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Draft proposal for multi-Member research on the Dissostichus mawsoni exploratory fishery in East Antarctica (Divisions 58.4.1 and 58.4.2) from 2018/19 to 2021/22

Delegations of Australia, France, Japan, Republic of Korea and Spain

EN

Draft Proposal for Multi-Member Research on the *Dissostichus mawsoni* Exploratory Fishery in East Antarctica (Divisions 58.4.1 and 58.4.2) from 2018/19 to 2021/22

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Abstract

Exploratory fishing for toothfish (*Dissostichus* spp.) in East Antarctica (Divisions 58.4.1 and 58.4.2) began in 2003. Robust stock assessments and catch limits according to CCAMLR decision rules remain to be determined for these Divisions. WG-FSA-16/29 outlined the first multi-member toothfish exploratory fishery research plan up to 2017/18 for East Antarctica, which the Scientific Committee agreed was appropriate to achieve the research objectives (SC-CAMLR-XXXV, para. 3.244). Subsequent research progress including evaluation of standard approaches to identify precautionary catch limits (WG-FSA-17 para. 4.28-4.38) and bycatch mitigation (Maschette et al. 2017), suggests a low risk profile for this fishery. Furthermore, examination of bycatch data and underwater video footage have not led to the identification of vulnerable marine ecosystem (VME) indicator species (Maschette et al. 2017). Final milestone results for the current research plan will be presented to WG-FSA-18. Here, we present a succeeding research proposal for 2018/19 to 2021/22, in accordance with ANNEX 24-01/A, Format 2. This succeeding plan has been designed as a 4-year plan, based on the low risk profile of this fishery and to allow more time for review by Working Groups of major reporting and review years in non-stock-assessment years. In this document we propose draft research objectives and an approach to review the locations of research blocks based on WG-SAM-11 para. 2.40. Based on WG-SAM-18 discussions and final milestone results for the current research plan, we will further develop the objectives and the locations of research blocks of this research plan for WG-FSA-18. In addition, the current genetics work (Maschette et al. 2018) will provide information on the stock structure of Antarctic toothfish in East Antarctica in relation to the wider Southern Ocean, and whether the species is suitable for an abundance estimate using a close-kin mark-recapture method.

1. Main objective

(a) Objectives for the research

Objective 1: Collect fisheries and biological data to inform an assessment of the status and productivity of toothfish stocks in Divisions 58.4.1 and 58.4.2.

Objective 2: Collect and utilise environmental data to inform spatial management approaches for the conservation of toothfish, bycatch species and VMEs.

Objective 3: Collect data on the spatial and depth distributions of bycatch species, and inform bycatch mitigation measures.

Objective 4: Improve the understanding of trophic relationships and ecosystem function to assist the development of ecosystem-based fisheries management approaches.

(b) Detailed description of how the proposed research will meet the objectives, including annual research goals

Objective 1: *Collect fisheries and biological data to inform an assessment of the status and productivity of toothfish stocks in Divisions 58.4.1 and 58.4.2*

Standard catch, fishing effort, tagging and biological data will be collected under Conservation Measures 41-05 and 41-11 to inform an assessment of the status and productivity of toothfish stocks in Divisions 58.4.1 and 58.4.2. Annual milestones include updated reports on research activity and collected data, ageing of collected toothfish otoliths, and updated estimation of biological parameters (Table 1). Stock assessment models for toothfish will be updated and refined biennially in non-stock-assessment years. Year 2022 will see an evaluation of existing management arrangements in Divisions 58.4.1 and 58.4.2, and updated advice on precautionary catch limits as appropriate.

Table 1. Scheme of milestones under Objective 1. Contribution refers to data processing and analyses. 'All' means all members who fish under this research plan.

Date	Milestone	Contribution	Coordination
WG-FSA-19	1.1 Report on research activity and collected data	Australia	Australia
	1.2 Ageing of collected toothfish otoliths & updated estimation of biological parameters	All	Spain
WG-FSA-20	1.3 Report on research activity and collected data	Australia	Australia
	1.4 Ageing of collected toothfish otoliths & estimation of biological parameters	All	Spain and Republic of Korea
	1.5 Migration of toothfish using satellite Pop-up tags	Republic of Korea	Republic of Korea
	1.5 Update and refine stock assessment models for toothfish within and across research blocks and Divisions	All	Australia and France
WG-FSA-21	1.6 Report on research activity and collected data	Australia	Australia
	1.7 Ageing of collected toothfish otoliths & updated estimation of biological parameters	All	Spain
WG-FSA-22	1.8 Report on research activity and collected data	Australia	Australia
	1.9 Ageing of collected toothfish otoliths & updated estimation of biological parameters	All	Spain
	1.10 Update and refine stock assessment models for toothfish within and across research blocks and Divisions	All	Australia and France

Objective 2: *Collect and utilise environmental data to inform spatial management approaches for the conservation of toothfish, bycatch species and VMEs*

The collection of environmental data will continue annually and will be summarised in 2022 (Table 2). Environmental data collection will entail the attachment of conductivity, temperature and depth loggers (CTD loggers) and Benthic Video Cameras (BVCs) to fishing gear. BVCs will be deployed from vessels flagged to Australia and France, and CTD loggers will be deployed from vessels flagged to Australia, France and Republic of Korea (see Section 2b, 3a).

BVCs and CTD loggers will record, or be used to infer:

- Water temperature
- Salinity
- Depth of longline deployments
- Substrate composition
- Density and species composition of benthic communities.

A summary of collected environmental data will be presented in 2022, with an evaluation of their use in habitat models for toothfish. Toothfish distribution models and the resulting hypothesis for toothfish stock structure across East Antarctica (Yates et al. 2017) will be updated in 2022. Data on benthic communities will also provide information on the distribution of benthic organisms, particularly of Vulnerable Marine Ecosystems (VME), within the study regions. Furthermore, vertical depth, temperature and salinity profiles will be shared with the Southern Ocean Observing System (SOOS), delivering additional value from the proposed research.

Table 2. Scheme of milestones under Objective 2. Contribution refers to data processing and analyses.

Date	Milestone	Contribution	Coordination
WG-FSA-22	2.1 Summary of collected environmental data, and evaluation of their use in habitat models and for informing on the distribution of VMEs	Australia, France, Republic of Korea and Spain	France
	2.2 Update hypothesis for toothfish stock structure across East Antarctica and links with other areas	Australia and Republic of Korea	Australia and Republic of Korea

Objective 3: *Collect data on the spatial and depth distributions of bycatch species, and inform bycatch mitigation measures*

Bycatch data will be collected in accordance with relevant conservation measures (CMs 33-03, 41-05 and 41-11). These data will help to inform estimations of the distribution, relative abundance, and life history of the main bycatch species. These analyses will be presented biennially (Table 3).

Table 3. Scheme of milestones under Objective 3. Contribution refers to data processing and analyses.

Date	Milestone	Contribution	Coordination
WG-FSA-20	3.1 Update estimation of spatial distribution, relative abundance, and life history of main bycatch species	Australia and France	Australia and France

WG-FSA-22	3.2 Update estimation of spatial distribution, relative abundance, and life history of main bycatch species	Australia and France	Australia and France

Objective 4: *Improve the understanding of trophic relationships and ecosystem function to assist the development of ecosystem-based fisheries management approaches*

Samples of fish muscle tissue, stomach contents, plankton and zooplankton will be used for the investigation of trophic relationships and ecosystem function using stable isotope analyses. Trophic and ecosystem relationships will be evaluated and reported on as presented in Table 4.

Table 4. Scheme of milestones under Objective 4. Contribution refers to data processing and analyses.

Date	Milestone	Contribution	Coordination
WG-FSA-19	4.1 Diet of Antarctic toothfish based on fatty acids and stable isotopes	Republic of Korea	Republic of Korea
WG-FSA-20	4.2 Analysis of stomach contents by morphological and genetic study	Republic of Korea	Republic of Korea
	4.3 Plan for continuing research in 2021 and 2022	Republic of Korea	Republic of Korea

(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

Toothfish utilise a broad range of habitats throughout their lifespan, from the epipelagic as planktonic larvae, to benthopelagic slope habitats in excess of 2000 m in depth (Hanchet et al. 2010). Previous studies have revealed varied movement patterns among individuals but also a relatively predictable distribution of these fish along the Antarctic continental shelf (Welsford 2011, Yates et al. 2017). Results of genetic studies have been consistent with the existence of limited gene flow among *D. mawsoni* populations across regions (East Antarctica, Ross Sea and the South Shetland Islands; Kuhn and Gaffney 2008, Mugue et al. 2013). However, additional sampling is underway (Maschette et al. 2018) and will be presented to WG-FSA-18 to determine whether this species exhibits discrete stock structure or a pattern of isolation by distance across its global distribution.

Significant research progress has been made in Divisions 58.4.1 and 58.4.2 over the last few years:

- Updated toothfish habitat models and stock hypothesis (WG-FSA-17/16)
- Updated ageing and growth estimation of *D. mawsoni* (WG-FSA-17/15, WG-FSA-17/66)
- Description of sex ratios, gonadal development and validation of macro- versus micro-staging of maturity (WG-FSA-17/09)
- Results of fatty acid and stable isotope signature analyses to examine the feeding ecology of *D. mawsoni* (WG-FSA-17/12)
- Next-generation sequencing of stomach contents collected from *D. mawsoni* (WG-FSA-17/P03)
- Development of approaches for mitigation of Macrourus by-catch in research block 58.4.1_6 and estimation of Macrourus biomass and sustainable bycatch in Divisions 58.4.1 and 58.4.2 (WG-FSA-17/16)
- Description of encounter rates of VME indicator species (WG-SAM-16/34)

The combination of results from this research, an evaluation of the previous research proposals against a set of generic criteria for research proposals in data-poor fisheries (WG-FSA-17, para. 4.7), the development of a standard approach to set precautionary catch limits (WG-FSA-17 para. 4.28-4.38), and historically low levels of IUU fishing activity suggests a low risk profile for this fishery.

Without an integrated toothfish stock assessment in these Divisions, further data collection, the development of methods to improve the estimation of toothfish biomass and productivity, and a better understanding of stock structure are research priorities. The dominance of large mature fish and absence of juveniles on nearby BANZARE Bank (Division 58.4.3b) suggest that it may be an important spawning ground for *D. mawsoni* (Welsford et al. 2008; Taki et al. 2011). In contrast, based on catches across Divisions 58.4.1 and 58.4.2 between years 2003–2011, the region around Prydz Bay (SSRU 58.4.2E) had the highest predicted catch rate of juvenile *D. mawsoni* (Yates et al. 2017). Therefore, it is hypothesised that mature fish on BANZARE Bank originate from nearby locations in East Antarctica, especially Prydz Bay (Welsford et al. 2008), which may serve as nursery areas (Welsford 2011). This stock hypothesis was supported by subsequent distribution modelling by Yates et al. (2017), and includes similar latitudinal patterns in sexual maturity and size composition to those hypothesised for the Ross Sea (Hanchet et al., 2008; Welsford et al. 2008). Combined, these stock models suggest a single stock across Prydz Bay in Division 58.4.2, Division 58.4.1, and Subdivision 58.4.3b. Further data on the distribution of different size-classes and maturity stages of toothfish, along with estimates of biological parameters and genetic studies, will allow for the refinement of models of stock structure, and the development of assessments models.

2. Fishery operations

(a) Fishing Members

Australia, France, Japan, Republic of Korea and Spain.

(b) Vessels to be used

Table 5. Fishing vessels of Australia

Vessel name	*Antarctic Chieftain*
Information	https://www.ccamlr.org/en/node/90599
Vessel owner	Australian Longline Pty Ltd
Vessel type	Commercial bottom longline fishing vessel
Registration port/number	Fremantle, Registration 859032
Radio call sign	VJT6415
Overall length and tonnage	62.8 m, 1148 MT
Equipment for determining position	GPS and other vessel monitoring systems required under CM10-04
Fishing processing/storage capacity	15 tonnes per day headed & gutted, blast frozen. Carrying capacity 480t. Capacity of all fish holds 1,090m^3
Divisions	58.4.1 and 58.4.2
Vessel name	*Antarctic Discovery*
Information	https://www.ccamlr.org/en/node/90595
Vessel owner	Australian Longline Pty Ltd
Vessel type	Commercial bottom longline fishing vessel
Registration port/number	Hobart, Registration 861507
Radio call sign	VKAD
Overall length and tonnage	55.3 m, 1580 MT
Equipment for determining position	GPS and other vessel monitoring systems required under CM10-04
Fishing processing/storage capacity	15 tonnes per day headed & gutted, blast frozen. Carrying capacity 410t. Capacity of all fish holds 851m^3
Divisions	58.4.1

Table 6. Fishing vessels of France

Vessel name	*Le Saint-André*
Information	https://www.ccamlr.org/en/node/94853
Vessel owner	SNC Saint-André
Vessel type	Commercial bottom longline fishing vessel
Registration port/number	Port aux Français FK 928451
Radio call sign	FNTD
Overall length and tonnage	56.4 m, 416 tonnes
Equipment for determining position	Balise Irridium type Thorium
Fishing processing/storage capacity	Fish processing capacity: $\leq$ 10 tons per day Freezer hold capacity: 300 tons.
Divisions	58.4.1 and 58.4.2
Vessel name	*Cap Kersaint*
Information	To be updated
Vessel owner	CAP BOURBON
Vessel type	Commercial bottom longline fishing vessel
Registration port/number	Port aux Français FK 932444
Radio call sign	FISH
Overall length and tonnage	59.45 m, 2086 UMS
Equipment for determining position	GPS FURUNO GP170
Fishing processing/storage capacity	Fish processing capacity: 15 tonnes per day Freezer hold capacity: 900 m^3
Divisions	58.4.1

Table 7. Fishing vessel of Japan

Vessel name	*Shinsei maru No.3*
Information	www.ccamlr.org/en/node/75733
Vessel owner	TAIYO A & F CO., LTD.
Vessel type	Commercial bottom longline fishing vessel
Registration port/number	Yaizu-Japan / 128862
Radio call sign	JAAL
Overall length and tonnage	47.2 m, 735 t
Equipment for determining position	GPS FURUNO GP500MK2
Fishing processing/storage capacity	Fish processing capacity: 10 tonnes per day Freezer hold capacity: 502.4 m^3
Divisions	58.4.1

Table 8. Fishing vessel of Republic of Korea

Vessel name	*Southern Ocean*
Information	www.ccamlr.org/en/node/86009
Vessel owner	Hongjin Corporation
Vessel type	Commercial bottom longline fishing vessel
Registration port/number	Busan, Korea / 1411003 6261106
Radio call sign	6KCD8
Overall length and tonnage	59.01 m, 684 t
Equipment for determining position	ARGOS MAR-V2
Fishing processing/storage capacity	Fish processing capacity: 30 tonnes per day Freezer hold capacity : 1220 m^3
Divisions	58.4.1

Table 9. Fishing vessel of Spain

Vessel name	*Tronio*
Information	https://www.ccamlr.org/en/node/94831
Vessel owner	Pesquerías Georgia S.L.
Vessel type	Commercial bottom longline fishing vessel
Registration port/number	Cillero/ 3GC-1-2-05
Radio call sign	ECJF
Overall length and tonnage	55 m, 1058 tonnes (GRT)
Equipment for determining position	VMS-c
Fishing processing/storage capacity	42.7t / 635.3 m^3
Divisions	58.4.1

(c) Target species

Antarctic toothfish (*Dissostichus mawsoni*) will be the primary species caught, and the focus for Objectives 1, 2 and 4.

(d) Fishing or acoustic gear to be used

Longline type

This research will employ a combination of Mustad Autoline system with integrated weight-longline (Australia and France), Spanish longline (Spain) and trotline (Japan and Republic of Korea). Full descriptions of gear configurations and deployment are located in the CCAMLR Fishing Gear Library at http://www.ccamlr.org/en/publications/fishing-gear-library.

Other sampling gear

- Echosounders (e.g. Simrad ES60; ES 70, 38 kHz; JRC JFV-250)
- Conductivity, temperature and depth (CTD) loggers
- Benthic video cameras

- Archival tags (MiniPAT; Wildlife computers)

Type of acoustic gear and frequency

If possible, vessels will collect acoustic 18, 38 and 120 kHz data as part of a program by the Integrated Marine Observing System (IMOS) for risk-based analyses of potential impacts on non-target fish populations or ecosystem interactions arising from impacts on the target stock.

(e) Fishing regions (divisions, subareas and SSRUs) and geographical boundaries

This research plan proposes research blocks in Divisions 58.4.1 and 58.4.2 as outlined in Section 3.

(f) Estimated dates of entering and leaving the CCAMLR Area

Table 10. Estimated months of operation during the 2018/19 season (shaded blue) in the CCAMLR Area for each notifying Member. Cut-off dates for confirmation of intention to fish, and commencement of fishing are outlined in Section 4a.

Notifying Member	2018	2019										
	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Australia												
France												
Japan												
Rep. of Korea												
Spain												

3. 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)

The geographical boundaries of research blocks in Divisions 58.4.1 and 58.4.2 for the research plan up to 2017/18 (WG-FSA-16/29) are listed in Conservation Measures 41-11 and 41-05 and are presented in Figure 1:

Division 58.4.1:

- 5841_1 (SSRU 58.4.1C)
- 5841_2 (SSRU 58.4.1C)
- 5841_3 (SSRU 58.4.1E)
- 5841_4 (SSRU 58.4.1E)
- 5841_5 (SSRU 58.4.1G)
- 5841_6 (SSRU 58.4.1G)

Division 58.4.2:

- 5842_1 (SSRU 58.4.2E)

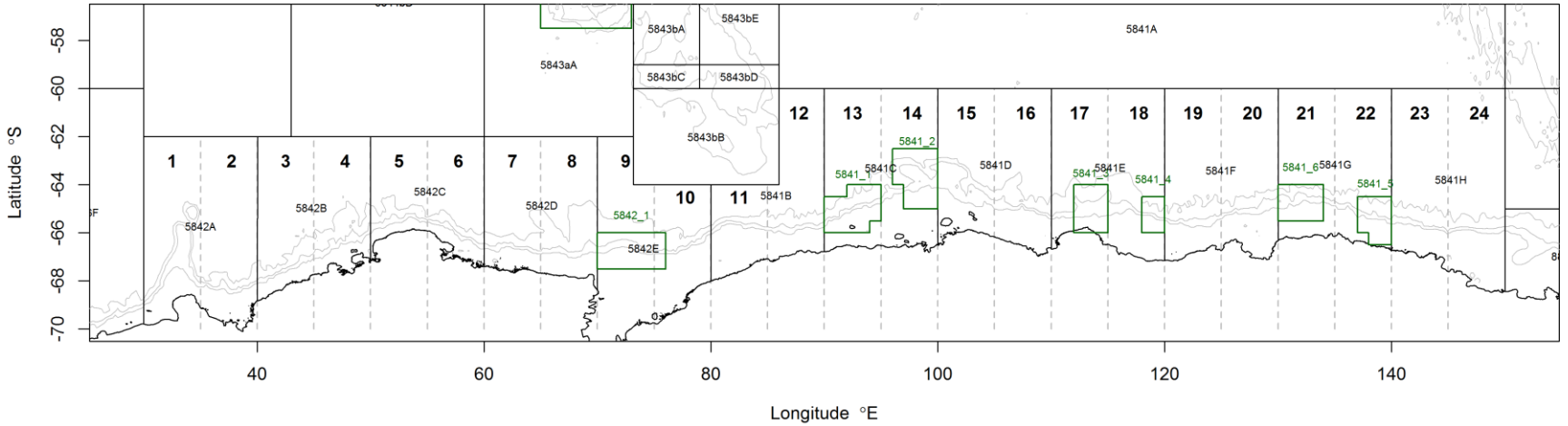
In this document, we propose an approach to review locations of research blocks based on WG-SAM-11 para. 2.40. Based on WG-SAM-18 discussions and final milestone results for the current research plan, we will then further develop this research plan for WG-FSA-18.

WG-SAM-11 (para. 2.40) recommended that for the designation of research areas in data-poor fisheries:

a) The area should be chosen with a reference to the stated objective of the research.
b) Priority areas include those where catch rates indicate that a viable toothfish fishery may be present depending on catch rates, catch history and size of fishable seabed areas.
c) Consideration should also be given to the likely role of a particular SSRU in the plausible stock hypothesis (i.e. is it only juveniles in the area?).

A list of criteria has been developed to enable an evaluation of geographic areas according to the recommendation above (Table 11, with data layers in Appendix A). Criteria to meet research objectives include the numbers of released and recaptured tagged fish, the ability to develop local and wider-area assessments, areas of key life-history stages, the availability (or lack) of data to develop habitat models, and the risk of encountering VMEs. Criteria to indicate a viable fishery include previous catch rates and catch history, likely fish habitat area, and spatio-temporal distributions of sea ice.
For each criteria, thresholds can be used to rank geographic areas according to their suitability as research locations. As an example, this ranking system has been applied to 24 five-degree-longitude sections across the longitudinal extent of Divisions 58.4.1 and 58.4.2 (Figure 1).
The research objectives of this research plan require the collection of a range of data types, including e.g. recapture data to develop toothfish stock assessments tag and data on ageing and maturity to inform stock productivity. The development of local assessments depends on local recaptures, while an area-wide assessment is facilitated by data collection from locations that are in relatively close

proximity to each other. For the stock hypothesis, key life-history stages in observed and predicted locations of spawning and settlement are of highest interest. The existing habitat model (Yates et al. 2017) is mainly informed from data collected in existing research blocks and can make predictions for surrounding areas, but lacks data from the more western parts of Division 58.4.2. VMEs have so far been detected only in SSRU 58.5.1H, but fishing effort in some of the remaining areas has been low. Viable research blocks also require a combination of good catch rates, sufficient suitable toothfish habitat area where bycatch is low (e.g. in the 1000-1700 m depth range) and accessibility with low sea ice conditions.



	Division	58.4.2										58.4.1													
	SSRU	A	A	B	B	C	C	D	D	E	E	B	B	C	C	D	D	E	E	F	F	G	G	H	H
	With research block									1				1	2			3	4			6	5		
	Segment	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
a) Objectives	Available tags	M	L	L	L	L	L	L	L	H	H	L	L	H	H	M	L	H	H	L	L	H	H	H	M
	Recaptures	L	L	L	L	L	L	L	L	L	L	L	L	M	M	L	L	H	M	L	L	H	M	M	L
	Local assessment	L	L	L	L	L	L	L	L	H	L	L	L	H	H	L	L	H	H	L	L	H	H	L	L
	Area-wide assessment	L	L	L	L	L	L	L	L	M	M	M	M	H	H	H	H	H	H	H	H	H	H	L	L
	Key life-history stages	H	M	L	L	L	L	L	M	H	H	M	L	M	H	H	L	M	M	L	L	L	L	L	L
	No data for habitat model	M	H	H	H	H	H	M	L	L	L	M	L	L	L	L	L	L	L	L	L	L	L	L	L
	Avoid VME	H	M	M	M	H	M	M	M	H	H	M	M	H	H	M	M	H	H	M	M	H	H	L	L
b) Viable fishery	Catch rates	M	L	M	M	H	H	H	H	H	M	M	H	H	H	M	L	M	M	M	M	M	M	H	H
	Fishing history	L	L	L	L	L	L	L	L	M	M	L	L	H	H	M	L	H	M	L	L	H	H	M	L
	Habitat area	H	L	L	M	L	L	L	L	L	L	L	L	L	M	H	L	M	L	L	M	M	L	L	L
	Sea ice	H	L	M	M	H	M	M	M	M	M	M	M	M	M	M	M	M	M	M	H	H	H	M	M
c) Stock hypothesis	See Key life-history stages																								

Figure 1. Suitability of geographic five-degree-longitude sections (upper panel) against the criteria under WG-SAM-11 para 2.40 (lower panel). Suitability is marked as high (H, green), medium (M, orange) or low (L, red). Upper panel: Black lines = SSRU boundaries, green lines = research blocks in Divisions 58.4.1 and 58.4.2 as set out in Conservation Measures 41-11 and 41-05.

Table 11. Criteria and possible thresholds for evaluating geographic sections according to their suitability as research areas. H = high, M = medium, L = low.

Criteria	Rank	Thresholds
Available tags	H	> 100 tags
	M	10-99 tags
	L	< 10 tags
Recaptures	H	> 5 recaptures
	M	1-5 recaptures
	L	0 recaptures
Local assessment	H	High likelihood (given existing data, e.g. ageing data)
	M	Medium likelihood
	L	Low likelihood
Wider-area assessment	H	High likelihood (given existing data and close spatial proximity)
	M	Medium likelihood
	L	Low likelihood
Key life-history stages	H	High interest as potential spawning (high proportion of stage 3+ fish) or settlement area (small fish)
	M	Medium interest
	L	Low interest
No data for habitat model	H	High level of uncertainty due to lack of data
	M	Medium level of uncertainty due to lack of data
	L	Low level of uncertainty due to lack of data
VME	H	High suitability: no reported VME despite high level of fishing effort
	M	Medium suitability: no reported VME but no or only low-level fishing effort
	L	Low suitability: reported VME
Catch rates	H	Maximum CPUE > 200 kg/1000 hooks (model prediction)
	M	Maximum CPUE of 100-200 kg/1000 hooks
	L	Maximum CPUE < 100 kg/1000 hooks
Fishing history	H	Total catch > 100 tonnes
	M	Total catch 20-100 tonnes
	L	Total catch < 20 tonnes
Habitat area	H	Area > 8000 km^2 (Area in 1000-1700 m depth)
	M	Area 4000-8000 km^2
	L	Area < 4000 km^2
Sea ice	H	> 70% of years accessible in Jan-March (averaged across months and for areas with depths between 1000 and 2000 m; Figure 12)
	M	20-70% of years accessible in Jan-March
	L	< 20% accessible in Jan-March

We propose to use such a list of criteria to review the location of research blocks for this research plan. In addition, the milestone reports of the research plan up to 2017/18 and outcomes from the genetics project (Maschette et al. 2018) will be presented at WG-FSA-18 and provide input for considerations of the objectives and sampling design of this research plan. We will also provide an analysis of the usefulness of the research grid in research block 58.4.1_2 to achieve the objectives of the current research plan.

Stratification according to e.g. depth or fish density

Fishing will be distributed across a range of depth strata where possible (<1000, 1001–1500, 1501–2000 m). Each Member will deploy at least 5 longlines in each depth strata (where present and sea-ice permitting) in each research block surveyed. In instances of large Macrourus bycatch, fishing should cease in areas with depths shallower than 1000m (Maschette et al. 2018). Once these minimum requirements for sampling in depth strata are fulfilled, vessels may conduct additional fishing within the research blocks, catch limit permitting. Hence it is anticipated that a combination of stratified and exploratory fishing may occur within each research block.

Calibration/standardisation of sampling gear

A full description of gear configuration (see Section 2d) and deployment is located in the CCAMLR Fishing Gear Library at http://www.ccamlr.org/en/publications/fishing-gear-library. Additional information about longline deployments, such as minimum separation distance and soak time, can be found in the Data Collection Plan for Exploratory Fisheries (Conservation Measure 41-01 Annex 41-01/A). Details on the fishing gears and deployment methods, as well as variables that can be difficult to control (e.g. soak time and percentage of hooks baited), will be recorded so they may be standardised a posteriori.

Proposed number and duration of stations/hauls

Fishing within each research block will include at least 8 longlines in each depth strata, where present, and catch limit and sea-ice permitting (see above). Once these minimum requirements have been met, the vessels will assess sea ice conditions and bycatch rates and may continue sampling within the same research block. Minimum soak time of each set will be 6 hours.

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

A key element of this multi-member research plan is a well-coordinated multi-year tagging program involving repeatedly visiting relatively small areas, and a commitment from all vessels to high tagging performance and to optimising the health of tagged fish.

The research will target toothfish of all sizes in order to meet CCAMLR tagging requirements outlined in Conservation Measure 41-01 Annex C. Only fish in suitable condition according to the CCAMLR Tagging Protocol (https://www.ccamlr.org/en/science/ccamlr-tagging-program) will be tagged and released. Five fish per retained tonne (green weight) will be tagged with two external T-bar tags inserted into the dorsal musculature (CM 41-05 para. 11 and CM 41-11 para. 11). Tag-size overlap will be maintained at > 60%, with an aim to achieve > 80% tag-size overlap.

Other requirements

CTD loggers will be attached from Antarctic Chieftain (AUS), Antarctic Discovery (AUS), Southern Ocean (KOR), Saint André (FRA) and Cap Kersaint (FRA). We propose to continue the use of Star-Oddi CTD loggers (www.star-oddi.com/products/3/salinity-temperature-depth-logger/default.aspx) as well as CTD-SRDL developed at Saint Andrews.

Benthic video cameras (BVCs) will be attached from Antarctic Chieftain (AUS; Figure 2), Antarctic Discovery (AUS)), Saint André (FRA) and Cap Kersaint (FRA) to 50% of their longline sets across all research blocks, or as often as operationally possible.

b) Data collection: types and sample size or quantities of catch, effort and related biological, ecological and environmental data (e.g. sample size by location/haul)

Table 12. Summary of data collection by each participating Member. AUS – Australia; ESP – Spain; FRA – France; JPN – Japan; KOR – Republic of Korea. 'All' means all members who have fished under this research plan.

Data type	Member	Number/size of samples	Collection method/device	Objective
Catch and effort	All	Every longline deployment. All fish will be identified to species where possible, including those lost at the surface.	Catch and effort data will be recorded and reported according to CCAMLR Conservation Measures in force within the proposed SSRUs (summarised in Conservation Measures 41–05 and 41–11).	1–3
Toothfish biological data: Length (cm), weight (kg), sex and gonad stage	All	Target of 50 fish set^{-1}. Fine-scale biological data will be collected and recorded in accordance with Conservation Measures 23–07 and 23–04. KOR will collect samples of muscle tissue (5 fish per 10cm length bin per sex per SSRU), and stomach contents (20 fish per haul), as well as plankton and zooplankton samples, for investigation of trophic relationships and ecosystem function using stable isotope analyses (Objective 4). AUS will also collect up to 5 stomach samples per 5cm length class in SSRU 58.4.2 E which will be used by KOR under Objective 4.	Biological data will be collected using electronic fish measuring board and scales (AUS) or equivalent equipment (ESP, FRA, JPN and KOR). Gonad stage will be determined by visual inspection at sea.	1, 4
Toothfish ageing	All	Target of five otolith pairs per 1-cm length class between 100–200 cm. Otoliths will be collected from all fish < 100 cm.	According to the AAD ageing protocol and/or CCAMLR guidelines.	1
Toothfish tagging	All	Five fish per retained tonne (green weight). In addition, KOR will continue with deployment of archival tags.	T-bar tags in accordance with the CCAMLR Tagging Protocol. One archival tag will be deployed by KOR in Division 58.4.1 during the 2016/17 season.	1
Environmental and habitat data • Depth (m) • Temperature (°C) • Salinity (PSU) • Substrate composition	AUS, FRA, KOR	CTD loggers (AUS, FRA, KOR) and BVCs (AUS and FRA) will be attached to at least 50% of longlines across all research blocks, or as often as operationally possible (i.e.$\geq$ 1 CTD deployment per SSRU by KOR). Seafloor and fished areas will be mapped using vessel-based single-beam acoustics throughout the voyage	CTDs and BVCs attached to fishing gear.	2

• Benthic species composition				
Fish bycatch biological data; Length (cm), weight (kg), sex and gonad stage	All	Target of 50 fish species^{-1} set^{-1} (length (cm), weight (kg), sex and gonad stage) Catches (kg) of VME indicator taxa will be recorded for each longline segment following protocols in Conservation Measures 22-07 and other bycatch following limits set out in 33-03.	Electronic fish measuring board and scales (AUS), or equivalent equipment (ESP, FRA, JPN and KOR). Gonad stage determined by visual inspection at sea.	3
Invertebrates bycatch data	All	Catches (kg) of VME indicator taxa will be recorded for each longline segment following protocols in Conservation Measures 22-07 and other bycatch following limits set out in 33-03. FRA will collect all benthic organisms as specified in Martin et al. (2017).	Standard on-board equipment or according the protocol outlined in Martin et al. (2017) (FRA)	2

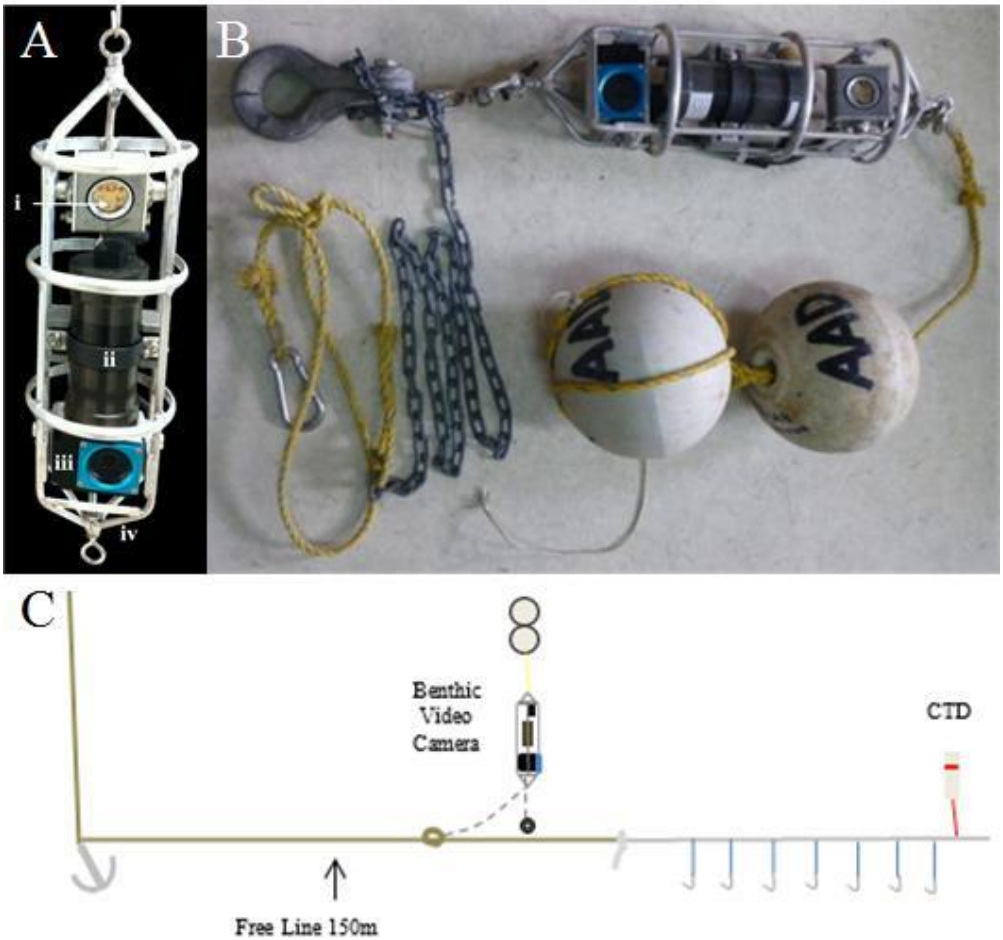


Figure 2. Benthic Video Camera system (panel A) containing light (i), battery housing (ii) and camera (iii) in crash frame (iv); its deployment setup (panel B); and attachment of BVC and CTD units on longlines (panel C). Diagram is not to scale.

(c) Method for data analysis to achieve the objectives in Section 1(a)

Objective 1: Toothfish catch rates, life-history-stage composition and size distributions will be summarized and compared between locations and depth strata. In areas where tagged fish are recovered, a detailed analysis of their movement, growth, and time at liberty will be made. Tagging and recapture data will be used in mark-recapture analyses (e.g. using Petersen tag-recapture models or integrated assessments) to estimate biomass within and across research blocks. Stock assessments for toothfish will utilize the following data:

- Toothfish catch (number and weight)
- Number of tagged and released fish
- Number of recaptured fish
- Catch length and age composition
- Biological parameters including estimates for growth, length-weight relationship, maturity, and natural mortality.

Objective 2: The processing of digital visual footage will be similar to those described in Welsford et al. (2014). Analysis may also be undertaken using computer programs such as *Benthic Video Annotator* (BVA) to derive benthos diversity and abundance counts from both stills and video footage. Spatially-explicit models (e.g. Generalized Linear or Generalized Additive Models) will be used to characterize

the relationships between toothfish relative density and the environmental covariates listed in Table 12, and make predictions of toothfish relative densities in un-fished sites.

Objective 3: Information and models of bycatch composition, species distribution and, catch rates will be updated. Demographic and biological information on the species encountered will provide additional information for assessments of predominant bycatch species.

Objective 4: Trophic transfers from organic-matter sources to higher trophic levels will be traced using stable isotope ratios and fatty acid profiles. This will include investigation of trophic relationships between *D. mawsoni* and its prey, and subsequent biomarker analyses, to better understand carbon-energy transfer throughout Antarctic ecosystems.

(d) How and when will the data meet the objectives of the research? (e.g. lead to a robust estimate of stock status and precautionary catch limits). Include evidence that the proposed methods are highly likely to be successful

This research plan aims to provide a comprehensive evaluation of existing management arrangements for toothfish in Divisions 58.4.1 and 58.4.2, and updated advice on precautionary catch limits as appropriate in 2022. In addition, environmental data will contribute to models of toothfish habitat use following surveys in 2021/22. It is also expected that data collected up to 2021/22 will allow for an updated assessment of spatial and depth distributions and comparison of relative densities between areas for predominant bycatch species.

The methods are likely to be successful based on the well-established fishing methods and sampling approaches already in place in Divisions 58.4.1 and 58.4.2, and Subareas 88.1 and 88.2. The notified vessels have extensive experience with these methods and their implementation in the Southern Ocean. Further, the research providers have a good track record of delivering science that informs management advice in CCAMLR.

BVC systems have been developed and successfully deployed in Division 58.4.1 during the 2015/16 and 2016/17 seasons. Similar devices have been deployed successfully on longlines during commercial and research fishing activities at Heard Island and McDonald Islands, and BANZARE Bank (see Welsford et al. 2014). Data from these recordings readily enabled the identification and enumeration of benthic invertebrates, and were utilized in assessments of fishing impacts on benthic habitats. More recently, WG-SAM-16/34 reported on environmental and video data collected in Division 58.4.1 by the FV Antarctic Discovery (AUS) in 2015/16. This video footage indicated that the seafloor of 15 surveyed locations consisted of soft sediments or cobbles with low densities of VME indicator organisms. Motile fauna, including squids, fish and echinoderms were also recorded. Thus the video technologies needed for Objective 2 have been demonstrated to be successful.

The employment of crew who are experienced in ice navigation and vessel handling will ensure that the vessels do not enter into areas beyond their ice classification. Fishing surveys have been planned with consideration of recent sea ice concentrations across the area using Passive Microwave Data (from Nimbus-7 Scanning Multichannel Microwave Radiometer [SMMR] and Defence Meteorological Satellite Program Special Sensor Microwave/Imager-Special Sensor Microwave Imager Sounder [DMSP SSM/I-SSMIS]) (Cavalieri et al. 1996), and detailed ice and weather forecasting from the Antarctic Climate and Ecosystem Cooperative Research Centre (based in Hobart). Based on spatio-

temporal overlap between historical sea ice concentrations and fishing activities, a threshold of 25% sea ice cover indicated the transition from fished to non-fished conditions. This threshold is much lower than the 60% used in the Ross Sea (Parker et al. 2014) due to the much harder and thicker sea ice found in this area. Based on these data, research blocks in Divisions 58.4.1 and 58.4.2 typically become accessible to longline fishing from January to April (Figure 11, Appendix A). This generalisation is supported by exploratory fishing experience in Division 58.4.1 and 58.4.2 during the 2016/17 (WG-FSA-17/17r1) and 2017/18 (in preparation) fishing seasons.

4. Proposed catch limits

(a) Proposed catch limits and justification. (Note that the catch limits should be at a level not substantially above that necessary to obtain the information specified in the Research Plans and required to meet the objectives of the proposed research.)

The proposed catch limits for each fishing season will be those set annually by CCAMLR based on updated local biomass estimates.

We propose to adopt a similar approach to research catch allocation among CCAMLR Members to that adopted by the Commission in 2015, 2016 and 2017 (e.g. SC-CAMLR-XXXVI, para 3.118); and set out in WG-FSA 15/54). Allocations of catch limits among members for the 2018/19 season will be discussed during the 2018 meetings in conjunction with the updated local biomass estimates.

The actual catch taken will be influenced by factors such as operational restrictions, macrourid by-catch limits, and sea-ice conditions. The allocation system in place to distribute initial catch shares between the research proponents in this area guarantees an agreed catch proportion in a research block, but can also lead to the catch limit not being taken in a research block.

We propose that notifying Members will confirm whether they intend to pursue research by SC CIRC by 1st January 2019. If any Member is not able to confirm that they will pursue research, their allocation will be evenly redistributed amongst the other notifying Members that have confirmed they will pursue research. If any Member has not commenced research activities by 1st February 2019, their allocation will also be evenly redistributed amongst the Members that have commenced research activities, or by another means agreed by all of members that have commenced research activities.

(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 is not expected to have an additional impact on stock status. The catch allocations referenced in Section 4a will be based on revised catch limits which are designated to provide reasonable assurances against negative impacts on stock status, consistent with the objective of CCAMLR and a precautionary approach.

Evaluation of timescales involved in determining the responses of harvested, dependent and related populations to fishing activities

Conditional upon CCAMLR review, survey and tag-recovery fishing from 2018/19 to 2021/22 will provide information on the biomass present in fished areas, and estimated long-term population responses to fishing activities.

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

IUU fishing activities have been recorded in Divisions 58.4.1 and 58.4.2 (SC-CAMLR 2015a,b). Evidence of IUU presence or activity continues to be recorded however no recent estimates of IUU toothfish catch exist.

CCAMLR-XXXVI/28 Rev. 2 provided information on IUU activity, including in Division 58.4.1. Catch data obtained by Spain from three IUU-listed vessels, the *Asian Warrior, Zemour 1* and *Zemour 2* operating in Division 58.4.1 in 2014. This data is likely to represent typical IUU fishing activity in Division 58.4.1 since 2004, when the vessels were first sighted, until 2015. Analyses of this data, including investigation of its utility for estimating total IUU removals for East Antarctica (WG-FSA-17 paragraph 2.16), will be presented to WG-FSA-18.

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

Based on previous catches in Divisions 58.4.1 and 58.4.2, we anticipate the most common bycatch species group to be *Macrourus spp.* (SC-CAMLR 2014a,b). Other bycatch may include:

- *Channichthyidae*
- *Muraenolepis* spp.
- *Rajiformes*
- *Antimora rostrata*
- *Notothenidae*
- *Pogonophryne* spp.

The proposed research will maintain strict compliance with conservation measures regarding bycatch (CMs 41-05, 41-11 and 33-03) and the protection of seabirds and marine mammals (CMs 41-05, 41-11 and 25-02). Previous cases of seabird and mammal mortalities in Divisions 58.4.1 and 58.4.2 have involved the southern giant petrel (*Macronectes giganteus*), sooty shearwater (*Puffinus griseus*) and leopard seal (*Hydrurga leptonyx*; SC-CAMLR 2014a,b); however no seabird or mammal mortalities have been reported since 2005 (SC-CAMLR 2017a,b).

Previously, two VMEs and no VME risk areas, have been identified in Division 58.4.1, and no fishing will occur in those VMEs identified in CM-22-09 Annex 22-09/A. VME-related data will be collected and notified in accordance with Conservation Measure 22-06. All registered and newly discovered vulnerable marine ecosystems (VMEs) will be avoided during fishing operations in accordance with Conservation Measure 22-07. Bycatch data and underwater video footage collected in Division 58.4.1 have been examined for the presence of vulnerable marine ecosystem (VME) indicator species, and these data have not lead to the identification of new VMEs (Maschette et al. 2017).

5. Research capability

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

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(b) Number of scientists and crew to be on board the vessel

Each vessel will carry at least two scientific observers, one of whom shall be appointed in accordance with the CCAMLR Scheme of International Scientific Observation. The other will be an observer appointed by fisheries management body/s of the Members participating in this research.

(c) Is there opportunity for inviting scientists from other Members? If so, indicate a number of such scientists

There is no space available for scientists from other Members aboard the fishing vessels.

(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 nominated vessels and on-board scientific observers have the resources and capability to fulfil all obligations of the proposed research plan. For example, the vessels (listed in Section 2b) are equipped with the fishing gear and all other facilities required to conduct this research in accordance with relevant conservation measures; as well as communication systems that allow direct telephone, fax, email and internet communication between the vessel and observer coordinators and fishery scientists. The nominated vessels and fishing companies are experienced operating in CCAMLR fisheries, including in Divisions 58.4.1 and 58.4.2.

Both Australian fishing vessels Antarctic Discovery (seasons 2015/16, 2016/17 and 2017/18) and Antarctic Chieftain (2017/18) have experience participating in research in Division 58.4.1 or 58.4.2. Australian Longline Pty Ltd (ALPL) has a long history of high compliance and reporting performance in CCAMLR fisheries, including exploratory toothfish fisheries. In 1997, ALPL entered the Heard Island and McDonald Islands (HIMI) fishery (Division 58.5.2) and has subsequently operated three vessels in the HIMI fishery (including the *Antarctic Chieftain* from 2009–2014). In 2007/08, *Janas* successfully conducted a random stratified longline survey to collect data on the relative abundance of toothfish and bycatch species across the entire fished area of the BANZARE Bank (Division 58.4.3b) while flagged to Australia. The information collected on this voyage revealed the importance of BANZARE Bank as a spawning ground for *D. mawsoni* (Welsford et al. 2008), since reinforced by data collected by Japan; and supported the hypothesis that the population in the area was likely to have been depleted by a combination of IUU and exploratory fishing (McKinlay et al 2008).

The fishing vessel *Le Saint-André* (France) has conducted exploratory fishing in Divisions 58.4.3a and 58.4.4b since 2012/13, in 58.4.2 since 2016/17 and in 58.4.1 in 2017/18. The fishing vessel *Cap Kersaint* (France) operated along *Le Saint-André* in toothfish fisheries in 58.6 and 58.5.1 (French EEZ). The Muséum National d'Histoire Naturelle (MNHN) has previously planned and carried out four scientific surveys of the toothfish stock (POKER) around the Kerguelen Islands in Division 58.5.1. The MNHN has developed stock assessments for *D.* eleginoides in Division 58.5.1 and in the vicinity of Crozet Islands (part of Subarea 58.6) using CASAL.

The fishing vessel *Shinsei maru No. 3* (Japan) has conducted exploratory fishing in these Divisions in three seasons since 2008/09. The National Research Institute of Far Seas Fisheries of Japan is developing formal collaborations with colleagues from New Zealand to consolidate its experience in toothfish aging.

The fishing vessel *Southern Ocean* (Republic of Korea) replaced the *Kingstar* in the 2017/18 season. The National Institute of Fisheries Science (NIFS) of Republic of Korea is developing formal collaborations with colleagues from New Zealand to consolidate its experience in toothfish aging, analyses of archival tag data, and stock assessment using CASAL.

The fishing vessel *Tronio* (Spain) has conducted exploratory fishing in Divisions 58.4.1 and 58.4.2 in five seasons since 2012/13. It has fished in Division 58.4.1 from 2006, always in compliance with conservation measures. Researchers of the Spanish Institute of Oceanography (IEO) have collaborated with CCAMLR since 1986 when a Spanish Scientific Survey was conducted on the Scotia Arc and Antarctic Peninsula. Currently a program on otolith aging is underway, as well as molecular analysis for species identification.

6. Reporting for evaluation and review

(a) List of dates by which specific actions will be completed and reported to CCAMLR. If the research is a stand-alone survey, Members shall commit to providing a progress report to WG-FSA and/or WG-EMM for review and comment and a final report within 12 months of completion of the research to the Scientific Committee

A list of dates by which specific actions will be completed and reported to CCAMLR is provided in section 1b. A final report will be provided to WG-FSA in 2022, which will contain a comprehensive evaluation of existing management arrangements and updated advice on precautionary catch limits as appropriate.

(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

Following each season of data collection, a progress report will be submitted to WG-SAM and WG-FSA that addresses how the research is meeting objectives and whether any changes are required to research plans (details in section 1b).

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Appendix A

We propose to review the locations of research blocks based on WG-SAM-11 para. 2.40. WG-SAM-11 recommended three themes to be considered for the designation of research areas in data-poor fisheries. Here, we present data that could be used to evaluate the suitability of geographic areas for research against these themes.

(a) The area should be chosen with a reference to the stated objective of the research

Objective 1: Collect fisheries and biological data to inform an assessment of the status and productivity of toothfish stocks in Divisions 58.4.1 and 58.4.2.
Tagging data is an important input in CCAMLR's approach to toothfish stock assessments. To identify areas with the highest probability of tag recaptures, the number of tagged fish in each research block in year *t* can be estimated using the equation in WG-SAM-11 para. 2.42:

$$Tt = X_{t-1}\,C_{t-1}\,(1 - M_x)\,(e^{-\lambda})\,(e^{-M})$$
$$+ X_{t-2}\,C_{t-2}\,(1 - M_x)\,(e^{-2\lambda})\,(e^{-2M})$$
$$+ X_{t-3}\,C_{t-3}\,(1 - M_x)\,(e^{-3\lambda})\,(e^{-3M})$$
.... etc.

where T_t = tagged fish in year *t*
X_t = tagging rate (fish per tonne) in year *t*
C_t = (catch) in year *t*
M_x = tagging mortality
λ = annual tag loss rate approximation
M = natural mortality.

This equation does not include emigration, and therefore assumes that tagged fish do not move large distances. Although some tagged and recaptured *D. mawsoni* have undertaken long-distance movements, there majority of recaptured individuals remained in the vicinity where they were tagged (WG-FSA-17/06). The estimated numbers of tagged fish available in 2018/19, released from 2010-2018, are shown in Figure 3, and total numbers of recaptures from 2010-2018 are shown in Figure 4. Year 2010 was chosen as the start year based on advice of WG-FSA-15 (para 5.22).

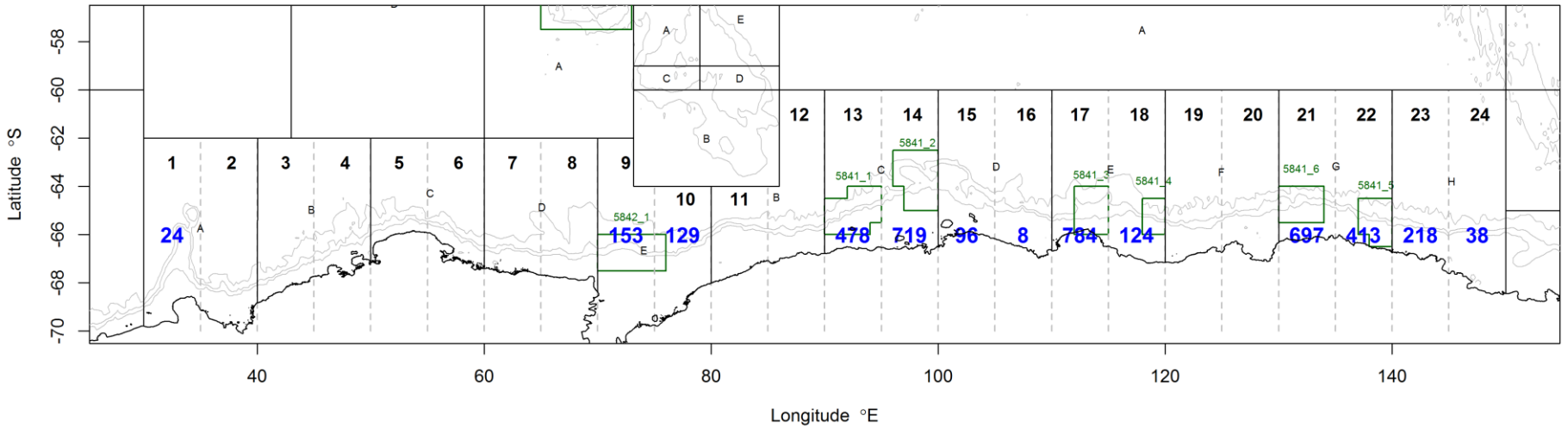

Figure 3. Estimated number of tags available in the 2018/19 fishing season (blue text) estimated using the equation in WG-SAM-11 para. 2.42. Black lines = SSRU boundaries, green lines = research block boundaries, grey dashed lines = areas considered in the review of research locations.

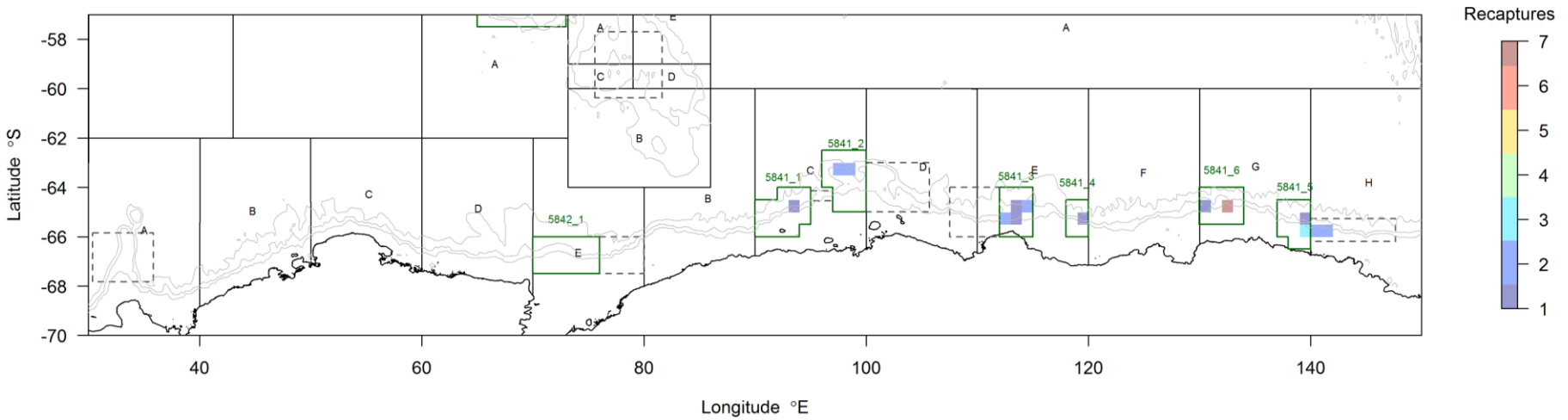

Figure 4. Number of tag recaptures from 2010-2018. Black lines = SSRU boundaries, green lines = research block boundaries, grey dashed lines = areas outside of research blocks with tag releases between 2010 and 2018.

Objective 2: Collect and utilise environmental data to inform spatial management approaches for the conservation of toothfish, bycatch species and VMEs.

Stock delineation and functioning is an important consideration for the development of spatial management approaches. Yates et al. (2017) used generalised additive mixed models to characterise relationships between environmental variables and (1) relative density, (2) mean weight, and (3) proportion mature of *D. mawsoni*; across Divisions 58.4.1, 58.4.2 and 58.4.3b. Considerable spatial heterogeneity in mean weight and maturity indicated that *D. mawsoni* are not randomly distributed across East Antarctica (Figure 5, Figure 6), and these results were used to refine hypotheses regarding stock structure and function. It has been hypothesised that spawning fish on BANZARE Bank originate from nearby locations along the slope and shelf, especially Prydz Bay (Welsford et al. 2008, Taki et al. 2011, Welsford 2011). Individuals of macroscopic gonad stage ≥ 3 were considered to have the potential to spawn during the season in which they were sampled (Yates et al. 2018). Therefore the predicted proportions of mature fish were used to investigate potential spawning areas. The majority of fish were in spawning condition on Gunnerus Ridge (SSRU 58.4.2A), BANZARE Bank (Division 58.4.3b) and two northward protrusions of fished depths within SSRUs 58.4.1C–D and 58.4.1E (Figure 5), providing additional evidence these may be important spawning areas. One of these putative spawning areas is within an existing research block, i.e. 5841_2 in SSRU 58.4.1C.

The models for relative density, mean weight and proportion mature used by Yates et al. (2017) are based on data sampled by fishing vessels and extrapolated into un-sampled areas. These, in some areas extensive, data gaps can introduce large uncertainty in predicting biological features and catch rates.

Objective 3: Collect data on the spatial and depth distributions of bycatch species, and inform bycatch mitigation measures.

Maschette et al. (2017) proposed to concentrate fishing effort to a depth range with the highest ratio of target to bycatch species, i.e. 1000 - 1700 m, in areas with large amounts of bycatch (Figure 7).

VMEs have been notified in SSRU 58.4.1H, adjacent to research block 5841_5 and fishing should be avoided in this area (CM-22-09 Annex 22-09/A).

Objective 4: Improve the understanding of trophic relationships and ecosystem function to assist the development of ecosystem-based fisheries management approaches.

Sampling across a range of locations and toothfish bode size and life-history stages will be important as reflected in Objectives 1-3.

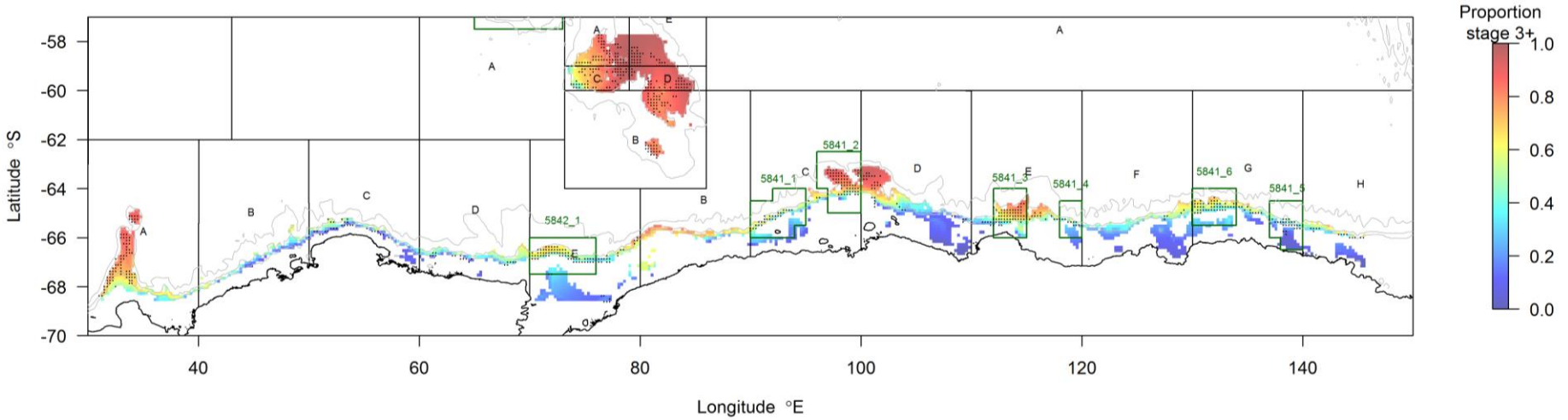

Figure 5. Predicted proportions of fish with maturity stage ≥ 3, from WG-FSA-17/16. Black lines = SSRU boundaries, green lines = research block boundaries.

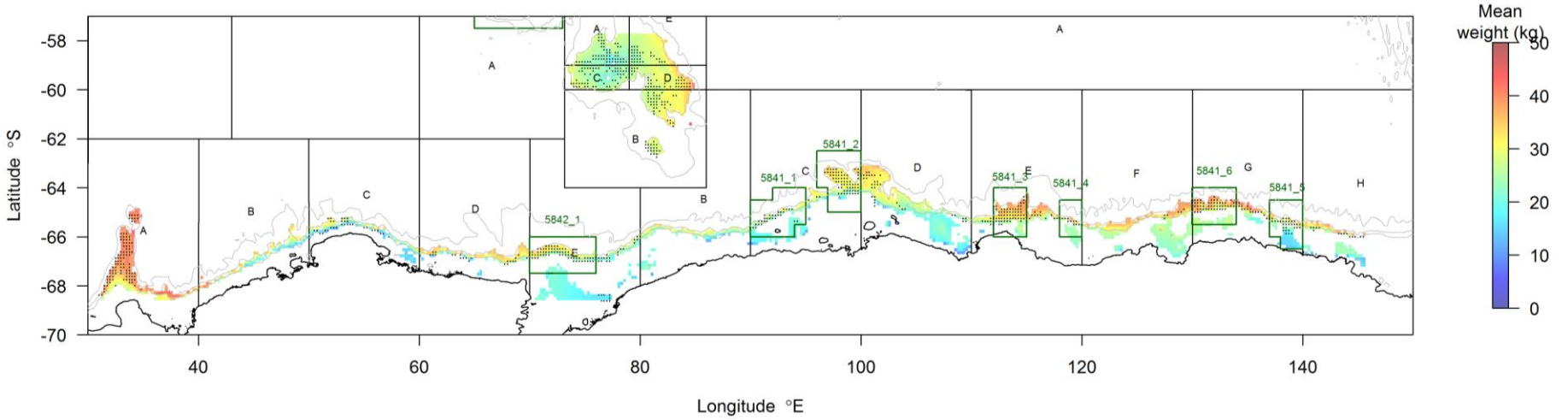

Figure 6. Predicted mean individual weight (kg), from WG-FSA-17/16. Black lines = SSRU boundaries, green lines = research block boundaries.

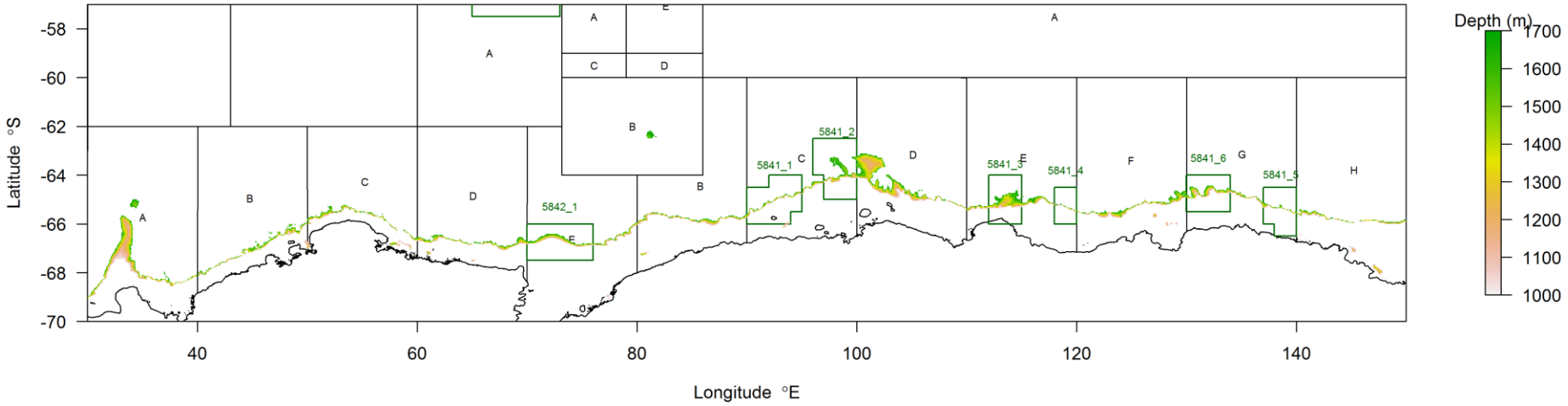

Figure 7. Distribution of depths between 1000 and 1700 m with the highest ratio of target to bycatch species (Maschette et al. 2017). Black lines = SSRU boundaries, green lines = research block boundaries.

(b) Priority areas include those where catch rates indicate that a viable toothfish fishery may be present depending on catch rates, catch history and size of fishable seabed areas

Data on predicted catch rates (Figure 8), catch history (Figure 9), previous fishing effort (Figure 10), and sea ice accessibility (Figure 11) can be used to evaluate the viability of fishing areas. The distribution of seabed areas within a depth range identified as (a) accessible to longline fishing, and (b) having high ratio of target to bycatch catch rates is provided in Figure 8.

(c) Consideration should also be given to the likely role of a particular SSRU in the plausible stock hypothesis (i.e. is it only juveniles in the area?)

Outputs for the consideration of the likely role of areas in the stock hypothesis are presented under section (a).

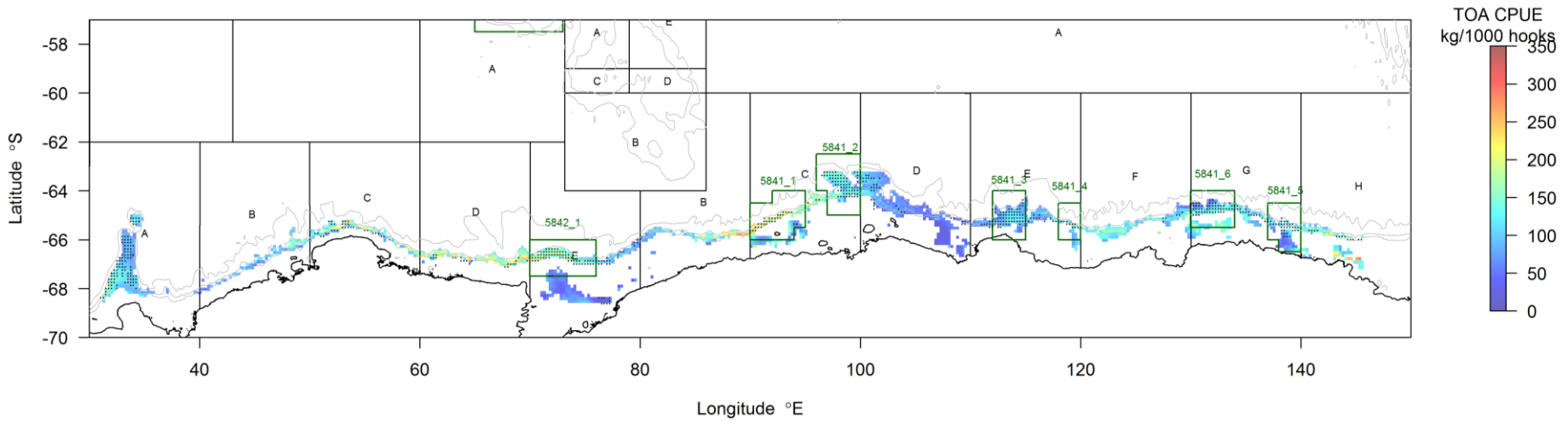

Figure 8. Predicted TOA CPUE from WG-FSA-17/16, based on data from 2003-2017. Black lines = SSRU boundaries, green lines = research block boundaries.

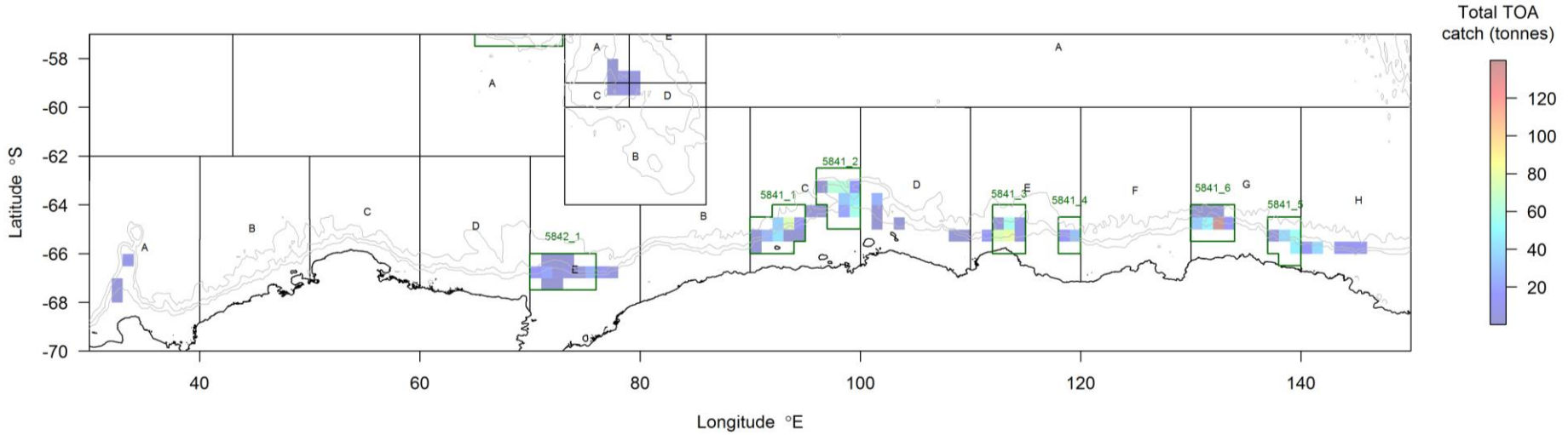

Figure 9. Total toothfish removals (t) between 2010 and 2018. Black lines = SSRU boundaries, green lines = research block boundaries..

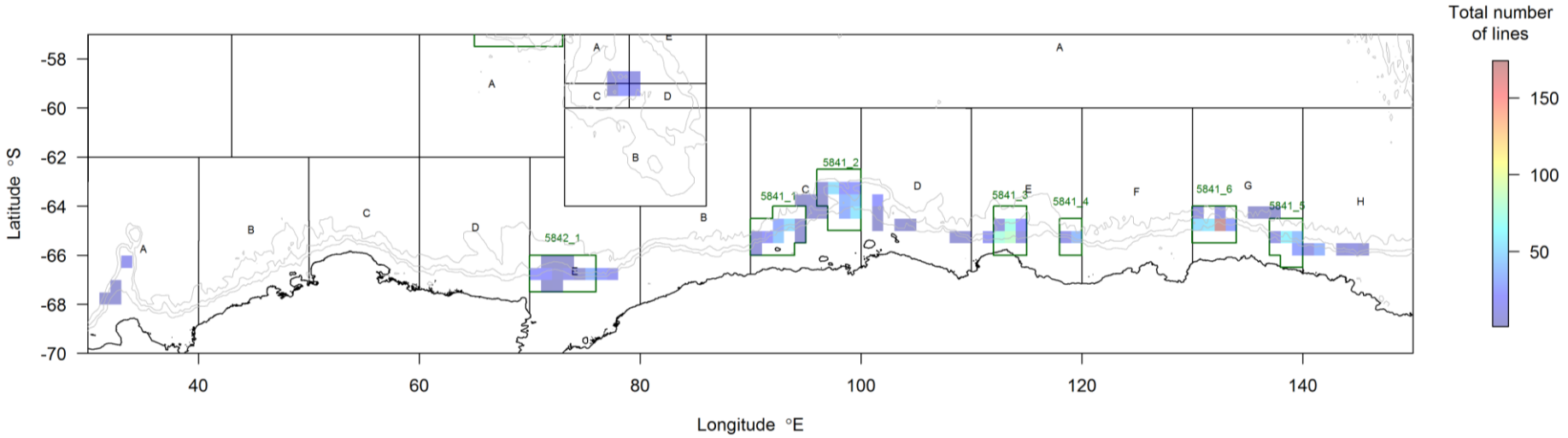

Figure 10. Distribution of fishing effort between 2010 and 2018. Black lines = SSRU boundaries, green lines = research block boundaries.

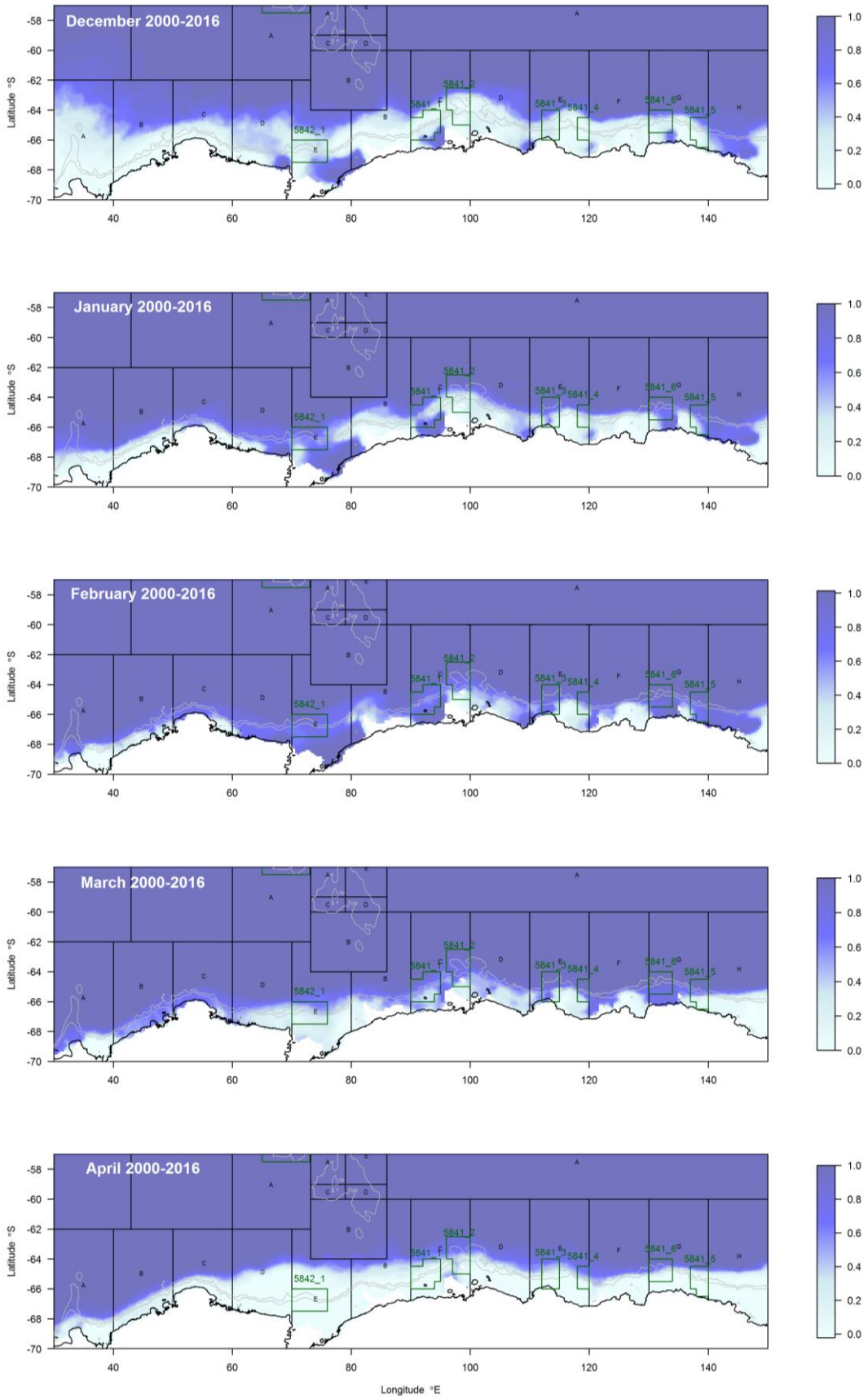

Figure 11. Proportion of years from 2000–2016 with sea ice cover. < 25% during December, January, February, March and April, respectively. Research blocks in Divisions 58.4.1 and 58.4.2 typically become accessible to longline fishing during January to April. Sea ice data are from Cavalieri et al. (1996). Bathymetric contours (GEBCO; grey lines) are for 2000 and 1000 m.

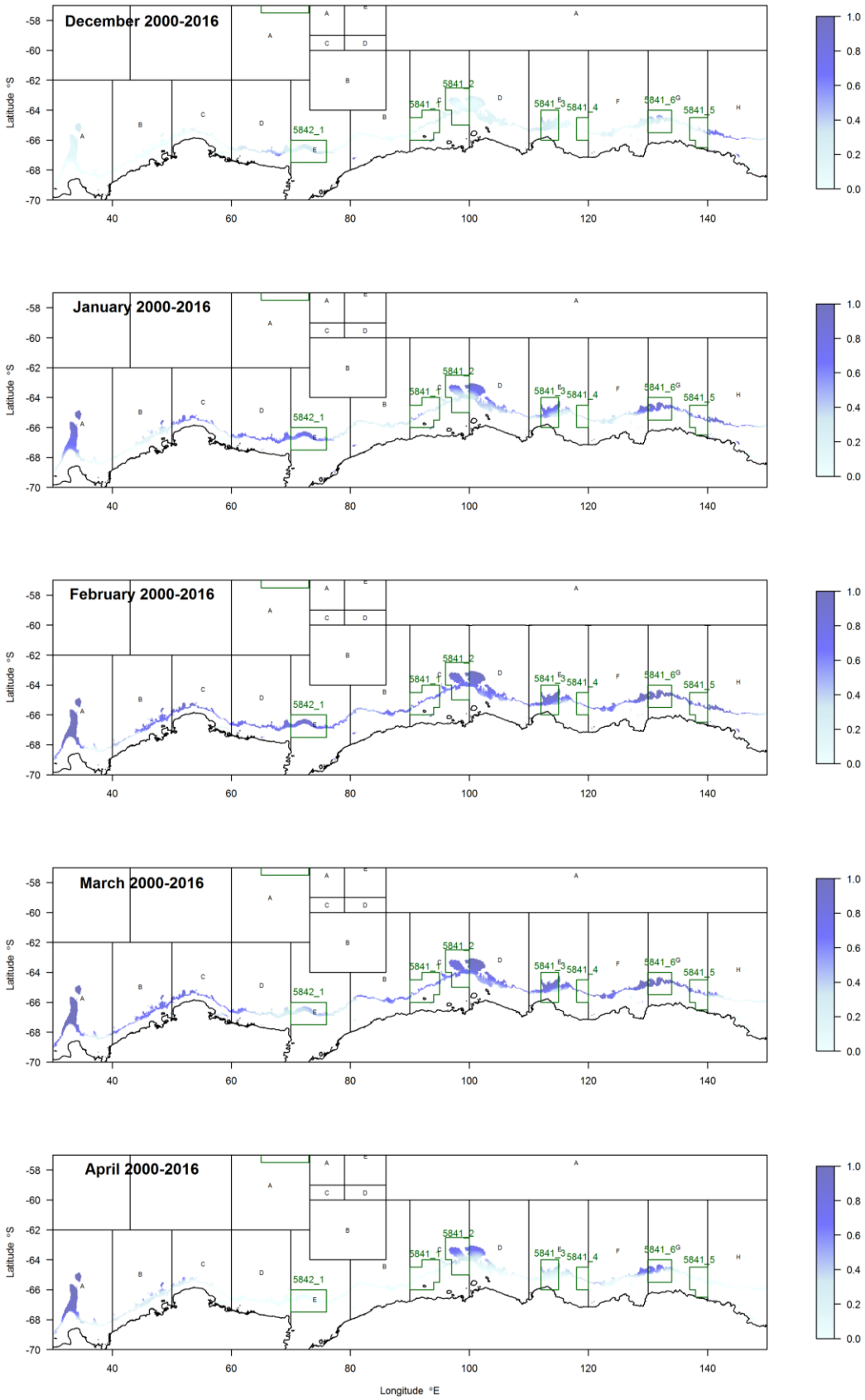

Figure 12. Proportion of years from 2000–2016 with sea ice cover. < 25% during December, January, February, March and April, respectively. This is the same ice data as in Figure 11, however it is cropped to areas with depths between 1000-2000 m to aid in visual interpretation of ice conditions in potential fishing areas. Sea ice data are from Cavalieri et al. (1996).