combined) is proposed to achieve the stated objectives, details on how this was derived are given in the Fisheries Operation Plan in later sections.

For all longlines set, detailed records and samples will be taken to allow the characterisation of: the target catch, including catch rates, size distribution, sex ratio, and spawning condition; fish bycatch; benthic fauna and interactions; and the attendance and any captures of seabirds, marine mammals, turtles, and other species of concern. To be consistent with CCAMLR surveys, a high proportion (three fish per tonne of toothfish retained) will be tagged and returned alive to the sea to contribute to studies of biology and movement, and as a contribution to the development of spatially structured stock assessment models by CCAMLR and SPRFMO. The high average size of toothfish caught during the previous exploratory fishery (~30 kg) suggests that about one in every ten fish caught will need to be tagged and released.

3.4. Details of the vessels to be used

This section serves as an application to the Commission to permit New Zealand vessels to fish in the proposed exploratory fishery for toothfish and includes information that satisfies paragraphs 2 and 3 of Annex 1 of CMM-05-2016 (Record of Vessels). New Zealand nominates two vessels to conduct the exploratory fishing, *San Aspiring*, owned and operated by Sanford Ltd, and *Janas*, owned and operated by Talley's Group Ltd (TGL). This section includes all vessel data required in terms of the SPRFMO Data Standards for vessel data, and confirmation that they appear on the list of approved SPRFMO vessels submitted by flag states to the SPRFMO Secretariat.

Details of the vessel to be used: *F.V. San Aspiring*

(i)	Name of fishing vessel Previous names (if known) Registration number IMO number (if issued) External markings Port of registry	*San Aspiring* *Gudni Olafsson* 900522 9226528 Blue hull with a white stripe, white upper works with blue around top of bridge and top of funnel, the vessel call sign ZMGO under bridge in large black letters. Sanford trademark on funnel, vessel name on bow both sides in blue over the white, vessel name and port of registry (Auckland) centre-stern. Auckland
(iii)	Previous flag (if any)	Icelandic until late 2002
(iv)	International Radio Call Sign	ZMGO
(v)	Name of vessel's owner(s) Address of vessel owner(s) Beneficial owner(s) if known	Sanford Limited 22 Jellicoe Street Freemans Bay Auckland Sanford Limited
(vi)	Name of licence owner Address of licence owner (operator)	As above
(vii)	Type of vessel	Demersal long line
(viii)	Where was vessel built When was vessel built	Huangpu Shipyard, Guangzhou province, China 2001
(ix)	Vessel length overall LOA (m)	51.2m
(x)	12 x 7 cm colour photographs - 1 x starboard side of the vessel - 1 x port side of the vessel - 1 x stern view	See attached
(xi)	Details of the implementation of the tamper-proof requirements of the VMS device installed	ALC 1. Sailor 6150 Mini C IMN# 451200644 Serial number: 13130251 MPI Seal Number: 048425 ALC 2. TT-3022D IMN# 451202712 Serial number: 2217707 MPI Seal Number: 048429 ALC3: Trimble Galaxy 7005 IMN#451202710 Serial number: 0200014534 MPI Seal Number: 019059
(i)	Name of operator Address of operator	As for (v)
(ii)	Names and nationality of master	Carl Fry or John Bennett, New Zealand
(iii)	Type of fishing method(s)	Demersal autoline
(iv)	Vessel beam (m)	12.21
(v)	Vessel gross registered tonnage	1508
(vi)	Vessel communication types and numbers (INMARSAT A, B and C)	Inmarsat C: Telex system (451200644) primary Fleet Broadband: +870773247108
(vii)	Normal crew complement	25
(viii)	Power of main engine(s) (kW)	1730 kW
(ix)	Carrying capacity (tonne) Number of fish holds Capacity of all holds (m^3)	Approx 380 MT 2 740 m3 (including bait hold 60 m3)
(x)	Any other information in respect of the vessel considered appropriate (e.g. ice classification).	DNV 1A1 Ice-C class vessel, built for operation in regions where ice floes of thickness 0.4m are anticipated. .

ZMGO

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SAN ASPIRING

Details of the vessel to be used: *F.V. Janas*

(i)	Name of fishing vessel Previous names (if known) Registration number IMO number (if issued) External markings: Port of registry	*F.V Janas* *F.V Kapitan Kartashov* 63634 9057109 Red Hull, White line and White super structure Nelson, New Zealand
(iii)	Previous flag (if any)	Barbados
(iv)	International Radio Call Sign	ZMTW
(v)	Name of vessel's owner(s) Address of vessel owner(s) Beneficial owner(s) if known	Talley's Group Limited P.O Box 7064, Nelson Talley's Group Limited
(vi)	Name of licence owner Address of licence owner (operator)	Talley's Group Limited P.O Box 7064, Nelson
(vii)	Type of vessel	Demersal long line
(viii)	Where was vessel built When was vessel built	Soviknes Verft AS, Norway 1993
(ix)	Vessel length overall LOA (m)	46.5m
(x)	12 x 7 cm colour photographs - 1 x starboard side of the vessel - 1 x port side of the vessel - 1 x stern view	See Attached
(xi)	Details of the implementation of the tamper-proof requirements of the VMS device installed	The vessel is fitted with a type approved Automatic Location Communicator (ALC), approved under the Fisheries (Satellite Vessel Monitoring) Regulations 1993. To be a type approved ALC, it must meet Government standards that include requirements to ensure accuracy in the data reported and prevent tampering. The satellite monitoring device is located in a sealed unit, inspected by a MPI Officer prior to departure, and protected with a mechanism to indicate if the unit has been accessed or tampered with.
(i)	Name of operator Address of operator	Talley's Group Limited PO Box 7064, Nelson
(ii)	Names and nationality of possible master	Jeffery Pitt — New Zealander Andy Smith — New Zealander Mike Rhodes — New Zealander
(iii)	Type of fishing method(s)	Demersal autoline
(iv)	Vessel beam (m)	10.8 m
(v)	Vessel gross registered tonnage	1,079 MT
(vi)	Vessel communication types and numbers (INMARSAT A, B and C)	Fleet Broadband +00870 773 202 957 Iridium:+ 881 621 463113 E-mail: capt.janas@nzll.amosconnect.com
(vii)	Normal crew complement	20 crewmembers, 2 observers
(viii)	Power of main engine(s) (kW)	780 kW
(ix)	Carrying capacity (tonne) Number of fish holds Capacity of all holds (m^3)	250 t 3 Cargo Hold 495 m^3 Fuel Oil 333 m^3 Meal Hold 190 m^3 Fresh Water 27 m^3 Bait Hold 50 m^3
(x)	Any other information in respect of the vessel considered appropriate (e.g. ice classification).	DNV +1A1 ICE-1C (See attached)

ZMTW

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JANAS

JANAS

3.5. Summary of results from previous research

Two SPRFMO approved research surveys were carried out by *San Aspiring* during the 2016 and 2017 winter period. This work was carried out within two allocated research areas near the southern border of the SPRFMO Convention area and are shown in Figure 2. The vessel uses the bottom longline method using an autoline system with integrated weight line to minimise seabird interactions. Key research data from these surveys are summarised in this section to provide a basis for the future experimental design.

3.5.1. Catch and effort

A total of seven sets were made, three in Research Area B and four in Research Area A between 1 and 9 August 2016. Research fishing was concluded when the allocation was almost caught. Twelve sets were carried out the following year between 13 and 20 September 2017, numbering eight in Research Area A and four in Research Area B. In this year also, research concluded when the allocation was nearly taken. A total toothfish catch of about 29 t (of the approved 30 t limit) was landed in each year, consisting almost entirely of Antarctic toothfish, except for two small Patagonian toothfish caught in Research Area A in 2017 (Tables 1 and 2).

In both years, catch rates of Antarctic toothfish were much higher in Research Area B than in research area A, and catch rates were highly variable (Figure 3, Table 1). Mean fish weight for Antarctic toothfish averaged about 29 kg which is similar to results from the northern part of SSRUs 882A–B in the neighbouring CCAMLR Convention Area.

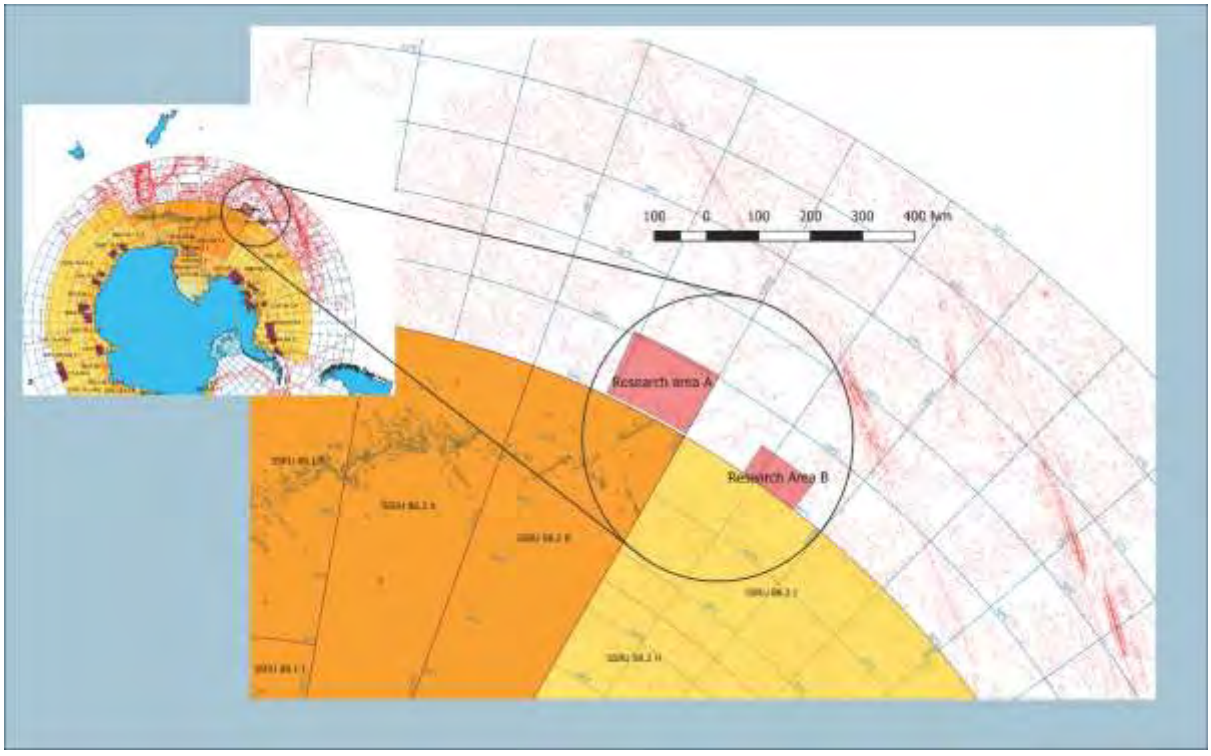


Figure 2 . Location of research areas for New Zealand's exploratory fishing for toothfish in the SPRFMO Area in 2016and 2017.

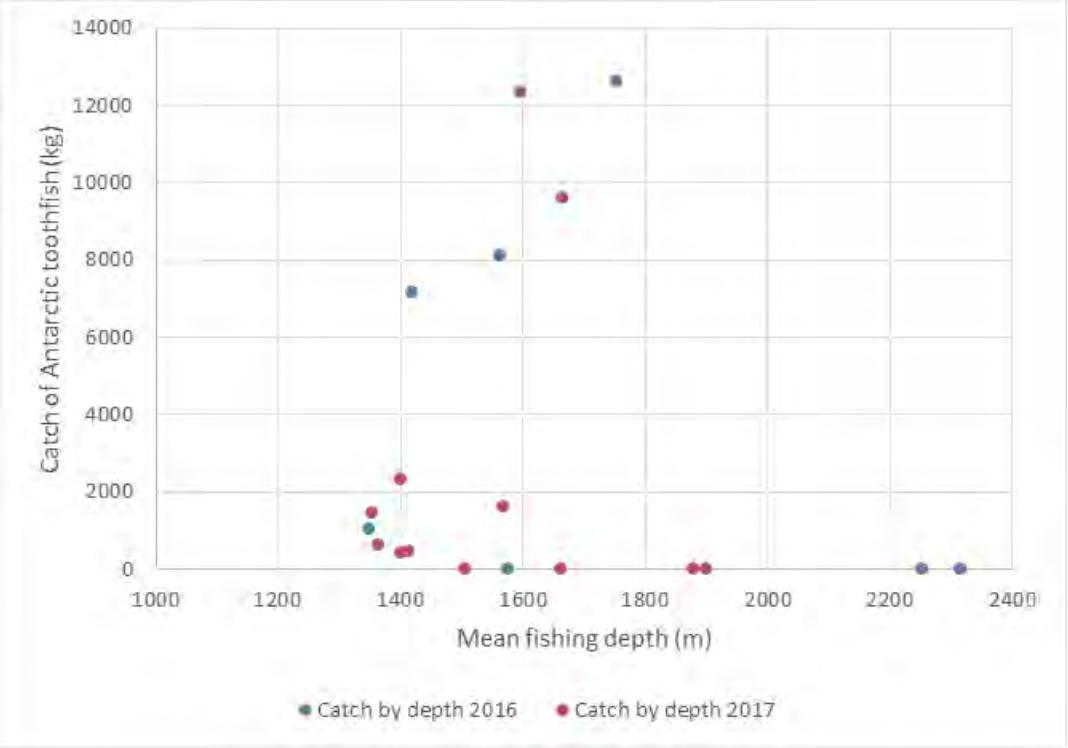


Figure 3. Retained catch per set of toothfish in relation to water depth during New Zealand's exploratory fishing in the SPRFMO Area in 2016 and 2017. Additional fish were tagged and released at a rate of three fish per tonne of catch retained.

Generally, catch-rates in Research Area B were very high compared with those typically recorded from most of the CAMLR Convention Area apart from features on the northern hills area of 88.1 and the northern section of 88.2. Those other areas are considered to be spawning locations for Antarctic toothfish based on biological information collected in these regions.

Bycatch was less than 1% of the total catch by weight in both years and consisted mostly of macrourids; these were identified as caml rattail, Whitson's grenadier, or cosmopolitan rattail (Table 2). Other bycatch taxa included muraenolepids, blue antimora, and Patagonian toothfish (two individuals). Invertebrate bycatch was less than 1 kg in total for both years and consisted of very small amounts of gorgonians, sponges, and crabs.

Table 1: Summaries of the catch and effort from New Zealand's exploratory fishing for toothfish in the SPRFMO Area in 2016 and 2017.

Research Area	Year	Sets	Toothfish catch (kg)	Hooks	Catch rate (kg / 1000 hooks set)	CV	Mean Soak time (h)	Mean toothfish weight (kg)
A	2016	4	1 049	14 569	72	88.2%	13.2	29.4
B	2016	3	27913	11 141	2 505	12.9%	15.7	26.4
A	2017	8	3 117	29 995	103	50.7%	9.3	30.4
B	2017	4	25 718	11 198	2 297	25.8%	9.9	30.4

3.5.2. Biological data

Biological data were collected from *Dissostichus* spp. and other associated catch species from each set as part of this research. Toothfish were sampled for length, weight, sex, gonad stage and gonad weight and otoliths were collected (Table 3). The two Patagonian toothfish caught in 2017 were also sampled for full biological data and otoliths. Biological data were also collected from bycatch species. Some otoliths were collected from other species in 2016 but toothfish ageing was a priority focus in 2017 and other species were not sampled for otoliths.

3.5.3. Toothfish biology

Antarctic toothfish total lengths ranged from 95–189 cm (Figure 4). Only 3.1% of the catch-weighted samples for both years were fish shorter than 120 cm total length (2.9% of the raw data). This indicates a population of almost entirely adult toothfish. The length distribution in males was smaller than females, as is found in CCAMLR toothfish fisheries.

The sex ratio was skewed in favour of males and the 2016 catch-weighted sample indicated that 84.7% of the catch was male (raw sample 84.6%). The proportion of males was also higher in 2017, but not so markedly (59.6% male of the weighted sample, 60.3% of the records). These results closely match observations from the northern hills area of CCAMLR Subarea 88.1 (Ross Sea).

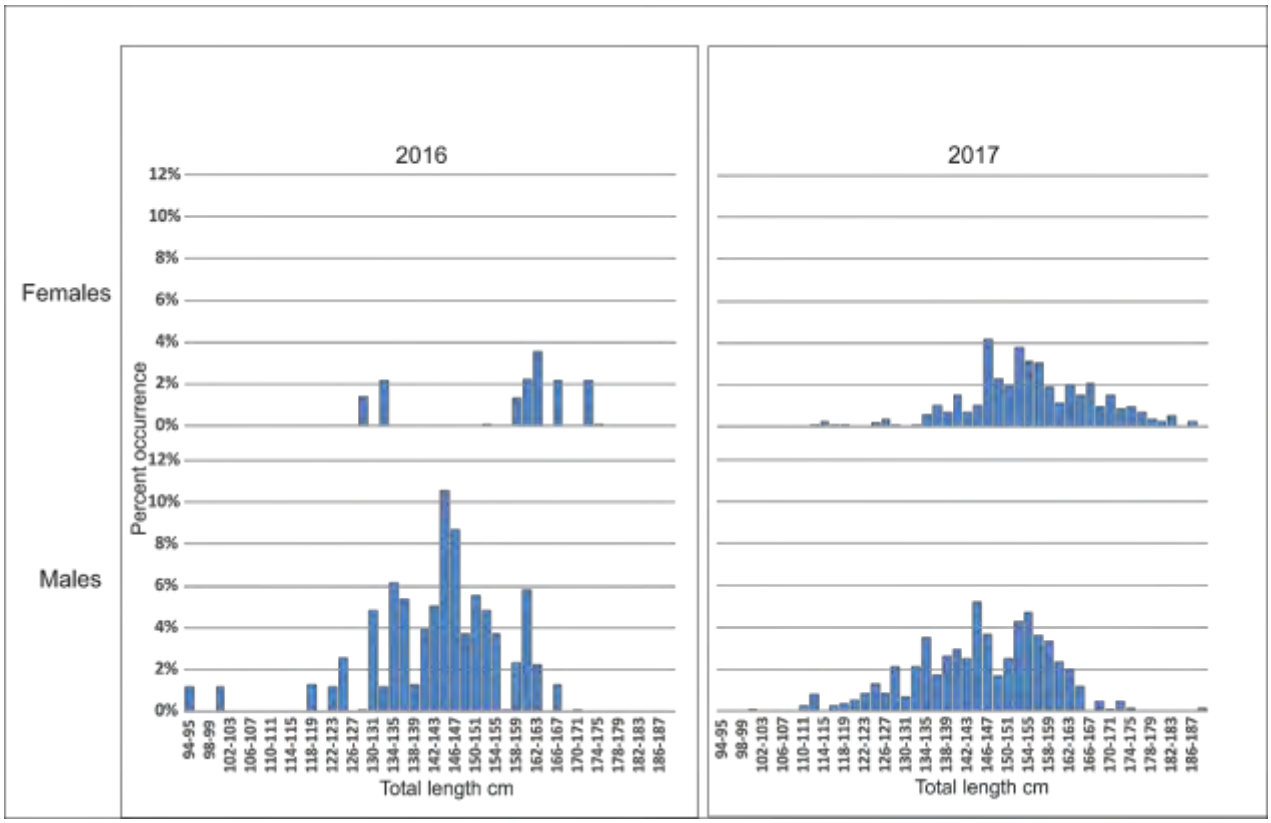


Figure 4. Length frequency of Antarctic toothfish by year weighted by overall catch number for each line, presented by sex for each season. Weighted sample n = 1070 for 2016 and n = 927 for 2017.

Table 2: Catch by species and disposition category during New Zealand's exploratory fishing for toothfish in the SPRFMO Area in 2016 and 2017.

		Retained (kg)		Discarded (kg)		Lost at surface (N)		Total weight (kg)	
Common name	**Taxonomic name**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**
Antarctic toothfish	*Dissostichus mawsoni*	28 961	28 835	0	0	15	8	28 961	28 835
Patagonian toothfish	*Dissostichus eleginoides*	0	7	0	0	0	0	0	7
Bigeye grenadier	*Macrourus holotrachys*	6	0	23	0	0	0	29	0
Blue antimora	*Antomora rostrata*	2	0	31	131	1	0	33	131
Cosmopolitan rattail	*Coryphaenoides armatus*	16	0	54	0	0	0	70	0
Rattail	*Macrourus whitsoni*	1	0	56	6	4	1	57	6
Rat tails, Grenadiers	*Macrourus* spp	0	0	0	82	0	0	0	82
Moray Cods	*Muraenolepis* spp	1	0	0	1	0	0	1	1

Table 3: Number of biological records collected during New Zealand's exploratory fishing for toothfish in the SPRFMO Area in 2016 and 2017. Some species listed in this table are not listed in Table 2 because these fish were reported under the general code for unidentified rattails and grenadiers.

		Lengths		Weights		Sex		Maturity		Gonad weight		Otolith pairs	
Common name	**Taxonomic name**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**
Antarctic toothfish	*Dissostichus mawsoni*	98	467	98	467	98	467	98	467	97	317	33	255
Patagonian toothfish	*Dissostichus eleginoides*	0	2	0	2	0	2	0	2	0	2	0	2
Bigeye grenadier	*Macrourus holotrachys*	16	1	16	1	16	1	16	1	15	0	16	0
Blue antimora	*Antomora rostrata*	10	123	10	123	10	123	10	123	1	0	10	0
Cosmopolitan rattail	*Coryphaenoides armatus*	39	0	39	0	39	0	39	0	39	0	10	0
Rattail	*Macrourus whitsoni*	2	16	2	16	2	16	2	16	2	0	2	0
Caml rattail	*Macrourus caml*	0	59	0	59	0	59	0	59	0	0	0	0
Moray cods	*Muraenolepis spp*	0	2	0	2	0	2	0	2	0	0	0	0

Gonadosomatic indices (GSI)[3] for Antarctic toothfish indicated that, as in other areas where spawning of Antarctic toothfish fisheries is thought to occur, females had bigger gonads for their body weight than males (Table). Lower average GSI values in 2017 probably reflect the fact that the samples were collected nearly six weeks later than in 2016. This may indicate an earlier spawning time, possibly around July.

Table 4. Gonadosomatic indices (GSI) of Antarctic toothfish by season and sex during New Zealand's exploratory fishing for toothfish in the SPRFMO Area in 2016 and 2017

		Females		Males
Year	**2016**	**2017**	**2016**	**2017**
Mean	4.68	3.31	2.91	1.66
Standard Error	0.19	0.17	0.20	0.10
Median	4.72	3.20	2.29	1.25
Standard Deviation	0.75	1.90	1.79	1.36
Sample Variance	0.57	3.60	3.21	1.84
Minimum	3.38	0.40	0.73	0.53
Maximum	5.85	21.65	9.98	10.50
Count	15	127	82	190

Gonad maturity (GMI) records for Antarctic toothfish indicate that fish were either spent or recovering / developing (i.e., not developing or ripe), suggesting that the sampling in both years was after the spawning season. It is difficult to distinguish between stage 5 (spent) and stage 2 (recovering / resting) except just before and just after the spawning season. GMI is regarded as a less precise measure of reproductive maturity and the measure is somewhat subjective and prone to variation in individual interpretations, including by experienced science staff (Williams, 2007). In addition, some reproductive states cannot be reliably identified by macroscopic methods (Hunter and Macewicz, 2001). For all these reasons, GSI is considered a more reliable indicator of reproductive status.

However, when both GSI and GMI measurements are taken it is possible to combine both measurements effectively in the manner as shown in Table 5 to describe the reproductive state. Note the data have been groomed with some changes made to the initial raw data collected. Although 18 toothfish over both seasons were recorded as having a maturity value of 1 (indicating and an immature gonad having reproductive tissue that has not undergone final maturation into either testis or ovary), in all but two cases either the size of the fish (greater than 120 cm total length) or the gonad weight (greater than 250 g) would indicate that the record is probably mistaken. For this specific analysis 15 fish of the entire sample were recoded from immature gonad (1) to developing gonad (2) – typically these may have been fish that had previously spawned but may be skipping a season. In addition, 151 zero values calculated for GSI (resulting from a null measurement for gonad weight) were omitted from the analysis and from the summary shown in Table 4. The low number of females measured during 2016 (only 15) makes comparison less precise, but GSI values in 2017 were consistently lower

[3] Gonad mass as a proportion of the total body mass.

than in 2016, reinforcing the premise that the 2016 sample had been taken closer to the end of the spawning period.

This conclusion is supported by the additional analysis of Fulton's Condition Factor (Figure 6) which shows higher condition for both sexes in 2017. Sampling occurred later in the year than in 2016 and this may indicate some recovery of body condition post-spawning. This implies a spawning event occurring earlier in the year than the August 2016 and September 2017 sampling.

Figure 7 shows the relationship between somatic body weight and length in Antarctic toothfish caught during the 2016 and 2017 surveys in both Research Areas. The relationship for weight in grams with total length in centimetres can be described for females using the standard equation $W=aL^b$ as $W = 0.177L^{2.864}$ and for males $W = 0.357L^{2.712}$.

In order to assess the similarity of the SPRFMO research areas and other areas where *Dissostichus mawsoni* are known to spawn, we compared length weight regression coefficients for samples collected by Sanford vessels from the Ross Sea region (CCAMLR subarea 88.1) and for five years of data collected in 48.4 near the South Sandwich Islands (Figure 8). These are both areas where pre-spawning fish have been sampled. Regression coefficients, including from the 2016-17 SPRFMO exploratory fishing are given in Table 5, including, for contrast, the relationship from the slope area of CCAMLR Area 88.1 (labelled "South"), an area thought to support a non-spawning population of fish feeding in a higher productivity area. The better condition of these "feeding" fish is evident; a fish of a given length in the south of 88.1 is heavier than those seen in spawning areas. What is also clear is that the fish sampled from the SPRFMO area (probably immediately post-spawning) are in a poorer condition than even those seen in the 88.1 and 48.4 spawning fisheries. This may be another indication that sampling has taken place earlier, within a few weeks of spawning.

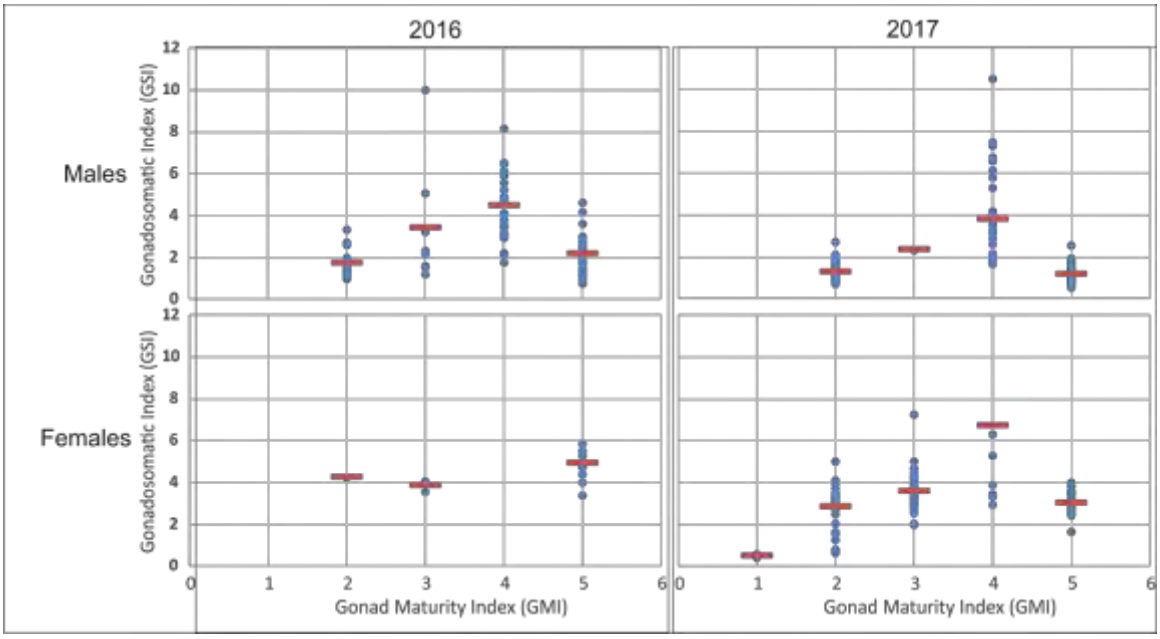


Figure 5: Antarctic toothfish GSI plotted against maturity index for each sex and each season (excluding all zero values). For plotting, one extreme value of 21.64 is not shown for 2017 females.

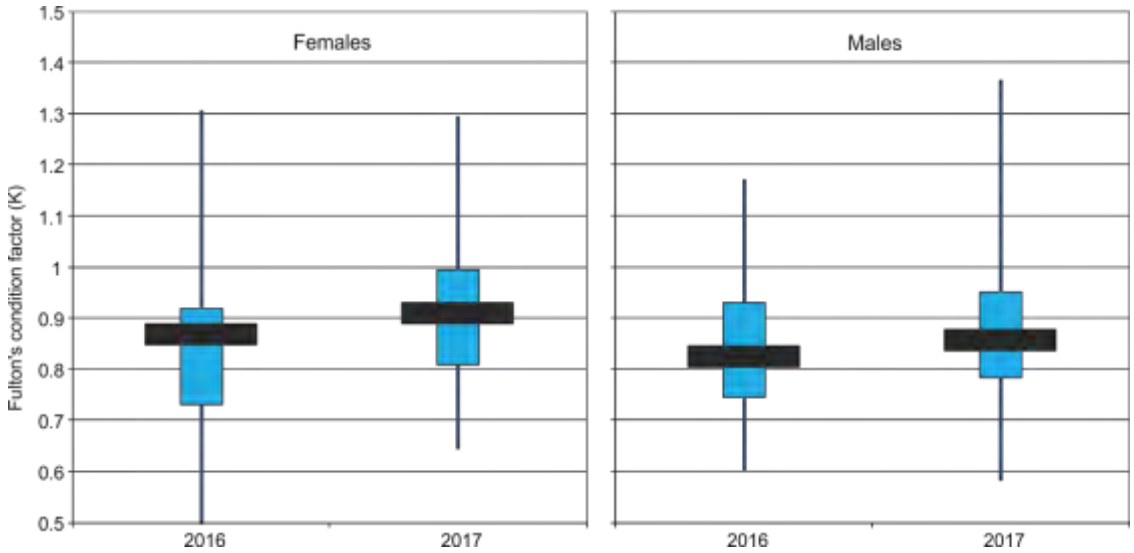


Figure 6: Fulton's Condition Factor (calculated using somatic body mass) describing fish 'condition' or 'fatness'. The black bar in each plot shows the median of these values, the blue boxes show the interquartile range, and the whiskers show the range of values recorded for each year-sex combination.

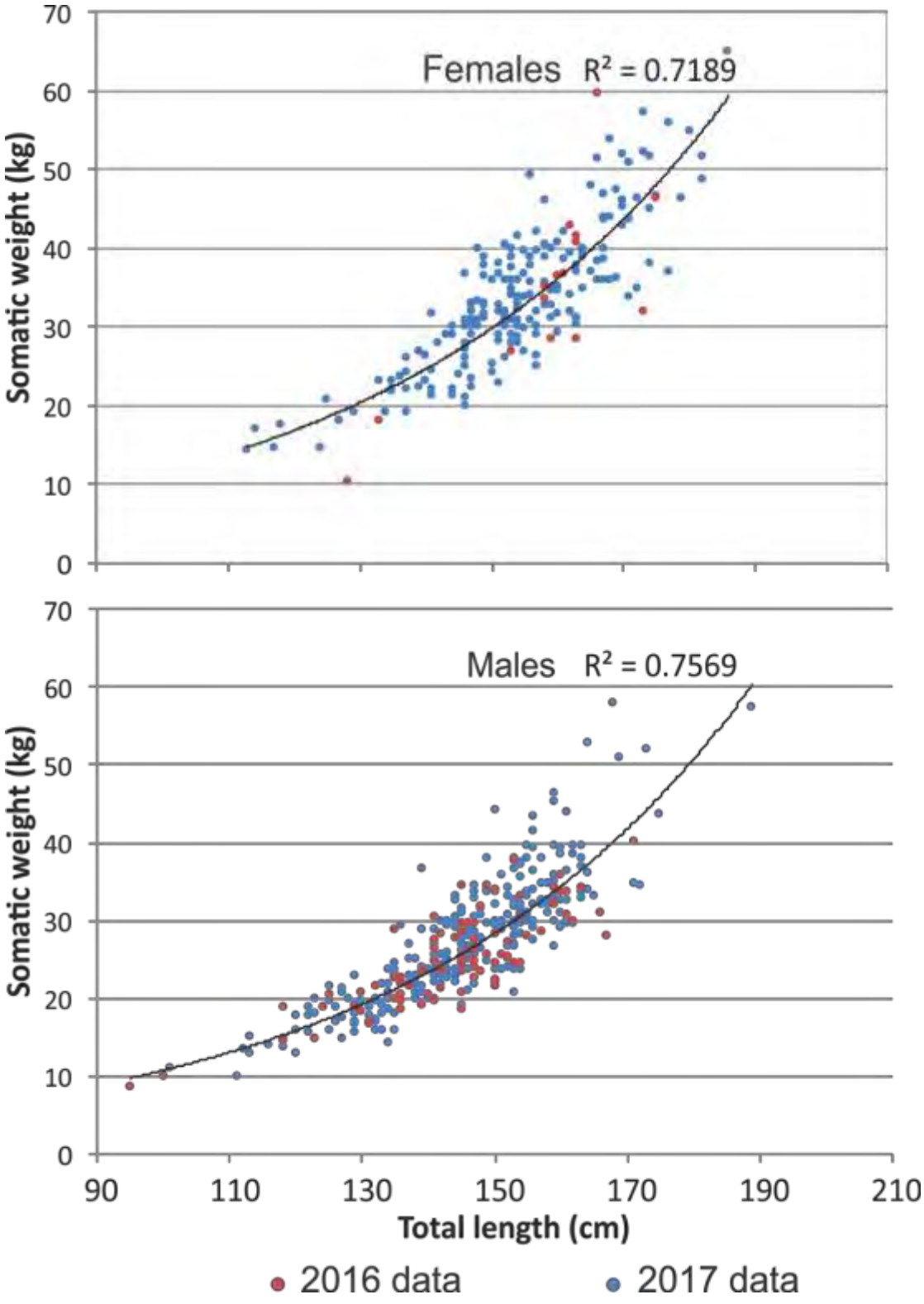


Figure 7: Length weight relationship of male and female Antarctic toothfish sampled during the SPRFMO exploratory toothfish fishery in 2016 and 2017.

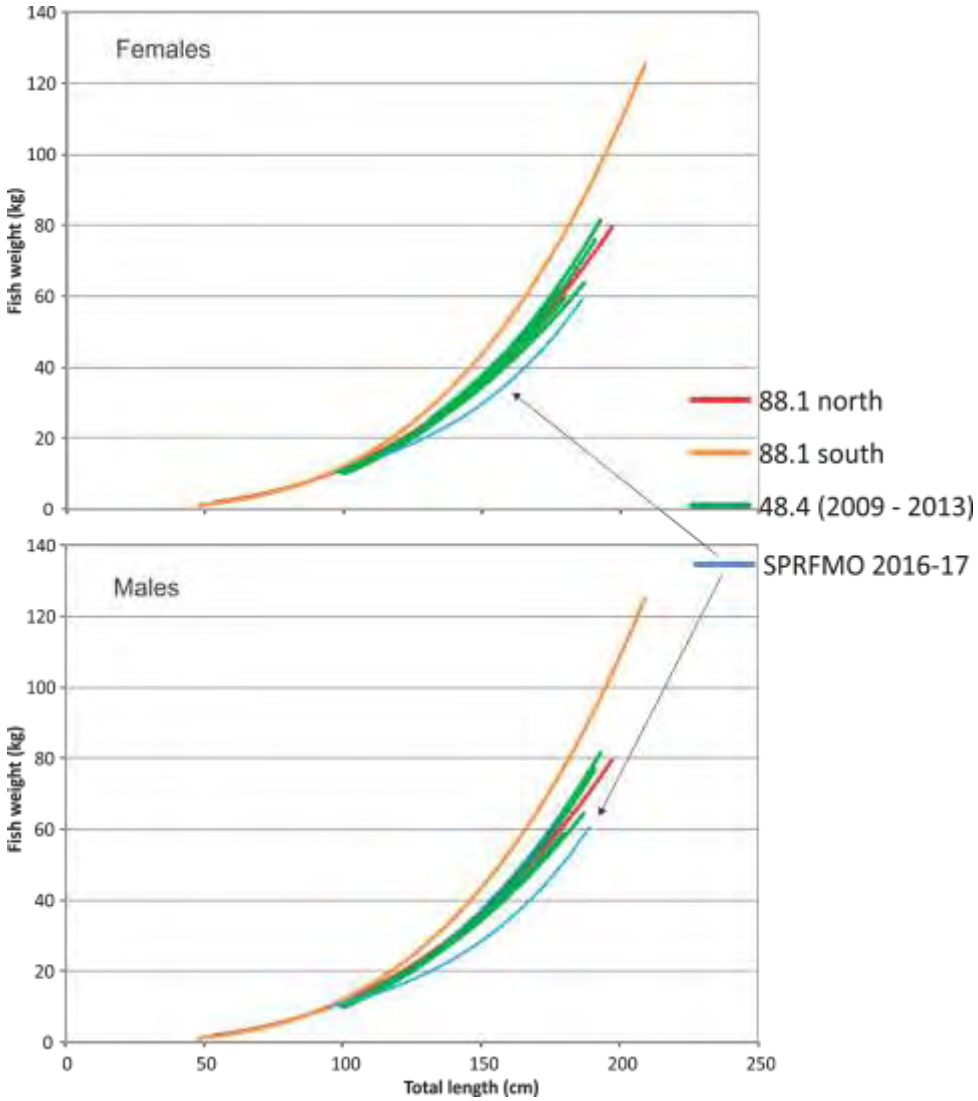


Figure 8. Length weight relationships (power regression lines) calculated from *D. mawsoni* samples collected within SPRFMO Research Boxes A and B compared with five years of 48.4 data and with Subarea 88.1 records from the north (both spawning areas) and south (a 'feeding' area).

3.5.4. Tagging data

Toothfish were required to be tagged at a rate of 3 fish per tonne of green weight catch retained. At a mean size of about 29 kg per fish, each tonne of catch represents about 35 toothfish, meaning about 1 in 10 fish captured need to be tagged to meet that target. In both seasons the required rate was met (Figure 9). Over the two years of the exploratory fishery so far, 194 Antarctic toothfish were tagged and released. The length distribution of tagged fish closely matched the length distribution of the overall catch (the size overlap statistics was 80% in 2016 and 72.5% in 2017). Two Antarctic toothfish that had been tagged during 2016 were recaptured during the 2017 survey. They had been released on the same seamount and no significant movement was observed over the year at liberty.

Table 5. Length-weight regression coefficients calculated from records taken from Sanford research sets in Subarea 88.1 (Ross Sea) north and south of 70 degrees S between 2001 and 2006, for the 2009 to 2012 seasons in the Subarea 48.4 research area, and from SPRMO Research Areas. The weight is in grams and total length in centimetres. The standard equation is $W=aL^b$

Sex	Area	Season	*a*	*b*	N	R^2
All	88.1 North	2001-2006	0.0176	2.9045	13 073	0.78
	88.1 South	2001-2006	0.0046	3.2068	40 657	0.96
	48.4	2009	0.0059	3.1839	628	0.82
	48.4	2010	0.0122	2.9730	486	0.81
	48.4	2011	0.0044	3.1766	119	0.78
	48.4	2012	0.0303	2.7895	121	0.79
	48.4	2013	0.0169	2.9044	466	0.74
	SPRFMO	2016-17	0.0180	2.8540	565	0.77
Male	88.1 North	2001-2006	0.0326	2.7708	6 547	0.73
	88.1 South	2001-2006	0.0048	3.1979	16 247	0.96
	48.4	2009	0.0106	3.0012	297	0.78
	48.4	2010	0.0143	2.9356	220	0.85
	48.4	2011	0.0332	2.7636	72	0.73
	48.4	2012	0.0217	2.8585	54	0.82
	48.4	2013	0.0482	2.8797	244	0.73
	SPRFMO	2016-17	0.0357	2.7123	365	0.76
Female	88.1 North	2001-2006	0.0188	2.8474	6 496	0.80
	88.1 South	2001-2006	0.0043	3.2178	24 092	0.97
	48.4	2009	0.0085	3.0572	331	0.81
	48.4	2010	0.0282	2.8116	259	0.71
	48.4	2011	0.0032	3.2522	47	0.79
	48.4	2012	0.0757	2.6037	67	0.69
	48.4	2013	0.0482	2.7023	220	0.65
	SPRFMO	2016-17	0.0177	2.8637	200	0.73

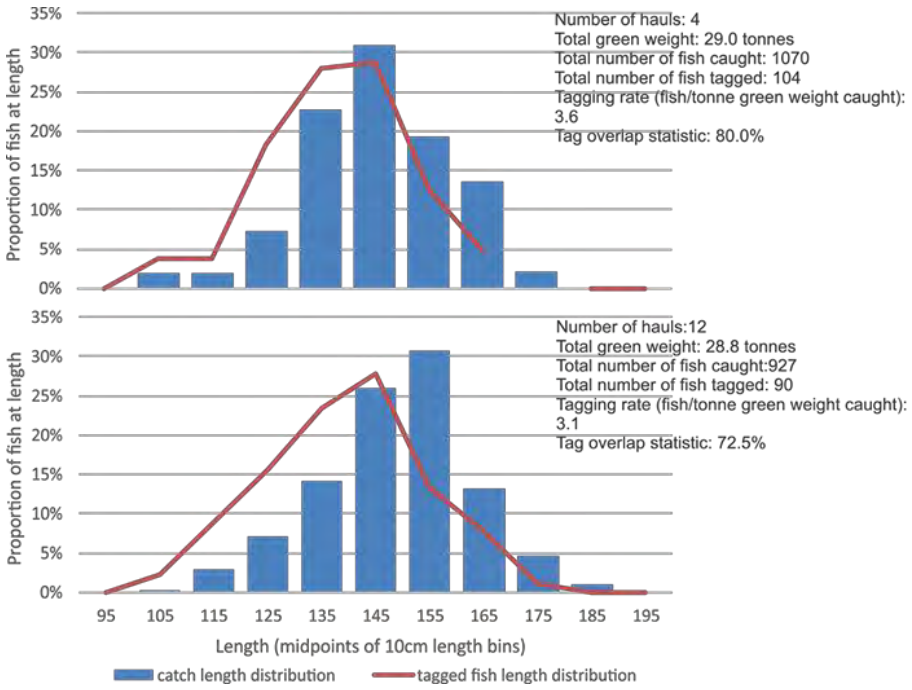


Figure 9: Tagging size overlap statistic for Antarctic toothfish from the SPRFMO exploratory toothfish fishery in 2016 and 2017. Weights given are retained weights.

3.5.5. Summary of research results from 2016 and 2017.

Analysis of the information collected during New Zealand's exploratory fishing for toothfish in 2016 and 2017 suggests that:

- Very high catch rates of post-spawning Antarctic toothfish were recorded from Research Box B in both years;
- The catch rates were similar to catch rates in two assumed spawning areas in the northern regions of CCAMLR subareas 88.1 and 88.2;
- The catch was almost entirely of Antarctic toothfish;
- Sex ratios were skewed with males dominating;
- Fish were in poor body condition potentially representing full or partial starvation during a spawning event presumed to precede the exploratory fishing;
- Body condition was slightly better in 2017, noting that fishing in 2017 occurred about 5 weeks later than in 2016; and
- Body condition and fish size (almost entirely adult) are both consistent with the general area of New Zealand's exploratory fishing being a spawning area for Antarctic toothfish.

3.5.6. Interactions with seabirds, marine mammals, turtles, or other species of concern

Seabirds

New Zealand government observers made counts of seabirds attending the vessel in 2016 and 2017. Standardised counts were made during setting and hauling, usually once while the gear was being set and once while the gear was being hauled, but, on occasion, additional tallies were taken. As expected, most seabirds observed from the vessel were common and widely distributed in southern waters, and none was considered rare or endangered (see risk assessments in Appendix 1). The most frequently-observed species were Cape petrels (55% of all birds observed) and snow petrel (25%) with smaller numbers of other species (Table 6). The number of birds observed, and the species mix, varied between 2016 and 2017 but the reasons for these differences are not known. There may be a seasonal effect, given the 2017 sampling took place later in the year. One unidentified prion (not included in Table 6) was found on the deck of the vessel one morning in 2017, having landed there during night; it had no injuries and was released unharmed. No other seabirds were observed colliding with the gear, entangled, or captured during either voyage.

Marine mammals, turtles, or other species of concern

No marine mammals, turtles, or other species of concern were observed during either voyage and none were entangled or captured in the gear.

Table 6. Summaries of observations of seabirds attending the vessel during exploratory longlining for toothfish in 2016 and 2017. Species identifications cannot be verified and are subject to some uncertainty.

Species or taxon	August 2016	September 2017	Total
Antarctic petrel (*Thalassoica antarctica*)	13	1	14
Cape petrels (*Daption* spp.)	37	41	78
Snow petrel (*Pagodroma nivea*)	35	0	35
Grey petrel (*Procellaria cinerea*)	3	1	4
Giant petrels (*Macronectes* spp.)	1	8	9
Prions (*Pachyptila* spp.)	0	2	2
All birds	89	53	142
Number of longline sets	7	12	19
Number of observation periods	18	31	49
Mean bird count per observation period	4.94	1.71	2.90

3.5.7. Benthic interactions and potential interactions with VMEs

A small number of benthic invertebrates were captured on the lines during both the 2016 and 2017 voyages. On average, only about one individual or colony was observed on each set (Table 7), the most frequently observed being hydroids, gorgonians, and sponges. Reporting of catch weights was different in the two voyages, so no weights are reported here (although the weight of invertebrate bycatch in the 2016 survey when better records were kept totalled only 4.0 kg). The small number of reported captures and slight differences in recording and reporting preclude accurate assessment of differences between the two voyages. Many of the benthic invertebrates captured during the two exploratory fishing voyages are VME indicators, especially the colonial taxa, but these very few captures do not suggest that it is necessary to review the risk assessment conducted in 2015 (wherein benthic impacts were considered to be of low intensity and low-medium overall risk).

Table 7. Summaries of observations of benthic invertebrates captured during exploratory longlining for toothfish in 2016 and 2017. Species identifications are subject to some uncertainty.

Taxon	August 2016	September 2017	Total
Hydroid (unspecified)	4	2	6
Gorgonian coral	3	2	5
Sponges (unspecified)	0	4	4
White hydrocoral	3	0	3
Glass sponges	2	0	2
Coral (unspecified)	1	0	1
Gorgonocephalus sp	1	0	1
Sea anemones	0	1	1
Sea lilies	0	1	1
Total number of observed individuals / colonies	14	10	24
Number of longline sets	7	12	19
Mean benthic invertebrate count per set	2.00	0.83	1.26

3.6. Fisheries Operation Plan

3.6.1. Description of the exploratory fishery

Based on the results of New Zealand's exploratory fishing under CMM-4-14 (see also Fenaughty and Cryer 2016) and liaison with CCAMLR scientists, it is proposed that exploratory fishery for toothfish be continued over a broader area than the initial two boxes to cover more features to the north and east of the initial exploratory fishing (**Error! Reference source not found.**). Fishing will be entirely by the m ethod of bottom longline using integrated weight line, and fishing for three consecutive calendar years is proposed (2019 to 2021).

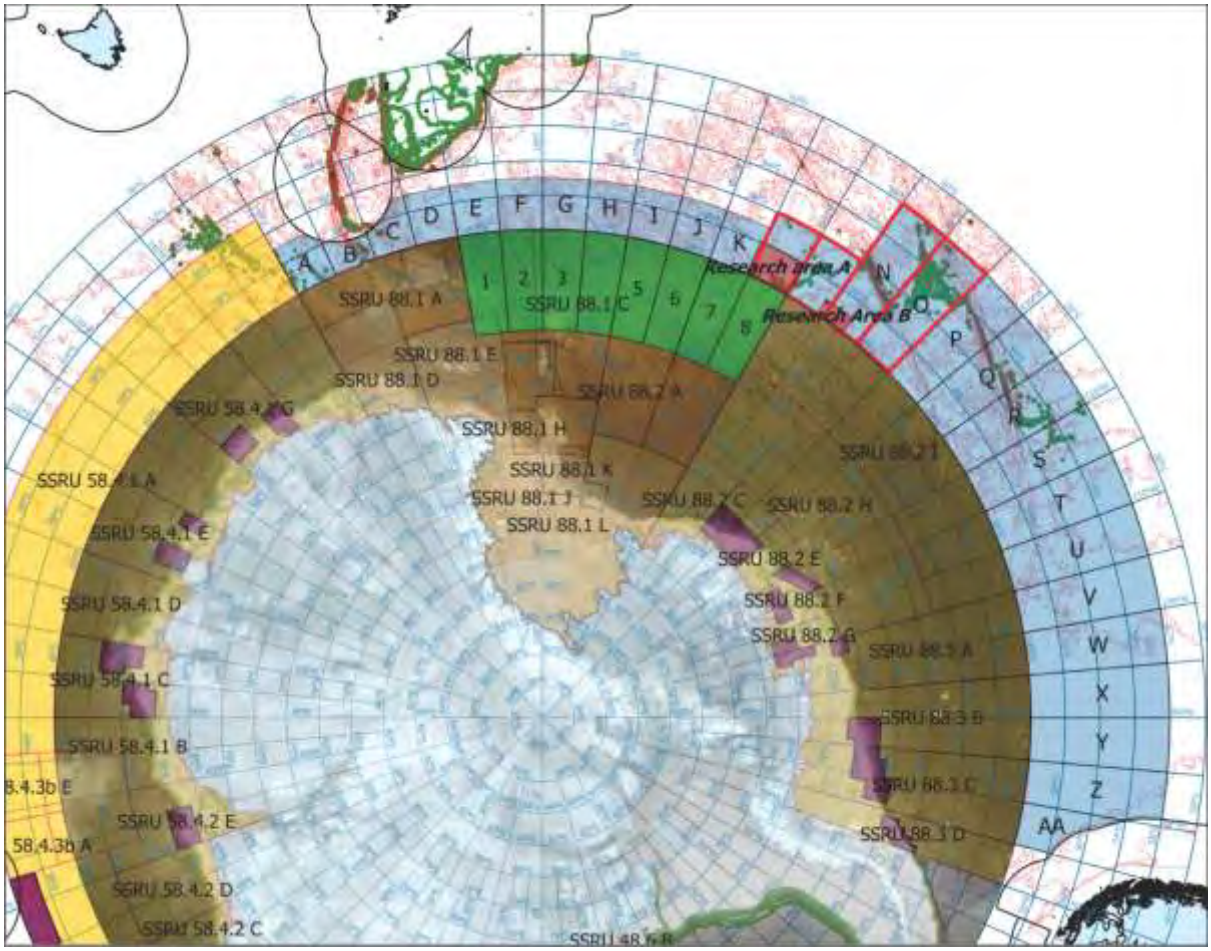


Figure 10. Map showing the survey strata (shaded green) for the proposed 2019 CCAMLR winter survey (1–8) as well as the survey strata proposed for the exploratory toothfish fishery in the SPRFMO Convention Area (outlined in red). Bathymetric contours shown at 500 and 3000 m. Also shown are the CCAMLR small scale research units (SSRUs).

The strata have been chosen to allow sampling of areas that appear potentially suitable for Antarctic toothfish, including the initial two Research Areas fished in 2016 and 2017. This proposal aims to extend the coverage already provided by CCAMLR surveys in Subareas 88.1 and 88.2. It is expected that the catch in these proposed areas will comprise almost entirely Antarctic toothfish, especially in these eastern areas (Figure 11). Only two Patagonian toothfish were captured in 2017 and none in

2016 in the previous exploratory fishing. The proposed exploratory fishing will greatly improve our information on the distribution, relative abundance, potential biomass, and spawning dynamics of Antarctic toothfish.

As this is an exploratory fishing exercise there will be a stepwise process of location of fishable bathymetric features, determination of suitability for fishing, and structured fishing according to a formalised design and subject to both effort and catch limits. To achieve the objective of understanding and quantifying spawning dynamics, it is important that individual fishing trips within the programme occur around the main winter spawning period for Antarctic toothfish (currently hypothesised to be July–September). Data collected during June and early July 2016 suggested a peak in gonadosomatic index (GSI) of near 20% for females at the end of June, with some indication of a decrease in July due to an increasing proportion of spent fish (Stevens et al. 2016). The length of the spawning period is unknown, hence a target period of September for some trips and at least half of the catch within this exploratory fishery to enhance chances of determining the end of the spawning season. Additional insights into the timing of the migration to CCAMLR's northern hills and into the SPRFMO Area should result from analysis of the biological characteristics of the toothfish caught during the pre- and post-spawning periods. For example, changes in sex ratio, fish condition, median age, and stable isotope indicators of diet could all provide evidence to test if a large proportion of fish had recently migrated into the area (Parker & Marriott 2012, Hanchet et al. 2015).

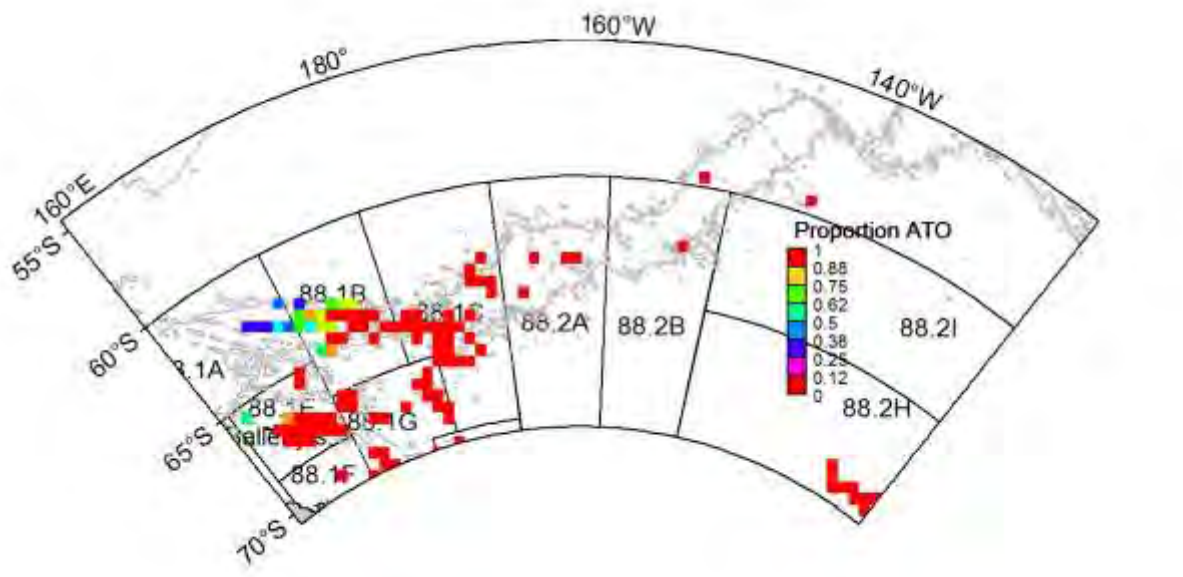


Figure 11. Proportion of *D. mawsoni* of the total *Dissostichus* spp. catch by number in longline catches by 2º longitude*0.4º latitude cells from CCAMLR and SPRFMO fine scale catch and effort data. Solid lines denote CCAMLR Subareas and Divisions, and lighter grey lines indicate CCAMLR SSRUs. The proposed exploratory fishing will occur to the north of 60º S and between 155º W and 135º W.

To ensure that fishing is spread geographically (to support description of spatial distribution) we propose to stratify the number of sets and anticipated maximum exploratory catch but also to provide some operational flexibility in situations where there are unexpectedly high or low catch rates. We

anticipate that three or four of the proposed SPRFMO toothfish strata could be sampled during the proposed voyages each year, and that a minimum of three sets per feature and up to about six features per stratum (about 72 sets) would be required to provide a reasonable assessment of spatial, seasonal, and depth distribution and their respective variability by the end of the programme.

At the average catch rates observed during the 2016 and 2017 exploratory fishing voyages (622 kg retained for each kilometre of line set or 3.07 t retained per set), 72 research sets could result in about 220 tonnes of *Dissostichus* catch. It is therefore proposed that a maximum catch limit of 220 tonnes of *Dissostichus* spp. (both species combined) be permitted, corresponding to approximately 7600 fish (the catch-weighed body mass of *D. mawsoni* in the 2016 and 2017 exploratory voyages was 28.8 kg, similar to the average weight in CCAMLR's northern SSRUs, 32.7 kg), all of which will be inspected for CCAMLR tags. At the tagging rate specified, it can be expected that up to about 2 000 tagged toothfish will be returned to the population over the 3 years of the programme.

This limit was based on the following design approach:

- A minimum of three strata should be surveyed with a maximum catch limit of 60 t per stratum to ensure geographic spread if catch rates are high in one or more strata;
- At least 10 sets, in at least 3 clusters, in each stratum fished, ice and operating conditions permitting;
- Clusters of no more than 5 sets will be separated by at least 10 nm (calculated as the minimum distance between any part of any set in any two clusters);
- Clusters of sets will not to be within 10 nm of a cluster already set within a voyage or fishing season (pre- and post-spawning)
- Some sets will be toward the deeper end of the expected depth range for toothfish (deeper than 2200 m), contingent on ice and other operating conditions and the risk of the backbone line snagging the bottom;
- A maximum combined catch limit of 220 tonnes live weight;
- No more than 110 t of toothfish catch to be taken by one vessel;
- To the extent practical, similar locations to be fished pre- and post-spawning to facilitate separation of spatial and seasonal trends;
- No more than 50% of a vessel's allocated catch to be taken outside the post-spawning period August to October.

A limit on the number of lines that could be set within the programme was considered but not included in the final design because it was redundant or counter-productive for the specified objectives. Spreading of effort to meet the objectives is already driven by the cluster design and the limit on the number of hooks per cluster. Conversely, a limit on the number of lines that could be set would provide incentives to set more hooks per line when better information on distribution and relative abundance can be gained from more lines with fewer hooks on each. In addition, shorter lines have the advantage on rough ground that they are more easily recovered, minimising the risk of losing sections of line.

The proposed catch limit of 220 tonnes is about 6% of the precautionary catch limit of 3 175 tonnes in place for *D. mawsoni* in CCAMLR Areas 88.1 and 88.2 for the 2017/18 year (see CM-41-09). If the

toothfish in the SPRFMO Area come from a straddling stock, it will almost certainly be the stock that inhabits CCAMLR Areas 88.1 and 88.2, including the Ross Sea. The report from the 2017 meeting of CCAMLR's fish stock assessment working group (WG-FSA-17) included model estimates of unfished biomass for that stock of 72 620 tonnes (95% CI: 65 040–81 050 tonnes) and current status of 72% of unfished biomass (95% CI: 69–75% of unfished biomass). Thus, the stock is estimated to be in good shape and the proposed exploratory fishing within the SPRFMO Area will only slightly increase the exploitation rate. If the toothfish in the SPRFMO Area do not come from a straddling stock (which is currently considered very unlikely), then the stock should be largely unfished and close to unfished biomass.

3.6.2. Gear specification

All exploratory fishing for toothfish will be by the method of bottom longline as practiced by New Zealand vessels in the CCAMLR Area (Figure 12, Tables 8 and 9). New Zealand deep-water demersal autoliners, including the vessels proposed for this fishery, *San Aspiring* and *Janas*, carry 20–30 magazines of longline. Each magazine holds about 840 to 1200 hooks, depending on hook size and magazine length. The hooks and snoods are normally spaced at 1.4 m intervals and connected to rotors and swivels that are permanently attached to the backbone (Figure 13). Snoods are usually 300–400 mm long. The average length of backbone on each magazine is 1.4–1.5 km (0.76–0.81 nautical miles (nm)).

During setting, the line is pulled off the magazine, through the baiting machine, and out through a port in the stern. As each magazine is emptied a new magazine is slid into place, connected to the line being set and made ready for setting. The average set has about seven magazines connected together to make a line of about 5.7 nm in length. A typical setting operation from float to float takes about 1 to 1½ hours. Hauling the same line from 500 m depth would take approximately 6 hours, or 8 hours when hauling from a depth of about 1500 m.

Between three and five lines are usually set in the chosen fishing area depending on line length and bathymetry. These lines are normally left to fish for between 12 and 36 hours depending on the fishing operation, presence (or absence) of sea lice, weather and ice conditions, and the number of lines already fishing in the area. Although bathymetric information for the target areas is limited, areas selected to be fished are likely to be in the range of 900 to 2500 m. Additional detail on the benthic longline setup and operation can be found in Fenaughty (2008). http://www.ccamlr.org/en/document/publications/wg-fsa-08/60 or the CCAMLR gear library. Table 9 shows the ranges of line lengths and hook numbers from *San Aspiring* records in the neighboring CCAMLR Subarea 88.1 as a guide.

Table 8: Description of main bottom long line gear items.

Item	Description
Backbone	11.5–12 mm lead-core internally weighted polypropylene/nylon line at 50g/m (Fiskevegn AS or equivalent for sink rate purposes)
Grapnels	40 or 50 kg: two or four used per line depending on sea, bottom, and tidal conditions
Weights	About 5 kg: rarely used, tied to the line occasionally when setting in loose sea ice or when turning while setting
Hook type	15 mm straight shank 14/O or 15/O hooks (Fiskevegn AS or similar).
Chain	Lengths of heavy chain generally 20 or 40 kg used for additional weighting at the line ends.
Floats	Only surface floats, either inflatable or pressure floats depending on ice conditions
Snoods	45–50cm blue Capron™ or similar snoods spaced 1400 mm apart

Table 9. Ranges of line lengths and hook numbers from *San Aspiring* records averaged over the past three completed fishing seasons in Subarea 88.1 and 88.2.

	Minimum	Average	Maximum
Line length	1 977 m	9 218 m	14 398 m
Number of hooks	1 714	6 270	10 284

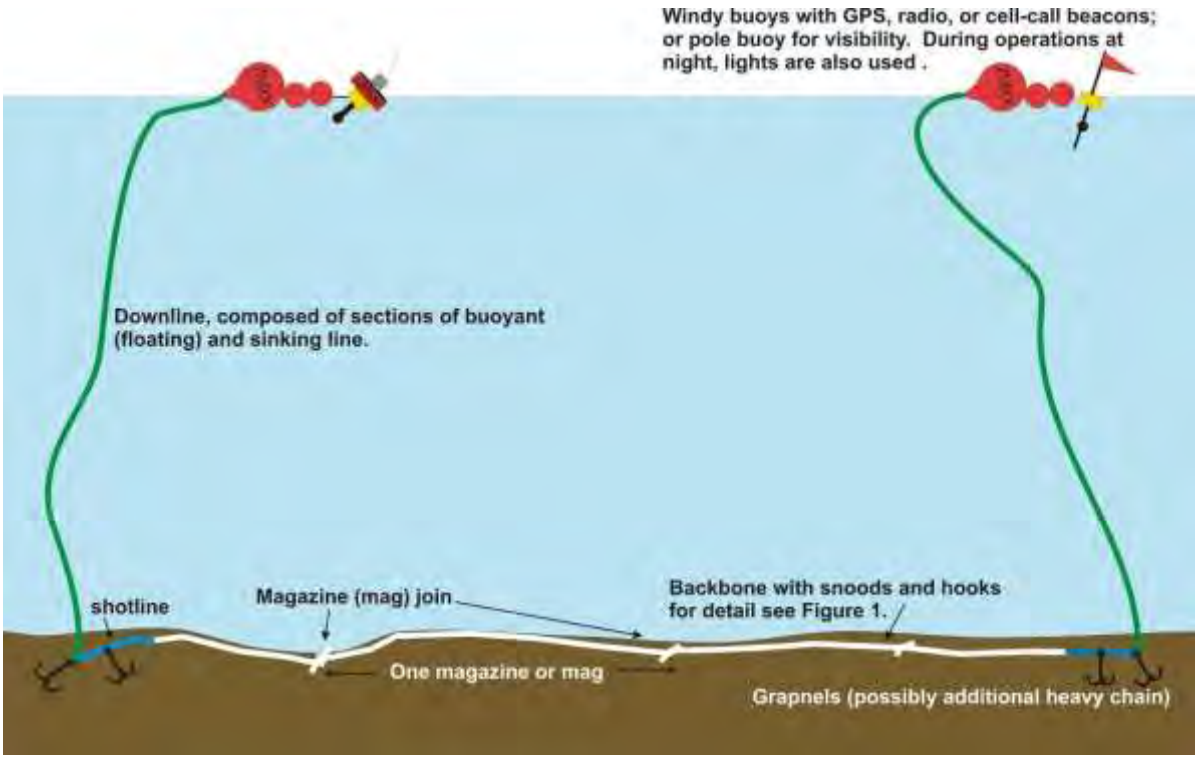


Figure 12: General arrangement for bottom longlining using an autoline system. There may be very minor differences between vessels in the equipment deployed.

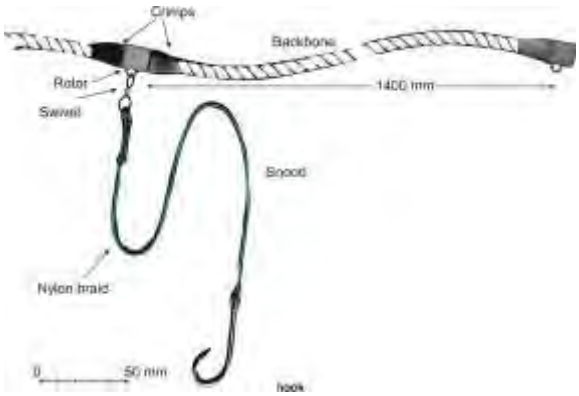


Figure 13: Generic arrangement of backbone and snood. There may be minor differences between vessels in the equipment deployed.

3.6.3. Impacts on non-target and associated or dependent species and marine ecosystems

Fish bycatch

New Zealand's exploratory fishing in 2016 and 2017 and in fishing the northern Ross Sea region within CCAMLR suggests that fish bycatch will constitute much less than 1% of the total catch (by weight) and comprise small numbers of relatively common and cosmopolitan species. In 2016 and 2017, the main bycatch was of rattails, *Macrourus* spp. (species composition probably varying with depth), totalling < 0.25% of the total catch by weight in each year. Even smaller amounts of the violet cod *Antimora rostrata* and eel cod were taken in each year (see Table 2). Other potential bycatch species include other morid cods and there could potentially be small numbers of skates, noting that there is a protocol for live release of skates which are known to have high survival following capture and release.

Deepwater sharks are not expected at these latitudes. However, if unexpectedly large amounts of deepwater sharks are caught in a cluster of lines (250 kg), then no further clusters will be set within 10 nm of that location until the information from that voyage has been reviewed by SPRFMO's Scientific Committee.

Seabirds

Longlines have a risk of capturing seabirds in many fisheries worldwide, including at similar latitudes (e.g., Anderson et al. 2011, Baird et al. 2015). However, seabird mortality mitigation measures have been successfully developed and implemented by the demersal longline fishers catching toothfish in the CCAMLR Area. For example, in the Ross Sea toothfish fishery, only two birds have been killed as a result of fishing operations in 20 years. Although observations in the 2016 and 2017 research fishing trip included no rare or threatened species, there is still potential for a higher rate of seabird interactions in the proposed exploratory fishing areas (and, therefore, a higher risk of captures) than in within CCAMLR Subareas 88.1 and 88.2 which lie immediately to the south. However, even though the proposed fishing areas may be heavily used by New Zealand breeding seabirds from December to April each year, the proposed seasonal timing of at least half of the trips (August-October) will help to minimising the risk of seabird bycatch (Graeme Taylor, Department of Conservation, personal communication). At this time, northern hemisphere migrants are still coming back and are unlikely to be in the proposed fishing areas in any numbers before mid to late October. Conversely, the local

summer breeders are all returning to the area of their colonies for courtship, prospecting and nest cleaning, so not so many will still be in the proposed fishing areas in September / October.

Birds attending the vessel in 2016 and 2017 were mainly Cape petrels, snow petrel, Antarctic petrel, and giant petrels and no seabirds were killed or injured in either year. However, a wide variety of other seabird species could be encountered, include threatened species such as Chatham petrel and antipodean albatross, whose at-sea distributions are known to include the proposed exploratory fishing areas (Figures 14 and 15). The risk of interactions with threatened species are considered to be very low and will be mitigated using a combination of the following measures:

- Integrated weight line (incorporating 50 g of lead in the core of each metre of longline backbone to facilitate fast sinking of the lines), and
- tori (streamer) lines deployed above the lines being set (to deter birds from approaching the lines), and
- night-setting (when seabirds are least active – further enhanced by conducting the fishery primarily in the winter), and
- strict offal management (to reduce the attractive effect of discarded material).

These measures have been found to be a highly effective combination (e.g., Løkkeborg 2011), were reported as working effectively in the exploratory fishery in 2016 and 2017 by the observers on board, and are likely to reduce the risk of capturing seabirds to very low levels. Robertson et al. (2006) recorded that integrated weight lines (50 $g.m^{-1}$ beaded lead core, sink rate: 0.24 $m.s^{-1}$) yielded a 94–99% reduction in the capture of white-chinned petrels and a 61% reduction for sooty shearwaters compared with unweighted conventional lines (sink rate: 0.11 $m.s^{-1}$) in the New Zealand ling (*Genypterus blacodes*) fishery. The observed sink rate of lines set by the vessel *San Aspiring* during operational fishing in the CCAMLR area between 2011 and 2014 was faster still at 0.34 $m.s^{-1}$ (range 0.19 to 0.56 $m.s^{-1}$, Figure 15) and no changes have been made to the gear since that would decrease this high sink rate.

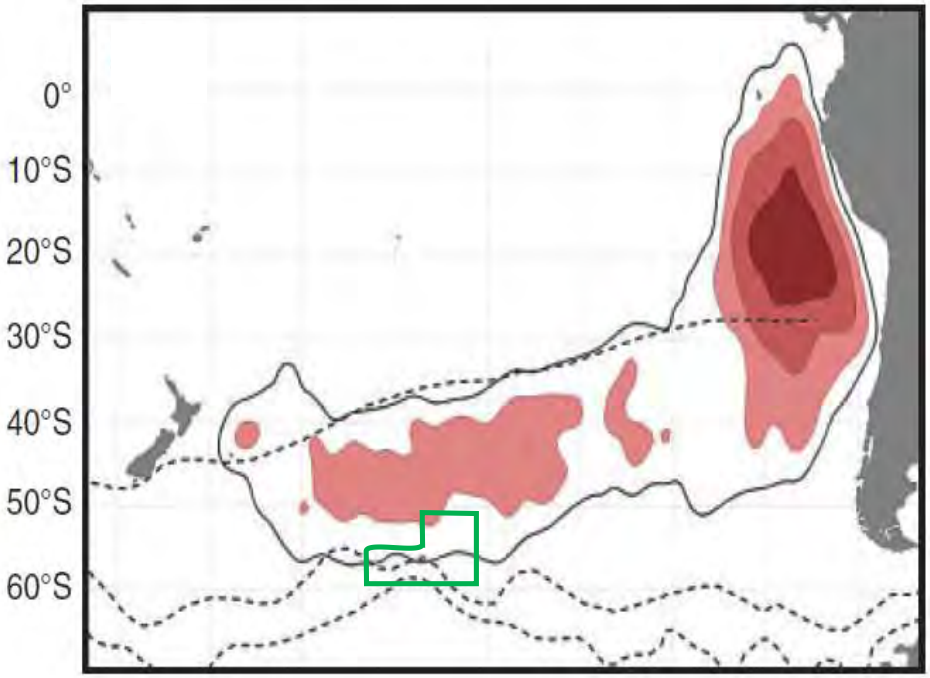


Figure 14 (after Rayner et al. 2012): Kernel density distributions for Chatham petrels tracked with geolocator-immersion loggers during the non-breeding period (May–October 2009). Coloured polygons represent the 25, 50 and75% density contours, and the outer grey line represents the 95% density contour. Approximate locations (north to south) of the Subtropical, Sub-Antarctic and Polar Fronts are shown as dotted lines. The approximate location of the proposed exploratory fishing area is shown as a green box.

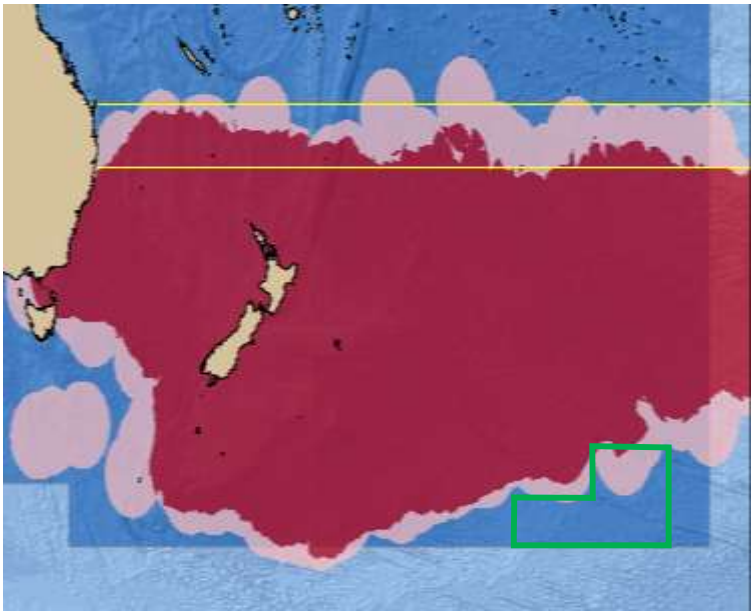


Figure 15 (after Debski et al. 2016): Kernel density distributions from tracking data for non-breeding adult female antipodean albatross (the birds with the widest distribution) between 2011 and 2015. Coloured polygons represent the 95 and 99% density contours. The approximate location of the proposed exploratory fishing area is shown as a green box.

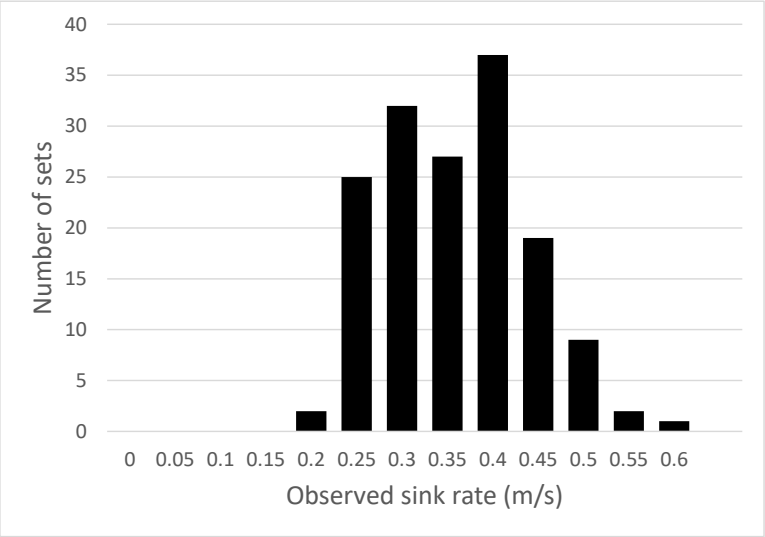


Figure 15: Observed sink rates for integrated weight line sets from the vessel San Aspiring in CCAMLR fisheries between 2011 and 2014.

Marine mammals

Interactions with orca and other marine mammals and turtles are considered unlikely based on experience in New Zealand's 2016–17 exploratory fishing (during which no marine mammals were observed from the vessel) and in the northern parts of the CCAMLR area. Observers will, however, record all sightings and interactions. If depredation by marine mammals (sperm whales) is observed or suspected, the crew will take action to prevent such interactions. This may include ceasing to haul the line, allowing it to sink back to depth, and moving away from the area until the whales have left.

Benthic impacts and vulnerable marine ecosystems

The bottom impact of line fishing methods is typically low (e.g., Pham et al. 2014, Clark et al. 2016), depending largely on the extent to which lines move laterally during hauling. Tethered camera observations by the UK (UK 2010) suggest that the frequency of lateral longline movement in contact with the ocean floor is likely to be negatively correlated with depth. In three deployments in shallow water (531–541 m; mean = 537 m) lateral movement was observed during hauling immediately prior to lift-off from the sea floor, whereas in two observed deployments in deeper water (1528 and 1390 m) the line was seen to lift vertically from the sea floor without any lateral movement. Australian work in the Heard and McDonald Islands fishery (Welsford et al. 2014) suggested some lateral movement of longlines (median ~3 m, mean ~6 m) and some indication that lateral movement decreased with depth. A negative correlation with depth is to be expected due to trigonometric considerations (Sharp 2010). Experience from the exploratory fishing in 2016 and 2017 and the limited bathymetry information suggest that fishing depths are likely to be in the range 900 to 2400 m so only limited lateral movement and consequently a low benthic impact is expected.

Notwithstanding the low expected impact, New Zealand government observers will record all benthic bycatch and will carry appropriate detailed identification guides to facilitate identification to a useful taxonomic level. VME indicator taxa associated with "structural VMEs" can be identified from the

guides normally used by New Zealand government observers (e.g., see pages 96 and 97 of New Zealand's Bottom Fishery Impact Assessment) and the CCAMLR VME Guide can be used to identify hydrothermal vent fauna (if encountered). No hydrothermal vents are known to occur in the proposed exploratory fishing area, but search effort has been minimal and the habitat appears broadly suitable.

Because the proposed exploratory fishery is a bottom fishery, an assessment of the impact of the proposed fishing activities is included in Appendix 1 as mandated by paragraph 5(b)(viii) of CMM-13-2016 (exploratory fisheries) and paragraphs 10, 11, 16, and 17 of CMM-03-2018 (bottom fisheries).

3.6.4. Cumulative impacts of all fishing activity in the area

The proposed exploratory fishery does not overlap spatially with any other fisheries so the cumulative impacts on taxa and habitats that do not move or migrate will be essentially the same as the impact of the exploratory fishery. Seabirds and marine mammals are likely to move in and out of the proposed exploratory fishery area, so cumulative impacts on these may be higher if interactions were to occur. These impacts are considered further in the risk assessment section.

Antarctic toothfish caught during the proposed exploratory fishery are likely to be a constituent of the stock found in the CAMLR Convention Area immediately south, so it will be important to consider cumulative effects with the CCAMLR fishery. Information from New Zealand's exploratory fishery in 2016 and 2017 has already been included in the CCAMLR stock assessment and all data from the proposed exploratory fishery will be shared, consistent with the MOU between SPRFMO and CCAMLR. The inclusion of data which would be collected during the proposed exploratory fishery into the working stock assessment model developed by CCAMLR constitutes an explicit mechanism for assessing the cumulative impacts of fishing on the target species of toothfish. It should be noted that CCAMLR has specified objectives and agreed decision rules to determine precautionary yields for the Ross Sea region toothfish fishery (CCAMLR Convention, Article II) but SPRFMO has not yet developed an analogous long-term fishing strategy for toothfish. The Scientific Committee has agreed to develop a tiered assessment framework (Nicol et al. 2017, paper SC-05-DW-04) and information gathered during the proposed exploratory fishing should help to inform that initiative.

3.6.5. Analysis and reporting

The timing of spawning for Antarctic toothfish (thought to be July to September) and the consequential timing of at least half of the exploratory fishing (August to October) does not mesh ideally with reporting to Scientific Committee. However, annual updates will be provided to describe progress each year, and to highlight any significant new findings and seek guidance as necessary. Reports will be copied to the relevant CCAMLR bodies. Data will be provided to the secretariat as part of New Zealand's annual data submission (CMM-02-2018) and, subject to SC agreement, the CCAMLR secretariat.

Final and comprehensive analysis following fishing in August to October 2021 will probably not be possible until SC in September 2022 and, therefore, Commission in January 2023.

3.7. Proposed Data Collection Plan

3.7.1. Standard SPRFMO data

The following is the SPRFMO standard for bottom line fishing activity data to be submitted by the vessel (Annex 3 of CMM-02-2018):

1. Data are to be collected on an un-aggregated (set by set) basis.

2. The following fields of data are to be collected:

(a) Vessel flag

(b) Vessel name

(c) Vessel call sign

(d) Registration number of vessel

(e) Set start date and time (UTC format)

(f) Set end date and time (UTC format)

(g) Set start position (1/10th degree resolution – decimal format)

(h) Set end position (1/10th degree resolution – decimal format)

(i) Intended target species (FAO species code)

(j) Number of hooks

(k) Bottom depth at start of set

(l) Estimated catch retained on board by species (FAO species code) in live weight

(m) An estimation of the amount of living marine resources discarded by species if possible

(n) Were any marine mammals, sea-birds, reptiles or other species of concern caught (yes/no/unknown-Y, N, U)

In addition, the New Zealand observer on board will meet or exceed the requirements of Annex 7 of CMM-02-2018 which specifies a wide variety of information to be collected by observers on board fishing vessels including:

A. Vessel & Observer Data to be Collected for Each Observer Trip
D. Catch & Effort Data to be Collected for Bottom Long Line Fishing Activity
E. Length-Frequency Data to Be Collected
F. Biological Sampling to be Conducted
G. Data to be Collected on Incidental Captures of seabirds, mammals, turtles and other species of concern
I. Data to be Collected for all Tag Recoveries

Annex J of CMM-02-2018 recognises that observers may not be able to collect all of the data described in the CMM on each trip, and suggests that, where no trip- or programme-specific priorities have been specified, the following generalised hierarchy of priorities be applied:

a) Fishing Operation Information
    i. All vessel and tow / set / effort information
b) Reporting of Catches
    i. Record time, weight of catch sampled versus total catch or effort (e.g. number of hooks), and total numbers of each species caught
    ii. Identification and counts of seabirds, mammals, turtles, sensitive benthic species and vulnerable species
    iii. Record numbers or weights of each species retained or discarded

iv. Record instances of depredation, where appropriate

c) Biological Sampling

i. Check for presence of tags

ii. Length-frequency data for target species

iii. Basic biological data (sex, maturity) for target species

iv. Length-frequency data for main by-catch species

v. Otoliths (and stomach samples, if being collected) for target species

vi. Basic biological data for by-catch species

vii. Biological samples of by-catch species (if being collected)

viii. Take photos

These priorities are broadly appropriate for the proposed exploratory fishing and the New Zealand observer will be briefed accordingly (noting also the more specific guidance in the following sections).

3.7.2. Additional data requirements 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. Data will be recorded and reported to SPRFMO and shared with CCAMLR 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 stock assessment and for reporting. The nominated vessels are both capable of reporting and electronically transmitting this information daily if necessary. Very similar information is regularly reported daily when these vessels are working within the CAMLR Convention Area.

3.7.3. Additional data requirements for estimating fishable area and habitat

Both vessels will operate high quality echosounders during the time they are within the SPRFMO Convention Area (Simrad ES60 or ES70, 38 kHz, or equivalent) and record all soundings and tracklines. These data will be provided to the New Zealand government for confidential storage and analysis to estimate fishable area and suitable habitat for toothfish. Vessels will operate their Simrad sounders to record acoustic information using the protocols already in place for operation within CCAMLR. The recorded information will be dealt with by the NIWA acoustic group using the existing confidentiality agreement and general protocols.

3.7.4. Tagging of toothfish

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. The rules applied by CCAMLR in the immediately adjacent SSRUs 88.2 A and 88.2 B north region where tagged fish were released in early 2015 will be used (CM 41-01 Annex C). 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

proposed vessels, *San Aspiring* and *Janas*, 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.

3.7.5. Specific guidance for the collection of biological information

The crews of the proposed vessels, *San Aspiring* and *Janas*, and New Zealand observers have experience collecting detailed biological information during fishing and research voyages in the CCAMLR Area. A suitable workstation for the observer will be supplied on board any vessel fishing in the exploratory fishery which will include facilities to measure, otolith, and take samples from small and large fish as well as motion-compensating scales for weighing gonads or other small items to a resolution of 10 g. The following minimum data collection requirements will apply:

- Hook size (whether 14/O or 15/O) will be recorded for each line set to facilitate analysis of any potential for selectivity impacts on the length frequency or catch rate of toothfish and fish bycatch composition.
- All toothfish captured will be observed carefully for the presence of CCAMLR or other tags, and all previously-tagged fish will be retained and sampled for a full suite of biological data and tissue samples.
- All fish and invertebrates will be identified to the finest taxon possible. Photographs and/or specimens of taxa not identified to species level will be retained by the observer. Standard CCAMLR codes will be used by the observer because these include more codes for the species likely to be caught in the exploratory fishing areas. These codes can readily be translated to standard New Zealand (MPI) and SPRFMO codes after the voyages.
- Up to 35 toothfish of each species per line will be measured for total length, weight, sex, and gonad stage and gonad weight. Stomachs will be examined, and stomach contents recorded to the finest visual taxonomic level possible. Sample numbers of each toothfish species will be in proportion to the number of hooks hauled in each line at a rate of 7 fish per 1 000 hooks (https://www.ccamlr.org/en/science/observer-sampling-requirements-dissostichus-spp).
- Additional samples such as muscle tissue, stomach contents, bycatch species, and gonad histology for stable isotope and genetic analysis for stock differentiation, trophic, and movement studies will be collected as specified in each vessel research plan.
- Contingent on the catch, 5 pairs of otoliths per 5 cm length class of toothfish between 100 and 150 cm will be collected for each sex. As it is likely that few toothfish shorter than 100 cm will be caught, otoliths will be collected from all retained fish shorter than 100 cm.
- Any macrourids, up to 10 of each species caught on a set, will be identified and sampled for length, weight, sex, and gonad weight.
- Full biological data (length, weight, sex, gonad stage, gonad weight) will be collected for any captured sharks and skates.
- Catches (including weights to the nearest 0.1 kg) of all benthic invertebrates, including VME[4] indicator taxa, will be recorded using standard SPRFMO protocols and codes.

[4] BFIAS: Annex 1 of the FAO Guidelines provides a list of examples of potentially vulnerable species groups, communities and habitats, as well as features that potentially support them and should be used as the basis for determining what constitutes VME taxa in the SPRFMO area.

In addition, continuous plankton recorders (CPR) and plankton nets suitable for the collection of toothfish eggs will, subject to availability, be carried and deployed to complement and extend deployments in the CCAMLR Area.

3.7.6. Marine mammals, seabirds, turtles, and other species of concern

New Zealand observers are trained to identify seabirds and marine mammals whether these are captured or attending the vessel. The following information will be collected for marine mammals, seabirds, turtles, and other species of concern:

- At least one standardised seabird and marine mammal abundance count will be made at the rear of the vessel during the setting of each line and again during the hauling of each line;
- Other opportunistic observations, photography and identification of marine mammals will be undertaken in collaboration with the crew;
- The observer will have a target of observing at least 10% of hooks hauled for marine mammal, seabird and turtle captures, and for comparison with a sample of recorded video observations;
- At least 50% of hooks hauled will be viewed on recorded video after the voyage[5];
- All marine mammals, seabirds, turtles, and other species of concern captured will be identified, and photographs will be taken of all live birds released and any birds colliding with the ship that can be recovered;
- All dead birds will be retained for formal identification and necropsy;
- Benthic species, VME indicator taxa are covered under benthic and VME section;
- Fish species of concern are covered under the biological measurements section.

4. Recommendations

It is recommended that the Scientific Committee:

- **notes** New Zealand's proposal and its Fisheries Operation Plan to extend its exploratory demersal longline fishery for toothfish (limited at 220 tonnes greenweight retained annually);
- **recognizes** the cautious, exploratory nature of the proposal;
- **recognizes** the scientific benefits of the proposed data collection, especially for understanding the distribution, movement, spawning dynamics, and stock structure of toothfishes and supporting the CCAMLR stock assessment models for Antarctic toothfish;
- **agrees** that data and analyses from New Zealand's exploratory fishing continue to be shared in a timely manner with CCAMLR;
- **agrees** that a spatial stratification consistent with CCAMLR's should be adopted by SPRFMO to facilitate the collection and sharing of data;
- **approves** or **amends** the Data Collection Plan included in the proposal;
- **advises** the Commission that the proposal is acceptable in terms of Articles 2 and 22, CMM-13-2016 (exploratory fisheries), CMM-03-2018 (bottom fisheries), and the BFIAS.

[5] Both vessels have agreed to operate multi-camera system to record both set and haul in CCAMLR voyages and these will be deployed during SPRFMO exploratory voyages using at least two cameras; one over the haul station, the other looking astern where tori/streamer lines are deployed over lines being set.

5. References

Anderson O.F.; Guinotte J.; Rowden A.A.; Clark M.R.; Mormede S.; Bowden D.; Davies A.J. (submitted) Field validation of habitat suitability models for Vulnerable Marine Ecosystems in the South Pacific Ocean: implications for the use of broad-scale models in fisheries management. Submitted.

Anderson O. R.; Small C. J.; Croxall J. P.; Dunn E. K.; Sullivan B. J.; Yates O.; Black A. (2011). Global seabird bycatch in longline fisheries. *Endangered Species Research* **14**: 91-106.

Allain, V., Kerandel, J. A., Andrefouët, S., Magron, F., Clark, M., Kirby, D. S., & Muller-Karger, F. E. (2008). Enhanced seamount location database for the western and central Pacific Ocean: screening and cross-checking of 20 existing datasets. Deep Sea Research Part I: Oceanographic Research Papers, 55(8), 1035-1047.

Baird K.; Small C.; Bell E.; Walker K.; Elliot G.; Nicholls D.; Alderman R.; Scofield P.; Deppe L.; Thomas B.; Dias M.P. (2015). The overlap of threatened seabirds with reported bycatch areas between 25° and 30° South in the Western Central Pacific Fisheries Commission Area. WCPFC-SC11-2015/ EB-WP-09.

CCAMLR Secretariat (2012) Preliminary assessment of known and anticipated impacts of proposed bottom fishing activities on VMEs in 2012/13. CCAMLR-XXXI/14 Rev. 1

Clark, M. R., Althaus, F., Schlacher, T. A.,Williams, A., Bowden, D. A., and Rowden, A. A. The impacts of deep-sea fisheries on benthic communities: a review. *ICES Journal of Marine Science* **73**: i51–i69.

Clark, M.R.; Anderson, O.; Bowden, D.; Chin, C.; George, S.; Glasgow, D.; Guinotte, J.; Hererra, S.; Osterhage, D.; Pallentin, A.; Parker, S.; Rowden, A.; Rowley, S.; Stewart, R.; Tracey, D.; Wood, S.; Zeng, C. (2015). Vulnerable Marine Ecosystems of the Louisville Seamount Chain: voyage report of a survey to evaluate the efficacy of preliminary habitat suitability models. *New Zealand Aquatic Environment and Biodiversity Report No. 149*. 88 p.

Cryer, M., Dunn, A., Fenaughty, J.M. (2017). New Zealand's exploratory fishery for toothfish within the SPRFMO Convention Area: Update and future directions. SC-CAMLR XXXVI/BG/18. 6 p.

Davies, A. J., & Guinotte, J. M. (2011). Global habitat suitability for framework-forming cold-water corals. PloS one, 6(4), e18483.

Day J, Haddon M and Hillary R (2015) Stock Assessment of the Macquarie Island fishery for Patagonian toothfish (*Dissostichus eleginoides*) using data up to and including August 2014. Report to SARAG 51, 24 February 2015. CSIRO, Australia.

Debski I.; Hjörvarsdóttir F.; and Knowles K. (2016). Distribution of highly at-risk New Zealand seabirds in the Western Central Pacific Fisheries Commission area. WCPFC-SC12-2016/ EB-WP-09 (rev1) submitted to SC-12, Bali, Indonesia, 3–11 August 2016. 7 p.

Fenaughty J.M. (2006). Geographical differences in the condition, reproductive development, sex ratio, and length distribution in Antarctic toothfish *Dissostichus mawsoni* from the Ross Sea, Antarctica (CCAMLR statistical Subarea 88.1). CCAMLR Science, 13: 27-45.

Fenaughty J.M (2008). The autoline system – an updated descriptive review of the method with recommendations to clarify CCAMLR Conservation Measures regulating longline fisheries within the Convention Area. WG-FSA-08/60.

Fenaughty J.M.; Cryer M. (20162016a). Report on the first year's fishing under New Zealand's exploratory fishery for toothfish within the SPRFMO Convention Area. Paper SC-04-DW-02 for the 4th Meeting of the SPRFMO Scientific Committee, The Hague 7 to 15 October 2016. 7 p.

Fenaughty, J.M., Cryer, M. (2016b). Report on the first year's fishing under New Zealand's exploratory fishery for toothfish within the SPRFMO Convention Area. SC-CAMLR-XXXV/BG/32. 8p.

Hunter, J.R. and B.J. Macewicz 2001. Improving the accuracy and precision of reproductive information used in fisheries: modern approaches to assess maturity and fecundity of warm-and cold-water fish squids. Fish. Bull., 90: 101-128.

Kitchingman, A., & Lai, S. (2004). Inferences on potential seamount locations from mid-resolution bathymetric data. Seamounts: Biodiversity and Fisheries. Fisheries Centre Research Report, 12(5), 7-12.

Løkkeborg, S. (2011). Best practices to mitigate seabird bycatch in longline, trawl and gillnet fisheries—efficiency and practical applicability. *Marine Ecology Progress Series* **435**: 285–303.

New Zealand Ministry of Fisheries (2008). Bottom Fishery Impact Assessment: Bottom Fishing Activities by New Zealand Vessels Fishing in the High Seas in the SPRFMO Area during 2008 and 2009. Downloaded from http://www.sprfmo.int/conservation-measures/benthic-impact-assessments/ on 12 August 2015.

Nicol S.; Cryer M.; Bock T.; Georgeson L. (2017). A draft stock assessment framework for bottom fisheries within the SPRFMO Convention Area. Paper SC5-DW04 for the 5th Meeting of the Scientific Committee, Shanghai, China, 23 - 28 September 2017. 9 p.

Parker, S.J., and M.H. Smith (2011). Can toothfish catches be used to predict the presence of vulnerable benthic invertebrate taxa? CCAMLR Science, Vol. 18 (2011): 87–96

Parker, S.J. and S. Mormede. 2009. Is the by-catch of vulnerable invertebrate taxa associated with high catch rates of fish in the Ross Sea longline fisheries? Document WS-VME-09/7. CCAMLR, Hobart: 11 pp.

Parker, S.J. and D.A. Bowden. 2010. Identifying taxonomic groups vulnerable to bottom longline fishing gear in the Ross Sea region. CCAMLR Science, 17: 105–127.

Parker, S.J., S. Mormede, D.M. Tracey and M. Carter. 2009. Evaluation of VME taxa monitoring by observers from five vessels in the Ross Sea region Antarctic toothfish longline fisheries during the 2008/09 season. Document TASO-09/8. CCAMLR, Hobart, Australia: 13 pp.

Penney A. (2010). Use of geospatial data and predictive habitat models to evaluate the likelihood of presence of vulnerable marine ecosystems in the SPRFMO Area. SPRFMO paper SWG-09-DW-03. 12 p.

Pham, C. K., Diogo, H., Menezes, G., Porteiro, F., Braga-Henriques, A., Vandeperre, F., and Morato, T. 2014. Deep-water longline fishing has reduced impact on Vulnerable Marine Ecosystems. *Scientific Reports* **4**: 6 p.

Rayner, M. J., Taylor, G. A., Gummer, H. D., Phillips, R. A., Sagar, P. M., Shaffer, S. A., & Thompson, D. R. (2012). The breeding cycle, year-round distribution and activity patterns of the endangered Chatham Petrel (*Pterodroma axillaris*). *Emu* **112**: 107-116.

Robertson G, McNeill M, Smith N, Wienecke B, Candy S, Olivier F (2006) Fast sinking (integrated weight) longlines reduce the mortality of white-chinned petrels (*Procellaria aequinoctialis*) and sooty shearwaters (*Puffinus griseus*) in demersal longline fisheries. *Biological Conservation* **132**:458–471

Rowden A.A.; Clark M.R.; Lundquist C.J.; Guinotte J.M.; Anderson O.F.; Julian K.A.; Mackay K.A.; Tracey D.M.; Gerring P.K. (2015). Developing spatial management options for the protection of vulnerable marine ecosystems in the South Pacific Ocean region. *New Zealand Aquatic Environment and Biodiversity Report No. 155*. 76 p.

Rowden A.A.; J Guinotte; S. J. Baird; D. M. Tracey; K. A. Mackay; S. Wadhwa (2013) Predictive modelling of the distribution of vulnerable marine ecosystems in the South Pacific Ocean region. *New Zealand Aquatic Environment and Biodiversity Report No. 120*. 74 p.

Sharp, B., S.J. Parker and N. Smith. (2008): An impact assessment framework for bottom impacting fishing methods in the CCAMLR area. CCAMLR, WSA-08/53.

Sharp B.R. (2010). Updated impact assessment framework to estimate the cumulative footprint and impact on VME taxa of bottom longline fisheries in the CCAMLR Area. CCAMLR Science, 16 (2009): 195–210

Tittensor, D. P., Baco, A. R., Brewin, P. E., Clark, M. R., Consalvey, M., Hall-Spencer, J., ... & Rogers, A. D. (2009). Predicting global habitat suitability for stony corals on seamounts. Journal of Biogeography, 36(6), 1111-1128.

UK. (2010). Preliminary assessment of the potential for the proposed bottom fishing activities to have significant adverse impact on vulnerable marine ecosystems. WG-EMM 10/33. 16 p. CCAMLR.

Williams, K., 2007. Evaluation of macroscopic staging method for determining maturity of female walleye pollock, Theragra chalcogramma in Shelikof Strait, Alaska. Alaska Fish Res. Bull., 12: 252-263.

Yesson, C., Clark, M.R., Taylor, M. L., Rogers, A.D. (2011). The global distribution of seamounts based on 30-arc seconds bathymetry data. *Deep-Sea Research* I 58, 442–453.

Yesson, C., Taylor, M. L., Tittensor, D. P., Davies, A. J., Guinotte, J., Baco, A., ... & Rogers, A. D. (2012). Global habitat suitability of cold-water octocorals. *Journal of Biogeography*, 39(7), 1278-1292.

Appendix 1: bottom fishery impact assessment (in accordance with FAO's Guidelines for the Management of Deep-sea Fisheries, taking into account the SPRFMO Bottom Fishery Impact Assessment Standard, BFIAS).

Key requirements of the FAO guidelines

47. Flag States and RFMO/As should conduct assessments to establish if deep-sea fishing activities are likely to produce significant adverse impacts in a given area. Such an impact assessment should address, inter alia:

    i. type(s) of fishing conducted or contemplated, including vessels and gear types, fishing areas, target and potential bycatch species, fishing effort levels and duration of fishing (harvesting plan);
    ii. best available scientific and technical information on the current state of fishery resources and baseline information on the ecosystems, habitats and communities in the fishing area, against which future changes are to be compared;
    iii. identification, description and mapping of VMEs known or likely to occur in the fishing area;
    iv. data and methods used to identify, describe and assess the impacts of the activity, the identification of gaps in knowledge, and an evaluation of uncertainties in the information presented in the assessment;
    v. identification, description and evaluation of the occurrence, scale and duration of likely impacts, including cumulative impacts of activities covered by the assessment on VMEs and low-productivity fishery resources in the fishing area;
    vi. risk assessment of likely impacts by the fishing operations to determine which impacts are likely to be significant adverse impacts, particularly impacts on VMEs and lowproductivity fishery resources; and
    vii. the proposed mitigation and management measures to be used to prevent significant adverse impacts on VMEs and ensure long-term conservation and sustainable utilization of low-productivity fishery resources, and the measures to be used to monitor effects of the fishing operations.

48. Risk assessments referred to in paragraph 47 (vi) above should take into account, as appropriate, differing conditions prevailing in areas where DSFs are well established and in areas where DSFs have not taken place or only occur occasionally.

Types of fishing proposed

The proposed exploratory bottom longlining for toothfish is described in detail in the main proposal. The sampling design for this work is closely modelled on the design adopted by CCAMLR for longline surveys for toothfish in the immediately adjacent CCAMLR subareas 88.2 A&B (northern parts).

The major objectives for the proposed exploratory fishing are as follows:

- Increase knowledge of the detailed bathymetry of fishable areas within the exploratory fishing area,
- characterise the local toothfish populations, including information relevant to life-cycle and spawning
- document the relative abundance of Patagonian and Antarctic toothfish in space and time, and with depth
- contribute to the understanding of stock structure, movement patterns, and spawning dynamics of toothfish in the SPRFMO area and interactions between SPRFMO, CCAMLR, and other management areas,
- tag toothfish as a contribution to stock linkage studies, and, potentially, to include in CCAMLR multi-area stock assessment models and for biomass estimation,
- collect information on distribution, relative abundance, and life history of bycatch species.

The proposed exploratory fishing area (Figure 16) was identified using a combination of experience in New Zealand's exploratory fishing in 2016 and 2017 and GEBCO data[6] (based on satellite-derived gravity observations). Given this 'low-knowledge' starting point, the main intent of the design for this programme is to continue the *prospecting*[7] phase to identify potential fishable ground, collect relevant bathymetric detail, and obtain increasingly detailed information on *Dissostichus* species and any associated fish and non-fish bycatch.

While existing information is sparse indications are that actual fishable areas are likely to be small. The research strata straddle some of the northern extent of the Pacific Antarctic Ridge and collectively comprise about 960,000 km² in area. Further south, this Ridge is characterised by small features such as seamounts, ridges and pinnacles. It is likely therefore that the fishable habitat in this area will be similar and that finding fishable ground may be time-consuming.

The fishing gear to be used for this work will be standardised and used very similar fishing gear to existing research surveys carried out within the CCAMLR Convention area as detailed in the original proposal (see the CCAMLR gear library, http://www.ccamlr.org/en/document/publications/wg-fsa-08/60). As is the case in other longline research surveys, integrated weight line (IWL) will be used and the target soak time will be 18 hours with a range of ±6 hours, environmental conditions and weather permitting. The gear has been the subject of substantial testing for use in CCAMLR surveys.

Because the depth and topography of the proposed exploratory fishing areas is poorly-known, it is not possible or appropriate to specify formal strata or randomised set locations.

CCAMLR has developed a protocol for research longline fishing on small, isolated features which was utilised to undertake research in the northern section of CCAMLR subarea 88.2 which lies immediately south of the proposed exploratory fishing areas and during the 2017 winter survey by the vessel *Janas*. A standard CCAMLR protocol would not be feasible as a research design in the seamount feature-dominated environment in the proposed exploratory fishing areas. Seamounts and other features

[6] GEBCO_08 Grid, version 20100927

[7] CCAMLR distinguishes prospecting, biomass estimation, and stock assessment phases in the development of a longline fishery. See Report of the Working Group on Fish Stock Assessment (Hobart, Australia, 7 to 18 October 2013

require vessels to have the flexibility to deploy clusters of shorter sets closer together to fish small or steep-sided features. Spreading of effort is achieved through spatial separation of clusters rather than separation of individual lines.

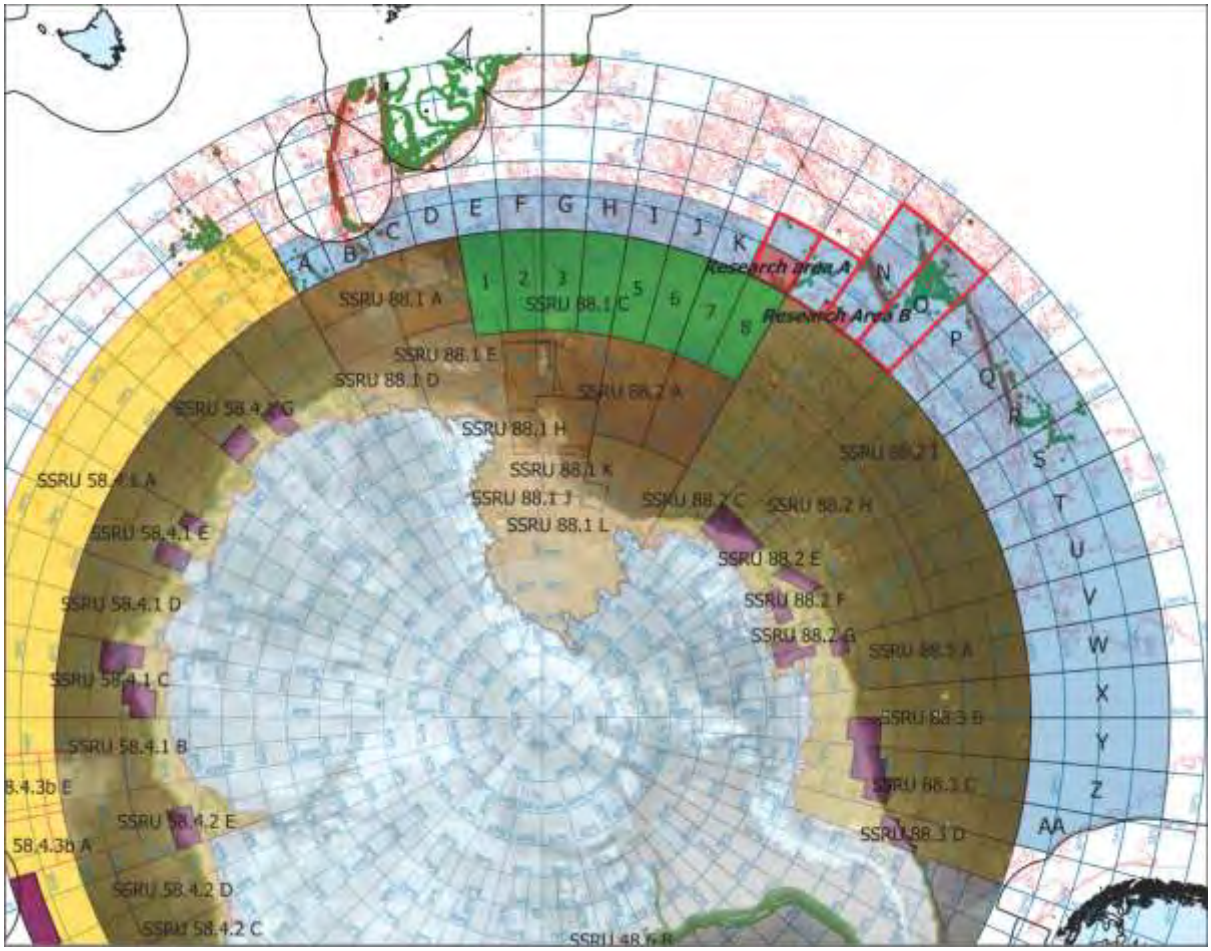


Figure 16. Map showing the survey strata (in green) for the proposed 2019 CCAMLR winter survey (1–8) as well as the survey strata proposed for the exploratory toothfish fishery in the SPRFMO Convention Area (outlined in red). Bathymetric contours shown at 500 and 3000 m. Also shown are the CCAMLR small scale research units (SSRUs).

Because the benthic environment in the proposed exploratory fishing areas is similar to that in CCAMLR 88.2 A and B North, a similar survey design approach is proposed. For consistency with CCAMLR surveys, the following rules are proposed:

- clusters of IWL lines are allowed with no rules for minimum separation between lines
- no more than 6,900 hooks may be set in a line
- no more than 17,250 hooks may be set in a cluster
- clusters of lines may be no closer together than 10 nautical miles (measured from the proximate lines of each individual cluster).

Current state of fishery resources and ecosystems

The primary target of this exploratory fishing, *Dissostichus mawsoni*, has broad circumpolar distribution and stock structure is poorly understood (Hanchet et al 2015). It is likely that fish of this species caught will be part of the stock resident in the Ross Sea region or the Amundsen Sea region.

In the absence of information on potential fishing areas and given the general homogeneity of circumpolar fish species in the Antarctic convergence area it is reasonable to use analogous catches from other CCAMLR and high latitude demersal longline fisheries. Typically, these fisheries take more than 90% toothfish, with about 5% rattails and smaller numbers of morid cods, skates and other species.

- *Tables of historic catches and catch trends of these species in the intended fishing area, if available.*
- *Results of any surveys conducted on the stocks to be fished.*
- *Results of the most recent stock assessments that have been conducted for the stocks to be fished.*
- *Any other information relevant to understanding the status and sustainability of target and by-catch species.*

Other than the research work carried out for SPRFMO by *San Aspiring* in 2016 and 2017, there is no known historical fishing or catch from the proposed exploratory fishing areas and no surveys have been carried out on any stocks to be fished. Some additional information is held by the SPRFMO secretariat indicating a history of fishing for Patagonia toothfish in the SPRFMO area, including by both bottom trawl and bottom longline methods (Table 10).

This information comes largely from New Zealand's national data report in 2007 during the preparatory meetings for the formation of SPRFMO which indicated catches of 11 t of toothfish in 1995 and 1145 t in 1996 (Table 11, reproduced from NZ Ministry of Fisheries 2007).

Detailed examination of the reported fishing that led to this summary shows that the 1156 t of toothfish taken in 1995–96 was from the Australian EEZ near Macquarie Island by a single vessel (flag unrecorded in New Zealand records, but probably Australian, fishing for a New Zealand company). That trip entailed 280 bottom trawl tows within the Australian EEZ and two bottom trawl tows within what is now the SPRFMO area with no catch of toothfish.

New Zealand holds records of about 1.5 t of Patagonian toothfish caught by bottom line in 1996 and 1999 and will explore why this is not included in the secretariat's records. Two NZ vessels long-lined for toothfish in the 2002–2006 reference period. The fishing occurred in 2003 and 2004 and targeted Patagonian toothfish (*Dissostichus eleginoides*) in SPRFMO General Fishing areas now known as the Hjort Trench and the Southwest Pacific Basin. There were 29 fishing events involving the setting and hauling of 116 000 hooks. A total of 5.6 t of fish was caught including 3.9 t of *Dissostichus eleginoides* and 0.1 t of Antarctic toothfish, *Dissostichus mawsoni*.

These data suggest that only a small amount of toothfish was taken from the SPRFMO area since 1990. Catches were previously mostly Patagonian toothfish, *Dissostichus eleginoides* and a small amount of Antarctic toothfish, *Dissostichus mawsoni*. The average catch each year (almost entirely Patagonian toothfish) during the reference years (2002–2006) was 780 kg.

The proposed exploratory fishing areas border the CCAMLR - SPRFMO boundary. As the methodology for carrying out stock assessments on toothfish stocks is well developed and widely used within CCAMLR this existing methodology will be used for consistency and an integrated management approach.

Table 10. Information on catch history of Patagonian toothfish within the SPRFMO area held by the secretariat as at 7 August 2015.

Participant	Year	Area	5-degree square	Fishing method	Species / group name	Catch weight (kg)
New Zealand	1995	HS-SPRFMO-FAO81		(Bottom trawl)	Patagonian toothfish	11,000
New Zealand	1996	HS-SPRFMO-FAO81		(Bottom trawl)	Patagonian toothfish	1,145,000
New Zealand	2003	HS-SPRFMO-FAO81	-57.5/157.5	09.9.0 Hooks and Lines (not specified)	Patagonian toothfish	1,000
New Zealand	2004	HS-SPRFMO-FAO81	-57.5/162.5	09.9.0 Hooks and Lines (not specified)	Patagonian toothfish	3,173
New Zealand	2004	HS-SPRFMO-FAO81	-57.5/217.5	09.9.0 Hooks and Lines (not specified)	Patagonian toothfish	44

Table 11. Reproduced from NZ Ministry of Fisheries 2007): catch by species and year for New Zealand vessels operating in the reporting area specified during the negotiations (now the SPRFMO area).

Year	Hoplostethus atlanticus	Epigonus telescopus	Allocyttus niger	Hyperoglyphe antarctica	Dissostichus eleginoides	Pseudocyttus maculatus	Macruronus novaezelandiae	Beryx splendens, B. decadactylus	Others	Total
1990	561						510		262	1,333
1991	141		9	3		20	19		183	375
1992	757	10	1	51		8	111	23	132	1,093
1993	4,943	245	28	223		31	37	43	529	6,060
1994	3,191	1,058	25	136		32	74	88	603	5,205
1995	12,505	320	844	175	11	350	261	18	681	14,971
1996	9,482	205	113	62	1,145	161	73	70	897	12,098
1997	4,178	351	123	109		89	119	31	517	5,576
1998	2,432	182	171	140		195	92	464	388	4,004
1999	5,892	325	51	53		169	89	39	189	6,806
2000	1,886	151	84	19		50	2	29	89	2,330
2001	2,942	485	16	49		109		22	117	3,739
2002	3,335	159	126	1		51	7	18	277	3,974
2003	2,496	227	72	20		29	4	191	599	3,643
2004	2,170	87	102	132	3	120	1	167	222	3,004
2005	2,570	188	531	101		95	1	25	311	3,822
2006	1,681	21	61	277		9	1	28	246	2,324
Total	61,169	4,081	2,146	1,657	1,160	1,567	1,348	1,261	6,051	80,440

Identification, description and mapping of VMEs known or likely to occur in the fishing area

- *What impacts are likely to result from the fishing gears to be used? All impacts should be identified, characterised and quantified or ranked.*

New Zealand has carried out cumulative impact assessments on bottom longline gear in the CCAMLR area since 2008. Although a low risk factor, relative to other interactions the complete or partial loss of gear was identified as the most important consideration. A direct relationship between the amount of gear loss and the presence of, and operating within, sea-ice has been established. For example, the same vessels working in the CCAMLR sub area 48.3 fishery where there is no sea ice have very little gear loss. Other risks include rough bottom having the potential to snag lines.

- *What will the probability, likely extent (% of habitat targeted) and intensity of the interaction between the proposed fishing gear / targeting practices on the VMEs in the proposed fishing areas be?*

In the absence of accurate bathymetry data for the proposed exploratory fishing areas, a precautionary estimate of the impacted area of seabed could be made using the footprint index of 6.67×10^{-3} km^2 of seabed area per kilometre of longline deployed. This would suggest the extent of interactions between fishing gear and benthic habitat is likely to be small. A number of other fisheries target toothfish but there is little evidence that such fishing focusses on VMEs. For instance, Parker and Smith (2011) compared indices of toothfish presence and abundance with the presence of VME organisms. They concluded that toothfish indices were not useful in predicting the occurrence of any of the six common VME indicator taxa captured on individual longline segments and toothfish catch never explained more than 4% of the null model deviance when forced into the model. Parker and Mormede (2009) explored the catch of VME indicator organisms collected during the 2008/09 Ross Sea longline fishery for any correlation with toothfish catch-rate. They also concluded that there was no evidence of a functional relationship. These studies suggest that CCAMLR fisheries for toothfish do not focus on VMEs.

- *What are the characteristics of the habitats and benthic communities which may be impacted? Are the fished seabed features likely to support VMEs?*
- *How diverse is the ecosystem in the proposed fishing areas, and will the fishing activity reduce this biodiversity? Do the proposed fishing areas contain rare species which do not occur elsewhere?*

Other than the information collected during New Zealand's exploratory fishing in 2016 and 2017, little precise bathymetric data is available to provide information on the characteristics of the habitats and benthic communities potentially impacted by this proposal. It may be possible by analogy to look at information available from the northern Ross Sea and Amundsen Sea (CCAMLR Subarea 88.2) regions. Figures 17 and 18 provide some information from the Ross sea toothfish fishery. Generally numbers of VME organisms recovered in the Northern Hills area - analogous to the proposed research areas A and B - are lower than observed further south. CCAMLR 5-day reports indicate that, of the 58 VME risk areas notified under conservation measure between 2009 and 2015, only one is north of the shelf break at 70 S. and lies at 65°'S 23' S.

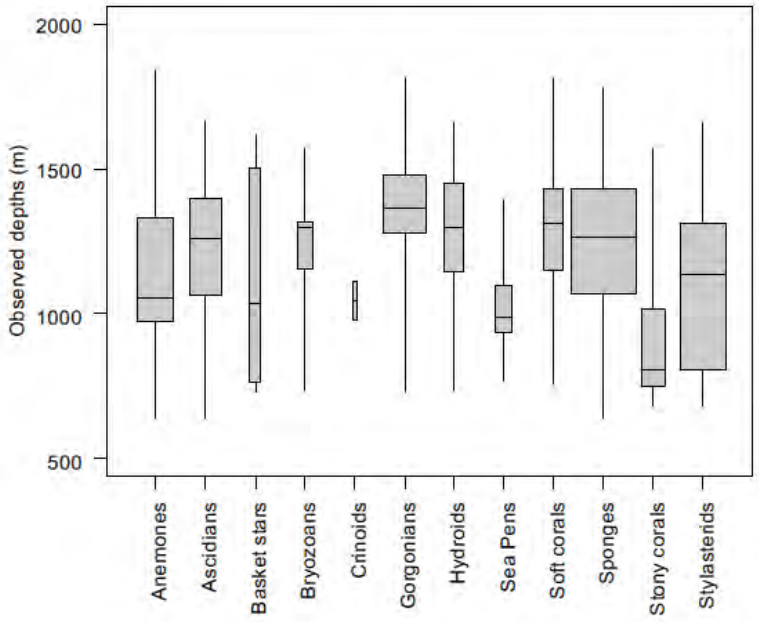


Figure 17: Scaled depth distribution of potentially vulnerable taxonomic groups from the 2009 Ross Sea longline fishery. Boxes show interquartile range, horizontal line indicates median and vertical lines indicate range. Box would is proportional to the number of observations. Note that fishing is not allowed shallower than 550 m in the CCAMLR Convention Area. From Parker and Bowden (2010).

- *What is the likely spatial scale and duration of the impacts? The overall scale of impact will be the product of spatial scale, duration and cumulative impact on VMEs and low productivity resources. To the extent possible, rates of recovery, regeneration and re-colonisation should be quantified or estimated.*

The current proposal is a stepwise research plan involving preliminary searching and investigation of potential bathymetric features that may constitute habitat for toothfish. Note that the most current information indicates that any fishing is likely to be deep resulting in limited sideways movement of the line. In such cases the maximum impact width is likely to be in the order of 1 m (given a snood length of 0.5 m between the hook and the mainline).

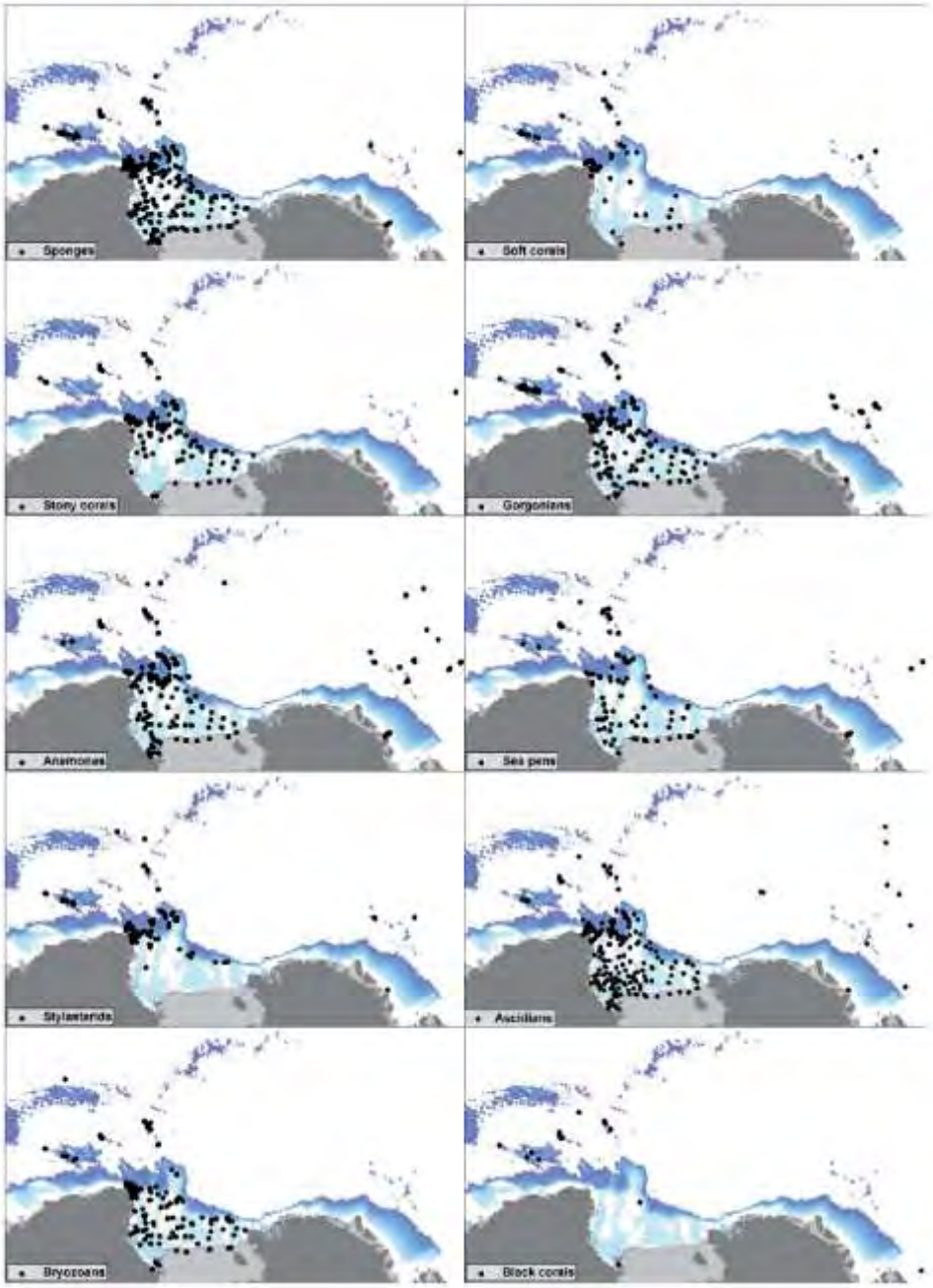


Figure 18: Distribution of selected Taxonomic Groups in the Ross Sea region based on samples from New Zealand's NIWA invertebrate collection, SCAR MARBIN and CCAMLR 2009 retained samples from New Zealand scientific observers collected on New Zealand fishing vessels. Bathymetry from 500 to 2500 m is shaded light to dark blue. From Parker and Bowden (2010).

New Zealand's combined trawl-longline footprint on the southwestern portion of the SPRFMO area is shown in Figure 19. It can be seen from these figures that there was no fishing in the exploratory fishing areas before New Zealand's exploratory fishing in 2016 and 2017. Building on that exploratory work, this will be a stepwise research programme firstly identifying any potential areas that are suitable for fishing and, if these are found, structured design-based fishing using bottom longline gear.

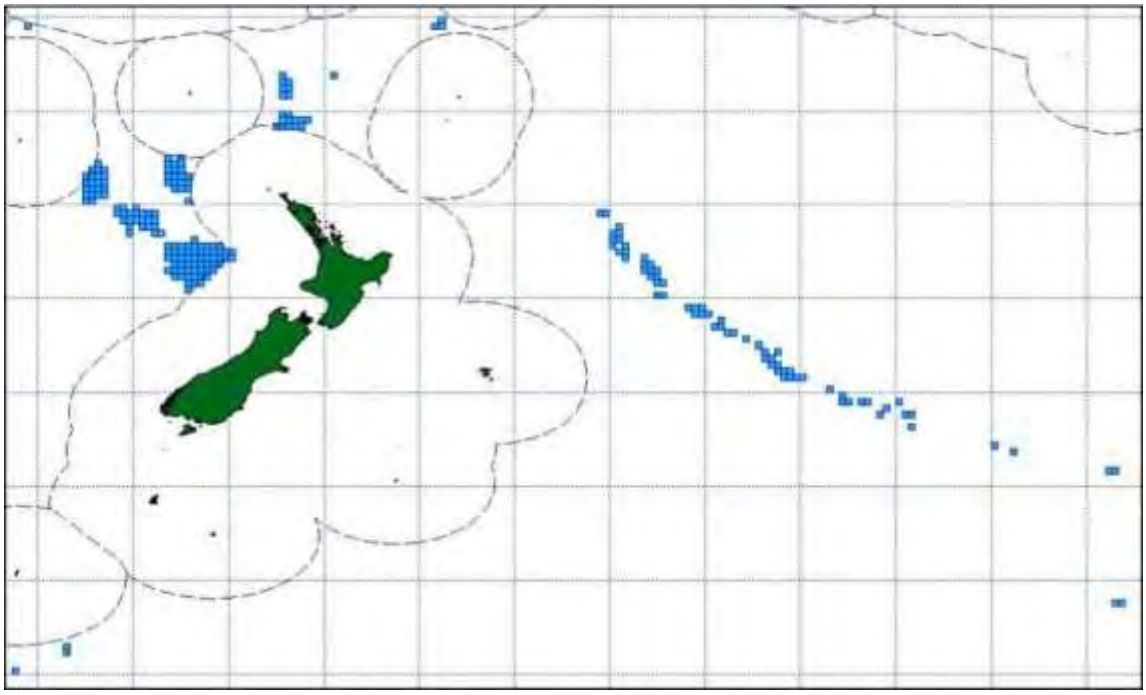


Figure 19: New Zealand all methods, all areas, combined bottom fishing footprint map, showing the total 218 blocks fished by any method over the 2002 - 2006 reference period (from New Zealand SPRFMO Area Bottom Fishery Impact Assessment Draft 1.0).

The proposed exploratory fishing block are shown in Figures 16 and 20. These represent the areas in which the vessel will search for suitable fishing ground. New Zealand fishing companies' knowledge of similar areas in the Southern Ocean and Antarctica suggest it is unlikely that much of this area (estimated less than 5%) will be within the depth ranges suitable for fishing.

The maps shown here below are based mostly on GEBCO 2014 data which are a publicly available global bathymetric grid with 30 arc-second spacing. The grid is based on a database of ship-track soundings but, where data are sparse, as in this case, the grid is based on ship-track soundings with interpolation between soundings guided by satellite-derived gravity data.

Relatively little information is available on topographic features likely to support VMEs in the proposed exploratory fishing areas. However, models that predict the likelihood of VME habitat or features (i.e. seamounts) and VME indicator taxa which include the SPRFMO area have been built (e.g., seamounts, Kitchingman & Lai 2004; Allain et al 2008; Yesson et al. 2011; VME indicator taxa Tittensor et al. 2009, Davies & Guinotte 2011, Yesson et al. 2012).

Penney (2010) showed several maps predicting habitat suitability for scleractinian corals based on broad-scale data (e.g., see Figure 20 for the depth range 750–1000 m). These predictions suggests that, at a very broad scale, there is low-moderate likelihood of stony corals (a key VME indicator taxon) occurring in the general vicinity of the proposed exploratory fishing areas.

After considerable development, Boosted Regression Tree (BRT) and Maximum Entropy (MaxEnt) habitat suitability models were constructed specifically for the SPRFMO area and for the New Zealand EEZ. Details of these models and the results of a field validation exercise are contained within a

manuscript submitted for publication (Anderson et al. 2016). That validation exercise showed that models predicting a suite of four stony coral VME indicator taxa (combined) did not perform very well, primarily because many of the environmental predicator variables used were scaled to 1 km resolution using a global bathymetry data set that was found to be very imprecise in the validation area (sometimes biased by many 100s of metres depth). However, the authors consider that the models predict the likelihood of suitable habitat for coral VME indicator taxa at a coarse-scale (i.e., at the scale of a large topographic feature such as a seamount or ridge, but not at within-feature scale.

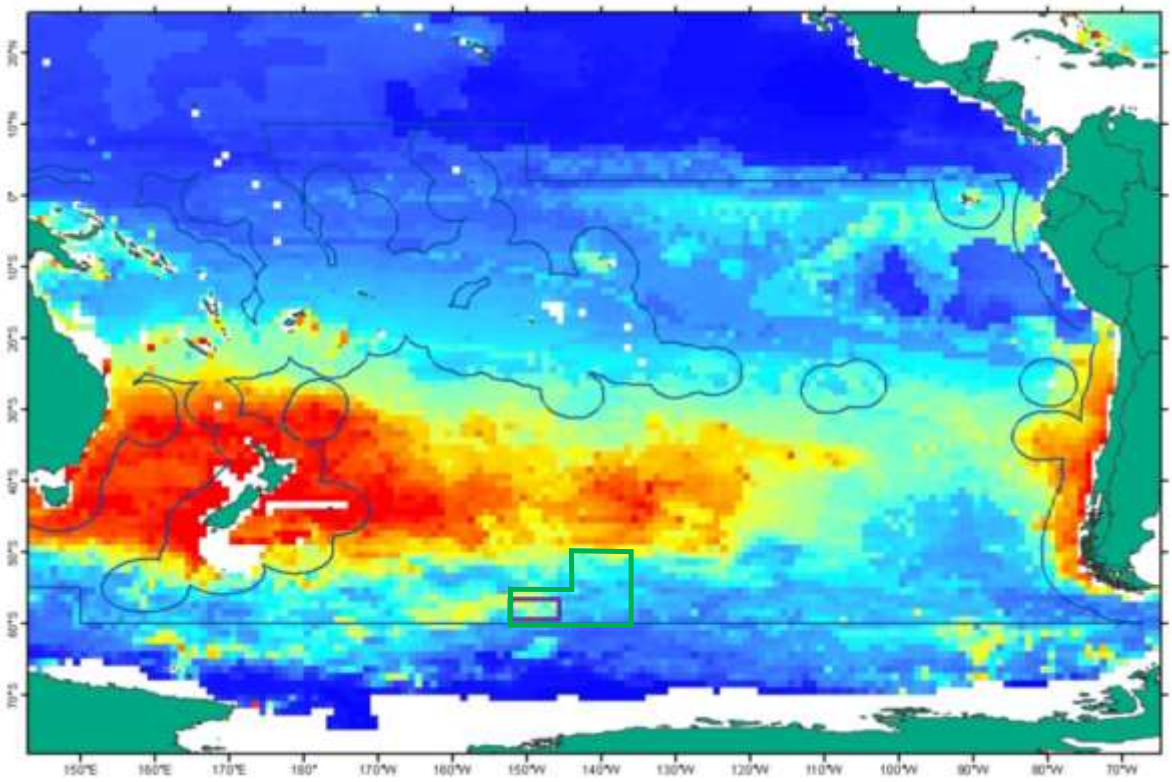


Figure 20 (after Penney 2010): Predicted 1° global scleractinian coral habitat suitability (dark blue=0 to dark red=1) in the 750m to 1,000m depth range, from Tittensor et al. (2009). The general location of the initial and proposed exploratory fishing areas are outlined in purple and green boxes, respectively. The SPRFMO Area and EEZ boundaries are outlined in blue.

Noting the general imprecision of the models, and some likelihood of over-predicting the likelihood of occurrence (Anderson et al. 2016), maps of the predicted distribution of four key VME indicator stony coral taxa (*Solenosmilia variabilis*, *Goniocorella dumosa*, *Enallopsammia rostrata* and *Madrepora oculata*) were generated for the initial exploratory proposal in 2015 (Figure 21) to give a broad indication of the likelihood of encountering VMEs. More detailed models developed to support the use of spatial decision-support tools in the design of spatial management areas for bottom fisheries (see Anderson et al. 2016) did not extend as far east as these boxes, mostly because of the lack of suitable data on invertebrate communities and bathymetry. BRT and MaxEnt models perform differently and make different predictions for the level of habitat suitability; in this case, BRT models generally predict higher habitat suitability for the suite of four stony coral species than MaxEnt models, especially on two features, one in each of the proposed exploratory fishing areas. It is important that the uncertainty in this model predictions is borne in mind but, taken together, these

outputs suggest that there are two large topographic features (one in each of the initial two exploratory fishing areas) that may provide suitable habitat for coral species that could indicate the presence of a VME. Most of the area within the larger proposed exploratory fishing area for 2019–2021 has a lower predicted likelihood of having suitable habitat for coral species (see Figure 21).

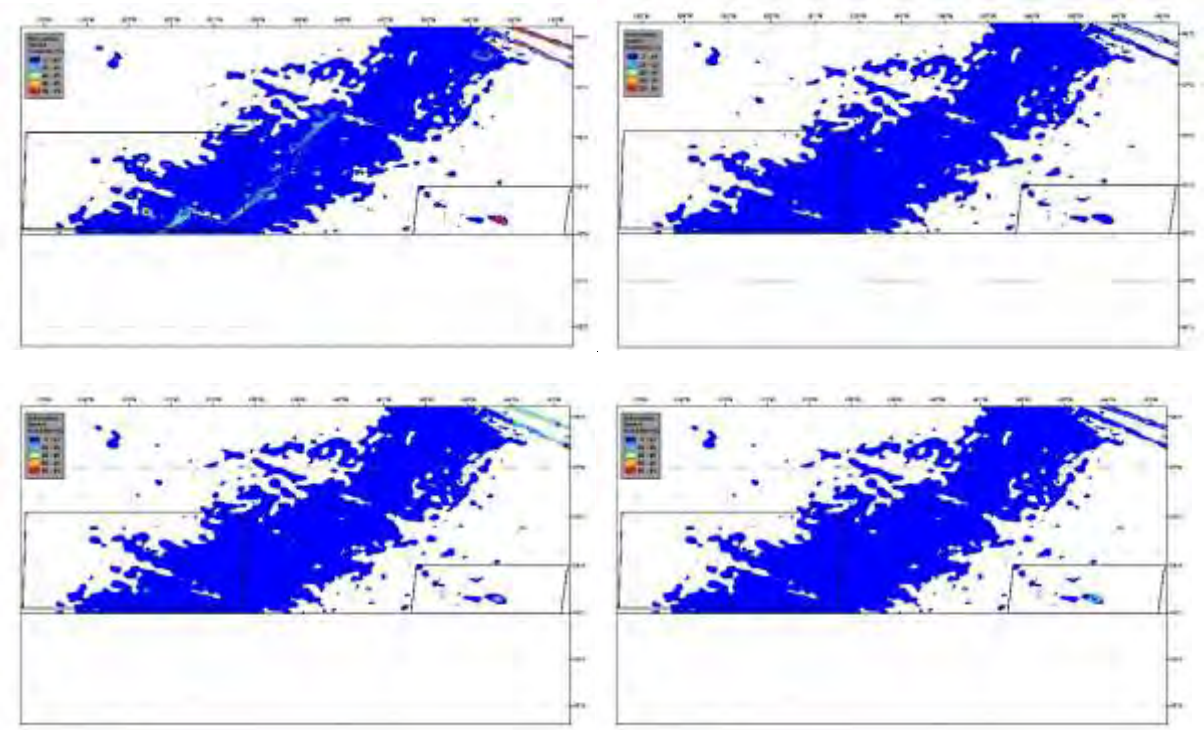


Figure 21: Indicative maps of model-predicted VME likelihood for the initial exploratory boxes fished in 2016 and 2017. The top two panels show predictions for four key species of scleractinian (stony) corals (combined) using BRT model on the left and a MaxEnt model on the right. The two lower panels show predictions for two individual species using MaxEnt model, *Goniocorella dumosa* on the left and *Solenosmilia variabilis* on the right. Areas plotted white are either outside the SPRFMO area or deeper than 2000 m.

Methods used to assess the impacts of fishing, including uncertainties

The proposed demersal longline fishing method is used in the CCAMLR area and its impact was extensively reviewed by Sharp (2010) to estimate the likely impacts of bottom longline fishing on vulnerable benthic invertebrate taxa and, generically, Vulnerable Marine Ecosystems (VMEs). This work was consistent with the requirements of CCAMLR Conservation Measure 22-06 (Bottom fishing in the Convention area).

Intensity. Sharp noted that effort densities associated with the New Zealand fishing effort as represented by fished pixels within the Ross Sea region was overall very low. Even within fished areas over his 12 year time series it is clear that fishing effort is highly concentrated in preferred locations; i.e. 94% of the fished pixels had effort densities less than 1.5 km of line / km2, and only 13 individual pixels (0.7%) had effort densities in excess of 4 km of line per km2. Applying the mean lognormal-input impact index estimate (1.84×10^{-3}) as calculated in the paper to the effort density distribution (Figure 22) implies that VME taxa in 94% of historically fished locations have experienced lethal impacts less

than 0.28%, and in only 0.7% of fished locations have VME taxa experienced impacts of greater than 0.74%, to a maximum lethal impact (on VME organisms) of 1.8%.

Limited knowledge of the proposed bathymetry and fauna as being an extension of the Pacific Antarctic Ridge suggests that this is likely to be similar to the northern hills area of the Ross Sea. Mean and maximum lethal impacts could be estimated based on the expected fishing pattern.

Sharp's (2010) assessment of the impacts of this comparable area (88.1 northern hills) which are shown in Figure 23 as bioregional categories 16 and 17. Intensity is likely to be much less during this proposed exploratory project than would be common in an operational fishery such as The Ross Sea. Full monitoring of VME indicator and other benthic organisms will take place during all fishing operations.

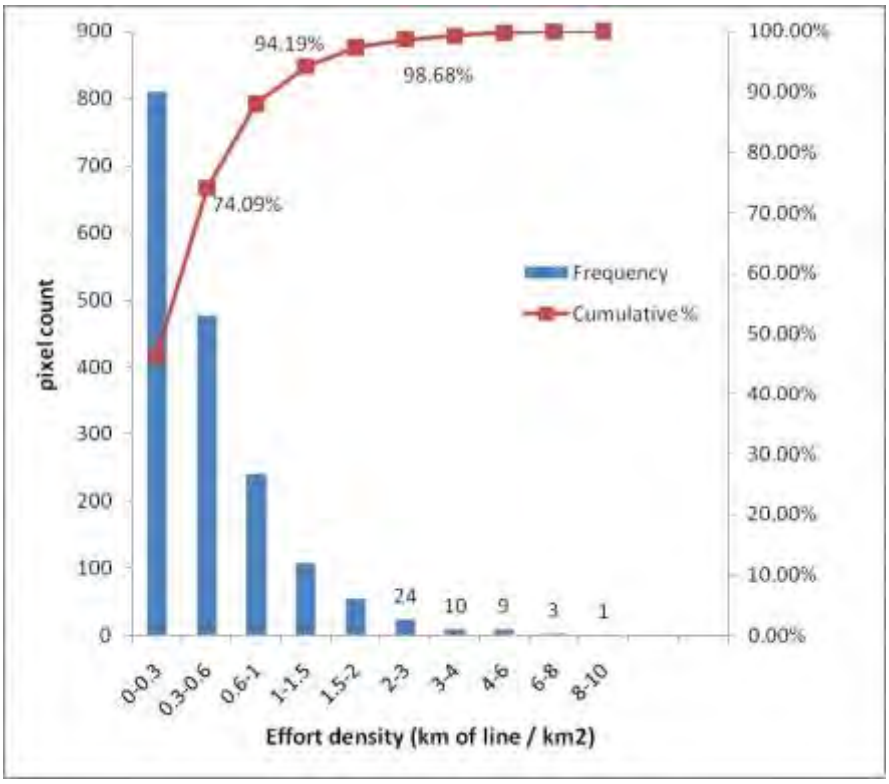
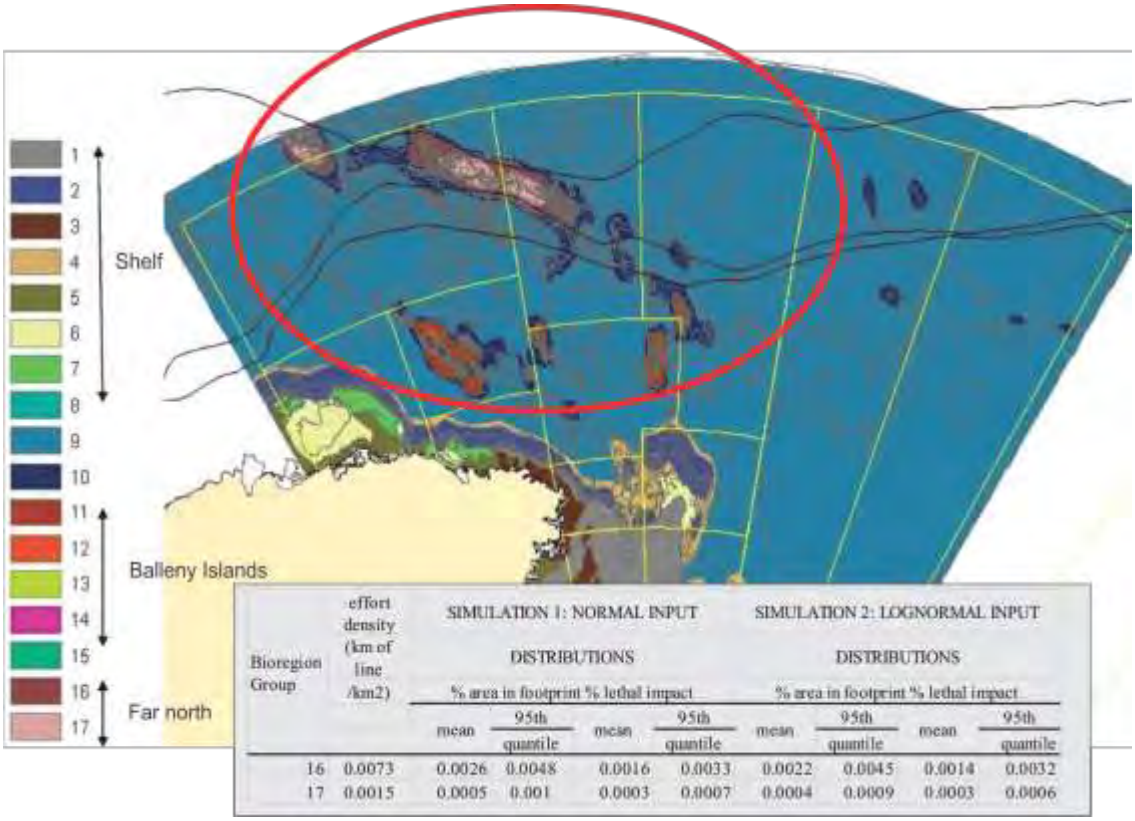


Figure 22 (after Sharp 2010): Spatial concentration of all historical New Zealand fishing effort in the Ross Sea. The histogram sorts 1737 non-zero-effort pixels (0.05° latitude x 0.177° longitude) as a function of cumulative effort density (in km of line per km^2). Note that the horizontal scale is not linear and that an additional 115 296 pixels in the Ross Sea with zero New Zealand effort (98.4% of the total) are not shown.



Bioregion Group	effort density (km of line /km2)	SIMULATION 1: NORMAL INPUT DISTRIBUTIONS % area in footprint		% lethal impact		SIMULATION 2: LOGNORMAL INPUT DISTRIBUTIONS % area in footprint		% lethal impact	
		mean	95th quantile	mean	95th quantile	mean	95th quantile	mean	95th quantile
16	0.0073	0.0026	0.0048	0.0016	0.0033	0.0022	0.0045	0.0014	0.0032
17	0.0015	0.0005	0.001	0.0003	0.0007	0.0004	0.0009	0.0003	0.0006

Figure 23: The benthic bioregionalisation of the Ross Sea region showing the analogous northern hills area (termed "far north" by Sharp) and the estimated cumulative footprints and impacts associated with all New Zealand effort in the history of the Ross Sea fishery (Areas 88.1 and 88.2, 1997-2009), within the northern hills bioregionalisation groups (16 and 17). Mean and upper bound confidence interval (95th quantile) values are shown. Modified from Sharp et al. (2010).

Duration *– how long the effects of the impact are likely to last.*

The duration of impact at the scale of individual organisms or communities is taxon-dependent. Some VME indicator taxa like stony and gorgonian corals are very long-lived and effects at particular sites where these are common or dominant can be expected to endure at least several years. Conversely, some other benthic taxa are more productive and mobile and effects where these are dominant will be more transient. Collection of samples taken by fishing gear to improve this information will be one of the priority objectives of the project.

Spatial extent *– The spatial impact relative to the extent of the VMEs (e.g. will fishing impact 5%, 30% or 80% of the VME distribution) and whether there may be offsite impacts (e.g. will reproduction be impacted at a broader spatial scale).*

The spatial risk assessment approach summarised here uses the CCAMLR approach as detailed in Sharp et al (2009) and Sharp (2010). In a preliminary assessment of known and anticipated impacts on proposed bottom fishing activities on VMEs in 2012/13 by the CCAMLR Secretariat (CCAMLR 2012) New Zealand reported that: *Consistent with the assumptions adopted by WG-FSA in 2010 and described in the Report on Bottom Fisheries and Vulnerable Marine Ecosystems (SC-CAMLR XXX, Annex 7, Appendix D), we apply an estimated footprint index of 6.67 x 10^{-3} km^2 of seabed area per km of longline deployed. This index is likely to over-estimate impact because it assumes a mean lateral movement frequency of 0.5 (i.e. lateral movement occurring in 50% of all deployments) irrespective of*

depth, whereas the only instances of lateral movement actually observed by the UK in tethered camera deployments in 2010 (WG-EMM-10/30) were shallower than fishable depths (observed deployments at typical fishable depths for longlines were observed to lift vertically from the seafloor with no lateral movement). Adopting the assumptions of WG-FSA in 2010 is therefore conservative (precautionary). In the absence of any current accurate bathymetry data for the target research areas a precautionary estimate of impact could be estimated using the footprint index above of 6.67 x 10^{-3} km^2 of seabed area per km of longline deployed. A sensitivity analysis could be conducted using the slightly greater line movement cited by Welsford et al. (2014).

The indications from Sharp (2010) were that an area in the northern Ross Sea (suggested as being analogous) has had very low fishing footprints (a mean value of 0.00142% across the two identified bioregions) and mortality/lethal impact had a mean value of 0.0009%. Based on experience in similar areas, New Zealand fishing companies estimate that less than 5% of the proposed research areas identified for exploration in the SPRFMO area will be fished and may have a similarly low footprint. However, the distribution of VMEs and the association between toothfish and VMEs is poorly known so the proportion of VMEs potentially impacted is less predictable.

There are unlikely to be any offsite or far-field effects from bottom longlining because such gear disturbs only a small amount of sediment relative to a bottom trawl tow.

Cumulative impact: Given the small footprint of individual demersal longline sets, multiple fishing events in the same location are unlikely even in the most intensively fished areas. Sharp (2010) indicated that even at the scale of the most heavily fished areas and impacted bioregionalisation groups in the Ross Sea simulations showed that the impacted bioregionalisation groups had experienced approximately 0.013% lethal impact of the most vulnerable VME taxa, with an upper bound (95th quantile) estimate of 0.03% lethal impact.

Evaluation of the occurrence, scale and duration of likely impacts on VMEs

At the level of fishing proposed and with the small footprint and impact of demersal longline gear, the overall risk is suggested to be low and the impact will probably have a negligible influence on the overall benthic environment. If toothfish and fishing effort are closely associated with VMEs (and these are predicted to take up only a very small fraction of the exploratory fishing boxes, see Figure 21), then additional analysis will be required to determine the area likely to be affected. Improving information on the bathymetry, benthic fauna, and likely distribution of VMEs are all objectives of this exploratory work.

Risk assessment of likely impacts

The proposed fishing activity entails the use of demersal bottom longline using integrated weight line. New Zealand's proposal for the initial exploratory fishing in 2016 and 2017 noted the following potential impacts:

- direct impact of bottom lines on VMEs
- over-exploitation of bottom lined species

- loss of bottom line fishing gear
- incidental capture and mortality of seabirds

Each of the four potential impacts was assessed, based on the FAO Deepwater Guidelines (FAO 2008), using specific definitions for the various rating criteria taken from New Zealand's 2008/09 bottom fishery impact assessment. To the extent possible in what is largely a qualitative, expert-based assessment, allocation to ranks was based on quantifiable criteria. Elements of risk evaluated were:

- Description of Impact - Provides a brief description of the expected impacts, answering the question, "What will be affected and how?"
- Extent - Indicates whether the impact will be: Site Specific (limited to within one kilometre of the fished site); Local (limited to within one fished 20' block, or 50km of the fished site); Regional (limited to the fishing area ~200-500 km radius); or Oceanic (extending across a significant proportion of an ocean basin, or of the SPRFMO Area).
- Duration - Gives the expected duration of the effects of the impact, being: Short (months, <1 year); Medium (years, 5-20); or Long (> 20 years, decades to centuries).
- Intensity - Provides an expert evaluation of whether the magnitude of the impact is destructive or innocuous and whether or not it exceeds set standards, and is described as: None (no impact); Low (where environmental processes are slightly affected); Medium (where environmental processes continue to function but in a noticeably modified manner); or High (where environmental functions and processes are altered such that they temporarily or permanently cease and/or exceed established standards / requirements).
- Cumulative Impact - An assessment of whether the impact is cumulative over time or space or not, and is expressed as being: Unlikely (the event is either a low-impact rare event, or recovery is rapid, such that effects will not accumulate over time or area); Possible (depending on extent, severity, natural disturbance levels and recovery rates); or Definite (at the intensities occurring, effects will endure such that, over time or space, impacts from a number of separate operations will accumulate).
- Overall Significance - The overall significance of each impact is then evaluated from the combination of duration, extent, intensity and cumulative effects. Overall Significance is determined as follows:
    - Low: Where the impact will have a negligible influence on the environment and no active management or mitigation is required. This would be allocated to impacts of low intensity and duration, but could be allocated to impacts of any intensity, if they occur at a local scale and are of temporary duration.
    - Medium: Where the impact could have an influence on the environment, which will require active modification of the management approach and / or mitigation. This would be allocated to short to medium-term impacts of moderate intensity, locally to regionally, with possibility of cumulative impact.
    - High: Where the impact could have a significant negative impact on the environment, such that the activity causing the impact should not be permitted to proceed without active management and mitigation to reduce risks and impacts to acceptable levels. This would be allocated to impacts of high intensity that are local, but last for longer than 5-20 years, and/or impacts which extend regionally and beyond, with high likelihood of cumulative impact.

The separate assessments against these criteria for New Zealand's proposed exploratory bottom longlining for toothfish in 2016 are summarised in Table 1 (details of the assessment are contained in the larger tables below). Although some of the deepwater benthic taxa and seabirds potentially impacted are long-lived, and both the target species and most seabirds range over regional to oceanic distances, the exploratory fishing activity was assessed as having low to medium risk. Significant mitigation and monitoring will be in place for the entirety of the exploratory fishing and information will be collected during the first exploratory fishing trip that will decrease the uncertainty in impact and risk assessments for any subsequent exploratory trips or commercial fishing.

Table 1: Summary of risk assessment for New Zealand proposed exploratory bottom longlining for toothfish in the SPRFMO Area in 2019–2021.

	Extent	Duration	Intensity	Cumulative	Overall
Direct impact of bottom lines on VMEs	Site-specific	Long	Low	Possible	Low / medium
Over-exploitation of bottom lined species	Regional-oceanic	Medium	Low	Possible	Low / medium
Loss of bottom line fishing gear	Site-specific	Short	None-low	Unlikely	Low
Incidental mortality of seabirds*	Oceanic	Medium	Low-medium	Possible	Medium

*, depending on species

Impact of bottom line fishing on VMEs

Description of Impact: Bottom line fishing operations make some catches of benthic organisms, including vulnerable hard corals, gorgonians and sponges. Bottom line operations can either catch benthic organisms directly on the fishing hooks, or may cause damage to benthic communities if lines are dragged laterally across the seabed by currents, or during hauling.

Extent: Site specific	*Duration*: **Long**	*Intensity*: **Low**
Cumulative impact: **Possible**	*Overall significance*: **Low / Medium**	

Extent – Seabed impacts will be limited to areas directly damaged by the fishing gear, including areas across which it may move during hauling. In the absence of accurate bathymetry, a precautionary estimate of impact was estimated using CCAMLR's footprint index of 6.67 x 10^{-3} km^2 of seabed area per km of longline deployed. A highly precautionary sensitivity analysis was conducted using a mean lateral line movement of 6 m (Welsford et al. 2014) and suggested a cluster of 17,500 hooks could disturb up to 0.147 km^2 compared with the area of the exploratory fishing boxes of 91,150 km^2 or the expected fishable area of ~4500 km^2. In this sensitivity analysis, a cluster of lines could be expected to disturb ~0.003% of the fishable area and a similar proportion of VMEs if these are restricted to the fishable area. The actual extent of impact is likely to be less.

Duration – Given the very low growth rates of some deepwater benthic organisms which may be impacted, a duration of Long is assumed. However, at the proposed low fishing effort levels, the duration of ecosystem level impacts are likely lower. For the areas damaged by bottom lining, re-colonisation from adjacent areas would be expected to be more rapid than for a larger impact area.

Intensity – Considered Low at the proposed exploratory fishing effort levels and spatial scales.

Cumulative Nature – Possible, given poor knowledge, but there are no other bottom fisheries in the area.

Overall significance: Potentially Medium because of the possible low recoverability of the benthic species concerned but, given the constrained nature of the proposed exploratory fishing, the significance is considered to be Low-medium

Management & Mitigation – At the proposed low levels and spatial scale of exploratory fishing effort and the spatially dispersed fishing design, active management or mitigation measures are not thought necessary. However, should a substantive fishery develop, fishing effort intensity and spatial scale, as well as benthic bycatch rates and composition would need to be monitored to ascertain whether effort or impacts rise to levels requiring active management.

Monitoring – Catch and effort returns will include start and end positions for bottom longline operations to allow the spatial scale of fishing effort to be monitored and analysed. Observer coverage will provide information on benthic bycatches, using the Benthic Materials form, to monitor and evaluate composition of benthic bycatches by bottom lines.

Classification of SPRFMO VME-indictor taxa (VME-indicator taxa in red)

1. Phylum Porifera – Sponges
Phylum Cnidaria, Class Anthozoa,
2. Order Actiniaria – Anemones
3. Order Alcyonacea – Soft corals, and 4. Gorgonian sea fans
5. Order Pennatulacea – Sea pens
6. Order Scleractinia – Stony corals
7. Order Antipatharia – Black corals
8. Class Hydrozoa, Order Anthoathecatae, **Family Stylasteridae – Hydro corals**
9. Phylum Echinodermata, **Class Crinoidea – Sea lilies**
10. Class Asteroidea, **Order Brisingida – Armless stars**

Over-Exploitation of Bottom Lined Species

Description of Impact: This exploratory fishery will target toothfish, a relatively long-lived species (M ~ 0.13, A_{mat} ~ 12–17 years, Mormede & Dunn, CCAMLR Science 21: 39–62, Day et al SARAG 51, Hobart, 24 February 2015). Bycatch of non-target fish species is likely to be a very small proportion of the total catch. Fish bycatch in 2016 and 2017 was less than 1% by weight and comprised mostly rattails. No sharks were caught.

Extent: **Regional / Oceanic**	*Duration*: **Medium**	*Intensity*: **Low**
Cumulative impact: **Possible**	*Overall significance*: **Low / Medium**	

Extent – Given the circumpolar distribution of both species of toothfish and the substantial distances travelled, the extent of impacts stemming from this lining is Regional, potentially Oceanic, in scale.

Duration – At the proposed exploratory fishing effort and catch, duration of impacts are likely to be Medium compared with the life history of the species.

Intensity – Low, for the proposed exploratory fishing, given the low level of bottom line fishing effort proposed

Cumulative Nature – Possible, depending on exploitation rates. There are no other bottom fisheries in the area but toothfish can migrate substantial distances and the Antarctic toothfish stock is probably shared with CCAMLR where fishing also occurs.

Overall significance: Potentially medium because of the life history of the target and bycatch species concerned but, given the constrained nature of the proposed exploratory fishing, significance is considered to be Low-medium.

Management & Mitigation – The proposed low effort and catch levels for this exploratory fishing are not considered to require any active management or mitigation measures. The exploratory fishing has a survey design that focusses on information gathering that will facilitate assessment of any subsequent fishing. Eventually it is anticipated that the information from this exploratory fishery will support a more certain stock assessment that will allow an assessment of the need for management or mitigation.

Monitoring – Existing New Zealand commercial catch return systems are already specifically designed to collect the necessary high-resolution catch and effort data for such species. Scientific observers will monitor catch and effort for the target species and supplement this with length-frequency and biological sampling (gonad staging and otoliths) as per the survey design. Shark bycatch is not expected but bycaught sharks will be returned for identification.

Loss of Bottom Line Fishing Gear

Description of Impact: Bottom line fishing operations targeting toothfish has an inevitable risk of gear loss (Webber & Parker, CCAMLR WG-FSA-11/48). The lack of sea ice in the exploratory fishing area for most of the year greatly reduces the potential for gear loss but rugged topography and strong tides may still cause the loss of some gear. In 2016, two broken lines (from 7 sets) led to the loss of 5 570 hooks (15% of hooks set) on unrecoverable sections of longline totalling about 7.8 km in length. The greatest risk is snagging of weights and anchors, and gear may be rigged with weak links to these components to prevent loss of fishing components and catch, should anchors stick fast. Lost anchors pose little ongoing threat to the seabed. Using integrated weighted cores on bottom longlines increases the risk of losing sections of line, including snoods.

Ghost fishing does not occur with longlines because the bait decomposes or is eaten within 24 to 36 hours.

Extent: **Site-specific**	*Duration*: **Short**	*Intensity*: **None / Low**
Cumulative impact: **Unlikely**	*Overall significance*: **Low**	

Extent – Usually Site Specific, as weighted lost gear will remain at the site at which it was lost. There is some risk of loss of floating components which may then drift away from the fished area. These pose no threat to the seabed.

Duration – Short: Lost gear is likely to take years to decades to degrade and become covered with benthic growth and integral with the seabed communities. This constitutes a level of pollution that will persist for 20 years or more. However, there is not likely to be any additional impact on benthic fauna once the gear is lost and the bait degrades in much less than 1 year.

Intensity – Low, there is almost no risk of ghost fishing by lost gear because the gear ceases to become effective once baits have been removed by scavengers or decayed away.

Cumulative Nature – Unlikely given the scope of the proposed exploratory fishing. There are no other bottom fisheries in the area.

Management & Mitigation – Operational procedures are in place to minimise expensive gear loss and consequent pollution (e.g., anchor trips). The proposed exploratory fishing has a focus of collecting information and is limited by catch and effort limits.

Monitoring – The vessel will record position, depth, type and quantity of gear loss.

Capture of seabirds

Description of Impact: Seabirds can be captured on baited hooks and those caught during line setting are likely to be drowned. A wide variety of seabirds are likely to use this area (see table below) and any impacts will depend on the species and the number captured (which is expected to be very low).

Extent: **Oceanic**	*Duration*: **Medium**	*Intensity*: **Low / Medium***
Cumulative impact: **Possible***	Overall significance: **Medium***	

Extent – Oceanic due to the migratory nature of many seabirds, including those thought to use the general area of the proposed exploratory fishing.

Duration – the duration of the impact is likely to be medium, between the age at first maturity (up to ~10 years for albatross species) and the lifespan (50 years or more for some long-lived species).

Intensity – The relative intensity will depend on the species attending and how many are caught. A rating of Low-medium is given rather than Low because of the large uncertainty about what species are involved. None of the species observed attending the vessels in 2016 and 2017 were threatened or endangered and no seabirds were observed captured.

Cumulative Nature – Cumulative impacts are possible, depending on the extent of captures and the rarity, threat status, and productivity of seabird species involved. There are no other bottom fisheries in the area but many seabirds forage and migrate over very large distances and are, therefore, exposed to risk in other fisheries.

Overall significance: The overall significance is considered Medium because, depending on the species attending, the impact could have an influence that will require active modification of the management approach and / or mitigation in the future. The distribution of seabirds in this area is poorly known and it is not known what seabirds will attend the vessel.

Management & Mitigation – Operational procedures to minimise seabird interactions and captures will be rigorously applied. Fast-sinking integrated weight line and streamer lines are used, there will be no offal discharge, and all setting will be done at night. These measures have been found to be highly effective in reducing seabird captures in CCAMLR and New Zealand fisheries.

Monitoring – The vessel will carry a scientific observer who will record, in conjunction with the crew and a dedicated video recording system to observe the hauling of all hooks, the number and identity of birds attending the vessel, the application of mitigation measures, and the capture of any seabirds. All dead seabirds will be retained by the observer for identification and necropsy. Birds returned alive (and any birds landing on the deck or colliding with the vessel) will be photographed.

*, depending on species

New Zealand seabird taxa potentially attending the vessel during exploratory fishing (G. Taylor, Principal Science Advisor, Department of Conservation, personal communication, 2015). IUCN (Red List accessed 12 June 2018) and New Zealand Threat Classifications (NZTC, 2016 revision, Robertson et al. 2017) are shown. ACAP taxonomy generally takes precedence. Taxa with either of the highest two threat classifications in either of the classification systems are shown in red. Birds attending the vessel in 2016 and 2017 were recorded by New Zealand observers: Cape petrels (78 observations), snow petrel (35), Antarctic petrel (14), giant petrels (9), grey petrel (4), and prions (2).

Common name	Scientific name	NZTC category 2016	IUCN category	Observed attending 2016-17 *
Wandering albatross	*Diomedea exulans*	Non-Resident Native: Migrant	Vulnerable	–
Antipodean albatross	*Diomedea antipodensis antipodensis*	Threatened: Nationally Critical	Endangered #	–
Southern royal albatross	*Diomedea epomophora*	At Risk: Naturally Uncommon	Vulnerable	–
Campbell albatross	*Thalassarche impavida*	Threatened: Nationally Vulnerable	Vulnerable	–
Black-browed albatross	*Thalassarche melanophris*	Non-Resident Native: Coloniser	Least concern	–
Salvin's albatross	*Thalassarche salvini*	Threatened: Nationally Critical	Vulnerable	–
Grey-headed albatross	*Thalassarche chrysostoma*	Threatened: Nationally Vulnerable	Endangered	–
Light mantled sooty albatross	*Phoebetria palpebrata*	At Risk: Declining	Near Threatened	–
Sooty shearwater	*Puffinus griseus*	At Risk: Declining	Near Threatened	–
Northern diving petrel	*Pelecanoides urinatrix urinatrix*	At Risk: Relict	Least Concern #	–
Southern diving petrel	*Pelecanoides urinatrix chathamensis*	At Risk: Relict	Least Concern #	–
Subantarctic diving petrel	*Pelecanoides urinatrix exsul*	Not Threatened	Least Concern #	–
South Georgian diving petrel	*Pelecanoides georgicus* †	Threatened: Nationally Critical	Least Concern	–
Grey petrel	*Procellaria cinerea*	At Risk: Naturally Uncommon	Near Threatened	2016 and 2017
White-chinned petrel	*Procellaria aequinoctialis*	Not Threatened	Vulnerable	–
Southern Cape petrel	*Daption capense capense*	Non-Resident Native: Migrant	Least Concern #	2016 * and 2017 *
Snow petrel	*Pagodroma nivea*	N/A	Least Concern	2016
Antarctic petrel	*Thalassoica antarctica*	Non-Resident Native: Vagrant	Least Concern	2016 and 2017
Southern giant petrel	*Macronectes giganteus*	Non-Resident Native: Migrant	Least Concern	2016 and 2017 *
Northern giant petrel	*Macronectes halli*	At Risk: Recovering	Least Concern	2017 *
Fairy prion	*Pachyptila turtur*	At Risk: Relict	Least Concern	2017 *
Fulmar prion	*Pachyptila crassirostris*	At Risk: Naturally Uncommon	Least Concern #	2017 *
Chatham fulmar prion	*Pachyptila crassirostris crassirostris*	At Risk: Naturally Uncommon	Least Concern #	2017 *
Lesser fulmar prion	*Pachyptila crassirostris flemingi*	At Risk: Naturally Uncommon	Least Concern #	2017 *
Antarctic prion	*Pachyptila desolata*	At Risk: Naturally Uncommon	Least Concern	2017 *
Blue petrel	*Halobaena caerulea*	Non-Resident Native: Migrant	Least Concern	–
Chatham petrel	*Pterodroma axillaris*	Threatened: Nationally Vulnerable	Vulnerable	–
Mottled petrel	*Pterodroma inexpectata*	At Risk: Relict	Near Threatened	–
Chatham Island taiko	*Pterodroma magentae*	Threatened: Nationally Critical	Critically Endangered	–
White-headed petrel	*Pterodroma lessonii*	Not Threatened	Least Concern	–
Wilson's storm petrel	*Oceanites oceanicus*	Non-Resident Native: Migrant	Least Concern	–
Black-bellied storm petrel	*Fregetta tropica*	Not Threatened	Least Concern	–

* Observer identification of birds attending a vessel may be inaccurate, cannot be verified at necropsy, and higher taxonomic groups are sometimes used.

IUCN classification is based on a broader definition of the species or taxon than listed in this table.

† Taxonomically Indeterminate in the New Zealand Threat Classification Scheme.

Proposed mitigation and management measures and monitoring.

The following SPRFMO CMMs apply to the proposed exploratory fishing and their requirements will be met in full.

- **02-2018** (data standards)
- **03-2018** (bottom fishing)
- **04-2017** (minimising bycatch of seabirds)
- **05-2016** (vessels authorised to fish)
- **06-2018** (Vessel Monitoring System)
- **07-2017** (port inspections)
- **10-2018** (Compliance and Monitoring Scheme)
- **11-2015** (boarding and inspection)
- **13-2016** (new and exploratory fisheries)

The BFIAS notes that monitoring should be implemented to ensure the effectiveness of any management or mitigation measures and to detect any change in the degree of impact which would prompt the need for a re-assessment. The BFIAS included the following measures.

- *VMS positional information should be collected in accordance with the SPRFMO Data Standards. Provide details of VMS systems to be operated on vessels, including who these will report to, reporting frequency and reporting accuracy.*

Details of the implementation of the tamper-proof VMS devices installed on the candidate vessel *San Aspiring* are shown in Section 1. This vessel normally operates within the CCAMLR Convention area and reports as required by Conservation Measure (CM 10-04 (2013)). This requirement is for automatic communications at least every four hours to a land-based fisheries monitoring centre (FMC) of the flag State of the vessel. The following data are transmitted:

(i) Fishing vessel's identification code;
(ii) the current geographical position (latitude and longitude) of the vessel, with a position error which shall be less than 500 m, with a confidence interval of 99%; and
(iii) the date and time (expressed in UTC) of the fixing of the said position of the vessel.

The VMS ALC as required is tamperproof (of a type and configuration preventing the input and output of false positions and not capable of being overwritten manually, electronically, or otherwise). The ALC is located within the sealed unit and protected by official seals indicating whether a unit has been accessed or tampered with.

San Aspiring is fitted with several ALCs in case of a malfunction to enable continuous reporting. These units are capable of meeting SPRFMO standards for VMS reporting (once every 2 hours) and can respond to polling at any rate if required.

- *Details of catch and effort data collection systems to be used, including catch and effort reporting systems to the flag states concerned, and additional systems to be implemented specifically for the proposed activity. Report how these data collection systems comply with the SPRFMO data standards. These monitoring systems should specifically address how retained and discarded by-catches are to be monitored and reported. There should also be reporting systems in place to record whether a VME has been encountered during fishing.*

San Aspiring and *Janas* both operate within the CCAMLR framework and report catch effort information on a daily and monthly basis (as required) to the Flag State and to CCAMLR Secretariat. Target toothfish catches are recorded using an electronic computerised on-board inventory system on a set by set basis. Fish are generally weighed on accurate motion compensated scales. All bycatch species are recorded by weight and number and reported on an aggregated daily basis and on a set by set basis in a monthly report. Both vessels are fully capable of complying with SPRFMO data standards and reporting or CCAMLR CM 22-07 (2013). Observers will record all benthic bycatch.

- *Details of any scientific observer coverage planned for the proposed fishing activity, including levels of coverage, how deployments will be designed to achieve statistically representative coverage of the proposed fishing activities, and what information observers will be collecting. Observer data should be collected in accordance with the SPRFMO Observer Data Standard.*

A flag state (Fisheries New Zealand) observer be carried at all times when fishing activity for toothfish in the SPRFMO Area is undertaken. Observer data will be collected to meet or exceed SPRFMO Observer data standards and will include gear deployment and retrieval data, catch and effort information, biological data collection, and information on marine mammals, seabirds, reptiles and other species of concern as described in the data collection plan. Both vessels have good facilities for biological data collection including provision of dedicated motion compensated scales for observer use. New Zealand and CCAMLR identification guides for CCAMLR 88.1 and 88.2 are available for observers to use. Operations will be designed such that an observer would always have at least 6 hours of uninterrupted sleep per 24 hours and make the necessary observations. In addition to the human observer, at least two suitably-sited video cameras will provide coverage of all lines and hooks set and hauled. Footage will be submitted to Fisheries New Zealand for review and comparison with observer records.

- *Description of the data that will be provided to the SPRFMO Secretariat for the fishing activity including, as a minimum, data required in terms of the adopted SPRFMO data standards, but also describing other information (e.g. seabed bathymetry or mapping, VME identification and characterization) that will be provided. Details regarding the reporting of evidence of a VME to the SPRFMO Secretariat should be included.*

New Zealand will submit of all data at least to the standard required by the adopted SPRFMO data standard, noting that substantially more information is likely to be collected as outlined in the data collection plan and detailed in a research report to the SC (and, as appropriate, presented to CCAMLR). The crews of both *San Aspiring* and *Janas* and all New Zealand observers are fully capable of supplying the information specified in SPRFMO data standard and additional data required by the design. Seabed bathymetry information within the target research areas will be provided to SPRFMO and Fisheries

New Zealand as well as any information on VME distribution and species composition. Vessel crews and observers are conversant with the CCAMLR and SPRFMO reporting requirements for VMEs. The CCAMLR system was used in the SPRFMO exploratory fishery in 2016 and 2017 and it is proposed that this continues until such time as a different approach is required by SPRFMO. Given the generally poor understanding of toothfish distribution, movement and stock structure of toothfish and the reliance of CCAMLR's spatially-explicit toothfish stock assessments on tag returns, exploratory fishing will include structured quasi-random tagging at the CCAMLR rate of three fish per greenweight tonne retained. This is broadly similar to the rate of tagging in the Macquarie Island longline fishery for Patagonian toothfish (~ 3.1 tags per tonne up to 2011/12 and ~2.0 tags per tonne since, Day et al. 2015). This should result in the release of 650 to 700 tagged toothfish each year, and about 2 000 by the end of the proposed programme. It is expected that about 7–8 000 toothfish will be captured, all of which will be inspected for CCAMLR tags.

Catch and effort against imposed limits (220 tonnes of toothfish in total, split 50:50 between the two nominated vessels, no more than 50% to be taken outside the key post-spawning period) will be monitored on a shot-by-shot basis and retention of toothfish by a vessel will cease once the limit has been caught. There are several ways this might be achieved, but it is currently considered that the ratio of tagged fish per tonne captured should be progressively increased as the limit is approached. This will need careful monitoring by the crew and observer but previous voyages in the SPRFMO exploratory fishery in 2016 and 2017 and the adjacent CCAMLR areas show it is feasible.

A specific move-on rule to further mitigate impacts on VMEs was explored, but was not considered necessary in addition to the cluster design because clusters of lines must be at least 10 miles apart. In effect, the design already incorporates a move-on component.

Appendix 2. Proposal for a winter longline survey of Antarctic toothfish in the northern region of Subareas 88.1 and 88.2

(NOTIFICATION TO CCAMLR WG-SAM FOR SCIENTIFIC RESEARCH IN 2019/20 UNDER CM 24-01 with minor changes to formatting)

Delegation of New Zealand

Abstract

We propose to test three hypotheses to describe the reproductive ecology of Antarctic toothfish (*Dissostichus mawsoni*):

1) *Antarctic toothfish eggs are buoyant and accumulate under sea ice*. If true, this would retain eggs near the spawning locations under the vast sea ice extent and once broken up in the spring, may provide access to a productive pagophilic ecosystem for feeding as well as a transport mechanism for subsequent advection patterns, all of which could be impacted by climate change. This would have implications on the understanding where recruiting fish originate and how those patterns may be influenced by changes in sea ice or circulation patterns that affect observed recruitment patterns.

2) *Antarctic toothfish spawn throughout the Pacific Antarctic fracture zone*. Evidence to date only exists from the west of the region (SSRU 88.1B), yet adult Antarctic toothfish are found much further east and north of the CCAMLR Convention area, which is bounded by latitude 60°S. Obtaining a better understanding of the location and movement of adult spawning toothfish has direct implications on the understanding of those parts of the adult stock that contribute to recruitment, and hence the productivity of the stock assumed in the stock assessment.

3) *Biological characteristics of the northern spawning population change as younger, fatter, female fish move to the north for spawning during winter*. Evidence to date found no change in these characteristics in June, suggesting sampling later in the spawning season is needed.

We propose to conduct a scientific survey during the austral winter in the northern Ross Sea region to test these hypotheses. The longline and plankton survey is designed to cover key gaps in the knowledge of the life cycle of Antarctic toothfish in the Ross Sea by collecting biological samples from a range of locations in the northern regions of Subarea 88.1 and 88.2 and begin in September 2019. The survey will be coordinated with a corresponding survey targeting Antarctic toothfish spawning dynamics in the southern area of the South Pacific Regional Fisheries Management Organisation (SPRFMO) area at a similar time.

Main objective

(a) Objectives for the research and why it is a priority for CCAMLR.

The objectives of this research survey are as follows:

I. To investigate the potential dispersion areas of eggs and larvae by studying the characteristics of Antarctic toothfish (*Dissostichus mawsoni*) eggs and larvae, especially in association with sea ice.
II. To investigate distribution of Antarctic toothfish in Subareas 88.1 and 88.2 in relation to spawning to further refine the developmental cycle and likely residence time on the spawning grounds.
III. To investigate the timing of the movement of Antarctic toothfish to and from the spawning grounds through an analysis of length and age composition of the catch, sex ratio, and condition factor.

There has been an exploratory longline fishery for toothfish in CCAMLR Subareas 88.1 and 88.2 for 20 years. There is now a good understanding of many aspects of the reproductive biology and ecology of Antarctic toothfish (e.g., Hanchet et al. 2015, Parker & Marriott 2012). Because little sampling has been carried out in winter, several important aspects of the spawning behaviour and early life history of Antarctic toothfish are still unknown (Hanchet et al. 2015).

The life cycle hypothesis suggests that toothfish spawn in the northern region of Subareas 88.1 and 88.2 during the winter months (Hanchet et al 2008, Stevens et al. 2016). However, the spatial and temporal distribution of spawning activity remains uncertain. These aspects of spawning ecology inform the structural assumptions of the spatially explicit operating model and have been identified in the medium-term research plan for the Ross Sea region (Delegations of New Zealand, Norway, and the United Kingdom 2014) and subsequently endorsed by the Scientific Committee (SC-CAMLR XXXII, para 3.76 (iv)).

Basic life history and movement patterns are key to understanding how the ecosystem role of toothfish may vary spatially and is therefore needed to inform the CAMLR Commission in respect to meeting the obligations of Article II of the CAMLR Convention. Life history and movement are components of ecology likely to be affected by climate change.

Stevens et al (2016) reported presence of ripe running male and female toothfish, successfully fertilised Antarctic toothfish eggs on board, measured egg buoyancy of newly fertilized eggs, and collected eggs from the plankton sampling. However, spawning fish were only found in one location at the western edge of the survey area (SSRU 88.1B) near the end of the survey. Thus, the spatial distribution of spawning and its timing remains unknown. Furthermore, eggs collected were early in the developmental process, so buoyancy and distribution of Antarctic toothfish eggs and larvae throughout development is yet to be determined.

We propose extending the survey area eastward, and to conduct the survey 3 months later than the previous survey focusing on the latter part of the spawning season. This will enable estimation of spawning duration, at a time when all fish moving to the north to spawn are expected to have already done so, and to search for eggs and larvae that may be found associated with sea ice.

This research programme may require multiple surveys to fully establish the spatial and temporal extent of spawning in the region, given the constraints of sea ice and the large target area. An

incremental approach would be the best option. Accordingly, the current proposal is for initial research to be carried out during the months of September and October in 2019 to characterise reproductive status of adults and the distribution of eggs and larvae at that time.

The intent is to conduct a survey during September-October 2019, provide a verbal summary at WG-FSA-19 and provide a full report on results at WG-SAM-20.

(b) Detailed description of how the proposed research will meet the objectives.

Adult Antarctic toothfish

The vessel will begin the survey in September 2019 by setting bottom longlines as far south as the ice conditions allow. The effort will be spread using defined research strata. Up to 100 Antarctic toothfish from each set collected during the research would be measured, weighed, sex determined, and gonad tissue sampled to determine reproductive status.

These results would be collectively analysed with similar data collected from summer and winter months to describe the progression of oocyte development from December through to October. This will enable better estimation of when the peak time of spawning.

Data collected during June and early July 2016 suggested a peak in gonadosomatic index (GSI) of near 20% for females at the end of June, with some indication of a decrease in July due to an increasing proportion of spent fish (Stevens et al. 2016). The length of the spawning period is unknown, hence a target period of September to avoid the period of sea ice maximum (in August), and to enhance chances of determining the end of the spawning season, as well as sampling eggs and larvae immediately after the spawning season.

Additional insights into the timing of the migration onto the northern hills may result from analysis of the biological characteristics of the toothfish caught during the sampling. For example, changes in sex ratio, fish condition, median age, and stable isotope indicators of diet could all provide evidence to test if a large proportion of fish had recently migrated into the area (Parker & Marriott 2012, Hanchet et al. 2015).

Eggs and Larvae

The distribution of toothfish eggs and larvae in the survey area are unknown. Only 19 eggs were collected in the 2016 winter survey, from 3 plankton tows carried out near the end of the survey in early July. Buoyancy measurements made from eggs fertilised on board indicate that Antarctic toothfish eggs are strongly buoyant and even with surface mixing would accumulate within 5 m of the surface. This would put them in direct contact with sea ice over most of the postulated spawning area.

We propose to carry out additional plankton sampling in open waters, especially near the surface, but also targeted sampling near and directly under sea ice to determine if toothfish eggs may collect on the underside of sea ice. It is possible that larvae may be present near the surface under the sea ice in September and October. Sampling will take place in three ways, concentrating effort in the vicinity of bathymetric features that may be spawning sites: 1) oblique tows of plankton nets near the ice edge, 2) deploying a small ROV to collect video of the underside of large ice floes, or 3) deployment of an underwater camera through cracks in sea ice floes made by the vessel. As part of this work we will also document the depth of the mixed layer to as an indicator of the potential

primary productivity using a CTD, and samples of the underside of sea ice plankton community will be collected.

A continuous plankton recorder will collect epipelagic plankton during all vessel transits more than 100 km (conditional upon sea ice conditions), which may also encounter eggs and larvae of toothfish in the survey area.

While this work complements a similar toothfish survey proposed for the South Pacific Regional Fisheries Management Organisation (SPRFMO) Convention Area, work focussed on sea ice and buoyancy measurement will occur only in the CCAMLR Convention area as sea ice typically does not extend into the SPRFMO area, and only one buoyancy chamber is available for the work.

(c) Rationale for research, including relevant existing information on the target species from this region, and information from other fisheries in the region or similar fisheries elsewhere.

The rationale for this research has been provided above. Here, we document existing information on these issues.

Spatial and temporal trends in GSI, confirmed by observations in July of 2016, indicate Antarctic toothfish spawn during winter months in the northern hills of the Ross Sea region (Fenaughty 2006, Fenaughty et al. 2008, Parker & Marriott 2012, Stevens et al. 2016). However, the duration and spatial extent of spawning remain unknown. This information is important to determine the potential advection pathways of eggs and larvae released during the spawning season. The proposed survey timing will focus on the latter portion of the spawning season.

Hanchet et al. (2008) reviewed existing knowledge on Antarctic toothfish biology and coupled that knowledge with ocean circulation to predict where larvae and juvenile Antarctic toothfish might be distributed. Further work by Dunn et al. (2012) and Ashford et al. (2012) supported the hypothesis that spawning is likely to occur on ridges and banks to the north of the Ross Sea during the austral winter (June to October) and that eggs spawned in this region would be retained within the wider Ross Sea region through entrainment in the Ross Gyre. However, there may also be spawning on the slope area during winter (Parker & Marriott 2012). The buoyancy of Antarctic toothfish eggs is an important consideration in the egg and larval circulation model, as their depth influences the resulting entrainment and subsequent distribution of the eggs and larvae. Buoyancy data collected by Stevens et al. (2016) suggest that Antarctic toothfish eggs are strongly positively buoyant and therefore may accumulate on the underside of sea ice. Sea ice may thus serve as an egg retention mechanism, allowing eggs and larvae to be retained in the spawning area for several months. Sea ice may also then provide a transport mechanism and access to a sea-ice associated ecosystem as a food source as the ice breaks up, drifts, and melts during the Austral summer.

This research will also provide new data on locations and movement of spawning adult toothfish. Obtaining a better understanding of the location and movement of adult spawning toothfish has direct implications on the understanding of what part of the adult stock contributes to recruitment, and hence the assumed productivity of the stock in the stock assessment.

We propose to tag fish while they are spawning, enabling subsequent movements from the spawning grounds to be monitored in future years by the commercial fishery. All fish captured will

be carefully checked for tags and will have relevant biological data collected to assist developing movement hypotheses of mature toothfish to and from the spawning grounds.

This research will be coordinated with a complementary voyage sampling Antarctic toothfish in the southern part of the SPRFMO area at the same time with a comparable vessel and using the same standardised gear. Data collected from 2016 and 2017 showed that area contained mainly Antarctic toothfish (only two Patagonian toothfish captured), and although only a few sites were sampled, fish were mainly in post spawning condition (Fenaughty & Cryer 2016, Cryer et al. 2017).

Fishery operations

(a) Fishing Member: New Zealand

(b) Vessels to be used: One of the following vessels will conduct the survey in Subareas 88.1 and 88.2

Category	Vessel details		
Vessel name	*Janas*	*San Aspiring*	*San Aotea II*
Vessel owner	Talley's Group Ltd	Sanford Limited	Sanford Limited
Vessel type	Commercial	Commercial	Commercial
Port of registration	Nelson, NZ	Auckland, NZ	Auckland, NZ
Registration number	63634	900522	63631
Radio call sign	ZMTW	ZMGO	ZM2534
Overall length	46.5 m	51.2 m	46.5 m
Overall tonnage	1079 GRT	1508 GRT	1079 GRT
Positioning equipment	GPS	GPS	GPS
Fishing capacity	N/A	N/A	N/A
Fishing processing capacity	20-25 tons GWT tonnes/day	30 tons GWT tonnes/day	20-25 tons GWT tonnes/day
Fish storage capacity	250 t frozen storage	740 t frozen storage	250 t frozen storage
Echosounder model	Simrad ES-60	Simrad ES-60	Simrad ES-60
Echosounder frequency	38 kHz	38 kHz	38 kHz

(c) Target species: *Dissostichus* spp.

(d) Fishing or acoustic gear to be used: Mustad Autoline system using Integrated Weight (IW) longline.

Other sampling gear: Echosounder (Simrad ES60 or ES 70, 38 kHz, equivalent), plankton net

(e) Fishing regions and geographical boundaries: Subarea 88.1 SSRUs B–C and Subarea 88.2A–B.

(f) Estimated dates of entering and leaving the CAMLR Convention Area: Survey effort would be conducted during winter months, targeting a start date of September 1, but depending on ice conditions.

Survey design, data collection and analysis

(a) Research survey/fishing design (description and rationale):

Spatial arrangements or maps of stations/hauls (e.g. randomised or gridded)

Survey plan

SSRUs 88.1BC and 88.2AB have been divided into eight strata to cover a wide area as plausible to detect areas where spawning is taking place (Figure 1). These strata have been drawn at widths of 5 degrees of longitude to accommodate variable northward extend to sea ice in a given season.

Sampling locations will be focus on seamount features where spawning of Antarctic toothfish is likely to occur. The exact sampling locations will depend on the ice conditions at the time, but we propose to begin sampling as far south as possible and then work back to more northerly regions as ice coverage permits while spreading effort east and west among survey strata as ice allows.

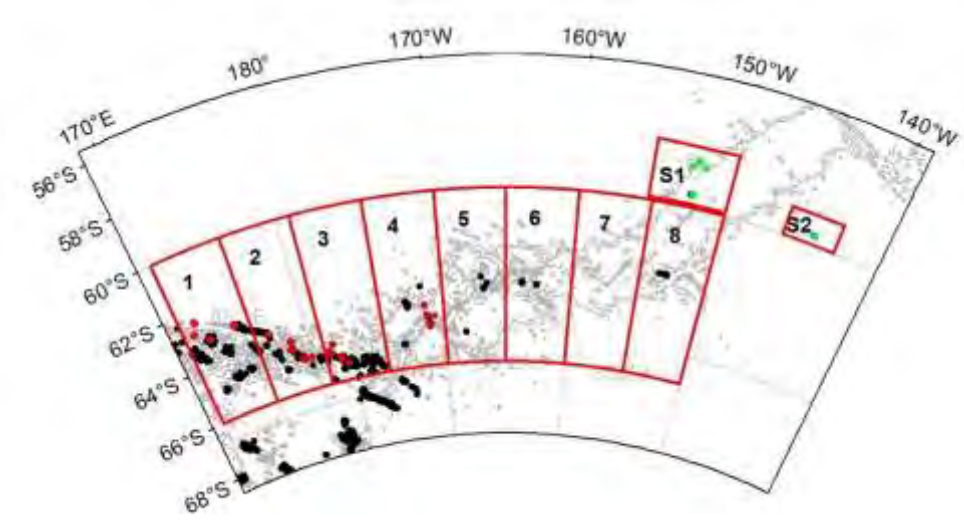


Figure 6. Locations of survey strata 1–8 (at 5 degrees of longitude intervals) and coordinated SPRFMO area strata (S1 and S2) for the 2019 Subarea 88 winter spawning survey. Black symbols show locations for all longline sets through 2017. Red symbols show location of the 2016 winter survey sets and green symbols show the locations of the 2016 and 2017 SPRFMO research sets. Note that spawning fish were identified only in Stratum 1.

Ice analysis

Newly formed sea ice will hinder access to the southern portion of all Subarea 88 survey strata during the sampling period. Ice coverage is summarised in line graphics for each stratum showing the average percentage of coverage per stratum for each day for 14 years (Figure 2). It shows that accessing the northern portions of the areas of interest containing fishable bathymetric features will be achievable after the ice maximum in August and early September. Sea ice typically advances only as far north as the major underwater regions of the Pacific-Antarctic Ridge. We expect some fishable area to be found in each defined stratum during September based on locations of historical fishing effort.

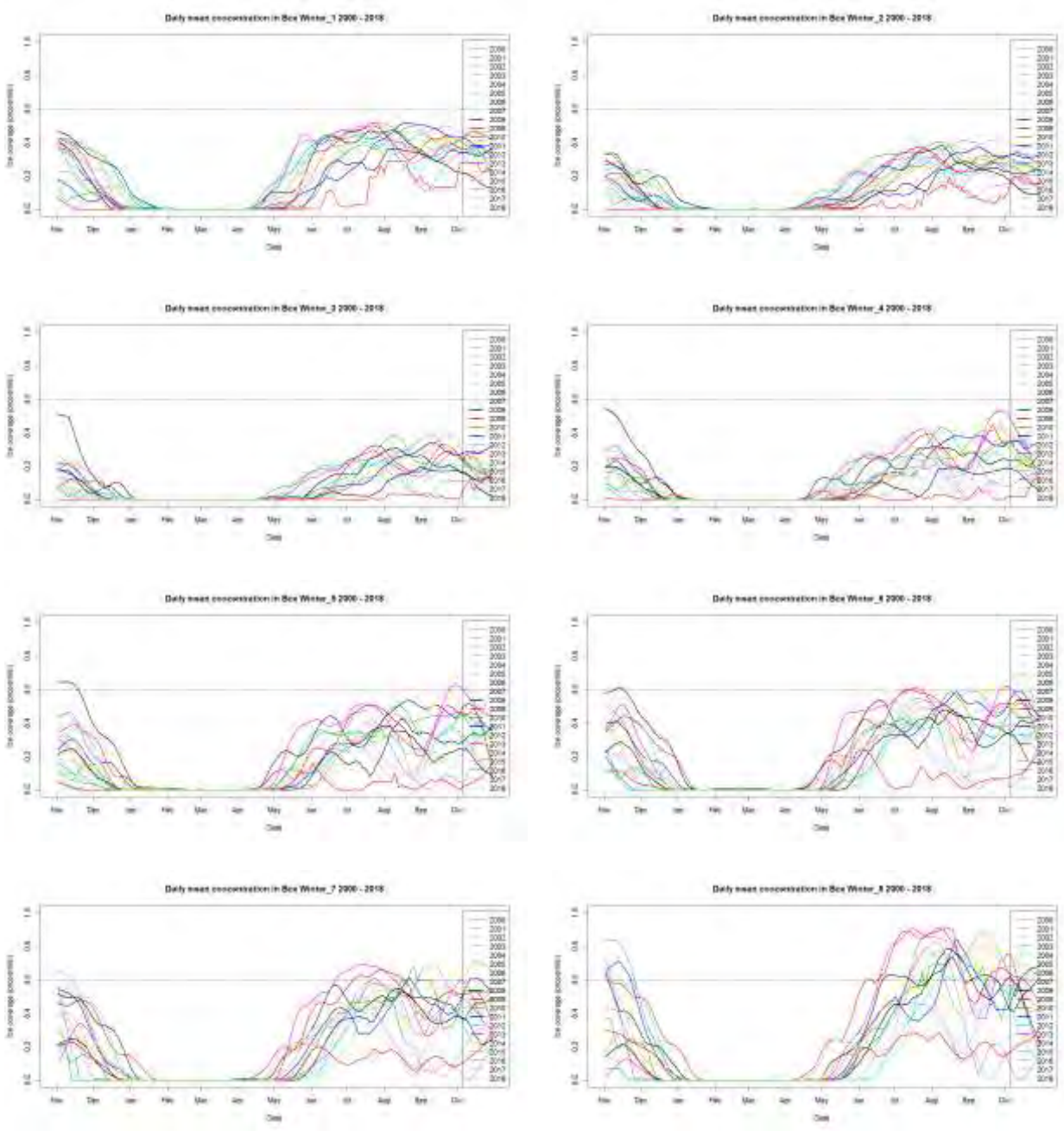


Figure 7. Daily mean sea ice concentrations in strata 1-8 shown in Figure 1.

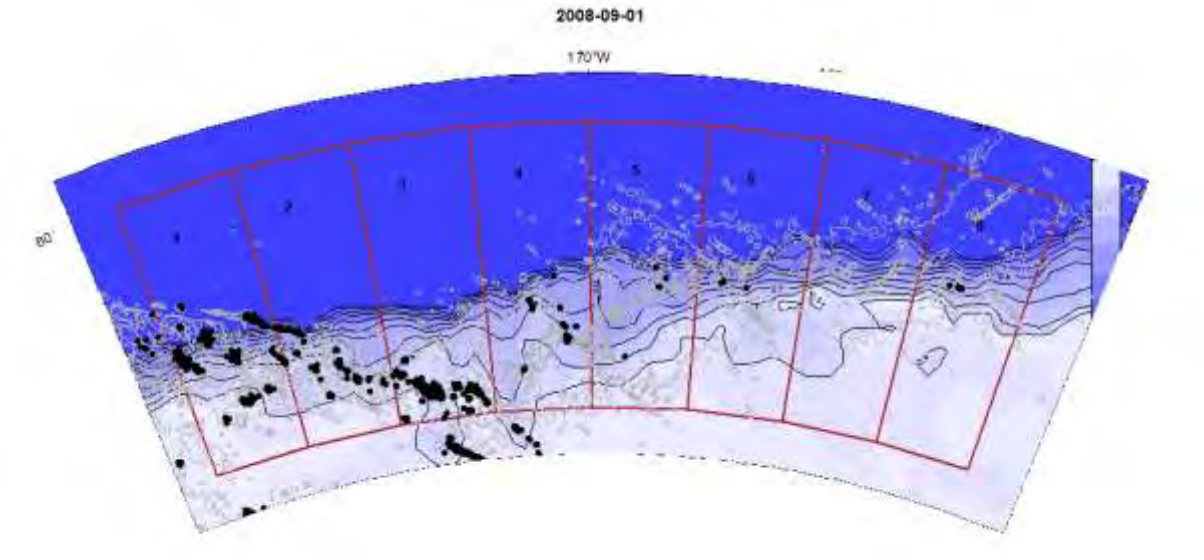


Figure 8. Sea ice distribution on 1 September of an "average" sea ice year (2008) with respect to the proposed survey strata. Previous longline fishing locations shown as black symbols. Bathymetry from 500–3000m shown as grey contours.

Stratification according to e.g. depth or fish density

No depth stratification is proposed as the bathymetric features are almost all deep, and our expectation based on previous standardised CPUE analysis is that catch rates will be adequately estimated through the analytical standardisation procedure and use of standardised gear types.

Calibration/standardisation of sampling gear

The vessel proposed for the research will use a standardised fishing gear enabling comparison with other vessels using the same gear type. Integrated weighted line will be used for all lines — this has about 50 g of lead weight per metre of backbone. The snoods will be multifilament and 300–400 mm long. The hooks used have been proven capable of catching toothfish of the target length when fish are available. Hooks will be baited using an automatic baiting machine and the type of bait and mean bait weight recorded. The percentage of successfully baited hooks per line will be closely monitored during the survey to ensure standardisation within and between strata. Video data will be collected using the scientific electronic monitoring system described in (WG-SISO-17/09) during the scientific research.

Although lines should ideally be set along the depth contour, the bathymetry or weather or ice conditions mean this may not always be possible. There will be a target soak time of 18 hours with a range of ± 6 hours subject to environmental conditions (ice, weather etc.,) and operational requirements. The spacing of hooks and snoods is a fixed value for each vessel as these are connected to rotors and swivels that are permanently attached to the backbone (see Fenaughty

2008, Figure 1). Any lost, tangled, or otherwise unusable set will still be counted toward the allocated effort limit, and fish caught on those sets will count towards the catch limit.

Proposed number and duration of stations/hauls

The proposed research is effort limited (see rationale below under catch limits). The survey is designed to sample the spatial extent of the spawning grounds by spreading survey effort across the survey strata consistent with the advice of WG-FSA-13 (SC-CAMLR XXXII, Annex 7, paragraph 6.10) in two ways. Firstly, there will be an upper limit on the catch which could be taken in each stratum based on the expected catch rate observed during the 2016 winter survey and the sampling density. To ensure spread of effort among strata a maximum of 50 tonnes may be taken from any one stratum and we aim to complete at least 10 sets in at least four of the eight strata, ice permitting and if the stratum catch limit has not been reached. As high catch rates have been observed in the area, a stratum catch limit of lower than 50 t could be exceeded with just a few short lines, so a stratum catch limit lower than this is not feasible

A second mechanism to spread effort is by line separation. Lines will be set on small features in clusters of approximately 3 sets. Clusters will be separated by at least 10 n miles (18.52 km) based on the midpoints of closest sets between adjacent clusters. Ten nautical miles creates significant spatial spread among clusters yet does not preclude surveying features identified at least 10 nm away from previous clusters. Separation distances of 10 nm have been used for research haul designs in the past (CM 200XIX/B). We also note that the expected average set spacing under these rules is similar to or larger than that used elsewhere in data poor fisheries (CM 41-01 2014), which addresses the objective of spreading effort throughout the research block.

Tagging rates and other performance metrics such as tag overlap statistics for tagging programs

Although estimation of abundance is not one of the key objectives of the research, it is recognised that this research provides the unique opportunity to tag fish in the north during the spawning season which might provide additional information on the route of post spawning movements and residence time in the north and therefore a standardised catch rate is important. As it is expected that fish populating this area are likely to be large, a tagging rate of three fish per ton could equate to 1 in 9 fish tagged (if mean weight = 32.7 kg) compared to the usual rate of 1 in 27 tagged in the Ross Sea as a whole. Therefore, we propose to tag a minimum of three fish per tonne caught, and to tag *Dissostichus* spp. proportional to the species caught. Note previous surveys (both the winter survey, the 88.2 AB north survey, and the SPRFMO surveys found almost no Patagonian toothfish.

Particular attention will be given to carefully monitoring the catch for tagged toothfish. The number of tags recovered will help describe the toothfish population in the northern Ross Sea, including the proportion that may be resident, and potentially providing insights about winter spawning migrations. Two tagged fish were recaptured during the second year of the SPRFMO area survey, both of which had been released in the same location during the previous year's survey.

(b) Data collection

Samples of Antarctic toothfish gonads will be collected for histological analyses; entire gonads will be collected for fecundity analyses; and samples of liver, muscle, and cartilage tissue for trophic work will be collected. Samples of tissue of other important fish and squid species caught will also be

collected for trophic interaction studies (specifically *D. eleginoides, Antimora rostrata, Muraneolepis evseenkoi, Macrourus whitsoni, Macrourus caml*). Stomach contents of toothfish and other key fish species caught will be sampled, and included as a subset of the trophic work samples to relate trophic level with stomach contents. All squid beaks will be retained as it is possible that different squid species might be caught in winter compared with the summer Ross Sea fishery. The two on-board scientists will concentrate on sampling and data recording with the assistance of the two Scientific Observers.

It is intended that vertical tows will be made using plankton nets to capture Antarctic toothfish eggs and larvae. The net will be attached to the longline down line at a depth of approximately 500 m and deployed periodically when ice and logistic conditions allow. If eggs are caught and conditions allow, buoyancy experiments will be carried out prior to preserving the eggs for further identification and analyses (see below).

When gravid females and ripe males are caught, fertilisation and fertilised egg buoyancy experiments will be conducted. This will involve fertilising eggs from running ripe female with milt from running ripe males (milt can be stored for several days prior to obtaining a running ripe female). Once fertilised, the eggs would be placed in cylinders for measuring buoyancy following the methods of Stenevik (2008). Culturing fertilised eggs also provides the opportunity to describe the early life history by preserving eggs each day of development and measuring buoyancy to determine if it changes during incubation.

In northern and western parts of the survey strata, we expect to encounter Patagonian toothfish (*D. eleginoides*) in addition to Antarctic toothfish. The primary focus of this research is to characterise the spawning biology of Antarctic toothfish and priority will be given to collecting data and samples from that species. If caught, Patagonian toothfish will also be sampled to characterise spawning and to collect otoliths for age structure studies. Data collected during 2016 suggested that Patagonian toothfish were not as reproductively advanced as Antarctic toothfish in July and that the spawning season may occur later for that species (Stevens et al 2016).

Data collection will focus on describing the spawning condition of the toothfish caught. Sampling requirements described below exceed the standard Observer Sampling Requirements specified in CM 41-01, Annex 41-01A.

- All toothfish will be scanned for tags.
- If feasible, all fish will be identified to species.

<u>Antarctic toothfish</u>

- Up to 100 retained Antarctic toothfish per set will be measured for total length, weight, gonad weight, and sex determined.
- Up to 40 retained Antarctic toothfish per set will be sampled for stomach weight, stomach contents, liver weight.
- Two Antarctic toothfish per set and all recaptured toothfish will be sampled for muscle, liver, and cartilage tissue for stable isotope analysis. Separate muscle tissue samples will be collected for genetic analysis and preserved in ethanol.

- A target sample size of 5 pairs of otoliths per 1-cm length class of Antarctic toothfish between 100 and 150 cm for each sex will be collected. It is likely that few toothfish less than 100 cm would be sampled in this area, therefore, otoliths will be collected from all fish less than 100 cm.

- Up to 200 Antarctic toothfish of each sex will be sampled for gonad histology, with samples spread across size range in 10-cm increments (80–180 cm).

- The entire gonad of up to 50 female and 25 male Antarctic toothfish from throughout the range of fish weights will be collected for fecundity work (expected range 15–55 kg).

- Egg buoyancy experiments will be conducted if Antarctic toothfish eggs or larvae are caught in plankton net sets.

- Opportunistic samples of fresh prey from Antarctic toothfish stomachs will be collected for stable isotope analysis.

Patagonian toothfish

- Up to 50 retained Patagonian toothfish per set will be measured for total length, weight, gonad weight, and sex determined.

- Up to 50 Patagonian toothfish will be sampled for muscle tissue for stable isotope and genetic analysis.

- A target sample size of 5 pairs of otoliths per 1-cm length class of Patagonian toothfish between 80 and 150 cm for each sex will be collected.

Bycatch species

- Up to 10 macrourids and *Muraenolepis* spp. per set will be sampled for length, weight, sex, and gonad weight (for each species).

- Muscle tissue samples for stable isotope analysis will be collected for up to 25 individuals per species for macrourids and *Muraenolepis*.

- Catches (kg) of VME indicator taxa will be recorded for each longline segment following protocols in CM 22-07.

(c) Method for data analysis to achieve the objective in 1(a).

Reproductive data will be analysed to determine if the spawning season had finished by the sampling date. GSI will be summarised relative to GSI data collected in other months (i.e., through July). Histological analysis will indicate if fish present on the spawning grounds are all mature and if they have spawned, will spawn, or have skipped spawning. Histological data and GSI data will be used to compare a spawning ogive from winter months with the spawning ogive generated from summer-collected data.

If tagged fish are recovered in the area, a detailed analysis of their movement, growth, and time at liberty will be made. Future analyses of the recovery of fish tagged during the winter survey will be carried out in subsequent years.

Condition factor has been observed to be different between slope and north caught fish in the summer months (Fenaughty 2006, Fenaughty et al. 2008, Parker & Marriott 2012). If a significant migration occurs prior to the spawning season, then the condition factor in the north should change to be at least intermediate with the slope value (assuming the proportion of fish migrating to the north in any year is a major component of the spawning population). There was no change in condition factor observed in the northern Ross Sea during the 2016 winter survey. It is possible that the survey was early compared to a spawning migration, so the later survey in this proposal will test the hypothesis again.

Bycatch species composition, catch rates and size distributions will be summarised and compared with those from the nearest locations fished with similar gear types. Information from bycatch species in the strata will provide additional life history information for future trophic modelling.

VME indicator taxa bycatch will be summarised and compared with that observed in the nearest locations fished with similar gear types.

(d) How and when will the data meet the objectives of the research?

Data collected will be analysed following the survey. Comparisons with expected distributions and summaries of addition information collected will be included in a progress reports to WG-FSA (see below) and could be used to propose design modifications for future surveys.

The methods are likely to be successful because the sampling entails normal, but standardised, fishing methodologies and sampling approaches already used by vessels and scientific observers.

Proposed catch limits

(a) Proposed catch limits and justification

To ensure that samples collected are spread geographically, we propose to stratify the number of sets and anticipated maximum research catch but also to provide operational flexibility in situations where there are bad ice conditions in some strata and unexpectedly high or low catch rates.

We anticipate that at least 5 of the 8 strata could be sampled during the voyage, and that up to 18 sets (comprising about 3 sets per feature and 6 features per stratum) would be required in each stratum to collect samples from multiple bathymetric features in each stratum. Therefore, an effort limit of 90 sets is proposed.

Sets are typically made in local clusters of 3 to 5 sets. At 75th percentile landed catch rates found during the 2016 winter survey (226 kg/km line or 1.088 t per set), 90 research sets could result in 97 t of catch. Setting this as an upper catch limit, we propose a maximum catch limit of 97 tonnes of *Dissostichus* spp. be allocated for the research, corresponding to approximately 3000 fish. (Note that median weight of *Dissostichus* spp. in the northern SSRUs is about 32.7 kg). This allowance was based on the following design:

- A minimum of four strata should be surveyed with a maximum catch limit of 50 t per stratum to ensure geographic spread if catch rates are high.
- Aim to complete at least 10 sets, ice permitting, in each stratum fished.

- Clusters of up to 5 sets will be separated by at least 10 nm (based on the minimum distance between sets in any two clusters).
- An effort limit of 90 sets and a maximum catch limit of 97 t.

The area for the proposed research is included in the Ross Sea stock assessment (Subarea 88.1 and Subarea 88.2 SSRUs A–B; SC-CAMLR XXXII paragraph 3.160). Therefore, following CM 24-01 paragraph 1, the catch associated with this research would be included within the yield estimated by the Ross Sea stock assessment and specifically within the catch limit for north of 70°S and specified in CM 41-09.

(b) Evaluation of the impact of the proposed catch on stock status:

• Rationale that proposed catch limits are consistent with Article II of the Convention

The proposed research catch of the target species is included within the Ross Sea stock assessment and therefore has no additional impact to stock status. However, this work will contribute to existing knowledge on stock structure.

• Information on estimated removals, including IUU fishing activities, where available.

Information on annual removals are included in the stock assessment. No estimates of IUU fishing activities from this area are available.

(c) Details of dependent and related species and the likelihood of their being affected by the proposed fishery.

Impacts on bycatch species will be managed as per CM 33-03, including a move-on rule for macrourids. Because the toothfish catch is managed as part of the agreed total toothfish yield for the Ross Sea, the allowed annual macrourid catch and skate catch the will also apply to this research.

Research capability

(a) Name(s) and address of the chief scientist(s), research institute or authority responsible for planning and coordinating the research:

Alistair Dunn, Ministry for Primary Industries, PO Box 2526, Wellington, 6140, New Zealand, Alistair.Dunn@mpi.govt.nz, +64 4 819 4607

(b) Number of scientists and crew to be on board the vessel: Two scientists including one international scientist (see below), two Scientific Observers (one CCAMLR, one NZ) and one industry representative to assist with sampling and an industry representative to assist with data management.

(c) Is there opportunity for inviting scientists from other Members? If so, indicate a number of such scientists: Yes - one scientist yet to be confirmed.

(d) Commitment that the proposed fishing vessel(s) and nominated research provider(s) have the resources and capability to fulfil all obligations of the proposed Research Plan.

The proposed fishing vessel and vessel operator have a long history of fishing with high compliance and reporting performance in CCAMLR exploratory fisheries for toothfish. The proposed research comprises sampling methods similar to those normally in place for exploratory fisheries, although at higher sampling rates for biological data collection. There is a facility for direct communication between the vessel and scientists on board and the observer coordinators, fishery scientists, and the chief scientists for the research program on shore while conducting the research. This will enable adaptive yet scientifically robust decisions to be made in real-time while the survey is undertaken. Therefore, the vessel, scientists and the scientific observers on board have the resources and capability to fulfil all obligations of the proposed research plan.

Health and Safety Plan

We recognise that while all fishing operations have inherent risks that are address through vessel health and safety plans, operations in the Southern Ocean in winter create additional risks, the most serious being the distance from other vessels that could provide assistance. We address this and other risks through a specific winter Ross Sea vessel risk management plan. In addition, the 2019 voyage would be coordinated with a SPRFMO toothfish proposal that would occur during the same period, providing another potential vessel in the general area that could provide assistance.

Reporting for evaluation and review

(a) List of dates by which specific actions will be completed and reported to CCAMLR.

Given the survey timing of September/October 2019 the results of the survey will be presented to WG-SAM-20. We will therefore provide a verbal update at WG-FSA-19 and provide a full report on results at WG-FSA-20.

(b) If research is multi-annual, Members shall commit to providing annual research reviews to be submitted to WG-FSA and/or WG-EMM, including review of progress towards meeting research objectives and associated proposed time lines in initial proposal, and proposals for adjustments to the research proposal if required.

The proposed research is for one year. Following the 2019 survey, a report will be submitted to WG-FSA that addresses how the research is meeting objectives.

Conservation measure exemptions

(a) Intended exemptions from applicable conservation measures

With respect to CM 24-05, the 2018/19 table should reflect a catch limit of 97 t to conduct research under CM 24-01. No exemptions from Conservation Measures other than those in CM 24-01 are needed to conduct this research.

References

Ashford, J., Dinniman, M., Brooks, C., Andrews, A., Hofmann, E., Cailliet, G., Jones, C. & Ramanna, N. (2012). Does large-scale ocean circulation structure life history connectivity in Antarctic toothfish (*Dissostichus mawsoni*)? *Canadian Journal of Fisheries and Aquatic Sciences 69:* 1903–1919.

Cryer, M., Dunn, A., Fenaughty, J.M. (2017). New Zealand's exploratory fishery for toothfish within the SPRFMO Convention Area: Update and future directions. SC-CAMLR XXXVI/BG/18. 6 p.

Delegations of New Zealand, Norway and the United Kingdom. (2014). Medium-term research plan for the Ross Sea toothfish fishery. *WG-FSA-14/60.*

Dunn, A., Rickard, G.J., Hanchet, S.M., Parker, S.J. (2012). Models of larvae dispersion of Antarctic toothfish (*Dissostichus mawsoni*). *WG-FSA-12/48*.

Fenaughty J.M. (2006) Geographical differences in the condition, reproductive development, sex ratio, and length distribution in Antarctic toothfish *Dissostichus mawsoni* from the Ross Sea, Antarctica (CCAMLR statistical Subarea 88.1). CCAMLR Science, 13: 27-45.

Fenaughty J.M., Joseph T. Eastman, and Bruce D. Sidell (2008). Biological implications of low condition factor "ax handle" specimens of the Antarctic Toothfish, *Dissostichus mawsoni*, from the Ross Sea. Antarctic Science 20 (6), 537–551 (2008).

Fenaughty. J.M. (2008). The autoline system – an updated descriptive review of the method with recommendations to clarify CCAMLR Conservation Measures regulating longline fisheries within the Convention Area. *WG-FSA-08/60*.

Fenaughty, J.M., Cryer, M. (2016). Report on the first year's fishing under New Zealand's exploratory fishery for toothfish within the SPRFMO Convention Area. SC-CAMLR-XXXV/BG/32. 8p.

Hanchet, S.M., Rickard, G.J., Fenaughty, J.M., Dunn, A.; Williams, M.J. (2008). A hypothetical life cycle for Antarctic toothfish *Dissostichus mawsoni* in Antarctic waters of CCAMLR Statistical Area 88. *CCAMLR Science 15:* 35–54.

Hanchet, S.M., Dunn, A., Parker, S.J., Horn, P.L., Stevens, D.W. & Mormede, S. 2015. The Antarctic toothfish (*Dissostichus mawsoni*): biology, ecology, and life history in the Ross Sea region. *Hydrobiologia,* 761, 397–414.

Parker, S.J.; Marriott, P. (2012). Indexing maturation of Antarctic toothfish *(Dissostichus mawsoni*) in the Ross Sea region. *WG-FSA-12/40.*

SC-CAMLR-XXXII. (2013). Report of the 32nd meeting of the Scientific Committee for the Conservation of Antarctic Marine Living Resources. 82 p.

Stenevik, E.K., Sundby, S. Agnalt, A.L. (2008). Buoyancy and vertical distribution of Norwegian coastal cod (*Gadus morhua*) eggs from different areas along the coast. – ICES Journal of Marine Science, 65: 1198–1202.

Stevens, D., DiBlasi, D., Parker, S.J. (2016). Results of the first winter longline survey to the northern Ross Sea region to investigate toothfish reproductive life history. *WG-FSA-16/37*.