Annex 9

Report of the Working Group on Fish Stock Assessment
(Hobart, Australia, 10 to 20 October 2022)

Contents

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Opening of the meeting

1.1 The 2022 meeting of the Working Group on Fish Stock Assessment (WG-FSA) was held in Hobart, Australia, from 10 to 20 October 2022. While registered participants were able to follow the meeting online through Zoom, only participants who were present in the room were able to directly contribute to the meeting and comment on report text.

1.2 The Convener, Mr S. Somhlaba (South Africa) welcomed the participants (Appendix A). He encouraged the discussions of the Working Group to be based on testable scientific hypotheses to ensure that, where participants held alternative views or perspectives, these could be debated using sound scientific principles.

1.3 Dr D. Agnew (Executive Secretary) welcomed all participants to the CCAMLR Secretariat. He looked forward to the seeing the outcomes of the meeting being presented to the Scientific Committee and the Commission and hoped that everyone would also have an opportunity to enjoy the spring weather in Hobart.

Adoption of the agenda

2.1 The Working Group reviewed, made minor reorganisations, and adopted the agenda (Appendix B).

2.2 Documents submitted to the meeting are listed in Appendix C. The Working Group thanked all authors for their valuable contributions to the work presented to the meeting.

2.3 The Working Group considered that with the return to rapporteuring and report development by delegates for in-person meetings, that the process should also revert to the usual practice of providing draft text within 24 hours of the close of an agenda item, while recognising that some topics may require additional time.

2.4 In this report, paragraphs dealing with advice to the Scientific Committee and other working groups have been highlighted. These paragraphs are listed under Item 9.

2.5 The report was prepared by J. Cleeland (Australia), C. Darby (UK), D. De Pooter (Secretariat), A. Dunn (New Zealand), T. Earl (UK), M. Eléaume (France), I. Forster (Secretariat), C. Jones (USA), D. Maschette (Australia), C. Miller (Australia), S. Parker (Secretariat), G. Robson (UK), S. Thanassekos (Secretariat) and P. Ziegler (Australia).

Review of data available

Catch limit management

3.1 The Working Group noted SC-CAMLR-41/BG/01 which presented a brief overview of catches of target species from directed fishing on toothfish, icefish and krill in the Convention Area in the 2020/21 and 2021/22 seasons, and from research fishing under Conservation Measure (CM) 24-05.

3.2 CCAMLR-41/BG/04 presented a summary of all fishery notifications for research fisheries, exploratory fisheries for toothfish and krill fisheries the Secretariat had received for the 2022/23 fishing season. Full details are available to authenticated users through the CCAMLR website (www.ccamlr.org/fishery-notifications).

3.3 The Working Group welcomed this contribution and noted that from the 2017 season onward it became mandatory for vessels to provide gear type in notifications. The Working Group requested the Secretariat determine the gear type used by vessels prior to 2017, where the gear type information was not yet required, and include that in future reports.

3.4 CCAMLR-41/BG/12 presented a comparison between the *Dissostichus* spp. Catch Documentation Scheme (CDS), and monthly fine-scale catch and effort data from the 2002/03 to 2020/21 fishing seasons. The analysis showed that for all seasons, the weight of the landings reported in the CDS data differed less than 5% from the weight of the catches reported in the catch and effort data, with differences in most seasons being less than 1%. The paper noted that the comparison was more complicated for the 2016/17 to 2020/21 seasons because some of the CDS documents issued for catches from the Ross Sea region incorrectly allocated catches from Subareas 88.1 and 88.2 into the respective other subarea.

3.5 The Working Group welcomed this contribution and noted that in cases where vessels use the catch and effort data to complete CDS documentation, the comparison is expected to show little difference, while in cases where the CDS documentation is prepared based on port inspections, the weight reported in the CDS data could be 1–3% lower because of the effects of dehydration caused by the freezing process.

3.6 The Working Group requested that the Secretariat review whether the difference thresholds of 10% and 200 kg weight are appropriate to identify where reconciliation is needed. For this purpose, a comparison between the variance in the percentage difference and the weight difference would help identify appropriate thresholds. Additionally, the Working Group requested the Secretariat to report on the efforts undertaken to reconcile data where this threshold was exceeded.

3.7 CCAMLR-41/16 Rev. 1 presented a summary of information held by the Secretariat in relation to illegal, unreported and unregulated (IUU) fishing in 2021/22 relevant to CCAMLR as well as unidentified gear retrieved from October 2021 to August 2022, including proposed updates, amendments, inclusions and removals from IUU vessel lists.

3.8 The Working Group welcomed this contribution and noted the limited ability to identify IUU fishing activities in the Convention Area. The Working Group expressed concern regarding the potential magnitude of IUU fishing activities in Division 58.4.1 and noted that historically, there were numerous reports of suspected IUU fishing activity in the area, but that

IUU activity could not be assessed in recent years due to a lack of reports as no directed fishing has been allowed since 2018. It noted that estimating removals due to IUU fishing was critical to the provision of scientific advice and encouraged exploration of options to better assess IUU fishing.

3.9 The Working Group considered methods, including the marking of fishing gear using radio-frequency identification tags, to ascertain whether gear found belonged to the legal fishery, which would help improve estimates of IUU fishing activity. The Working Group recalled previous discussions on this topic (CCAMLR-XXXVII, paragraph 3.30) and recalled that the 'Unidentified fishing gear in the Convention Area' e-group has been created to address this issue. The Working Group requested that the Secretariat reinitiate efforts to develop improved methods of gear marking, including renewed use of the e-group and encouraged Members to participate in discussions on this topic in the e-group.

3.10 WG-FSA-2022/05 detailed the circumstances of catch limit overruns for toothfish fisheries in Subareas 88.1 and 88.2 and krill fisheries in Subarea 48.1 from the 2017/18 to the 2021/22 season.

3.11 The Working Group welcomed the paper and noted that the algorithm for forecasting toothfish closures was generally working well as demonstrated by the low number of catch limit overruns, which in most cases were small as well. It noted that overruns in small-scale research unit (SSRU) 882H in the 2020/21 and 2021/22 seasons were over 20% and discussed the characteristics of fishing operations in that particular area (see also paragraph 3.26).

3.12 The Working Group noted that high catch variability among lines reduced the ability to forecast catches. The Working Group considered whether the accuracy of the forecasting algorithm would improve by reducing the number of fishing vessels or by limiting the number or length of lines in the water as catches approach the catch limit.

3.13 The Working Group noted that in SSRU 882H in the 2022 season, due to reporting issues, the reported catch had been adjusted twice for a vessel after the fishery closure (SC CIRC 22/87). While the tagging rate fluctuated through time in the area, the overall tagging rate for the vessel in question was above the required 3 fish per tonne for that season.

Management of krill fishery catches

3.14 WG-FSA-2022/06 presented an analysis of the risk (probability) of exceeding catch limits in the krill fishery using daily catch reporting and compared it with the risk of exceeding catch limits using the current practice of five-day catch reporting.

3.15 The Working Group welcomed this contribution and noted that the potential future catch limit overruns would be reduced if catches were reported daily instead of every five days. The Working Group noted the increased workload associated with daily catch reporting and considered the possibility of transitioning during the season from five-day reporting to daily reporting as catches approached the catch limit. It also noted that this issue should be considered while accounting for the different fishery dynamics between subareas, and that discussion of this issue was pertinent to the revision of the krill fishery management approach where small catch limits could be assigned to some areas.

Ross Sea region toothfish

3.16 WG-FSA-2022/49 presented a summary of the fishing catch and fishing effort in the Ross Sea region (Subarea 88.1 and SSRUs 882A–B) together with biological characteristics of the catch of Antarctic toothfish (*Dissostichus mawsoni*) through the 2021/22 fishing season.

Ross Sea Data Collection Plan Workshop

3.17 WG-FSA-2022/44 presented the report on the Workshop on the Ross Sea Data Collection Plan (WS-RSDCP), which was held online on 11 and 12 August 2022 (Appendix D).

3.18 The Working Group thanked the Co-conveners for the useful workshop and noted it demonstrated the advantages of Member collaborations in the Convention Area.

3.19 WG-FSA-2022/46 presented a review of the management of the Ross Sea toothfish fishery and progress made under the 2014 medium-term research plan (MTRP), and WG-FSA-2022/45 presented proposals for an MTRP and data collection plan for the Ross Sea region for the next 5 to 7 years.

3.20 The Working Group thanked the proponents for their comprehensive data collection plan and noted that the list of tasks highlighted the need for funding to support the analysis of data and samples to be collected under the plan, potentially from all Members involved. The Working Group discussed the need for the establishment of protocols pertaining to this data collection plan with support from the Secretariat, and noted that the sampling protocols had been submitted to the meeting to assist the Secretariat in any modifications needed to the observer manual.

3.21 The Working Group considered a reformatted version of the proposed RSDCP (WG-FSA-2022/46, Table 1), with all proposed baseline data collection items separated into one table (Table 1) and all research items proposed to be undertaken in a voluntary manner in a second table (Table 2).

3.22 The Working Group recommended that the Scientific Committee endorse the RSDCP to commence for the 2023/24 to 2027/28 fishing seasons, as outlined in Tables 1 and 2.

3.23 The Working Group recommended that Members and the Secretariat work together intersessionally to finalise the required sampling protocols to enable data collection under the RSDCP prior to WG-SAM-2023.

3.24 The Working Group recommended that additional voluntary data collection approaches be undertaken by Members during the 2022/23 fishing season in the lead-up to the initiation of the RSDCP in the following season. Several voluntary data collection approaches were suggested, including:

- (i) verification of appropriate conversion factor sampling rates (paragraphs 8.18 and 8.20)
- (ii) collection of skate biological sampling and caudal thorns from tag recapture sampling.

Amundsen Sea toothfish

3.25 WG-FSA-2022/50 presented a summary of the toothfish fishery and tagging program in the Amundsen Sea region until the 2021/22 season. The paper proposed a workshop be held on age determination and aggregation of age data for *Dissostichus* spp. and recommended that an age database should be implemented by the Secretariat (paragraph 4.18). The paper also proposed the development of a structured fishing approach to support the development of a stock assessment for the region.

3.26 The Working Group welcomed these papers and noted that in the northern Amundsen Sea region (SSRU 882H) the fishery has become increasingly spatially contracted onto fewer seamounts, which has previously led to decreasing catch limits for this area and further spatial contraction of fishing.

3.27 The Working Group recommended that the Scientific Committee consider mechanisms to revise the management of the fishery in SSRU 882H as outlined in Table 3 and highlighted the practicality of option 3 in Table 3 where structured fishing with research hauls on several seamounts would precede the Olympic fishery. The Working Group also noted that delaying the start of the fishery by two weeks would help increase the number of seamounts available to the fishery as the sea-ice coverage would be reduced.

3.28 The Working Group discussed the rate of fish movement between Subareas 88.1 and 88.2, as well as between northern and southern areas, as indicated by tagging data, and noted that more information on movement of fish between areas was needed to adequately quantify such migrations to better understand stock structure.

3.29 The Working Group noted that many otolith samples from SSRUs 882C–H are yet to be analysed and recommended that Members participating in the fishery should coordinate fish ageing of around 300 fish from each of SSRU 882H and the southern research blocks in each season. The Working Group noted the benefits of establishing a single group for conducting fish ageing for multiple Members, which could result in improved consistency in ages and more progress in processing and reading otoliths.

Fish stock assessment and management advice

Icefish (*Champsocephalus gunnari*)

Assessment of *C. gunnari* in Subarea 48.3

4.1 The fishery for mackerel icefish (*Champsocephalus gunnari*) in Subarea 48.3 operated in accordance with CM 42-01 and associated measures. In 2021/22, the catch limit for *C. gunnari* was 1 457 tonnes. Details of this fishery and the stock assessment of *C. gunnari* are contained in the Fishery Report (https://fisheryreports.ccamlr.org/).

4.2 The Working Group noted that in recent years fishery effort has decreased in Subarea 48.3 and that this had resulted in very low catches by the fishery.

Management advice

4.3 The Working Group agreed that the catch limit for *C. gunnari* in Subarea 48.3 of 1 708 tonnes for 2022/23, as specified in CM 42-01, remain in place.

Assessment of *C. gunnari* in Division 58.5.2

4.4 The fishery for *C. gunnari* in Division 58.5.2 operated in accordance with CM 42-02 and associated measures. In 2021/22, the catch limit for *C. gunnari* was 1 528 tonnes. Details of this fishery and the stock assessment of *C. gunnari* are contained in the Fishery Report (https://fishdocs.ccamlr.org/FishRep_HIMI_ANI_2021.pdf).

4.5 The results of a random stratified trawl survey in Division 58.5.2 undertaken during April 2022 were summarised in WG-FSA-2022/07. The survey recorded the highest catch of *C. gunnari* in the survey time series at 71 tonnes.

4.6 The Working Group noted that estimates of assessed by-catch were within the range of abundance observed in previous surveys. The composition of skates showed a difference to previous years, with an increased number of Eaton's skate (*Bathyraja eatonii*) and a decreased number of Murray's skate (*B. murrayi*).

4.7 WG-FSA-2022/08 presented an assessment of *C. gunnari* in Division 58.5.2 using the generalised yield model in R (Grym) following the results of the trawl survey described in WG-FSA-2022/07. Bootstrapped biomass estimates had a mean of 53 162 tonnes, with a one-sided lower 95% confidence bound of 26 434 tonnes, mainly comprised fish of age 3+ and 4+. Projecting forward the proportion of the one-sided lower 95th confidence bound of fish aged 1+ to 3+ (14 879 tonnes) gave yields of 2 616 tonnes for 2022/23 and 1 857 tonnes for 2023/24 that allow for 75% escapement and therefore satisfy the CCAMLR decision rules.

Management advice

4.8 The Working Group recommended that the catch limit for *C. gunnari* in Division 58.5.2 should be set at 2 616 tonnes for 2022/23 and 1 857 tonnes for 2023/24.

Toothfish (*Dissostichus* spp.)

4.9 WG-FSA-2022/11 summarised methods used to link releases and recaptures of tagged toothfish and skates in the Convention Area, and the current state of the database of linked tags held by the Secretariat. The Working Group thanked the Secretariat for the work that has improved the linking of tag recaptures to releases and noted that 98% of recaptured fish have been linked to their release event.

4.10 The Working Group recommended that as the database of links improves, the Secretariat expand the reporting of species-specific movements (e.g. distance moved, time-at-liberty), size and growth, and other relevant aspects of the tagging data in its reports of the tag links to WG-FSA.

4.11 The Working Group requested that the Secretariat identify and describe the nature and scale of the underlying problems with the tag linking, including whether these are related to reporting or transcription errors, missing information, or due to the tag linking algorithm, as this will identify components of the tagging program to improve.

4.12 The Working Group noted the importance of using consistent and uniquely numbered tags to avoid potential ambiguity in the tag matches. The Working Group recommended that the Secretariat liaise with Members to ensure that released tags used a unique numbering and naming scheme to avoid potential duplicates between CCAMLR and Member tagging programs. The Working Group requested the Secretariat also investigate alternative tag text and numbering sequences (e.g. use of alpha-numeric tag numbers) to help reduce typographic and transcription errors in the recording of tag numbers at release and recapture.

4.13 The Working Group requested the Secretariat check the photographs of tags submitted with observer cruise reports to determine if these are useful in resolving ambiguous links.

4.14 WG-FSA-2022/38 analysed data on fish tagged and subsequent recaptures in Subareas 88.1 and 88.2 for the period 2009–2017. The authors concluded that most (87%) of recaptures were within 100 km from their release location, and the average distance of fish movement was about 60 km. The authors noted that increasing the tagging rates for juveniles and smaller toothfish and the re-release of tagged small fish that are in good condition, may help describe migration trajectories.

4.15 The Working Group noted that while information obtained from the re-release of recaptured fish would provide additional information on migrations and growth, the rate of recapture in Subareas 88.1 and 88.2 was about 2% and observations of multiple recaptures would be uncommon. If recaptured fish were re-released, otolith and biological sampling (e.g. stage and sex) would not be possible and these recaptures would not be used in the stock assessment.

4.16 The Working Group recalled that the tagging of small fish had previously been evaluated by WG-FSA (WG-FSA-09, paragraph 5.16) and that tagging large numbers of small fish in exploratory fisheries would have very limited use for the estimation of abundance. In addition, tagging of small fish would result in a low tag-size overlap statistic and is likely to bias biomass estimates in a stock assessment (WG-FSA-12, paragraphs 5.159 to 5.161).

4.17 The Working Group noted that tagging of specific sizes of toothfish in specific locations could be proposed as a part of a specific research experiment and would allow the Working Group to evaluate the merits of the research as well as the effects on the tagging program and stock assessments. The Working Group noted that there was little understanding of the drivers of long-distance movement of toothfish and encouraged Members to consider research to address this question.

Workshop on Age Determination Methods

4.18 In 2021, WG-FSA recommended that a workshop be convened to compare toothfish age determination methods among research programs in the region and to develop procedures and criteria for pooling age data (WG-FSA-2021, paragraph 4.40).

4.19 The Working Group noted that the workshop was not able to be held in 2022 and recommended that the Workshop on Age Determination Methods (WS-ADM) be conducted virtually in the intersessional period and provide an adopted report of its recommendations to WG-FSA and SC-CAMLR in 2023.

4.20 The Working Group recommended the following terms of reference for WS-ADM:

(i) identify ageing protocols and methods used to age Antarctic and Patagonian toothfish (and common by-catch taxa such as *Macrourus* spp. and Rajiformes if time and resources allow) by Members, including:

(a) processes to:

- collect otoliths at sea
- select otoliths for ageing
- prepare and read otoliths
- conduct quality control and readability measurement methods, including reader agreement metrics and thresholds for using the read ages in analyses
- construct and use reference sets

(b) mechanism of ageing validation across laboratories/Members

(c) the minimum number of samples required and methods to estimate age compositions and catch age structure

(d) develop updated documentation and guidelines on ageing, considering documentation used by Members laboratories, recommendations from the 2012 Workshop on Techniques and Procedures for Ageing of Otoliths from *D. eleginoides* and *D. mawsoni* (WG-FSA-2012, paragraphs 10.1 to 10.19) and relevant documentation from other organisations recognised for best practice in fish ageing

(e) provide recommendations on the structure and implementation of an age reading database to be maintained by the Secretariat for toothfish otolith readings

(f) undertake a comparison of age estimates and subsequent evaluation metrics by Members from a standard reference set of otoliths using images of otoliths from the CCAMLR otolith image library

(g) recommend standard guidelines for ageing and future work needed to improve and validate ages between readers and Members.

4.21 The Working Group recommended, prior to WS-ADM, Members exchange information on their ageing programs, and undertake interlaboratory comparisons (see WG-FSA-02/51) to inform the recommendations of the Workshop. It encouraged Members to facilitate staff currently undertaking, or aspiring to undertake, ageing to visit existing laboratories. It further requested that the Secretariat establish a CCAMLR meeting webpage where Members could share documents such as laboratory manuals, reference collection imagery and data.

4.22 The Working Group requested the Secretariat present an update on the CCAMLR image library and progress on the development of an age database to WS-ADM.

4.23 The Working Group thanked Dr J. Devine (New Zealand) and Dr P. Hollyman (UK) for their offer to co-convene WS-ADM.

Patagonian toothfish (*D. eleginoides*) in Subarea 48.3

4.24 WG-FSA-2022/55 described improvements to a survey design and data simulation tool previously presented to WG-SAM (WG-SAM-2022/16). Stations may be generated randomly or based on a specific survey design. Analyses that can be conducted using the simulated data include catch-per-unit-effort (CPUE) standardisation, length-frequency comparisons, or power analyses. The tool provides a method for evaluating the likelihood of achieving survey objectives in areas with historical fishing data. The authors intend to further refine the tool, based on feedback from the Working Group, and make it available as an open-source framework. The authors also invited Members to contact them to collaborate on analyses using the tool.

4.25 The Working Group noted the additional enhancements made since WG-SAM and noted that the tool was useful for a range of investigations using catch, effort and tagging data and could potentially be modified to simulate outcomes from data derived from operating models such as vector autoregressive spatio–temporal (VAST) or spatial models. The Working Group also recommended that the code be modified to allow each realisation of the simulations to be output.

4.26 WG-FSA-2022/59 presented updated estimates of growth and maturity for Patagonian toothfish (*Dissostichus eleginoides*) in Subarea 48.3 and incorporated the recommendations made at WG-SAM-2022, including comparing the Candy method for fitting length data, reading additional otoliths, and investigating the effect on growth parameters of changing from a random selection of otoliths to a stratified sampling. The authors noted that the assumed selectivity at length used by the Candy method did not correspond to the observed length frequencies of sampled otoliths, and the stratified selection of otoliths had produced better estimates of growth than random sampling.

4.27 The Working Group noted the amount of work that had been done on ageing historical data and subsequent maturity and growth analyses using this additional data. The Working Group noted that estimates of maturity were the same as previously reported to WG-FSA, and that there was no evidence of a change in the maturity ogive over time.

4.28 The Working Group noted that estimates of growth did appear to change with the additional data, specifically as it included additional observations of older fish. The Working Group recommended further investigation of the growth curves, including constant coefficient of variation (CV) rather than constant standard deviation von Bertalanffy models; investigating different selectivity functions, including applying a constant selectivity, when using the Candy method; including diagnostic and residual plots; and showing patterns in residuals over time to evaluate if there are trends in growth rates over time.

Whale depredation

4.29 WG-FSA-2022/P05 compared six different methods for estimating whale depredation to determine whether it was possible to improve upon the generalised linear model (GLM) method currently used for the assessment. The generalised additive model (GAM) approach was comparable to the current method, but the authors noted there was some work still needed to resolve overfitting to killer whale abundance and defining the smoother function.

4.30 The Working Group noted that all different model structures estimated similar annual depredation removals, indicating about 5% of the catch being removed annually due to depredation. While depredation varied spatially, the different modelling approaches highlighted consistent areas where the impact of depredation was highest.

4.31 WG-FSA-2022/56 Rev. 1 presented a characterisation of the *D. eleginoides* fishery in Subarea 48.3. The authors noted that the toothfish fishery had become more concentrated in depth and season fished. The length and age at maturity has not changed over time, although the average length of fish caught has increased.

4.32 The Working Group noted that the fishery characterisation was extremely helpful to understand the dynamics of the fishery and the stock. The Working Group noted that the differences in sex-based movement and growth rates suggested that a sex-based stock assessment model should be investigated as it may better capture the sex-specific dynamics of *D. eleginoides* in Subarea 48.3.

Stock assessment of *D. eleginoides* in Subarea 48.3

4.33 WG-FSA-2022/57 Rev. 1 and 2022/58 presented updates to the assessment for *D. eleginoides* in Subarea 48.3 that was presented to WG-SAM-2022, with the inclusion of data from the 2021 season and addition of historic age information. The additional information did not result in a significant change to the assessment, and the current status of the stock was estimated to be 47% of B_0. The harvest rate estimated by the CASAL stock assessment was consistent with that estimated from the tag recapture rates. Based on the CASAL stock assessment and following the CCAMLR decision rules, the authors recommended that the catch limit for *D. eleginoides* be set at 1 970 tonnes for 2022/23 and 2023/24.

4.34 The CASAL version and parameter files were verified by the Secretariat for the CASAL assessment presented in WG-FSA-2022/57 Rev. 1. The CASAL version used was CASAL v2.30-2012-04-03 03:09:50 UTC (rev.4686) and the input parameter files (population.csl, estimation.csl and output.csl) used in the assessment were used as inputs to a CASAL run performed by the Secretariat. Verification of the maximum of the posterior density (MPD) using these files produced the same B_0 estimate as reported by the authors (77 198 tonnes).

4.35 The Working Group noted that the issues raised at WG-FSA-2021 were addressed but that sensitivity analyses should be considered in future assessments to determine the impact of CPUE data.

4.36 The Working Group noted that the effect of spatial concentration of the fishery on the recapture of tagged fish posed a challenge that was common to all tag-based stock assessments, and that Members should work collaboratively towards addressing potential spatial biases in tag-based and integrated stock assessments.

4.37 The Working Group recalled that WG-SAM-2022, paragraph 3.47, noted that the stock assessment process undertaken for Subarea 48.3 was the best available approach.

4.38 The Working Group recalled that WG-SAM-2022, paragraphs 3.48 and 3.54, noted that three independent methods of estimating fishing mortality led to the same conclusion that the harvest rate in Subarea 48.3 is precautionary in achieving the CCAMLR objective of a long-term average of 50% of B_0.

4.39 The Working Group recalled the advice from WG-SAM-2022, paragraph 4.2, and agreed that inclusion of a Kobe plot as part of the diagnostics presented for toothfish assessments would help to communicate to managers the stock status in relationship to the target and thresholds resulting from the CCAMLR precautionary decision rules. The Working Group noted that the Kobe plot for *D. eleginoides* in Subarea 48.3 showed that the population fluctuated about the target (50% B_0), and exploitation rates had been lower than the maximum sustainable yield (F_{MSY}) in almost all years (Figure 1).

4.40 Dr S. Kasatkina (Russia) noted that since 2008/09, the *D. eleginoides* fishery in Subarea 48.3 has been based on the fishery removing fish less than 100 cm in length, an excessive number of immature *D. eleginoides* and those maturing for the first time (recruits) are currently being caught in Subarea 48.3. This indicates a change in the size structure of spawning *D. eleginoides* and has been accompanied by decrease in the toothfish biomass. *D. eleginoides* population in Subarea 48.3 requires protection and revision of the precautionary approach for the use of the *D. eleginoides* stock in the CCAMLR area (Subarea 48.3) as the current approach does not provide for the sustainable use of this living resource as rational use is not being ensured (SC-CAMLR-40/15; SC-CAMLR-40, paragraphs 3.47 and 3.48). Dr Kasatkina stated that, in her opinion, this is based on the best available data (CCAMLR papers, Fishery Report, more than 100 articles by renowned scientists in peer-reviewed journals) and reflected in Russian documents submitted since 2018 to meetings of WG-SAM, SC-CAMLR and the Commission.

4.41 Dr Kasatkina also noted that the fishery performance (mean length, percent immature fish by year in catches) for the toothfish fishery in Subarea 48.3 cannot be compared with toothfish fishery for other CCAMLR areas (*D. eleginoides* fisheries in Subarea 58.6 and Divisions 58.5.1 and 58.5.2, and for the *D. mawsoni* fishery in Subarea 88.1 and SSRUs 882A−B) (WG-FSA-2019). *D. eleginoides* is the main target species in Subarea 48.3, while in other fisheries areas, the target species is the *D. mawsoni*, and *D. eleginoides* is taken as by-catch. These two species (*D. eleginoides* and *D. mawsoni*) differ in life cycle stages and behaviour, as well as the fishing areas themselves, primarily in terms of hydrological characteristics such as thermal regime, etc. Furthermore, the fishery for *D. eleginoides* in Subarea 48.3 has been ongoing since 1985, including over 25 years under CCAMLR management. The very high life expectancy of *D. eleginoides* up to 50 years, its population should consist of a large number of length-age groups, the number of which on the histogram usually decreases quite smoothly in accordance with long life cycle of the fish, providing the basis of catches. Dr Kasatkina stated that this is exactly what is observed in the length histogram of *D. mawsoni* from the toothfish fishery in Subarea 88.1 (SC-CAMLR-40/15). The fishery for *D. eleginoides* in Subarea 48.3 was based on recruitment fish.

4.42 Dr Kasatkina noted that the specific proposals from Russia regarding the regulation of the toothfish fishery in Subarea 48.3 in SC-CAMLR-XXXVII/14 Rev. 2 (limiting the length of *D. eleginoides* in catches; fishing only at depths of 1 000 m; reducing the catch limit to

500 tonnes, according to the fishing grounds with depths from 1 000 to 2 250 m; conducting an international survey to assess toothfish stock) had not been accepted. Dr Kasatkina noted that no scientifically substantiated documents have been submitted to CCAMLR meetings that contradict the Russian position on the management of the toothfish fishery in Subarea 48.3. Also, WG-FSA-2022/56 and 2022/57 also were not considered to provide new scientific data regarding issues of an irrational use of the *D. eleginoides* stock in Subarea 48.3 (Figures 5 and 13 in WG-FSA-2021/59, and Figure 13 in WG-FSA-2022/55).

4.43 Dr Kasatkina noted that setting a catch limit for the *D. eleginoides* fishery in Subarea 48.3 for the 2022/23 and 2023/24 seasons would not be consistent with rational use of this living resource and the fishery should be closed for the 2022/23 season.

4.44 The Working Group noted that the statements by Dr Kasatkina were the same as those made at WG-FSA in 2018, 2019 and 2021. The Working Group noted that previous working groups had discussed these statements (WG-FSA-18, paragraphs 3.16 to 3.20; WG-FSA-2019, paragraphs 3.50 to 3.68; WG-SAM-2019, paragraphs 3.12 to 3.19; SC-CAMLR-40, paragraphs 3.47 to 3.60) and had concluded that little scientific evidence had been provided that supported these statements. The Working Group also noted that a large number of papers had been presented to the Scientific Committee and its working groups since 2018 that provided scientific evidence that refuted these statements. The evidence from these papers was used as the basis for advice to the Scientific Committee in 2019. The papers summarising this evidence is presented in Table 4.

4.45 The Working Group recalled that evidence presented in previous years and in WG-FSA-2022/56 Rev. 1 had shown that the fishery selected multiple age classes and length classes of the population, not only immature fish, and immature fish had remained a constant proportion of the catch consistent with other *D. eleginoides* stocks in the CCAMLR area (Figure 2).

4.46 The Working Group recalled that WG-SAM-2019, paragraph 3.13, noted that 'when the effects of confounding factors, such as depth, are included in the analysis, there was no indication of systematic change in maturity or growth parameters that would indicate potential impacts from external influences such as the fishery or climate change' (Figures 3 and 4).

4.47 The Working Group recalled that in 2019 the Scientific Committee noted that the stock assessment calculations for Subarea 48.3 and the application of the CCAMLR decision rules were in line with CCAMLR procedures, demonstrating there are no differences in characteristics between Subarea 48.3 and all other CCAMLR stock assessment areas (SC-CAMLR-38, paragraph 3.69).

4.48 The Working Group noted that there was a large amount of data available for the assessment of *D. eleginoides* in Subarea 48.3, including over one million observations of length and age, 22 trawl surveys since 1987, tag release and recapture data over 17 years since 2004, and standardised CPUE indices since 2004. The Working Group also noted that data for the fishery were from the fishing reports of 14 Members and observed by 155 Scheme of International Scientific Observation (SISO) observers from 14 Members and these have all contributed to the data available for the assessment.

4.49 The Working Group noted that no information on a survey objective, design, or analyses of the survey that was proposed by Dr Kasatkina had been provided to the Working Group. However, the Working Group recommended that the survey simulation tool in WG-FSA-2022/55 should be used to evaluate any such survey proposal.

4.50 The Working Group noted that the statements made by Dr Kasatkina were not supported by the information provided and that this issue has been reviewed by WG-SAM, WG-FSA and the Scientific Committee since 2018. The Working Group noted that, with the return to in-person meetings, it had had adequate time to discuss and resolve issues but that not all participants had engaged in the scientific process and requested advice from the Scientific Committee on how to progress this issue (paragraphs 9.12 and 9.13). In light of the position taken by Dr Kasatkina, the Working Group was not able to provide consensus advice for *D. eleginoides* in Subarea 48.3.

4.51 In light of the position taken by Dr Kasatkina, the Working Group recommended that the Scientific Committee consider an independent review of the information presented may be useful to enable a resolution of these issues.

4.52 All other participants of the Working Group agreed that the CCAMLR assessment and management decision rule protocols are:

(i) consistent in the application across all toothfish stocks, including the stock in Subarea 48.3

(ii) in accord with the precautionary approach and CCAMLR's objectives under Article II

(iii) appropriate for the robust management of CCAMLR's toothfish stocks, given the wide range of stock and fishery characteristics across the CAMLR Convention Area.

4.53 The Working Group noted that a catch limit for *D. eleginoides* in Subarea 48.3, set at 1 970 tonnes for 2022/23 and 2023/24 based on the outcome of WG-FSA-2022/57 Rev. 1, would be consistent with the precautionary yield estimated using the CCAMLR decision rules, the process for setting catch limits used in previous years, and the use of best available science.

4.54 The Working Group noted it had been unable to provide consensus advice on catch limits for *D. eleginoides* in Subarea 48.3.

Antarctic toothfish (*D. mawsoni*) in Subarea 48.4

4.55 WG-FSA-2022/60 presented estimates of the vulnerable biomass of *D. mawsoni* in Subarea 48.4 from tagging returns using data from one vessel that fished for 37 days and tagged 166 fish, with 22 recaptures. The five-year biomass average was estimated at 1 110 tonnes since 2018. Applying the CCAMLR-agreed precautionary assumption of a five-year average biomass, and harvest rate (gamma) of 0.038, a yield of 42 tonnes was determined for 2022/23.

4.56 The Working Group noted that there appeared to be a strong spatial effect in the tag recaptures, as noted previously. The Working Group expressed interest in the long-distance movements that were exhibited by predominantly mature fish in spawning condition and suggested this may be capturing migration through the area related to spawning. The Working Group recommended that future work include biological information on recaptured fish to help elucidate these movements.

4.57 The Working Group noted that a catch limit for *D. mawsoni* in Subarea 48.4, set at 42 tonnes for 2022/23 based on the outcome of this assessment, would be consistent with the precautionary yield estimated using the CCAMLR decision rules, the process for setting catch limits used in previous years, and the use of best available science.

4.58 The Working Group recommended that the catch limit for *D. mawsoni* in Subarea 48.4 should be set at 42 tonnes for 2022/23.

D. eleginoides in Division 58.5.2

4.59 WG-FSA-2022/09 presented an update on the Heard Island and McDonald Islands *D. eleginoides* fishery in Division 58.5.2, including recruitment indices from the random stratified trawl survey and Chapman estimates of vulnerable biomass from tag recapture data.

4.60 The Working Group noted that these data indicate that the stock trajectory remains consistent with what was predicted by the 2021 stock assessment (WG-FSA-2021/21). The Working Group noted that the recent high survey biomass and strong cohorts of young fish in the survey catch composition were consistent with a pulse of recruitment between 2016 and 2018.

4.61 No new information was available on the state of fish stocks in Division 58.5.2 outside areas of national jurisdiction. The Working Group, therefore, recommended that the prohibition of directed fishing for *D. eleginoides*, described in CM 32-02, remain in force in 2022/23.

Biomass estimation for toothfish from trend analysis

4.62 WG-FSA-2022/13 presented updated estimates of toothfish biomass for research blocks in data-limited toothfish fisheries for the 2022/23 season following the trend analysis. The paper was an update of a version presented in WG-SAM-2022/08 and addressed recommendations from WG-SAM-2022. The decision tree diagram includes a new step for those research blocks where fishing occurred only in the most recent of the past five seasons. In such cases, after one year of effort-limited fishing, the new catch limit would be computed as 4% of the latest CPUE-by-seabed area biomass estimate. Once two years of data are available, the trend analysis would be applied in subsequent years.

4.63 The Working Group recommended that the updated decision tree for the trend analysis as shown in Figure 5 be endorsed by the Scientific Committee.

4.64 The Working Group recommended catch limits for research blocks in data-limited toothfish fisheries for the 2022/23 season as given in Table 5.

4.65 WG-FSA-2022/53 proposed a draft workplan to develop a management strategy evaluation (MSE) for the CCAMLR trend analysis and potential alternative data-limited approaches for managing toothfish fisheries under research plans. The paper proposed to develop models to simulate toothfish populations as a first step to testing how the management system performs relative to chosen metrics, with the initial developments presented to WG-SAM in 2023.

4.66 The Working Group supported the work plan and considered that the MSE of the trend analysis should include, inter alia, the evaluation of the appropriateness of the currently used 4% harvest rate, the maximum catch limit change of 20% between years and the effects of applying the rules to fish stocks at different levels of exploitation, as well as alternative harvest control rules not currently included in the trend analysis.

4.67 Based on the work plan, the Working Group requested that the Secretariat coordinate an intersessional subgroup of interested parties to progress the development of an MSE for the CCAMLR trend analysis and assist Members with the development of toothfish population simulation models. The Working Group requested that any initial developments be presented to WG-SAM in 2023.

Research fisheries

Research plans in exploratory fisheries under CM 21-02 and management advice

5.1 The Working Group noted that there would be benefit in refining the requirements for research plans in exploratory fisheries conducted in accordance with CM 21-02, paragraph 6(iii). The paragraph states that research plans shall be reported in accordance with the format of CM 24-01, Annex 24-01/A, format 2.

5.2 The Working Group noted that the original intent of CM 24-01, Annex 24-01/A, format 2, was to allow for: (i) a broad range of research to be undertaken, and (ii) a consistent research plan format among Members, both in exploratory fisheries under CM 21-02 and in closed areas under CM 24-01 (SC-CAMLR-XXX, paragraphs 3.137, 3.138 and 9.13).

5.3 The Working Group recommended that a new annex (Appendix E) be added to CM 21-02 which outlines the format for research plans notified under CM 21-02, paragraph 6(iii). The Working Group noted that this new format would also allow research plans in exploratory fisheries to be better aligned with the assessment tables used by working groups, as endorsed by CCAMLR in 2017 (CCAMLR-XXXVI, paragraph 5.26).

5.4 At the time of report adoption, Dr Kasatkina noted that she considers it inappropriate for a new annex (Appendix E) to be added to CM 21-02 in paragraph 6(iii). In her opinion, Research Plans for *Dissostichus* spp. exploratory fisheries in data-poor areas shall be reported in accordance with the format of CM 24-01, Annex 24-01/A, format 2. Dr Kasatkina noted that this format 2 defines categories and criteria necessary to achieve the Scientific Committee goals for the assessment of *Dissostichus* spp. in data-poor fisheries over 3–5 years (SC-CAMLR-XXIX, paragraphs 3.125 to 3.145, SC-CAMLR-XXX, Annex 7, paragraph 6.74) with special attention to use of different longline gear types in research plans and issues associated with gear effects (SC-CAMLR-XXXVI, paragraph 3.115).

5.5 Research plans were evaluated against the agreed criteria outlined in WG-FSA-2019/55. The results are presented in Table 6 and following the review schedule summarised in Table 7.

Area 48

5.6 The Working Group noted that the research plan for Subarea 48.6 was in year two of a three-year plan and was therefore not required to be reviewed by WG-FSA (CCAMLR-38, paragraph 5.64 and Table 7).

5.7 WG-FSA-2022/15 presented a preliminary analysis of conductivity temperature depth probe (CTD) data collected by the *Tronio* whilst fishing within research blocks in Subarea 48.6 during the 2019/20 and 2020/21 seasons. A total of 27 vertical profiles conducted over the two seasons with results showing declines in temperature between 50 and 100 m depths and sharp increase at depths of 300–400 m. This indicates that the water temperature at depths shallower than 200 m is cold and well mixed but is stable and warmer at depths deeper than 300 m.

5.8 The Working Group noted the value of collecting oceanography data during fishing activities, especially in relation to studies relating to otolith microchemistry, and that the data could be combined with research surveys conducted in the same area by the research vessel *Polarstern*. The Working Group recommended that future reports include more details on methodology used; specifically, deployment procedures and data availability would be useful to assist other Members who may wish to conduct similar research.

5.9 WG-FSA-2022/16 presented a genome-wide analysis into the genetic population connectivity of *D. mawsoni* within Subarea 48.6. The study, using 5 020 single nucleotide polymorphisms from 87 fish, showed no population structure across the subarea. The paper noted that a multidisciplinary approach is recommended to address uncertainty in stock discrimination.

5.10 The Working Group noted that the results of this paper were consistent with those presented previously (WG-FSA-2019/P01) and recent literature (Ceballos et al., 2021) which had larger spatial areas and showed genetic connectivity. The Working Group recalled the difference between a local stock and a genetic stock, the latter of which requires only small amounts of mixing to obscure genetic stock structure.

5.11 The Working Group noted that given the consistent results across genetic studies showing genetic mixing, it is important to combine information from different methods to update stock hypotheses for these areas. This includes methods such as traditional tagging studies, popup satellite tagging studies, otolith microchemistry, stable isotope analysis, and oceanographic modelling of egg and larval transport (such as WG-FSA-2022/25).

5.12 WG-FSA-2022/36 presented an investigation of stock connectivity in Subarea 48.6 using otolith microchemistry. The study used a comparison of core and edge chemistry to infer fish movement between research blocks including more fish moving from the northern research blocks to the southern research blocks during the early life stages. The authors also suggested modelling of egg and larval transport be conducted to assist with the stock hypothesis for this area.

5.13 The Working Group noted that this study, combined with WG-FSA-2022/36, may indicate a single stock in Subarea 48.6, however, this could be combined with other analyses to confirm. The Working Group recommended modelling of egg and larval transport in this area to help evaluating the three stock hypotheses previously presented to CCAMLR

(WS-DmPH-18/14). The Working Group suggested to include barium in future analyses to allow for comparison with other *D. mawsoni* studies. The Working Group highlighted the collaborative study and encouraged Members to continue such work.

5.14 WG-FSA-2022/24 presented a report of research on *D. mawsoni* conducted in Subarea 48.6 between 2012/13 and 2021/22 by Japan, South Africa and Spain noting the achievement of the milestones detailed in the research objectives.

5.15 The Working Group noted that the tag-overlap statistics by vessel and research block for 2022 reported in the paper showed low tag overlap for the *Tronio*. Recalculation provided by the Secretariat showed that the tag-overlap statistic of the *Tronio* was >60% for each research block, with the exception of research block 486_4 (58.4%). The tag-overlap statistic for the subarea, which is what is currently monitored by the Secretariat, was 74.2%.

5.16 The Working Group noted that CM 41-01 does not specify the area for which the tag-overlap statistic should be applied, creating ambiguity among different regions. The Working Group recalled that the aim of the tag-overlap statistic is to ensure that the tags in each area are released in a similar proportion to the length composition of the overall catch, in order to not bias tag-based estimates of biomass.

5.17 The Working Group recommended that both the tagging rate, and tag-overlap statistic, be specified and applied to the smallest scale for which a catch limit is set (e.g. research block, SSRU, or management area) and requested that the Scientific Committee consider this issue.

5.18 WG-FSA-2022/23 presented an initial two-area CASAL stock assessment model for Subarea 48.6. The model is an extension of the single-area stock assessment model presented in WG-FSA-2021/49 to better account for the spatial structure within the Subarea 48.6 fishery. The model assumes a proportion of the population based in the south along the continental shelf/slope and another proportion located on seamounts to the north with movement between the two areas. However, the authors noted that they encountered an error in the model and it could not be run.

5.19 The Working Group noted that whilst no stock assessment model was currently used for management advice, a two-area model would better account for the stock structure in Subarea 48.6 than a single-area model. The Working Group welcomed the offer by Mr Dunn to help identify the reasons preventing the model from running.

5.20 The Working Group recommended that the catch limits for Subarea 48.6 be based on the trend analysis as shown in Table 5.

Area 58

5.21 WG-FSA-2022/10 provided a summary of environmental data collected from deployments of CTD loggers and benthic video cameras (BVCs) on fishing gear operating in the *D. mawsoni* exploratory fishery in Divisions 58.4.1 and 58.4.2 since 2016. BVC data revealed that a majority of fishing activity occurred in waters with unconsolidated soft substrate with very low densities of vulnerable marine ecosystem (VME) indicator taxa.

5.22 WG-FSA-2022/34 presented an update of ageing and biological parameters as well as a preliminary stock assessment for *D. mawsoni* in East Antarctica. The assessment identified differences in catch age composition and fishing selectivity between Prydz Bay and other fished areas. Output from the assessment suggested that the current level of fishing mortality is unlikely to deplete the *D. mawsoni* stock in this area. However, the assessment model also highlighted that the lack of data due to no fishing in Division 58.4.1 over the last four years had a detrimental impact on the ability of the model to accurately estimate spawning biomass and precautionary catch levels for this exploratory toothfish fishery.

5.23 WG-FSA-2022/25 presented an update of an egg and larval transport modelling simulation under three different southern annular mode (SAM) scenarios in the continental shelf-slope regions of East Antarctica. Results showed that the overall successful transport levels were higher (>80%) when passive advection by ocean current was modelled: (i) at the surface layer, or (ii) in addition to diel vertical migration between the surface layer and the mid-layer. A negative relationship was reported between the relative SAM phase and the predicted percentage of successful transport. The paper recommended that both continuous sampling and tagging research would be useful to inform model structure and validate outputs.

5.24 The Working Group noted those studies and thanked the authors for their contributions.

5.25 WG-FSA-2022/21 presented information on fish by-catch during exploratory fishing activities undertaken in Divisions 58.4.1 and 58.4.2 during the period 2016 to 2022. Of the 14 species reported, by-catch records were dominated by the Macrouridae and Channichthyidae families (~98%). In 2021 and 2022, exploratory fishing occurred in Division 58.4.2 only, and none of the by-catch limits set in CM 33-03, Annex 33-03/A, were reached. The report noted that exploratory fishing under a research plan with high numbers of fixed stations in depth range where *Macrourus* catch rates were highest would increase the risk of reaching by-catch limits and compromise research objectives.

5.26 The Working Group commended the authors of this report for the detailed and useful presentation of by-catch records reported by fishing vessels in Divisions 58.4.1 and 58.4.2.

5.27 WG-SAM-2022/04 detailed a new research plan by Australia, France, Japan, the Republic of Korea and Spain to continue research in Divisions 58.4.1 and 58.4.2. The research plan has been updated with relevant details for all notified vessels, and random depth-stratified sampling locations in all research blocks as per the survey design for the 2022/23 season.

5.28 Dr Kasatkina noted that the new research plan for the *D. mawsoni* exploratory fishery in the East Antarctic (Divisions 58.4.1 and 58.4.2) under CM 21-02, paragraph 6, item 3 (WG-SAM-2022/04) should be reported in accordance with the format of CM 24-01, Annex 24-01/A, format 2. An integral part of this format 2 is category 3 (survey design, data collection and analysis) listed items such as:

- spatial arrangements or maps of stations/hauls (e.g. randomised or gridded)
- stratification according to, for example, depth or fish density
- calibration/standardisation of sampling gear.

5.29 Dr Kasatkina stressed that Russia has repeatedly raised the issue that the research plan for the *D. mawsoni* exploratory fishery in East Antarctica (Divisions 58.4.1 and 58.4.2) involving vessels from Australia, France, Japan, the Republic of Korea and Spain should be carried out using a standardised longline gear and survey design based on a randomised and stratified placement of longline stations by depth layers (SC-CAMLR-XXXVII/BG/23, WG-FSA-2021/42, WG-FSA-2019/52). She noted that the new research plan includes a randomised design for setting longline stations by depth layers. However, as before, the requirement for using standardised sampling gear has not been met. Dr Kasatkina maintains her position that the use of different gear types and constructions for the implementation of the research plan for the *Dissostichus* spp. exploratory fishery in East Antarctica (Divisions 58.4.1 and 58.4.2) is a critical factor for efficiency and reliability of this research plan.

5.30 Dr Kasatkina stated that the new research plan for the *D. mawsoni* exploratory fishery in East Antarctica (Divisions 58.4.1 and 58.4.2) in the 2022/23 to 2025/26 seasons does not comply with CM 21-02 and will not provide adequate data to achieve the main goals and objectives of this new research plan. Dr Kasatkina did not support this new research plan.

5.31 The Working Group noted that there was no requirement for standardised gear types in exploratory fisheries. It requested clarity from Dr Kasatkina on why, in her opinion (see paragraph 5.29), a requirement for standardised gear types applies to the exploratory fishery in Divisions 58.4.1 while other exploratory fisheries such as those in the Ross Sea and SSRUs 882C–H have been conducted for many years with multiple longline gear types. However, Dr Kasatkina did not provide an answer to this question.

5.32 The Working Group recalled discussions at WG-SAM-2019, paragraphs 6.1 to 6.13 and Table 1, which outlined the influential factors for abundance studies using tag data, location, time and vessel operational features but not gear type or hook number. The Working Group agreed that biomass estimates from tag recapture data relied on the number of accumulated tag recaptures over time and were not adversely impacted by the use of different gear types.

5.33 The Working Group recalled that CM 24-01, Annex 24/01/B, format 2, applies to both research plans under CM 24-01 and CM 21-02 and was written to represent a wide variety of research proposals (paragraphs 5.1 to 5.3). The Working Group developed a new annex (Appendix E) which outlines the format the research plans notified under CM 21-02, paragraph 6(iii), should follow.

5.34 The Working Group recalled that the exploratory fishery in Divisions 58.4.1 was open to any notifying Member. It further noted that an informal coordination of fishing activities and catch between participating Members of a research plan allowed Members to conduct their research with sufficient catch available.

5.35 To facilitate further discussions on the scientific aspects of the regulatory framework, Dr Kasatkina agreed to present a paper to the Scientific Committee in 2023.

5.36 The Working Group concluded that there was no scientific evidence presented against the survey design outlined in the research plan for Divisions 58.4.1 and 58.4.2 in WG-SAM-2022/04.

5.37 The Working Group reviewed the research proposal against the criteria in WG-FSA-2019/55 in Table 6.

5.38 The Working Group recommended that the catch limits for Divisions 58.4.1 and 58.4.2 to be based on the trend analysis as shown in Table 5.

5.39 The Working Group endorsed the research proposal in WG-SAM-2022/04 for Division 58.4.2 but was unable to reach consensus on the research proposal for Division 58.4.1 due only to the use of multiple longline gear types.

Research proposals and notifications under CM 24-01 and management advice

5.40 The Working Group considered proposals submitted under CM 24-01 for *C. gunnari* in Subareas 48.2 and 48.3, and *D. mawsoni* in Subareas 88.1 and 88.3. The proposals are presented in Table 7.

Subarea 48.2 icefish survey

5.41 WG-FSA-2022/17 presented a proposal by Ukraine to conduct a local acoustic-trawl survey to determine the distribution and abundance of *C. gunnari* in an area on the western shelf of Subarea 48.2. The proposal aims to characterise stock structure, depth distribution and estimate catchability of fishing gear (midwater trawl) using acoustic and video data from a trawl video camera system.

5.42 The Working Group noted the responses to feedback when the paper was presented to WG-SAM-2022 (WG-SAM-2022/06 Rev. 1), and how the authors addressed the recommendations.

5.43 The Working Group noted that using an additional smaller mesh on the survey trawl to assess selectivity was an option. The Working Group noted that that a smaller mesh may result in pressure waves in panels in the trawl, and that this may force fish into the larger mesh to be trapped. It was unclear what effect this may have.

5.44 The Working Group noted from WG-ASAM-2022, paragraphs 3.1 to 3.8, that additional information was needed on the two different acoustic frequencies, as well as on target strength identification. In addition to clarifying how acoustic estimates will be obtained, the Working Group requested more details on catchability estimation methods. The authors informed that catchability would be assumed to be 1.

5.45 The Working Group noted that any biomass estimated from this survey would be restricted to the local area in which the survey was undertaken, and not the entire Subarea 48.2 shelf (Figure 6). It noted that there could be difficulties in distinguishing *C. gunnari* from other species during the acoustic survey, although targeted hauls may provide information on this. The Working Group noted that UK scientists offered to provide assistance in acoustic data analysis.

5.46 The Working Group recommended that the survey should proceed for one year, with results presented at the subsequent WG-ASAM and WG-SAM-2023. It was further recommended that the trawl sampling be randomised to better collect information that would lead to an estimate of biomass. To accommodate this, the Working Group recommended that hauls should first be taken using oblique tows as opposed to targeted hauls for the primary survey of biomass. A revised survey plan with eight acoustic transects and locations of hauls is provided in Tables 8 and 9, Figure 6 and Appendix F. Australia offered to provide a 38 kHz transducer for the acoustic component of the survey, which could be used for the next possible stage of this research.

5.47 The Working Group recommended that some additional targeted hauls on acoustic marks would permit species identification of the acoustic backscatter and confirm the composition of fish or other pelagic organisms. The Working Group recommended a maximum of 32 targeted tows, up to the survey catch limit.

5.48 The Working Group recommended that the survey be both effort limited (Appendix F), and catch limited, with a precautionary survey catch limit of 120 tonnes of *C. gunnari*.

5.49 The Working Group agreed that any krill caught in the survey should be included in the total catch for krill in Subarea 48.2. It recommended a krill by-catch limit of 0.1% of the trigger level catch limits for krill allocated for Subarea 48.2 (279 000 tonnes).

5.50 The Working Group recommended a by-catch limit for krill of 279 tonnes. The Working Group noted that krill and all other biological material collected during the Subarea 48.2 icefish survey will be recorded and data submitted to the Secretariat.

5.51 The Working Group reviewed the research proposal against the criteria in WG-FSA-2019/55 in Table 6.

Subarea 48.3 icefish survey

5.52 SC-CAMLR-41/BG/26 proposed a combined trawl and acoustic survey of *C. gunnari* in Subarea 48.3 to estimate biomass for the length-based method to derive catch limit advice.

5.53 The Working Group noted that the current survey and assessment methodology uses a precautionary approach, utilising the lower 95% one-sided confidence limit of biomass. This is then used in the short term (two-year projection), in addition to a 75% escapement, as part of the decision rule to provide catch advice. It further noted that any observed declines in biomass across time may be related to icefish utilising the water column as habitat, and that this may be affected by the timing of the survey.

5.54 The Working Group noted that the precautionary approach utilised for the icefish assessment does not require constant catchability or a proportion of the stock to be located near the seafloor. The Working Group agreed that there would be value to better understand the degree to which catchability changed over time. In particular the Working Group noted that it would be advantageous for biomass surveys to be undertaken at the same time each year if possible.

5.55 The Working Group noted that it would be advantageous for biomass surveys of icefish to account for their semi-pelagic distribution during sampling. Progress towards the development of a combined trawl and acoustic survey could lead to more robust estimates of both demersal and pelagic components of icefish biomass.

5.56 The Working Group noted that icefish is an important part of the ecosystem in Area 48, as it is a krill predator and a prey for fur seals. It further noted the southern Scotia Arc subareas have been closed to directed icefish fishing for decades as a result of past overfishing.

5.57 The Working Group noted that existing estimates of target strength for icefish were preliminary only (paragraph 5.45), and that more work was needed to refine these estimates. The Working Group requested that WG-ASAM and/or acoustic specialists evaluate methods to achieve robust estimates of the target strength of icefish.

Ross Sea shelf survey

5.58 WG-FSA-2022/40 presented a characterisation of the 2022 Ross Sea shelf survey results, including objectives, survey design, gear standardisation and trends. The authors noted that the time series of relative abundance and age structure from the survey had provided information about year-class strength and variability.

5.59 The Working Group noted that Ross Sea shelf survey results indicated that the relative biomass index of toothfish in 2022 was lower than that estimated for the previous three years but was still above the 2018 estimate. It noted that the 2022 catch limit of 65 tonnes was not exceeded, primarily because catches in the core strata were lower than in the previous three years.

5.60 The Working Group agreed that the Ross Sea shelf survey represented a large investment that had yielded critical data. The Working Group noted that the survey had demonstrated how vessels of opportunity can contribute important information to the understanding of fish stocks. The Working Group also noted that the use of such vessels was a valuable and underutilised resource.

5.61 The Working Group noted that the data from this survey was an important input for the Ross Sea region stock assessment and has contributed valuable data relevant to the research and monitoring plan for the Ross Sea region marine protected area (MPA).

5.62 The Working Group noted how toothfish length and age composition data from the Ross Sea shelf survey has informed the estimates of year-class strength, and that the cohorts observed in the Ross Sea shelf survey are subsequently observed in the special research zone (SRZ), the management area south of 70°S (S70) and the management area north of 70°S (N70) of the Ross Sea region fishery. The Working Group noted that the Ross Sea shelf survey provides valuable information on year-class strengths of the population and provided an important signal on recruitments for the fishery.

5.63 WG-FSA-2022/41 Rev. 1 presented a proposal to continue the time series of research surveys to monitor abundance of *D. mawsoni* on the Ross Sea shelf for the next three seasons (2022/23–2024/25) under CM 24-01.

5.64 The Working Group noted that WG-SAM had reviewed the proposal (WG-SAM-2022/01 Rev. 1) and had recommended that the survey series continue. It agreed that the objectives, survey design, data collection procedures and catch limit calculations were appropriate. The Working Group highlighted the value of the Ross Sea shelf survey and suggested that the information in the summary of milestones in Appendix 2 of WG-FSA-2022/41 Rev. 1 that does not apply to the survey could be removed in future proposals.

5.65 The Working Group noted that the Ross Sea shelf survey vessel carried out continuous acoustic data collection during the survey, although this information has not yet been fully analysed. It requested that acoustics information, including the specifications of the echosounder, from the survey be reviewed by WG-ASAM in the future to formalise a procedure for analysis.

5.66 The Working Group recommended that the Ross Sea shelf survey continue using the same methodology and design. It recommended the following catch limits for the next three years of this survey:

(i) 2022/23: 99 tonnes (including the core strata and the Terra Nova Bay stratum)
(ii) 2023/24: 69 tonnes (including the core strata and the McMurdo Sound stratum)
(iii) 2024/25: 99 tonnes (including the core strata and the Terra Nova Bay stratum).

5.67 The Working Group reviewed the research proposal outlined against WG-FSA-2019/55 in Table 6.

D. mawsoni in Subarea 88.3

5.68 WG-FSA-2022/26 presented a research plan for continuing *D. mawsoni* research fishing under CM 24-01 in Subarea 88.3 by Korea and Ukraine from 2021/22 to 2023/24. The Working Group noted that the plan was an update that was previously submitted to WG-SAM-2022 (WG-SAM-2022/25).

5.69 The Working Group noted the recommendations of WG-SAM-2022, which included conducting work towards: (i) addressing the by-catch analysis milestones of the research proposal; (ii) including latitudes and longitudes in maps in the proposal; and (iii) evaluating the purpose and value of research blocks 883_9 and 883_10. The Working Group agreed that the proponents had addressed all recommendations of WG-SAM in their revised research plan.

5.70 The Working Group noted that in relation to milestones for by-catch, the research plan mentioned measuring up to 30 individuals of each species. It recommended that it be revised to indicate a minimum of 30 individuals (if possible), to ensure that a minimum number of specimens were measured. It was further noted that including research blocks along with maps of sea-ice accessibility would be worthwhile.

5.71 The Working Group noted that in relation to Subarea 88.3, there was very little fishable area in research blocks 883_9 and none in 883_10 in accordance with the definition of CCAMLR fishable area depth ranges (600–1 800 m). Because there is very little information on bathymetry in this area, collecting this information and making it available was encouraged. The proponents agreed to provide the bathymetry data if they did fish in these research blocks.

5.72 The Working Group noted that there were some milestones due in 2020, when WG-FSA was not held due to the COVID-19 pandemic, and that 2021 milestones appeared to be missing from WG-FSA-2022/26, Appendix 1. The proponents informed the Working Group that that they will review the status of the milestones and update the appendix.

5.73 The Working Group recommended that the catch limits for Subarea 88.3 be based on the trend analysis as shown in Table 5.

5.74 WG-FSA-2022/27 and 2022/28 provided results from analyses of diet composition and feeding strategy of *D. mawsoni* in Area 88 (Subareas 88.1 and 88.3) and geographical diet variations of *D. mawsoni* in Area 88.

5.75 The Working Group noted that the three main prey items for *D. mawsoni* during 2016–2020 were *Macrourus caml*, crocodile icefish (*Chinobathyscus dewitti*) and Whitson's grenadier (*M. whitsoni*), as well as 28 species of prey taxa. There was broad similarity between subareas in prey assemblage. For the samples collected in 2019–2022, DNA metabarcoding of stomach contents indicated 158 prey haplotypes, with 124 haplotypes identified as fish. Analyses of geographical and temporal variation in main prey items indicated a different species composition between shelf and slope regions.

5.76 The Working Group noted that this study demonstrated that *D. mawsoni* have a very wide range of prey items, and if there are prey items available regardless of their geographic area, they will likely be consumed. Given this, it noted that *D. mawsoni* could potentially serve as a sampling platform for marine organisms in the region.

5.77 The Working Group noted that understanding the reasons that underpin geographic patterns of prey would benefit from additional studies that endeavour to link diet, depth, physical and oceanographic features.

5.78 WG-FSA-2022/29 Rev. 1 introduced a study of population genetic structure of *D. mawsoni* from fish sampled in Area 88 based on 21 microsatellite markers. The Working Group noted that studies aiming to characterise genetic structure have yielded evidence in support of both single or multiple genetic populations.

5.79 The Working Group noted two potential hypotheses related to grouping in the preliminary work not related to geographic groupings: (i) cohorts that may be related to changes in population structure over time, and (ii) potential environmental conditions that certain groups are exposed to in different geographic areas that might contribute to potential differences observed in the analysis.

5.80 The Working Group reviewed the research proposal outlined against WG-FSA-2019/55 in Table 6.

Subarea 48.1

5.81 WG-FSA-2022/32 provided results of age determination studies of *Dissostichus* spp. and *Macrourus* spp. from the research longline catches in Subarea 48.1 by the Ukrainian vessel *Calipso* in 2019–2021. The Working Group noted that *D. mawsoni*, *M. caml*, and *M. whitsoni* otoliths were collected during three fishing seasons, from 2019 to 2021. It noted that the demographic structure of *D. mawsoni* had changed little over the three years, and findings were most likely influenced by the fishing coverage across the years.

5.82 The Working Group agreed that it would be useful to include a discussion of macrourid ageing at the proposed 2023 ageing workshop (WS-ADM, paragraph 4.18), as there has been relatively little discussion of ageing of these common by-catch species. The importance of a reference set of otoliths was emphasised to facilitate inter-laboratory comparisons.

5.83 The Working Group agreed that it would be valuable to consider other ageing issues and methodologies for macrourids, such as methods of preparation and comparison between readers. It agreed that in preparation for the proposed age determination workshop, a reference set of otoliths prior to ageing would be valuable, and that information can be stored in the Secretariat's database.

Non-target catch and incidental mortality associated with fishing

By-catch in krill fisheries

6.1 WG-FSA-2022/22 presented a characterisation of recent trends in finfish by-catch (total weight) from the krill fishery using data reported from the fine-scale catch and effort (C1) data from 2010 to 2021. By-catch generally increased in recent years with increasing krill catch in Area 48 and in particular in the South Orkney West (SOW) and South Orkney North East (SONE) small-scale management units (SSMUs) in Subarea 48.2. *C. gunnari* represented the main by-catch species by weight in Subarea 48.2. The author noted that current by-catch of *C. gunnari* in the krill fishery may be affecting the recovery from very high catches in the late 1970s and 1980s. A general increase in the number of species recorded in Area 48 was reported, with Subarea 48.1 recording the highest number of species.

6.2 The Working Group noted that the increase in total by-catch and number of species recorded may be influenced by increased observer coverage and improvements in species identification in recent years. The Working Group noted the likely occurrence of data quality issues and recommended the inclusion of an additional field in the C1 data form to indicate whether the information on by-catch was collected by the fishing crew or the scientific observer on a haul-by-haul basis.

6.3 The Working Group also recommended that relevant changes in conservation measures, data collection protocols and observer coverage requirements through time be summarised in the Krill Fishery Report to assist with the interpretation of the time series of data from this fishery.

6.4 WG-FSA-2022/03 presented an update by the Secretariat of the analysis of fish by-catch in the krill fishery. In addition to updating the analysis of frequency of occurrence of fish in by-catch data, a preliminary approach to estimating by-catch rates (kg fish per tonne of krill) was introduced, and spatial and temporal patterns of total fish by-catch summarised. The Secretariat requested feedback regarding the approach, as well as potential further analyses, and suggested the Working Group consider specifying by-catch data collection objectives for the krill fishery to aid in observer instruction and observer logbook development.

6.5 The Working Group acknowledged the importance of these analyses (WG-FSA-2022/03 and 2022/22) and recommended further investigation of spatial patterns in species composition and habitat relationships be conducted.

6.6 The Working Group noted patterns of finfish by-catch in the krill fishery were highly variable spatially and temporally. Furthermore, that occasional instances of high finfish by-catch and low krill catch increased uncertainty in the estimation of by-catch rates. The Working Group also noted the importance of high-quality data collection and recommended the development of specific objectives and corresponding data collection of finfish by-catch by observers and crew. The Working Group recognised subsampling of finfish by-catch is intensive and to maintain high-quality by-catch data, two observers may be required.

6.7 The Working Group recommended that the Secretariat continue this important work, coordinated with Member scientists, analysing finfish by-catch in the krill fishery and noted that future analyses may include total by-catch weight as well as length-frequency distributions as these may help identify errors or to determine by-catch rate thresholds above which by-catch events maybe be considered outliers and analysed separately. It noted that although CM 23-01 requires vessels to report total by-catch, the expectation of the vessel crew being able to reliably quantify total by-catch, including very small fish, during fishing operations was unrealistic and noted the need for discussions on alternative approaches to ensure accurate by-catch reporting from vessels. The Working Group also noted that vessels were aiming to only catch krill, as by-catch could impact product quality, and that improving understanding of spatial and temporal distribution patterns in by-catch would benefit both the fishing industry and conservation efforts.

By-catch in toothfish fisheries

6.8 WG-FSA-2022/47 presented a summary of trends in performance indicators, including catches, fishing effort, catch rates, fish size, sex ratios and fish body condition, for the main by-catch species/species groups in the longline fishery targeting *D. mawsoni* in the Ross Sea region. Five species groups (macrourids, skates, icefish, eel cods and morid cods) were found to dominate the by-catch of the fishery by weight. The authors made recommendations to support the ongoing monitoring of by-catch species in the Ross Sea region toothfish fishery.

6.9 The Working Group welcomed the report into the data holdings from the Ross Sea and noted the large amount of work that had been undertaken in the region by scientists and SISO observers to collect and catalogue the data. The Working Group recommended that both the number and estimated weight of skates released alive should be presented. The Working Group also reflected that species identification of Notothenioids is challenging and to improve data quality, observers could assist crew with identification.

6.10 The Working Group recommended the following actions to support ongoing monitoring of by-catch species in the Ross Sea region toothfish fishery:

(i) data collection should continue for by-catch species as proposed in the updated Ross Sea MTRP (WG-FSA-2022/45 and Tables 1 and 2)

(ii) the Secretariat investigate mechanisms to increase the number records that are identified to the species level for the main by-catch groups (particularly macrourids, skates and rays, Notothenioids and eel cods), including collaborating with scientific observer coordinators, providing species identification aids and ensuring relevant species codes are available

(iii) Members collaborate on targeted analyses of by-catch ratios, to understand why there are differences in catch rates of by-catch among gear types and among vessels

(iv) Members collaborate to monitor by-catch performance indicators at regular intervals (every two years suggested), for submission to WG-FSA

(v) the Secretariat consider including relevant figures from WG-FSA-2022/45 on by-catch within the Fishery Reports.

Macrourids

6.11 WG-FSA-2022/33 presented an update on the modelling of grenadier (caught as by-catch) relative abundance in the longline fishery in Subarea 48.6 using the VAST framework. The authors noted that future analyses would benefit from the development of a single VAST model (instead of separate VAST models for each research block) via the specification of ‘strata’ within VAST.

6.12 The Working Group thanked the authors for the improvements brought to the analysis, noted its usefulness and potential applicability to other species and areas, and indicated that the increased use of Spanish longlines in recent years indicated the need to include different gear types in the model. It encouraged the authors to investigate additional types of model diagnostics and discussed the future potential application of the method in management approaches such as move-on rules and by-catch limit determination.

6.13 WG-FSA-2022/48 presented an update on modelling of spatio–temporal changes in macrourid (*M. whitsoni* and *M. caml*) by-catch in the Ross Sea region toothfish fishery using VAST, indicating that the model results may be used to set by-catch limits for *Macrourus* spp. in the Ross Sea region while accounting for the different productivity of each species. The authors recommended that future studies should investigate how changes in by-catch reporting might impact these results.

6.14 The Working Group thanked the authors for the progress made on this analysis, discussed the implications of temporal changes in species distributions on the resulting predictions and encouraged the authors to account for the use of different gear types in future iterations. Noting that this preliminary analysis was restricted to a subsample of data that was considered reliable, the Working Group encouraged the authors to expand their data inputs in the future as well as to investigate model sensitivity to such expansion (e.g. gear type and vessel effects). Noting that this method offered a path to more robust by-catch limits, the Working Group encouraged the authors to submit a paper in the future, detailing the methods used as well as a description of potential uses of this framework to inform management approaches.

6.15 WG-FSA-2022/P03 presented an analysis of the use of otolith shape to differentiate between the morphologically similar grenadiers, *M. caml* and *M. whitsoni*, and to validate species identifications by observers in the Ross Sea region. Otoliths of *M. caml* were found to be larger and more elongate than those of *M. whitsoni* and this reliable and predictable difference was useful to identify species, an approach applicable to both ongoing and archived otolith collections. With more than 88% correct species assignment, results highlighted the potential for using otolith shape as an effective tool for assessing the accuracy of species identifications in fisheries sampling programs. Individual observer identification success was found to range from 50% to 98%.

6.16 The Working Group thanked the authors for the useful method and discussed the potential for regional and ontogenetic differences in otolith shape for a given species, which could potentially be detected using this method. It noted that the approach required careful imaging protocols and discussed the potential for emerging technologies to automate species identification in the future.

6.17 WG-FSA-2022/P04 presented an analysis comparing the biology of the grenadiers *M. caml* and *M. whitsoni* in the Ross Sea region. *M. caml* was found to live longer, grow slower, and have a larger maximum length. For both species, females of a given age were larger than males, potentially indicating greater fishing pressure on females than males, as evidenced by female-biased sex ratios. Estimates of natural and fishing mortality rates were low for both species. *M. whitsoni* matured later in life and at larger lengths than *M. caml*. Results indicated prolonged spawning for both species, with peak spawning during summer.

6.18 The Working Group thanked all authors of these papers for the extensive data collection and analysis presented, noted its importance to the understanding of the species' biology as well as to the development of species-specific by-catch limits.

Skates

6.19 WG-FSA-2022/19 presented an analysis of skate handling practices and condition assessment methods in the longline toothfish fisheries operating in the southern Indian Ocean (French and Australian exclusive economic zones (EEZs)). Thirteen types of injuries were identified from photographs and analysed by veterinarians specialised in elasmobranchs. Results provided clear guidelines for crew members operating on longline vessels to maximise the survival of released skates. The authors welcomed feedback on their communication tools (two posters and one video tutorial) and that they would be willing to share them with other CCAMLR Members.

6.20 The Working Group congratulated the authors for their useful guide, and recommended to the Scientific Committee that the poster and the training video for skate handling and injury assessment be made available on the CCAMLR website along with other SISO manuals.

6.21 WG-FSA-2022/20 presented a preliminary study on the use of the vertebrae centrum in the age determination of skates (whiteleg skate (*Amblyraja taaf*) in Crozet, and *Bathyraja eatonii* and Kerguelen sandpaper skate (*B. irrasa*) in Kerguelen waters). Results indicated that vertebrae centrum observations would provide an alternative approach to *corpus calcareum* observations for ageing deep-sea skates.

6.22 The Working Group thanked the authors for their useful analysis and encouraged them to continue this work as age determination of skates is critical to the management of skate by-catch in the fishery. It noted the issue of freezing-induced fracturing and suggested trying either higher freezing temperatures or flash freezing in liquid nitrogen as alternatives.

6.23 WG-FSA-2022/42 and 2022/43 presented an update of the skate tagging program in the Ross and Amundsen Sea regions that was implemented since 2020 for population size estimation and to validate the thorn ageing method for Antarctic starry skate (*A. georgiana*). The authors indicated that further sampling was required to determine if age validation could be assessed with chemical uptake in caudal thorns and encouraged Members to send them thorns of recaptured tagged skates for analysis. The authors also recommended the continuation of caudal thorn sampling as well as the implementation of another two-year pulsed tagging event in approximately five years, as specified under the RSDCP.

6.24 The Working Group thanked the authors for their extensive work and noted the significant likelihood of recapture of chemically marked skates by vessels from other Members. It noted that in such cases, other Members were encouraged to coordinate with the National Institute of Water and Atmospheric Research (NIWA) to send their thorn samples to New Zealand (who will cover shipping costs) and requested the Secretariat make thorn sampling protocols available on the CCAMLR website, along with other SISO protocols. The Working Group discussed the difficulty of ageing skates and encouraged Members to further develop methods to that end, recalling alternative methods such as eye lens radiocarbon analysis (Nielsen et al., 2016).

Management of VMEs and habitats of particular concern

6.25 WG-FSA-2022/02 presented a report on the discovery of an extensive icefish (*Neopagetopsis ionah*) nesting ground in the southern Weddell Sea and the corresponding discussions and recommendations from WG-EMM-2022, paragraph 3.28. The authors identified two ways forward to achieve protection in a timely manner, either through modifying CM 22-06 or a new specific conservation measure. In addition, the authors recalled that the Food and Agriculture Organization (FAO) had developed criteria for recognising VMEs among which were 'discrete areas or habitats that are necessary for the survival, function, spawning/reproduction or recovery of fish stocks' (https://www.fao.org/in-action/vulnerable-marine-ecosystems/criteria/en/). The authors highlighted that icefish nesting grounds as described in WG-FSA-2022/02 fit the FAO criteria.

6.26 The Working Group agreed that the presence of an extensive icefish nesting ground was indicative of a VME and requested the Scientific Committee to consider a modification of CM 22-06 as a mechanism to protect these nesting areas when discovered.

6.27 The Working Group noted that although a precautionary approach was desirable, additional data was required to inform a potential extension of the area if more icefish nests were found and to monitor the use of the area for nesting through time. It noted that fishing vessels operating in the area under a research plan could be tasked to deploy an underwater camera or environmental sensors to achieve scientific objectives such as the identification of spawning ground extent or the continuing presence of icefish nests in the area identified.

6.28 WG-FSA-2022/14 presented a report by the Secretariat on the status of the CCAMLR marine debris monitoring program. Results showed that most debris are plastic items or fishing gear, that the amount of debris observed each year is increasing (although standardising for effort is difficult), and that lost longline gear reported by fishing vessels in the Convention Area has been decreasing in recent years.

6.29 The Working Group noted that marine debris was harmful to ecosystems, especially birds and mammals, and that they are not necessarily a direct effect of CCAMLR fisheries. Information contained in the report was helpful, but data collection should be improved to include the origin of the debris if possible, type of lines found, and whether lines were retrieved or not so as to understand what mitigation measures can be put in place to reduce gear loss.

6.30 The Working Group noted that the Chair of the Scientific Committee had reported to the Committee for Environmental Protection (CEP) on the efforts by CCAMLR Members to monitor trends in marine debris in the Convention Area and noted that more detail would be provided to the CEP in the future to facilitate collaboration between SC-CAMLR and the CEP and communicate the impact of debris around Antarctica.

6.31 The Working Group recommended that the Scientific Committee consider adding marine debris as a topic of mutual interest to their joint reporting with the CEP.

6.32 The Working Group recommended that the 'Intersessional Correspondence Group – Marine Debris' be used to progress discussions and that the Secretariat coordinate integration of the results from WG-FSA-2022/14 into the correspondence group's workplan.

6.33 WG-FSA-2022/61 presented a revised VME Taxa Classification Guide for the toothfish fishery and the authors recommended it replace the existing one (https://www.ccamlr.org/node/74322) to realign the guide with recent changes to the taxon code database.

6.34 The Working Group noted that the details about the changes recommended were useful in evaluating the revised VME Taxa Classification Guide. It noted that the new guide included taxonomic changes and an alignment of taxonomic names with FAO taxa codes. Although the revised guide did not include additional taxa, the Working Group suggested considering extending the guide to new indicator species as previously proposed (WG-EMM-18/35). The Working Group noted that the document needed to be circulated among taxonomic experts within CCAMLR Members and among experts outside CCAMLR. It suggested to proceed in two steps: (i) agree taxonomic names with experts to ensure that they are used throughout the Convention Area, and (ii) request any new codes from FAO. The results could be presented at WG-EMM.

6.35 At the time of report adoption, the Working Group requested the Secretariat provide a VME code translation table to Member observer coordinators to assist observers using the current guide as some e-logbook codes currently differ from what is on the existing identification guide for the upcoming season.

Ecosystem structure and function

6.36 WG-FSA-2022/18 presented an analysis of the trophic ecology of *D. mawsoni* near the northern tip of the Antarctic Peninsula, based on a combination of morphological identification of prey composition and fatty acid analysis from dietary samples collected in two seasons (2020–2021). The results showed that the diet of *D. mawsoni* was mainly composed of Macrouridae, Cephalopoda, Anotopteridae and Channichthyidae and contained small amounts of Crustacea and Spheniscidae.

6.37 The Working Group welcomed this paper and noted the presence of small amounts of Anthozoa and penguins in the diet of *D. mawsoni* and recalled similar findings by studies in other areas (paragraph 5.74). The Working Group noted that identification to species level using otoliths might provide further insights.

6.38 WG-FSA-2022/P01 presented an analysis of parasitic worms (helminths) recovered from 12 different fish species collected by the trawl vessel *More Sodruzhestva* near the South Orkney Islands between December 2020 and March 2021.

6.39 WG-FSA-2022/P02 presented an analysis of the trophic interaction between *C. gunnari* and Antarctic krill (*Euphausia superba*) based on stomach content analysis of icefish and comparison of the fatty acid profiles of icefish and krill. The stomach contents analysis showed that krill was the predominant prey of icefish during winter at South Georgia.

6.40 The Working Group welcomed this study and noted that the *C. gunnari* samples had been collected as by-catch from the krill fishery and those *C. gunnari* would have been feeding on krill when caught. The Working Group also noted the potential variability in prey choice for the species and encouraged comparisons of *C. gunnari* diet using samples obtained from research surveys conducted away from krill fishing grounds by Members in other areas such as Subareas 48.1 and 48.3 and Divisions 58.5.1 and 58.5.2.

6.41 The Working Group noted that SC-CAMLR-41/BG/35 reported a low abundance of krill in icefish diet in Subarea 48.3 during May 2021 and recalled a previous study on the condition of *C. gunnari* in relation to local abundance of the krill stock (Everson et al., 1997). The Working Group noted that more work was needed on the relationship between icefish diet and local abundance of krill, including the potential for prey switching to *Themisto* spp. when the krill abundance was low (WG-FSA-17/44).

6.42 SC-CAMLR-41/BG/33 presented a proposal for a workshop to enhance the CCAMLR Ecosystem Monitoring Program (CEMP) based on recommendations arising from WG-EMM-2022.

6.43 The Working Group welcomed the paper and endorsed the proposal to convene a workshop on CEMP as recommended by WG-EMM-2022, paragraph 2.95. The Working Group noted the importance of reinvigorating CEMP given its role in the developing krill management approach and in monitoring the effects of climate change on the ecosystem.

6.44 WG-FSA-2022/31, which was also submitted for consideration by the Scientific Committee and Commission (CCAMLR-41/31 Rev. 1), proposed a workshop on integrating climate change and ecosystem interactions into CCAMLR science. The paper invited the Working Group to consider terms of reference for such a workshop.

6.45 The Working Group welcomed the paper and recommended the Scientific Committee support the proposal contained in WG-FSA-2022/31.

6.46 The Working Group recalled discussions during the Scientific Committee Symposium noting the value of collaboration with the CEP and the Scientific Committee on Antarctic Research (SCAR) to better understand climate change implications for the Antarctic ecosystem (WG-ASAM-2022/01, paragraph 4(a)v). It noted that, in line with the use of CCAMLR conservation measures, an applied and practical approach to accounting for climate change in management was needed, including the tracking of population biological parameters through time.

Antarctic krill (*Euphausia superba*)

Catch recording

7.1 WG-FSA-2022/04 provided an update on issues identified in krill fishery data related to the reporting of by-catch data from Chilean and Ukrainian vessels, green weight estimation parameters reported from the Chilean vessel *Betanzos* and the Norwegian vessel *Juvel*, and the allocation of catch amounts to two-hourly trawl periods for continuous trawling vessels.

7.2 For all items, considerable progress or resolution of issues has been made through consultation with Members and vessel operators. The Working Group agreed with the following recommendations:

(i) The Secretariat undertake data changes for krill green weight estimation parameters for the vessel *Juvel* for the 2015 and 2016 seasons, using the ρ value of 1 reported in the paper.

(ii) The use and submission of two-hourly catch reporting form for continuous trawling vessels where a flow meter or flow scale is not installed on the primary inlet hose prior to the distribution of catch into holding tanks. Any such requirement may also require relevant changes to CMs 21-03 and 23-06.

7.3 The Working Group thanked the Secretariat, Member scientists and the fishing industry for clarifying the way in which catch data were collected and reported.

7.4 The Working Group noted that the changes do not impact its advice to the Scientific Committee as the corrections impact the checking of green weight calculations only; catch limits are managed using the C1 data, reporting of which is not impacted.

Management framework

7.5 The Working Group recommended the Scientific Committee inform the Standing Committee on Implementation and Compliance (SCIC) that the issues with catch reporting by the *Betanzos* and *Juvel* (SC-CAMLR-40, paragraph 3.5) have been resolved.

7.6 SC-CAMLR-41/19 provided comments on the development of the krill fishery management in Subarea 48.1. The authors noted that the revision of CM 51-07 should not start with krill management in Subarea 48.1 followed by Subareas 48.2–48.4 in a staged approach. It should be updated on the basis of a coordinated management framework for krill fisheries across the whole of Area 48. The authors considered that as Subareas 48.1, 48.2, 48.3 and 48.4 are connected as a system, this process would require the development of a krill stock structure hypothesis and the collection of data on the spatial and temporal distribution patterns of krill. The authors proposed that they design and implement a system of biannual (summer and winter) standardised acoustic surveys, including synoptic and regional krill surveys in Area 48, accompanied by comprehensive environmental data collection and observations of marine mammals and seabirds. In the authors' view, implementing such a system of standardised surveys, throughout Subareas 48.1 to 48.4, would provide the necessary and sufficient scientific support to develop a fisheries management strategy and provide the scientific basis for a comprehensive revision of CMs 51-07 and 51-01. The authors expressed concern that there is still no clarity on how the risk indicators used in the spatial management scenarios for the fishery (the proportion of juvenile krill and krill consumed by each group of predator and spatial distribution of predator consumption) are related to key parameters, the state of the predator population and reflect the ecosystem impact of the fishery. In particular, it is important to link risk indicators to measurable responses of predator populations (e.g. changes in population size, breeding success, foraging behaviour) and CEMP indices to changes in krill availability.

7.7 The Working Group noted that there are shortcomings in the data that are used for the provision of advice on the krill management, and that there is always room for improvement. The ambition of the Scientific Committee and its working groups is the establishment of a pragmatic data collection and analysis program that supports regular advice updates to the Commission. While there is a need to address outstanding issues (example krill flux) in the future, the Working Group noted that the information available can be used to carry out its task to provide advice on the updating of CM 51-07 this year. The Working Group noted that the work program concentrating on Subarea 48.1, initially, and then the remaining subareas of Area 48 has been agreed by both the Scientific Committee and Commission.

7.8 The Working Group discussed the process that has been agreed in the Scientific Committee and Commission for the provision of advice on the revision of CM 51-07. The Working Group noted that it had been agreed that Subarea 48.1 would be the first subarea that the revised krill management approach would be applied to in order to derive regional catch limits. It noted the work to develop the approach, with a work plan developed in 2019 and significant progress made since 2021, had continued in WG-ASAM, WG-SAM and WG-EMM which had provided:

(i) further advice on the development and refinement of the management units (strata) in Subarea 48.1

(ii) krill acoustic biomass estimates for the agreed strata

(iii) a training workshop on the application of the Grym model

(iv) development of a method for the derivation of improved length weight data for the Grym

(v) further analysis and consideration of appropriate recruitment information.

Biomass estimates

7.9 WG-SAM noted that the development of the Grym methodology still required the refinement and agreement of some parameters, particularly a proportional recruitment time series (WG-SAM-2022, paragraph 3.8). In the absence of agreed parameter values, WG-SAM recommended that a suitable range of parameter options be used to provide catch estimates on which advice to the Scientific Committee from WG-FSA can be based (WG-SAM-2022, paragraph 3.8).

7.10 WG-EMM agreed on the biomass estimates for Subarea 48.1 management units (strata) (WG-EMM-2022, Table 1) and noted that a workshop to develop a stock structure hypothesis for the krill stock, similar to that which had been conducted for Area 48 Antarctic toothfish

(SC-CAMLR-XXXVII/01), would progress the discussions on regional links between subareas particularly the movement of krill, within and between subareas (flux) (WG-EMM-2022, paragraph 2.89).

7.11 WG-FSA-2022/37 presented proposals to standardise the collection and processing of krill acoustic survey data. The authors noted the Scientific Committee recommendations to develop standardised methods for processing and reporting future acoustic survey results, and that they considered it important to streamline the system of krill acoustic surveys carried out in the Convention Area. In particular, standardisation of acoustic surveys would require:

(i) clear and transparent definitions and requirements to streamline the system of krill acoustic surveys carried out in the Convention Area

(ii) for each type of survey recommendations for design and timing of the acoustic survey; methodological aspects and standardised procedures for data collection and processing, and reporting results

(iii) the authors also considered that there is no scientific basis for swarming behaviour in krill which forms the basis of the swarm-based analysis approach, highlighting a substantial difference between swarm-based and dB-difference methods derived from their survey data. Under the example of the 2020 *Atlantida* data it was clearly demonstrated that a significant part of the krill biomass may be underestimated if the swarm-based method is used. The authors noted that there is no adequate scientific justification regarding the need and possibility of using the swarms-based method for estimating krill biomass for the krill fishery management.

7.12 The Working Group noted that this was a similar paper to that which had been submitted to WG-ASAM (WG-ASAM-2022, paragraphs 2.3 and 2.4). WG-ASAM had noted that both the dB-difference and swarms-based krill identification methods had been agreed for estimating acoustic biomass. It was noted that the differences between methods were not as apparent in other comparative studies using the two methods. The Working Group noted that many of the issues discussed in the paper, including standardisation, have previously been discussed at WG-ASAM and are being progressed (WG-ASAM-2022, Table 1).

7.13 WG-FSA-2022/30 presented an evaluation of proposed stratum-scale catch limits for the krill fishery in Subarea 48.1 to assess whether they are likely to be precautionary. The authors compared stratum catch limits for Subarea 48.1, which have been proposed in papers to WG-FSA, WG-SAM and WG-EMM, to the time series of stratum survey biomass in WG-ASAM-2022, Figure 2. The ratio of a proposed stratum catch limit to survey biomass was used to derive an estimate for the exploitation rate that would have occurred, in that year, if the catch limit had been applied. The authors noted that there is sufficient information available to evaluate whether proposed management options for Subarea 48.1 are likely to allow CCAMLR to fulfil its obligations under Article II of the Convention, and to objectively compare alterative management options.

7.14 The Working Group noted that the method had the potential for development as a diagnostic approach to compare catch limits derived from a range of approaches against the information collected across a time series of acoustic estimates. Uncertainties associated with the approach were noted including the timing and availability of surveys (summer vs winter).

Estimation of gamma

7.15 WG-FSA-2022/35 presented alternative proportional recruitment estimates for Subarea 48.1 based on reanalysis of the US AMLR data series. The authors noted that previous proportional recruitment parameter estimates were based on the entire US AMLR summer survey time series but only using data collected during the daytime. They noted that it had previously been recommended that data collected at night only be used to reduce the light-linked net avoidance of krill. In addition, the Joinville Island stratum, which has been recognised as an important area for krill recruits, was not fully covered by the entire US AMLR survey time series. The authors provided alternative proportional recruitment estimates based on reanalysis of the US AMLR data given the above two considerations, resulting in a gamma estimate of 0.0355 based on the 2002–2011 continuous time series and a gamma estimate of 0.0412 based on all surveys (2002–2011 plus 1997) that covered all four US AMLR survey strata using data collected at night only.

7.16 The Working Group noted that CCAMLR data collection protocols recommend that night-time samples are collected when 'open and close' nets are deployed. Where samples are collected using normal nets, day and night-time oblique tows are recommended for collecting length distribution data and as such samples from both day and night could be used.

7.17 The range of proportional recruitment scenarios calculated in WG-FSA-2022/35 were based on the US AMLR surveys. The Working Group noted that the scenarios presented within WG-FSA-2022/35 did not include the 2020 *Atlantida* data (WG-EMM-2021/12).

7.18 The Working Group therefore recalculated the Grym scenarios presented in WG-FSA-2022/35 to include both day and night data from all US AMLR surveys which sampled Joinville Island strata (1997, 2002–2011) as well as the 2020 *Atlantida* survey. The mean and standard deviation of the proportional recruitment from the 12 surveys were 0.5047 and 0.2406 respectively. All other model parameters were chosen from scenario 18 of WG-FSA-2021/39 to be consistent with the models presented in WG-FSA-2022/39. The inputs to the model and the results are presented in Appendix G. The revised gamma estimate was 0.0338.

7.19 The Working Group agreed to use the US AMLR survey recruitment series from all trawls (day and night) from years which include data from the Joinville stratum, as well as the Russian Subarea 48.1 survey to derive recruitment parameters for Grym which resulted in a new value of gamma, 0.0338 (Appendix G).

7.20 The Working Group recommended that a gamma value of 0.0338 be used in the calculation for the Subarea 48.1 catch limits.

7.21 WG-FSA-2022/39 reviewed progress made by the Scientific Committee and its working groups towards an agreed, science-based, krill management approach since 2019. The authors also reviewed progress made by WG-ASAM-2022, WG-SAM-2022 and WG-EMM-2022 and presented updated spatial and seasonal allocation of krill catch limit based on analysis by the working group meetings as well a revised harvest rate estimate presented to the WG-FSA-2022 meeting (WG-FSA-2022/35).

7.22 The Working Group noted that there is a need for a concise explanation of the revised krill management process to the Scientific Committee and Commission. Appendix H presents the workflow of the krill management approach that has been in development in Scientific

Committee's working groups over the last three years. This approach is comprised of three components, namely the biomass estimation, the stock assessment using the Grym and the spatial overlap analysis (formerly called the risk assessment, see WG-EMM-2022, paragraph 2.72).

Catch limit allocation

7.23 The spatial overlap analysis computes relative spatial and seasonal overlap between krill and its predators within a region and can evaluate overlap associated with different proposals, or scenarios, to subdivide the catch. It is intended that the krill management approach will be improved and progressed as it is applied to other subareas in Area 48 individually or in a holistic approach based the experiences and knowledge gained.

7.24 The Working Group recommended the Grym data and parameters in Appendix G and acoustic biomass estimates in WG-EMM-2022, Table 1, be used for allocating catch limits noting that the baseline scenario from the spatial overlap analysis (Table 10) should be applied as it is considered more precautionary than the catch allocation derived using fisheries desirability scenario.

7.25 The Working Group also noted the paucity of winter krill data in the spatial overlap analysis and that dedicated surveys would be required to further refine the approach.

7.26 The Working Group discussed how the workflow of the three components (biomass estimation, the stock assessment using the Grym and the spatial overlap analysis) can be integrated, and whether gamma should be applied to each biomass estimated for each stratum independently to derive spatial distribution of catch limits or gamma to be applied to the total biomass for Subarea 48.1, and multiply alpha for each stratum estimated from the spatial overlap analysis. The Working Group agreed that distributing catch simply based on biomass estimates in strata does not take account of uncertainties in predator requirements, and information on critical areas for krill reproduction, as determined in the spatial overlap analysis.

7.27 During the WG-FSA meeting, the catch limits by stratum were recalculated using the baseline scenario in the spatial overlap analysis and with a gamma value of 0.0338 (paragraphs 7.18 and 7.19). Table 10 shows the recalculated catch limit for the seven candidate management units (strata).

7.28 The Working Group agreed that a total catch limit for *E. superba* in Subarea 48.1 set at 668 101 tonnes for 2022/23 would be consistent with the precautionary yield estimated using the CCAMLR decision rules for krill and that subdividing this total catch limit among management units and seasons as presented in Table 10 would be consistent with the process agreed for setting krill catch limits (SC-CAMLR-38, paragraph 3.30). The Working Group further agreed that the catch limits presented in Table 10 are based on the use of the best available science.

7.29 The Working Group reviewed distribution of mean catch for each stratum during summer and winter periods in the last five years. It noted that the majority of the current trigger level catch limit allocated for Subarea 48.1 was taken from the Bransfield Strait stratum during winter period, followed by Gerlache Strait stratum (Figure 7, upper maps).

7.30 Based on the spatial overlap analysis, which allocates a low alpha to the Bransfield Strait due to the higher relative overlap with predators, the proposal in Table 10 reduces catch in this stratum. Higher alphas, and therefore associated catch limits, are allocated to strata where the current fishery does not concentrate (Figure 7, lower maps). The recommended catch limit allocation will reduce the current concentration of catch occurring in Bransfield Strait and distribute fishing effort across to the strata that are currently not intensively fished.

7.31 The Working Group noted the importance of realistic tests for the recommended catch limit allocation.

7.32 The Working Group also noted the concentration of research stations and CEMP sites in certain strata, and that there are some strata that do not have any CEMP site and/or stations (Figure 7, top left and Table 11).

7.33 The Working Group noted that substantial scientific progress had again been made this year, despite the restrictions on time available due to the requirement for virtual intersessional meetings. The development of a revised krill fishery management approach over the last three years and, following reviews and comments on the approach and information contributing to it during 2022 by WG-ASAM, WG-SAM and WG-EMM, can form the basis for Scientific Committee advice on the revision to CM 51-07.

7.34 The considerations and progress achieved in each working group are summarised in Figure 8.

Implementation of the agreed catch limits for the management of the Subarea 48.1 strata

7.35 Dr Kasatkina noted that it is important to consider that the management process is currently working on one area, Subarea 48.1, and not yet including Subareas 48.2, 48.3 and 48.4 assuming that a management review of the fishery in other Subareas 48.2, 48.3 and 48.4 to be provided at a later stages. This stepwise approach to reviewing the management of the krill fishery in Area 48 has no scientific justification and assumes independent krill subpopulations in each Subarea 48.1, 48.2, 48.3 and 48.4. In a changing climate there is a need for new information rather than relying on historic data and a system of standardised acoustic surveys for krill, including synoptic surveys and regional surveys should be considered to estimate the biomass and population structure of krill during the summer and winter seasons in Area 48 covering Subareas 48.1 to 48.4. Moreover, the proposed system of standardised acoustic surveys will provide adequate data for the krill management based on feedback, following the recommendations of the Commission (CCAMLR-XXXV, paragraphs 5.17 to 5.19), which remain unfulfilled.

7.36 Dr Kasatkina noted that a schedule of work should be agreed by the Scientific Committee in order to progress Subarea 48.1 with special attention to other subareas as soon as practicable, identifying the information that is needed, a program for collecting it and a timetable for provision of advice as soon as is possible.

7.37 The Working Group noted that interactions between the subareas due to the flow of krill between areas (flux), needs to be investigated.

7.38 The Working Group discussed the revised catch limits allocated to the strata as set out in Table 10. It was noted that the data/information available for the setting of catch limits in some of the Subarea 48.1 strata was very limited particularly Gerlache Strait, Drake Passage and Powell Basin.

7.39 Table 11 provides information to support understanding of how the revised catch limits compare to fishing activities since 1988. The Working Group discussed the various implications of the revised catch limits in the context of the information provided within the table. The Working Group noted that in several of these areas, Elephant Island, Gerlache Strait, Drake Passage and Powell Basin, the proposal in Table 10 could lead to a substantial increase in catches. In the case of the Bransfield Strait stratum, the catch limit will be lower than the maximum catch since 1998.

7.40 Dr S. Hill (UK) welcomed Table 11 and noted that additional information on local harvest rates can be obtained by comparing the stratum catch limits with the time series of krill biomass estimates in WG-ASAM-2022, Figure 2. These comparisons suggest local harvest rates for the Bransfield Strait stratum in the range of 2.5% to 100% of local biomass. For the Elephant Island stratum the range is 1.1% to 17.8%, for Joinville it is 0.6% to 17.3% and for South Shetland Islands West it is 1.3% to 100%. Dr Hill also noted that additional precaution can be achieved by splitting the combined Drake Passage-Powell Basin catch limit among its constituent strata using baseline alphas from the spatial overlap analysis.

7.41 The Working Group agreed that substantial catch increases in the Elephant Island, Gerlache Strait, Drake Passage and Powell Basin strata could outpace the ability to monitor catches, by-catch and the impact on the wider ecosystem and that a staged increase in catch limits, in line with increased survey frequency, CEMP sites and data collection should be considered by the Scientific Committee in order to ensure that increases in fishery exploitation are concomitant with increased collection of data to ensure that CCAMLR meets its objectives for management of the krill fishery and related species under Article II.

7.42 The Working Group discussed the types of information that would be required to be collected, as well as a staged approach in Elephant Island, Gerlache Strait, Drake Passage and Powell Basin to monitor the various ecosystem components while the krill catch limit is increased. This included:

(i) krill biomass, recruitment and demography, and its distribution in relation to the fishery, especially during winter season where most catch is allocated

(ii) monitoring of fish by-catch and regular collation of information, analysis and reporting of trends, stock status and seasonal distribution of those species

(iii) monitoring of the status of dependent predator species through, for example, the CEMP, and cetaceans

(iv) the development and assessment to the potential impact of the increased fishery to the ecosystem in general.

7.43 In addition, the Working Group recommended that the Scientific Committee should consider the impact on monitoring of the fishery, including:

(i) the ability of the Secretariat to implement monitoring in the new management approach

(ii) revision of reporting requirements, including more frequent catch reporting to enable management of smaller catch limits; for example the C1 form and the observer logbook may need revision to accommodate the refined management unit

(iii) the fishery closure forecasting procedure may need some refinement to adapt to the small catch limit allocated in some management units

(iv) increases in SISO observer coverage, and refinement of sampling and reporting protocols.

7.44 The Working Group noted that there will also need to be considerations of how the changed catch limits interact with proposed spatial management measures such as the Domain 1 MPA.

7.45 The Working Group noted that a staged approach to the increasing catch limits, while fishery and predator monitoring and reporting are established and information analysed and reported would provide a mechanism for feedback management.

7.46 The Working Group reiterated its advice that the current management approach as outlined in CM 51-07 is considered precautionary. The Working Group noted that if the future monitoring of the krill and ecosystem status and reporting (for example see paragraphs 7.42 and 7.43) does not provide regular information updates required to support the krill management approach used in Subarea 48.1, the catch limit currently outlined in CM 51-07 should be reinstated.

Scheme of International Scientific Observation

8.1 SC-CAMLR-41/16 Rev. 1 presented a proposed workplan for developing and implementing data collection needs for CCAMLR krill fisheries and re-scoping of the Krill Fishery Observer Workshop, to be held in China, that was delayed by COVID-19.

8.2 The Working Group supported the changes to the terms of reference for the Krill Fishery Observer Workshop (Appendix I). The Working Group requested that more detailed terms of reference be drafted in advance of SC-CAMLR-41, noting the need to clearly define data collection objectives prior to revising the data collection protocols for observers (paragraph 8.28).

8.3 The Working Group reviewed and endorsed the recommendations outlined in SC-CAMLR-41/16 Rev. 1, including the workplan for developing and implementing data collection needs (SC-CAMLR-41/16 Rev. 1, Table 1):

(i) the workplan for developing and implementing data collection needs for CCAMLR krill fishery outlined in SC-CAMLR-41/16 Rev. 1, Table 1

(ii) the re-scoped Krill Fishery Observer Workshop and revised term of reference and the Workshop timing, including the two options for venues

(iii) terms of reference of each issue group, including outcomes of working group discussions on various workshop timings, locations, conveners and financial requirements.

8.4 SC-CAMLR-41/BG/32 considered how electronic monitoring systems (EMS) could be used across CCAMLR fisheries. The paper highlighted how electronic monitoring can be used to enhance the work of the observer, and can increase observer safety by allowing remote monitoring of some tasks. The paper considered the data collection requirements for each of the scientific working groups and SCIC. The paper further examined fishery-specific data collection requirements under SISO and provided recommendations on those elements that could benefit from electronic monitoring.

8.5 The Working Group considered the ways in which electronic monitoring could contribute to its work, and noted that some of the key benefits included observer safety, having an independent source of information (e.g. time-stamped video), and the use of electronic monitoring to free up observer availability to prioritise active tasks such as biological sampling over passive observation which can be carried out with appropriate EMS. The Working Group noted that any redundancy in EMS would be a vessel responsibility.

8.6 The Working Group noted that a number of toothfish vessels had already implemented EMS, and Norwegian krill vessels were using EMS to monitor warp strike trials. The Working Group recognised that as well as benefits to the vessel operators and observers, there are cost implications, including initial investment costs and post-collection review of footage. The Working Group also noted the future application of developing technologies and the application of machine learning.

8.7 The Working Group recalled CCAMLR-38/BG/40, which detailed how electronic monitoring could be used on toothfish vessels to supplement data collection by observers and monitor compliance with conservation measures, and noted that technological advances (such as thermal cameras to monitor whale blows), have created new opportunities to facilitate scientific research in other areas such as monitoring seabirds and marine mammals.

8.8 The Working Group considered how to harmonise the implementation of electronic monitoring across CCAMLR fisheries and suggested that the Scientific Committee liaise with fishing industry bodies such as the Coalition of Legal Toothfish Operators (COLTO) and the Association of Responsible Krill harvesting companies (ARK) on this topic to progress these issues. The Working Group noted that the 10th International Fisheries Observer and Monitoring Conference, to be held in Hobart, Australia, from 6 to 10 March 2023, will provide a useful forum for EMS discussions.

8.9 WG-FSA-2022/01 Rev. 1 presented the report from the Workshop on Conversion Factors for Toothfish, co-convened by Mr N. Walker (New Zealand) and Mr N. Gasco (France), held virtually on 12 and 13 April 2022. The Workshop terms of reference were outlined in WG-FSA-2021, paragraphs 2.6 and 2.7. The report noted that there are currently four conversion factor application methods used in the toothfish fishery and that the calculation of conversion factors can be variable.

8.10 The Working Group noted that discussions on improvements to instructions on how to carry out a conversion factor test were undertaken, and noted potential benefits of sampling fewer fish within a conversion factor test but conducted more frequently.

8.11 The Working Group welcomed the Workshop Co-conveners' report and agreed to append it to the WG-FSA report (Appendix J). The Workshop noted that a more consistent approach for undertaking conversion factor tests and supplying data to the Secretariat needs to be developed, along with a consistent approach for setting conversion factors to be utilised by vessels.

8.12 The Working Group noted the relevance of the Workshop recommendations in reducing the variability observed in conversion factors and the importance of progressing the Workshop's recommendations.

8.13 WG-FSA-2022/52 presented a summary of deployment information for all observers on board vessels in the CAMLR Convention Area appointed under the terms of SISO during the 2022 season, and an update on the development and implementation of commercial data forms and manuals.

8.14 The Working Group thanked SISO observers for their invaluable contribution to CCAMLR science, and the Secretariat for the logbook developments.

8.15 WG-FSA-2022/12 presented an analysis on the factors influencing conversion factors using generalised additive mixed models (GAMMs) in CCAMLR toothfish fisheries conducted by the Secretariat with the support of Dr Devine.

8.16 The analysis only included conversion factors obtained using the head, gutted and tailed (HGT) processing type as this was the most used method for toothfish. For both *Dissostichus* species, fish length, fishing location, seasonal timing and vessel were found to have significant effects on conversion factors. The relative importance of each factor differed between species, as well as the shape of their relationship with conversion factors, although model parameter estimates were uncertain due to the lack of overlap in observations between locations, months and vessels.

8.17 The Working Group noted the variability in *D. eleginoides* conversion factors due to the fishery spanning the spawning season, while for *D. mawsoni*, the fishery occurs outside the spawning period so sampled fish are commonly observed in a 'resting' maturity phase.

8.18 The Working Group further noted the importance of identifying the sample size needed to reliably obtain conversion factors and the methodology, i.e. how many fish are selected and how often. The Working Group requested that the Secretariat undertake a power analysis to identify appropriate sample sizes by species, area and season.

8.19 The Working Group recommended that the Secretariat work with Members to develop a proposal for the collection of conversion factor data and the use of conversion factors on vessels.

8.20 The Working Group recommended the proposals should consider the following:

(i) recording sex and gonad and liver weights during conversion factor sampling, noting that this would require changes to the CCAMLR SISO data collection forms to include additional biological information fields (e.g. sex)

(ii) the stratification of conversion factor sampling across variables of interest (fish size, season and area)

(iii) the methods for application of conversion factor data by vessels to best estimate green weight.

Krill fishery by-catch sampling

8.21 The Working Group noted that clear research and monitoring objectives for finfish by-catch data collection in the krill fishery should be identified prior to developing observer and crew protocols. The Working Group identified that priority research objectives should include:

(i) quantifying the abundance of finfish by-catch
(ii) identifying species composition of finfish by-catch
(iii) understanding patterns in the biological parameters (e.g. length frequency) of finfish by-catch.

8.22 The Working Group noted the current 25 kg by-catch subsampling regime should be re-evaluated to enable key research objectives to be met. The Working Group noted that any adjustments to data collection protocols should consider the physicality of work undertaken on vessels by observers.

8.23 The Working Group recalled that WG-SAM-16/39 provided an example methodology to determine the effective sample size required to evaluate the efficiency of length samples collected by at-sea observers in the krill fishery and may provide an appropriate approach for determining sample sizes for finfish by-catch analysis.

8.24 The Working Group recommended the development of a power analysis and/or productivity susceptibility analysis to be submitted to the Krill Fishery Observer Workshop to guide the development of observer data collection protocols.

8.25 The Working Group discussed the workloads and coverage of SISO observations across hauls, as this is related to spatio–temporal patterns for: (i) krill biological sampling, (ii) fish by-catch sampling, and iii) warp observations. The Working Group noted that observation rates were highly variable between vessels in 2020/21. The rates varied for krill biological samples from 1 to 22%, by-catch biological samples from 11% to 69% and warp observations from 7% to 46%.

8.26 The Working Group noted that there may be a number of drivers for the variability of observation rates among vessels, particularly the number of observers on board or other sampling requirements. Noting that this is only a single year's summary, the Working Group requested the Secretariat provide an analysis of sampling rates to WG-EMM-2023 over a longer time period and identify possible causes of variability between vessels.

8.27 The Working Group discussed future priority research areas. It noted that the development of electronic monitoring protocols and data collection would alleviate some tasks from observers and provide time for more comprehensive sampling of finfish by-catch. The Working Group also encouraged future research focused on the rapid on-board processing of acoustic data to discriminate between icefish and krill aggregations to further understand patterns in finfish by-catch and provide mitigation options. The Working Group also noted that advancements in eDNA research may assist in quantifying abundance and diversity of finfish by-catch in the krill fishery.

8.28 The Working Group noted that observer data collection tasks are developed by multiple working groups, and requested the Scientific Committee provide advice on how to prioritise these work tasks.

Future work

Chair's report of the Scientific Committee Symposium

9.1 The Chair of the Scientific Committee (Dr D. Welsford) presented the report of the CCAMLR Scientific Committee Symposium that met virtually on 8 and 10 February 2022 (WG-ASAM-2022/01). The informal Scientific Committee meeting discussed the progress and outcomes from the first CCAMLR Scientific Committee's workplan (SC-CAMLR-XXXVI/BG/40) and provided an opportunity for participants to propose priorities and strategies for the next five years to inform the development of the strategic plan (2023–2027). Dr Welsford noted that recommendations and plans have been refined by all working groups and will be considered at SC-CAMLR-41 according to the Scientific Committee's Rules of Procedure. Additionally, the terms of reference for WG-FSA were presented for review.

9.2 The Working Group welcomed the approach that will enable the Scientific Committee to identify priority work and assign tasks to the appropriate working groups. WG-FSA undertook to review the priority research topics presented in Table 2 of WG-ASAM-2022/01 and preliminary discussions and recommendations for work sequencing took place. However, due to the time constraints of the meeting, the review of the priority research tasks was only partially completed and deferred to Members to complete for the Scientific Committee meeting.

9.3 The Working Group noted that the WG-FSA terms of reference had not been changed since drafted in 1984, and further noted that a holistic approach to reviewing the terms of reference for all CCAMLR's working groups by the Scientific Committee was appropriate as the Scientific Committee is ultimately responsible for tasking the working groups to manage cross-cutting issues.

9.4 The Working Group recommended a number of revisions to the WG-FSA terms of reference (Appendix K) for the consideration by the Scientific Committee, and requested that a preamble for the terms of reference be developed by the Scientific Committee to explicitly describe the purpose of WG-FSA.

Data access rules (Data Services Advisory Group)

9.5 On behalf of the Chair of the Data Services Advisory Group (DSAG), the Secretariat presented CCAMLR-41/08 which provides a summary of the working group reviews of the Rules for Access and Use of CCAMLR Data (hereafter referred to as 'the Rules'), during the Scientific Committee Symposium 2022, WG-ASAM-2022, WG-SAM-2022, WG-EMM-2022 and the 'Data Services Advisory Group' e-group. The paper proposed modifications to the Rules for Access and Use of CCAMLR Data and provides several recommendations and future work.

9.6 The Working Group noted that assigning digital object identifiers (DOIs) to data extracts would be a practical approach to create a stable citable reference to the specific subset of data that was used to conduct analyses whether presented in a working group paper or a peer-reviewed paper.

9.7 The Working Group discussed data use and noted that upon release, data are only authorised for use for the purposes cited in the data request that was presented to the data owners for approval. The Working Group further noted that language defining the responsibilities of the data requestor to the data owner (paragraph 6 of the Rules) could be reworded to be more compulsory.

9.8 The Working Group reflected that the current data request procedure considers the absence of reply within a three-week period as consent to release the data. It requested that revisions to this procedure be given consideration by the Scientific Committee.

9.9 Dr X. Zhao (China) requested the Scientific Committee consider appropriate procedures for the use of data with a purpose other than for the work of CCAMLR.

9.10 The Working Group noted that there was a lack of clarity around categories of data and requested that DSAG identify and detail data categories and report these to the Scientific Committee and its working groups and the Commission.

9.11 The Working Group recommended that:

(i) where possible, Members identify alternate representatives for approving data requests to account for periods when the Scientific Committee Representative might not be available

(ii) the current data request response period of three weeks be retained

(iii) the Rules be modified to explicitly clarify that data owners ‘shall’ have rights as set out in paragraph 6 of the current Rules

(iv) a manual be developed that explicitly details data use and responsibilities for Scientific Committee Representatives

(v) the Scientific Committee clarify the rules of data access for data submitted to e-groups.

Communicating difference in scientific interpretation

9.12 The Working Group recalled paragraph 4.1(b)(i) in WG-ASAM-2021 where the SC-Symposium agreed that resolving differences in interpretation was of crucial importance to ensure the effective provision of scientific advice to the Commission. The Working Group noted that this issue could be addressed through a process involving the use of external expert reviews of data and analysis that had been undertaken to arrive at a particular scientific interpretation. Although the Scientific Committee provided advice in the meeting of SC-CAMLR in 2016 (SC-CAMLR-XXXV, paragraphs 16.1 to 16.5) on expressing differences in scientific interpretations, the Working Group had been unable to progress issues when statements devoid of a scientific basis were opposed to scientifically informed interpretations.

9.13 The Working Group requested the Scientific Committee revisit the issue of differences in opinion between Members to provide a pathway for resolution of these issues on a scientific basis.

Communicating with the public

9.14 The Working Group recommended that the Scientific Committee expand the stock assessment/management approach for Subarea 48.1 to an independent document specifically describing the progress in the revised krill management approach.

9.15 The Working Group noted that the Secretariat is compiling information on by-catch species and previously fished target species in the Fishery Reports, and looked forward to seeing this at its next meeting.

Other business

10.1 Dr Hollyman informed the Working Group that the South Georgia groundfish survey will be conducted in January–February of 2023.

10.2 Dr Ziegler informed the Working Group that the Heard Island random stratified trawl survey will be conducted in March–April of 2023.

10.3 Dr Parker suggested that to best inform the discussion of workshops by the Scientific Committee, workshop proposals should include the necessary information discussed during the WG-FSA meeting, including objectives, convener, venue, invitation of observers or experts, and a budget for review by the Standing Committee on Administration and Finance (SCAF) if funding was required.

Advice to the Scientific Committee

11.1 The Working Group's advice to the Scientific Committee and the Commission is summarised below, and the body of the report leading to these paragraphs should also be considered.

(i) Ross Sea data collection plan –

  (a) endorse the RSDCP (paragraph 3.22).

(ii) Amundsen Sea toothfish –

  (a) consider mechanisms to improve structured fishing to support stock assessment (paragraph 3.27).

(iii) *C. gunnari* catch limit recommendations –

(a) catch limit for *C. gunnari* in Subarea 48.3 (paragraph 4.3)

(b) catch limit for *C. gunnari* in Division 58.5.2 (paragraph 4.8).

(iv) Workshop on age determination methods –

(a) convene a workshop on age determination methods (paragraphs 4.18 to 4.20).

(v) Subarea 48.3 toothfish –

(a) consider an independent report of information from Subarea 48.3 toothfish (paragraph 4.51)

(b) precautionary catch limit value for Subarea 48.3 toothfish (paragraph 4.53)

(c) lack of consensus advice on Subarea 48.3 toothfish (paragraph 4.54).

(vi) Antarctic toothfish in Subarea 48.4 –

(a) recommended catch limit for Antarctic toothfish in Subarea 48.4 (paragraph 4.58).

(vii) Toothfish Division 58.5.2 –

(a) continue prohibition in areas outside national jurisdiction (paragraph 4.61).

(viii) Trend analysis –

(a) update the decision tree (paragraph 4.63)

(b) recommended catch limits for data-limited toothfish fisheries (paragraph 4.64).

(ix) Advice on data-poor toothfish fisheries and research proposals –

(a) recommended annex to CM 21-02 (paragraph 5.3)

(b) revise area of application of the tag-overlap statistic (paragraph 5.17)

(c) recommended catch limits for Subarea 48.6 (paragraph 5.20)

(d) recommended catch limits for Divisions 58.4.1 and 58.4.2 (paragraph 5.38)

(e) lack of consensus on catch limits for Divisions 58.4.1 and 58.4.2 (paragraph 5.39)

(f) recommendation for a survey of icefish in Subarea 48.2 (paragraphs 5.46 to 5.50)

(g) recommendation for continuation of the Ross Sea shelf survey and associated catch limits (paragraphs 5.65 and 5.66)

(h) recommended catch limits for Subarea 88.3 (paragraph 5.73).

(x) Fish by-catch in the krill fishery –

(a) data quality status of fish by-catch in the krill fishery (paragraph 6.2).

(xi) By-catch in toothfish fisheries –

(a) support ongoing monitoring in Ross Sea region (paragraph 6.10)

(b) include skate handling poster and training video on website (paragraph 6.20)

(c) develop a mechanism to protect fish nesting sites (paragraph 6.26).

(xii) Marine debris –

(a) add marine debris as a mutual topic of interest between SC-CMALR and CEP (paragraph 6.31)

(b) reinvigorate the Intersessional Correspondence Group – Marine Debris (paragraph 6.32).

(xiii) Monitoring to support management –

(a) convene a CEMP workshop (paragraph 6.43)

(b) convene a workshop on integrating climate change into CCAMLR science (paragraph 6.45).

(xiv) Krill management framework –

(a) inform SCIC on data reporting issues in krill fishery (paragraph 7.5)

(b) agreement on recruitment time series for krill (paragraph 7.19)

(c) recommended value for gamma for Subarea 48.1 catch limits (paragraph 7.20)

(d) catch limit determination (paragraph 7.24)

(e) catch limit for krill in Subarea 48.1 (paragraph 7.28)

(f) monitoring of the krill fishery (paragraph 7.43)

(g) revision of CM 51-07 (paragraph 7.46).

(xv) Observer work in krill fisheries –

(a) prioritising krill observer work tasks (paragraph 8.28).

(xvi) Terms of reference –

(a) revision of terms of reference for WG-FSA (paragraph 9.4).

(xvii) Data access rules –

(a) consideration of data request procedure (paragraph 9.8)

(b) modifications of the data access rules (paragraph 9.11).

(xviii) Communication –

(a) resolving differences of opinion (paragraph 9.13)

(b) develop a document to describe krill management approach (paragraph 9.14).

Adoption of the report and close of meeting

12.1 The report of the meeting was adopted.

12.2 At the close of the meeting, Mr Somhlaba thanked all participants for their patience, positive contributions, enthusiasm, and creativity in progressing the work of the group.

12.3 On behalf of the Working Group, Dr Darby thanked Mr Somhlaba for his leadership, insight and patience in guiding the discussions of the Working Group. In addition, he reluctantly noted that this was Doro Forck's 25th meeting of WG-FSA and that she will be retiring in the coming months. He thanked her for all her efforts and skill in producing CCAMLR reports

12.4 Mr Dunn thanked the Secretariat team for their high-quality work and quick response times for summaries during the meeting. He also recognised the immense contributions of Doro through the years and on behalf of the Working Group wished her a happy retirement.

References

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Table 1: Proposed baseline components of the Ross Sea Data Collection Plan (RSDCP) for the Ross Sea toothfish fishery. V – vessel lead, O – observer lead, TOA – Antarctic toothfish, TOP – Patagonian toothfish, TL – total length, CHW – icefish spp., ANT – blue antimora, MRL – moray cod spp., SL – standard length, PL – pelvic length, WS – wingspan, SRZ – special research zone, SSRU – small-scale research unit, VME – vulnerable marine ecosystem.

Lead	Data collected	Frequency	Priority	Protocol	Current requirement	Change form	Change manual	Processing overhead
	Catch and effort data							
V	C2 and catch and effort data	Every set	Mandatory	CM 41-01 (2019)	Yes			Low
O	Observer tally period catch	ID to species group	Very High		Yes			
	Ongoing yearly toothfish biological data							
O	Length, sex, gonad stage	**TOA and TOP**: 35 per haul, target 7 per 1 000 hooks everywhere. TL and SL are requested.	Very High	BIO-01, BIO-01a	Yes			Low
O	Length, weight, sex, gonad stage and weight, axe handle	**TOA**: First 20 fish sampled per set	Very High	BIO-01, BIO-01a				Low
O	Otoliths	**TOA and TOP**: 10 per set for each species, 5 per sex.	Very High	BIO-01	Yes			Medium
O	Conversion factors	**TOA/TOP**: Refer to WG-FSA-2022/01	High	BIO-03a, BIO-03b	Yes	No	Update	Low
	Tagging							
V	Toothfish tagging	One per tonne (in Subarea 88.1 and SSRUs 882A–B), double tagged, overlap statistic > 60%. Three fish per tonne (SRZ).	Very High	BIO-02, BIO-02a, BIO-19	Yes			Low
V	Skate tagging	Vessel decision to tag skates. If tagging, only tag skates in good condition. Record wingspan, any injury codes in comments. Follow tagging protocols from year of the skate.	Very High	BIO-07, BIO-07a, BIO-07b	No	No	No	Low
V	Toothfish recaptures	**TOA and TOP**: Scan every fish for tags. Photograph tags with number readable. Keep stomach and muscle tissue sample. Length, weight, sex, gonad stage, gonad weight and otoliths.	Very High	BIO-05, BIO-02	Yes			Low

(continued)

Table 1 (continued)

Lead	Data collected	Frequency	Priority	Protocol	Current requirement	Change form	Change manual	Processing overhead
V/O	Skate tag recaptures	Scan every skate for tags, identify species, photograph tags, bag and return first 10 tagged skates for the trip whole to NIWA with tag in situ, otherwise, sample biologically (PL, WS, TL, sex, stage, weight), collect thorns and freeze with label including tag number. If easier to send whole skate than thorns, feel free to do that. Note: all skates even if frozen whole must have PL, WS, TL, sex, stage, weight entered in eLongline form.	Very High	BIO-02, BIO-07	Yes			Low
	Ongoing yearly bottom fishing effects							
V	Mid-point latitude and longitude of segment and total weight of any VME-indicator taxa	All segments. A segment is 1 000 hooks or 1 200 m line.	Very High	BIO-11, BIO-11a	Yes			Low
	Year-specific fish biological data – skates 2027/28season							
O	Skate biologicals: Species, length, (total/pelvic/disc width), weight, sex, gonad stage, condition, thorns on recaptures	On any dead or tag recapture skates only. Identify to species, measure PL, TL and WS, weight, sex, condition, stage. Thorns (at least 10) on recaptures.	Very High	BIO-12 SC-CAMLR-39-BG/31	No (currently only required to sample up to 10 per line)	No	Yes	Low
	Year-specific fish biological data – CHW, ANT, MRL (Focus species group 2025/26 and 2026/27 seasons)							
O	ID to species, length, weight, sex, gonad stage and weight	All fish up to 10, every set (mixture) (WG-FSA-10/32 and 15/40)	Very High	BIO-12	Yes except for gonad stage and sex	No	Yes if gonad stage and sex required	Low
O	Otoliths	5 otolith pairs every set	High	BIO-12	No	No	If baseline	Medium
	Year-specific fish biological data – Macrourids (Focus species group 2023/24 and 2024/25 seasons)							
O	ID to species, length (TL and PAL), weight, sex, gonad stage and gonad weight	All fish up to 10, every set (mixture)	Very High	BIO-10	Yes except for gonad stage and sex	No	Yes if gonad stage and sex required	Low
O	Otoliths	5 otolith pairs every set (matched to fish with biological data)	High		No	No	Yes if baseline	

Table 2: Proposed research components of the Ross Sea Data Collection Plan (RSDCP) for the Ross Sea toothfish fishery. V – vessel lead, O – observer lead, TOA – Antarctic toothfish, TOP – Patagonian toothfish, TL – total length, SL – standard length, PL – pelvic length, DW – disc width, SRZ – special research zone, CPR – continuous plankton recorder.

Lead	Data collected	Frequency	Priority	Protocol	Current requirement	Change form	Change manual	Processing overhead
O	Macrourid spp: Stomach, isotope sample	Macrourid spp: Up to 50 but only non-everted stomachs from each species Isotope: from all fish with retained stomachs	High	BIO-10	No	Yes if baseline	Yes	High
O	Genetics	**TOA**: 1 fin clip in ethanol per set from otolith fish, max of 50 combined **TOP**: 1 fin clip in ethanol per set, max. of 50	Medium	BIO-04	No	Minor change	Minor change	Medium
O	Liver weights	**TOA/TOP**: Record liver weight from first 10 fish sampled	Medium	BIO-05	No	Yes	Yes	Low
O	Onboard stomach sampling: stomach weights, fullness, contents, digestive state	**TOA/TOP**: Record stomach weight, contents from first 10 fish sampled	Medium	BIO-05	No	Yes	Yes	Low
O	Stomach samples (retained)	**TOA/TOP**: Freeze first 10 stomachs for analysis on shore	Medium	BIO-05	No	Yes (sample label)	Yes	High
O	Muscle tissue	**TOA/TOP**: Freeze small sample of muscle tissue for stable isotope analysis	Medium	BIO-05	No	Yes (sample label)	Yes	Medium
V	Skate tagging	Vessel decision to tag skates. If tagging, only tag skates in good condition (include measurement of physiological parameters (lactate)). Record wingspan, any injury codes in comments.	Very High	BIO-07, BIO-07a, BIO-07b	No	Yes – if physio parameters are made baseline	No	Low
V	Mid-point latitude and longitude of segment, weight and ID VME-indicator taxa	Any segment where 5 kg or more is caught, and 30% of other segments	Very High		Yes			Low
V	VME samples	Retain a small subsample of VME specimens for all segments where 5 l/kg or more caught in a segment AND taxonomic ID is in question.	High	BIO-11, BIO-11a	No			Low
O	VME (sponges)	Inspect sponges for presence of fish eggs. If present, take photo the sponge and freeze a sample of the eggs and sponge.	High	Protocol needed		If baseline	If baseline, (add protocol)	

(continued)

Table 2 (continued)

Lead	Data collected	Frequency	Priority	Protocol	Current requirement	Change form	Change manual	Processing overhead
O	Squid beaks	Opportunistic from toothfish stomachs	Low	BIO-06	No	Yes	Yes	
O	Squids	Up to 20 squids of any species with hooked tentacles, frozen whole (including from stomachs)	Low	BIO-16, BIO-16a, BIO-16b	No	Yes	Yes	
O	Colossal Squid	Tissue samples (mantle, ink sac, digestive gland, beak)	Medium	BIO-16, BIO-16a	No	Yes	Yes	
O	Fish specimens	Various opportunistic specimen collection for museum – see protocol	Low	BIO-09	No	Yes	Yes	
V	Underwater camera	Longline autonomous camera. Every set possible	High	BIO-08	No	Yes	Yes	
V	Acoustic data (e.g. for toothfish, macrourids)	Record data within the CCAMLR region (e.g. on ES60 echosounder)	High	Vessel			Yes	
O	Sea lice observations	Subsample each line on form, link to vessel B grade	Low	BIO-15			Yes	
V	Toothfish tagging training videos	Opportunistic video recordings of tagging and release methods used	High	BIO-19			Yes	
O	Alien species	Freeze unusual specimens for museum	Very High				Yes	
V	Zooplankton and microplastics (CPR)	Towing the CPR to collect zooplankton and microplastic samples. Requires the vessel to have gear and CPR expertise, and have filters fitted to all waste-water outlets on the vessel (to avoid plastic contamination)	Low	Plankton e-group protocols			Yes	
V	Passive acoustic recorder (tow)	Potential to deploy underwater hydrophones while on station (for sperm whales)	Low				Yes	
V	Temp/salinity profilers on longline	Self-logging mini depth-temperature sensors on longlines to measure mixed layer depths	Medium				Yes	

(continued)

Table 2 (continued)

Lead	Data collected	Frequency	Priority	Protocol	Current requirement	Change form	Change manual	Processing overhead
V	Small fish sampling trap	Baited small traps deployed on freeline; one per set. Contents to be identified to lowest resolution possible. Count and weigh total amount of each species/species group. Freeze entire sample for museum. Ensure label includes 'trap' and haul number.	Medium	BIO-20			Yes	
O	Air sampling	(Weather dependent.) Fill containers during steam down and return from range of latitudes: 45°S, 50°S, 53°S, 56°S, 59°S, 61°S, 64°S, 70°S, 75°S	Medium	Air samples_GNS			Yes	
O	Cetaceans	Opportunistic whale sightings. Photographic data collection for estimating abundance of animals with notable marks (WG-FSA-13/08). (Biopsies, tagging-noting specialised staff may be required)	Medium	Cetaceans_2022; (SIOFA template, SIOFA CMM 2021/02, Annex E)	Sightings currently collected during tally period. Photography and biopsies really require specialist researchers		Yes	
O	Seawater (acidity)	Fill small sampling bottle	Medium				Yes	
O	Plankton community sampling	Fill small sampling bottle with fixative	Medium	Plankton e-group protocols			Yes	

Table 3: Options for the structure of the exploratory toothfish fishery in small-scale research unit (SSRU) 882H, and advantages and disadvantages for each option. 'Major' seamounts are those where most historical fishing has occurred (numbered 1, 3, 7, 8), and 'minor' seamounts include all others which have been less fished to date (see WG-FSA-2021/29, Figure 2). CM – conservation measure; CPUE – catch-per-unit-effort. SSRU – small-scale research unit.

Option	Advantages	Disadvantages
1. Olympic fishery (status quo)	• No CM changes • Full and flexible participation by all notifying Members • No commitment to multi-year research required • All seamounts available	• Unlikely to generate information required in the long term • Lack of commitment to desk-based research (e.g. fish ageing) • Data (tag and CPUE biomass estimates) do not index entire seamount area
2. Olympic fishery – spatially constraint to major Seamounts	• Minimal changes to CM 41-10 • Maintains Olympic fishery with access by all notifying Members • Fewer seamounts open will generate more consistent effort • Constraining local area biomass estimate to only those seamounts fished is more conservative	• No guarantee that effort will spread • Limited seamount options available if sea-ice constraints • Unlikely to produce index of abundance for SSRU 882H as a whole • If constrained to a few seamounts, then catch limit is likely to decrease
3. Structured fishing with research hauls on minor seamounts, followed by Olympic fishery	• Limited changes to CM 41-10 since research hauls already specified in CM 41-01 • After conducting research hauls, vessel can choose any seamount to fish • Some effort on less-fished seamounts in each season	• More fishery operation rules to monitor and manage • Some seamounts may still not be fished routinely due to low catch limits • Inaccessibility of minor seamounts due to sea-ice at start of season could delay the fishery
4. Split catch limits spatially into several (e.g. 2 or 3) areas of seamounts	• Limited changes to CM 41-10 • Several management areas are simple to implement • Dividing the area at 124°W would divert significant effort to areas away from the minor seamounts	• Dividing the catch limit into smaller areas could be difficult for Secretariat to monitor and predict closure • Without seamount-specific catch limits, effort could still be focused on specific seamounts in each area
5. Combined Olympic fishery and fishery with catch allocation under research plan	• Some changes to CM 41-10 • Vessel-specific allocations used to target less-fished areas each season • Vessels can coordinate effort to sample seamounts more effectively • Vessels fish in both Olympic fishery and under research plan • Desk-based research and sample processing more likely to be completed under a research plan. • Fishing under research plan likely to occur after Olympic fishery and therefore less constrained by sea-ice	• Requires significant portion of the Olympic catch to be set aside for fishing under research plan • Requires research plan coordination and off-water research • Quota available may not allow significant effort on all seamounts • Information from Olympic fishery may not be available for fishing under research plan to effectively spread effort

(continued)

Table 3 (continued)

Option	Advantages	Disadvantages
6. Entire fishery under research plan	• Limited changes to CM 21-02 • No complex catch monitoring required • Increased coordination of fishing effort and research among vessels and Members • Members likely to contribute to desk-based research • Entire fishery focused on providing information needed to develop stock assessment • Fishing under research plan allows fishing to occur later if sea-ice constraints in a season	• Significant intersessional coordination among Members required • If research plan is not approved by the Commission, then no fishing can occur • Details of fishing design yet to be developed

Table 4: Developments in the understanding of Patagonian toothfish (*Dissostichus eleginoides*) in Subarea 48.3 during 2018–2022 contributing to the integrated stock assessment and catch advice. CPUE – catch per unit effort.

Paper	Context	Data used	Developments
SC-CAMLR-XXXVII/02 Rev. 1	Independent review of CCAMLR toothfish stock assessments	CCAMLR toothfish stock assessments	The review found that 'CCAMLR applies assumptions in the stock assessments in a precautionary manner when there is uncertainty in parameters and assumptions. Management of the fisheries is consistent with CCAMLR's precautionary approach and Article II (WG-FSA-2018, paragraph 3.5iv)
WG-SAM-2019/32	An exploration of the biological data used in the Subarea 48.3 Patagonian toothfish stock assessments	Length, sex and maturity data from around 80 000 samples collected during the period 1996–2018	WG-SAM-2019 concluded that the statistical analysis showed no systematic trends in growth or maturity through time, after the effects of confounding factors were included in the analysis.
WG-FSA-2019/28	Update of 2017 stock assessment to include extra data from the 2018 fishing season	• 51 393 tag releases • Ages from 6 071 otoliths • CPUE standardised based on data from 29 733 hauls • Length compositions from 20 trawl surveys with 232 trawl hauls • Data from 5 892 tag recaptures • 1 014 351 length measurements	Used as the basis for CCAMLR catch advice in 2019.
WG-FSA-2019, paragraphs 3.22 to 3.34, Figures 4 and 5	Comparison of length and maturity compositions between fisheries in the Convention Area	Length and maturity data for Antarctic and Patagonian toothfish from Subareas 48.3, 48.6, 58.7, 88.1 and 88.2, Divisions 58.4.1, 58.4.2, 58.4.4b and 58.5.2, since 1995.	Subarea 48.3 fishery shown to be within the range of maturity and length compositions shown for other areas. Proportion of immature fish in the catch decreasing in recent years.
WG-FSA-2021/59	Update of 2019 stock assessment to include extra data from 2019 and 2020 fishing seasons	Data included in 2019 assessment, plus: • 6 709 tag releases • Ages from 1 306 otoliths • CPUE standardised based on data from 2 397 hauls • Length compositions from 19 trawl survey hauls in 2021 • Data from 1 055 tag recaptures • 67 964 length measurements	

(continued)

Table 4 (continued)

Paper	Context	Data used	Developments
WG-SAM-2022/17	Estimates of tag loss rates for Patagonian toothfish in Subarea 48.3 tagged between 2004 to 2020	Tag releases and recaptures as included in the stock assessment	Demonstrates the longevity of tagged toothfish in the population, consistent with low exploitation rates.
WG-SAM-2022/18	The utility of surface plots in the development of the CCAMLR decision rule, its interpretation, and the rationalisation of current management and fishery metrics	Data as for the 2021 assessment	Beverton and Holt yield and biomass per recruit analysis which established that the current fishery selection pattern optimises yield and achieves the long-term equilibrium target spawning biomass of 50% of B_0.
WG-SAM-2022/20	Analysis and recommendations for a revised CASAL assessment model structure. Proposed changes recommended as the basis for the 2022 assessment for WG-FSA	Same data as for the 2021 assessment, and additional otoliths	WG-SAM-2022 noted that the stock assessment process undertaken was the best available approach for the Subarea 48.3 toothfish stock assessment.
WG-SAM-2022/23	A comparison of fishing mortality estimates derived using data-rich and data-limited approaches	Tag releases and recaptures as included in the stock assessment	Demonstrated that a simple, readily understandable, application of data limited analysis is consistent with the integrated stock assessment in showing that exploitation rates on the Subarea 48.3 Patagonian toothfish are consistent with CCAMLR objectives.
WG-SAM-2022/24	A comparison of estimates of Patagonian toothfish maturity and growth in Subarea 48.3 using different otolith selection procedures	Data from 10 628 otoliths and length measurements	Updated growth parameters for the stock assessment
WG-SAM-2022/14	Comparison of model estimates between CASAL and Casal2	As per WG-FSA-2021/59	A comparison of CASAL and Casal2 model implementations using the 2021 CASAL assessments of Patagonian toothfish in Subarea 48.3 (South Georgia).
WG-FSA-2022/56	Characterisation of the fishery	Age data 1998–2021, length and maturity data 1996–2021	Review of the fishery including fishing effort, catch distributions, by-catch.

(continued)

Table 4 (continued)

Paper	Context	Data used	Developments
WG-FSA-2022/57	Update of 2021 stock assessment to include extra data from the 2021 fishing season, and additional historic otoliths	• Data included in 2021 assessment, plus (additional): • 2 915 tag releases • Ages from 3 251 otoliths • CPUE standardised based on data from 1 098 hauls • Length compositions from 19 trawl survey hauls in 2021 • Data from 519 tag recaptures • 32 515 length measurements	
WG-FSA-2022/59	Estimation of growth and maturity	6 897 otoliths with associated length, sex and maturity data.	Ongoing work to ensure that the most appropriate parameter estimates are used in the assessment.
WG-FSA-2022/P05	Developments of CPUE standardisation methodology showing strong agreement with the method used currently	CPUE and mammal observations from 8 710 hauls during 2003–2019	Peer-reviewed collaborative paper comparing methods for depredation estimation. The model outcomes were very similar and reflect what is currently used in the assessment.

Table 5: Research block biomass (B, tonnes) and catch limits (CL, tonnes) estimated using the trend analysis or effort-limited catch limits. PCL – previous catch limit; ISU – increasing, stable or unclear; D – declining; Y – yes; N – no; - – no fishing in the last season; x – no fishing in the last five seasons and catch limit set outside the trend analysis; [] – insufficient data. CPUE – catch per unit effort, SSRU – small-scale research unit.

Area	Subarea or Division	Research block/SSRU	Species	PCL	Trend decision	Adequate recaptures	CPUE trend decline	B	B × 0.04	PCL × 0.8	PCL × 1.2	Recommended CL for 2022/23
48	48.6	486_2	*D. mawsoni*	134	ISU	Y	N	3 074	123	107	161	123
		486_3	*D. mawsoni*	36	ISU	N	N	934	37	29	43	37
		486_4	*D. mawsoni*	196	D	Y	Y	5 366	215	157	235	157
		486_5	*D. mawsoni*	210	D	Y	Y	40 087	1603	168	252	168
58	58.4.1	5841_1	*D. mawsoni*	138	-	-	-	-	-	-	-	138
		5841_2	*D. mawsoni*	139	-	-	-	-	-	-	-	139
		5841_3	*D. mawsoni*	119	x	x	x	x	x	x	x	79**
		5841_4	*D. mawsoni*	23	x	x	x	x	x	x	x	46**
		5841_5	*D. mawsoni*	60	-	-	-	-	-	-	-	60
		5841_6	*D. mawsoni*	104	-	-	-	-	-	-	-	104
	58.4.2	5842_1	*D. mawsoni*	72	ISU	Y	Y	9 935	397	58	86	86
		5842_2	*D. mawsoni*	55*	[]	N	[]	6 450	258	-	-	258
88	88.2	882_1	*D. mawsoni*	230	-	-	-	-	-	-	-	230
		882_2	*D. mawsoni*	223	ISU	Y	Y	9 977	399	178	268	268
		882_3	*D. mawsoni*	204	ISU	N	N	5 193	208	163	245	208
		882_4	*D. mawsoni*	154	ISU	Y	N	5 862	234	123	185	185
		882H	*D. mawsoni*	102	ISU	Y	Y	10 834	433	82	122	122
	88.3	883_1	*D. mawsoni*	16	-	-	-	-	-	-	-	16
		883_2	*D. mawsoni*	20	-	-	-	-	-	-	-	20
		883_3	*D. mawsoni*	60	ISU	N	Y	6 668	267	48	72	48
		883_4	*D. mawsoni*	60	ISU	N	Y	2 788	112	48	72	48
		883_5	*D. mawsoni*	8	-	-	-	-	-	-	-	8
		883_6	*D. mawsoni*	30	ISU	N	N	2 289	92	24	36	36
		883_7	*D. mawsoni*	30	ISU	N	N	2 500	100	24	36	36
		883_8	*D. mawsoni*	10	-	-	-	-	-	-	-	10
		883_9	*D. mawsoni*	10	x	x	x	x	x	x	x	10**
		883_10	*D. mawsoni*	10	x	x	x	x	x	x	x	10**

* Catch limit for effort-limited research fishing in 2021/22.

** Catch limit for effort-limited research fishing.

Table 6: Summary of the assessment of proposed and ongoing research plans and proposals under Conservation Measure (CM) 21-02 and CM 24-01. AUS – Australia, ESP – Spain, FRA – France, JPN – Japan, KOR – Korea, NZL – New Zealand, UKR – Ukraine, ZAF – South Africa, ANI – *Champsocephalus gunnari*, TOA – *Dissostichus mawsoni*, Y – yes, N – no, n/a – not applicable, MPA – marine protected area. Section references refer to sections of the proposal listed in row 1 of the table.

Subarea/division:	48.2	48.6	58.4.1 and 58.4.2	88.1[1]	88.3
Proposal:	WG-SAM-2022/06 WG-FSA-2022/17, Appendix F of this report	WG-SAM-2022/02 * This is the second year of an ongoing three-year plan, with no significant change proposed. It was not required to be reviewed by WG-SAM and WG-FSA in 2022.	WG-SAM-2022/04	WG-SAM-2022/01 Rev. 1 WG-FSA-2022/41 Rev. 1	WG-SAM-2022/05 WG-FSA-2022/26
Members:	UKR	JPN, ESP, ZAF	AUS, ESP, FRA, JPN, KOR	NZL	KOR, UKR
Conservation measure under which the proposal is submitted:	CM 24-01	CM 21-02	CM 21-02	CM 24-01	CM 24-01
Time period:	February–April 2023	2021/22–2023/24	2022/23–2025/26	2022/23–2024/25	2021/22–2023/24
Main species of interest:	ANI	TOA	TOA	TOA	TOA
Main purpose of the research (e.g. abundance, population structure, movement, …)	Distribution and abundance of ANI in Subarea 48.2; develop method to estimate biomass for ANI; improving integrated, ecosystem-based approach to fisheries; ecosystem changes studies	Abundance	Abundance	Population structure and distribution, monitoring of recruitment	Abundance, stock structure, etc.
Is the purpose of the research linked to Commission or Scientific Committee priorities?	Y	Y: section 1a	Y: section 1a	Y: sections 1a, 1b	Y: 1. Objective of the research plan (a)

(continued)

Table 6 (continued)

Subarea/division:	48.2	48.6	58.4.1 and 58.4.2	88.1[1]	88.3
1. Quality of the proposal					
1.1 Is there enough information to evaluate the likelihood of success of the research objectives?	Y	Y: all of this proposal	Y: sections 3a–3c	Y: sections 3a–3d	Y: 1. Objective of the research plan (b)
2. Research design					
2.1 Is the proposed catch limit in accordance with research objectives?	Y: Catch limit was estimated on the ground of CPUE given for the period 1978–1985 (mid-water trawl data)	Y: sections 3d, 4a and 4b	Y: sections 4a and 4b	Y: sections 4a and 4b	Y: 3. Survey design, data collection and analysis (Proposed number of stations/hauls) 4. Proposed catch limits
2.2 Is the sampling design appropriate to achieve research objectives?	Y: see Appendix F of this report	Y: section 3b	Y: section 3b WG-SAM-2022/09	Y: section 3a	Y: 3. Survey design, data collection and analysis
2.3 Have the environmental conditions been thoroughly accounted for?	Y	Y: section 3b	Y: Appendix 2, section b	Y: section 3a	Y: 3. Survey design, data collection and analysis (updated sea ice analysis)
3. Research capacity					
3.1 Have the research platforms demonstrated experience in:					
3.1.1 Conducting research/exploratory fishing following a research plan?	Y	Y: section 5	Y	Y	Y: Research fishing by the *Greenstar* has occurred annually since 2016. *Marigold* joined in this research from 2020.
3.1.2 Collecting scientific data?	Y	Y: section 5	Y: section 5	Y: section 5, Appendix 1, section 3.1.1	Y: 3. Survey design, data collection and analysis (b)

(continued)

Table 6 (continued)

Subarea/division:	48.2	48.6	58.4.1 and 58.4.2	88.1[1]	88.3
3.2 Do the research platforms have acceptable tag detection and survival rates?	n/a	Y: WG-FSA-17/36 and WG-FSA-2019 report (Figure 7). *Shinsei-maru No. 8* is a new vessel, same gear and crew as the withdrawn *Shinsei-maru No. 3*.	Y: See WG-SAM-2022/04, Appendix 2	Y: WG-FSA-17/36 (*San Aotea II*: survival = 0.83, detection = 1.0; *Janas*: survival = 0.76, detection = 1.0; *San Aspiring*: survival = 1.0, detection = 1.0) *Janas* and *San Aotea II* have been active in the Ross Sea fishery since 1999 and the *San Aspiring* since 2005.	Y: WG-FSA-17/36 *Greenstar* which does not have its tagging performances calculated but has had tag recaptures before in this area.
3.3 Have the research teams sufficient resources and capacity for:				Y	
3.3.1 Sample processing?	Y	Y: section 1c	Y: section 3b	Y: section 3b	Y: 3. Survey design, data collection and analysis
3.3.2 Data analyses?	Y: UK will assist in the analysis of hydroacoustic data	Y: section 1c	Y: Table 5	Y: sections 3c, 3d	Y: 3. Survey design, data collection and analysis
4. Data analyses to address the research questions					
4.1 Are the proposed methods appropriate?	Y	Y: sections 1a and 3c	Y: section 3c	Y: section 3c	Y

(continued)

Table 6 (continued)

Subarea/division:	48.2	48.6	58.4.1 and 58.4.2	88.1[1]	88.3
5. Impact on ecosystem and harvest species					
5.1 Is the catch limit proposed consistent with Article II of the Convention?	Y: effort-limited survey unlikely to have negative effect on the stock	Y: sections 3d, 4a and 4b	Y: sections 4a and 4b	Y: sections 4a, 4b	Y: The proposed catch limits are planned to be updated during WG-FSA-2022, reflecting the data collected in the 2021/22 season.
5.2 Are the impacts on dependent and related species accounted for and consistent with Article II of the Convention?	Y	Requires more analysis on by-catch populations, see WG-SAM-2019/09 (WG-FSA-2019 report, Table 8): section 3b	Y: Figure 1, section 4c	Y: sections 4b, 4c, Appendix 3	Y
6. Progress towards objectives for ongoing proposals					
6.1 Have the past and current milestones been completed?	n/a	Y: section 1c, and WG-FSA-2019/23 Rev. 1, Appendix 1	Y: Table 5, section 1c	Y: WG-SAM-22/01, see Appendix 2	Y: Appendix 1 (Vessel calibration still outstanding)
6.2 Has previous advice from the Scientific Committee and its working groups been addressed?	Y	Y: WG-FSA-2019 report, paragraph 4.58	Y	Y	Y
6.3 Are all the objectives likely to be completed by the end of the research plan?	Y: Research plan is for one year, some results will be preliminary, and survey design, methods will be developed for the next research years	Y: Table 1	Completion of research objectives is conditional on the continuation of the exploratory fishing activities in Division 58.4.1.	Y	Y

(continued)

Table 6 (continued)

Subarea/division:	48.2	48.6	58.4.1 and 58.4.2	88.1[1]	88.3
6.4 Are there any other concerns?	N	N	Y: Despite extensive discussions between the proponents of this research plan and Russia since 2018, the different parties were not able to agree on a sampling design in Division 58.4.1.	N	N

[1] Responses to MPA-related evaluation questions are provided in WG-FSA-2022/41 Rev. 1.

Table 7: Summary of submitted proposals and ongoing research under Conservation Measure (CM) 21-02 and CM 24-01. New proposals under CM 21-02 or CM 24-01 should be notified by 1 June and reviewed by WG-SAM and WG-FSA. Ongoing proposals need to be notified each year by 1 June with proposals under CM 24-01 to be reviewed by WG-FSA annually and proposals under CM 21-02 to be reviewed by WG-FSA every other year. AUS – Australia, ESP – Spain, FRA – France, JPN – Japan, KOR – Korea, NZL – New Zealand, UKR – Ukraine, ZAF – South Africa.

CM	Project plan	Description	Member	Subarea/ Division	Fishing seasons	Years since approval	2022	2023	2024
24-01	WG-FSA-2021/34	New research plan for *Dissostichus* spp. under CM 24-01, paragraph 3 in Subarea 88.3 by Korea and Ukraine from 2021/22 to 2023/24	KOR, UKR	88.3	2022–2024	1	WG-FSA	WG-FSA	New proposal required to continue
24-01	WG-FSA-2022/41	Proposal to continue the time series of research surveys to monitor abundance of Antarctic toothfish (*Dissostichus mawsoni*) in the southern Ross Sea, 2022/23–2024/25: Research Plan under CM 24-01	NZL	88.1	2023–2025	New	WG-SAM WG-FSA	WG-FSA	WG-FSA
24-01	WG-FSA-2022/17	Proposal to conduct a local acoustic trawl survey of mackerel icefish (*Champsocephalus gunnari*) in Subarea 48.2	UKR	48.2	2023–2025	New	WG-SAM WG- FSA	WG-FSA	WG-FSA
21-02	WG-SAM-2022/04	New research plan for the *D. mawsoni* exploratory fishery in East Antarctica (Divisions 58.4.1 and 58.4.2) from 2022/23 to 2025/26; Research plan under CM 21-02, paragraph 6(iii)	AUS, FRA, JPN, KOR, ESP	58.4.1, 58.4.2	2023–2026	New	WG-SAM WG-FSA		WG-FSA
21-02	SC-CAMLR-39/BG/04	Proposal for continuing research on *D. mawsoni* in Subarea 48.6 in 2020/21: Research Plan under CM 21-02, paragraph 6(iii)	JPN, ZAF, ESP	48.6	2021–2023	2		New proposal required to continue	

Table 8: Oblique haul locations in decimal degrees.

Station number	Latitude	Longitude
1	–60.3	–46.15
2	–60.3	–46.4667
3	–60.3	–46.7833
4	–60.3	–47.1
5	–60.4167	–47.4167
6	–60.4167	–47.1
7	–60.4167	–46.7833
8	–60.4167	–46.4667
9	–60.4167	–46.15
10	–60.5333	–46.4667
11	–60.5333	–46.7833
12	–60.5333	–47.1
13	–60.5333	–47.4167
14	–60.65	–47.4167
15	–60.65	–47.1
16	–60.65	–46.7833
17	–60.65	–46.4667
18	–60.7667	–46.4667
19	–60.7667	–46.7833
20	–60.7667	–47.1
21	–60.7667	–47.4167
22	–60.8833	–47.4167
23	–60.8833	–47.1
24	–60.8833	–46.7833
25	–60.8833	–46.4667
26	–60.8833	–46.15
27	–61	–45.8333
28	–61	–46.15
29	–61	–46.4667
30	–61	–46.7833
31	–61	–47.1
32	–61	–47.4167
33	–61.1167	–47.1
34	–61.1167	–46.7833
35	–61.1167	–46.4667
36	–61.1167	–46.15
37	–61.1167	–45.8333

Table 9: Location of acoustic transects extremities points.

Transect	Latitude	Longitude_start	Longitude_end
T1	–60.3	–46.15	–47.1
T2	–60.4167	–47.4167	–46.15
T3	–60.5333	–46.4667	–47.4167
T4	–60.65	–47.4167	–46.4667
T5	–60.7667	–46.4667	–47.4167
T6	–60.8833	–47.4167	–46.15
T7	–61	–45.8333	–47.4167
T8	–61.1167	–47.1	–45.8333

Table 10: Precautionary catch limits allocated for the candidate management strata in Subarea 48.1 based on the 'alphas' from the 'AMLR strata new5' baseline scenario (WG-FSA-2021/16) and gamma = 0.0338. JI – Joinville, EI – Elephant Island, BS – Bransfield Strait, SSIW – South Shetland Islands West, GS – Gerlache Strait, PB – Powell Basin, DP – Drake Passage.

Management unit	Baseline (risk value, 0.46)				
	alpha		Catch limit (tonnes)		
	Summer	Winter	Summer	Winter	Sum
Joinville (JI)	0.0008	0.0178	525	11 860	12 385
Elephant Island (EI)	0.0662	0.1097	44 253	73 298	117 552
Bransfield Strait (BS)	0.0061	0.1094	4 075	73 112	77 187
South Shetland Islands West (SSIW)	0.0549	0.0731	36 694	48 857	85 551
Gerlache Strait (GS)	0.0238	0.2116	15 921	141 378	157 300
Powell Basin (PB) and Drake passage (DP)	0.0450	0.2815	30 046	188 079	218 125
Total	0.1968	0.8032	131 515	536 585	668 101

Table 11: Proposed catch limit for each stratum as well as local biomass estimates, information related to fishing activities, research efforts and future research required in each stratum. JI – Joinville, EI – Elephant Island, BS – Bransfield Strait, SSIW – South Shetland Islands West, GS – Gerlache Strait, DP – Drake Passage, PB – Powell Basin, CEMP – CCAMLR Ecosystem Monitoring Program.

Strata	JI#	EI#	BS	SSIW	GS#	PB and DP#
Catch limit tonnes (summer/winter)	12 385 (525/11 860)	117 552 (44 253/73 298)	77 187 (4 074/73 112)	85 551 (36 694/48 857)	157 300 (15 921/141 378)	218 125 (30 046/188 079)
Biomass (tonnes) and CV%	860 697 49.15	3 382 428 26.92	1 187 487 42.83	2 515 678 36.27	703 327* n/a	11 116 674* n/a
Local area harvest rate	1.44%	3.48%	6.5%	3.4%	22.37%	1.90%
Maximum catch since 1988 (Year)	32 015 (2022)	51 521 (1989)	120 453 (2020)	64 872 (1992)	52 909 (2017)	2 600 (1998)
Maximum catch since 2018 (Year)	32 015 (2022)	2 040 (2019)	120 453 (2020)	8 159 (2018)	42 642 (2018)	1 500 (2021)
Ratio of proposed catch limit to historical maximum catch	0.39	2.28	0.64	1.32	2.97	83.89
Current and past fishing activities	Very limited	Moderate in the past, currently limited	Currently active	Active in the past, currently limited	Moderate to active since 2010	Very limited
Number of surveys used in biomass estimates	11	27	30	29	1	1
Number of CEMP sites available	0	0	5	1	1	1
Monitoring and science required	• Recruitment surveys • Biomass surveys • Krill population connectivity with neighbouring strata • Further predator monitoring					

* Note these biomass estimates were the lower one-sided 95% confidence interval due to only having a single survey.

The Working Group noted these areas should have a stepwise increase towards the proposed limits (see paragraphs 7.41 and 7.45).

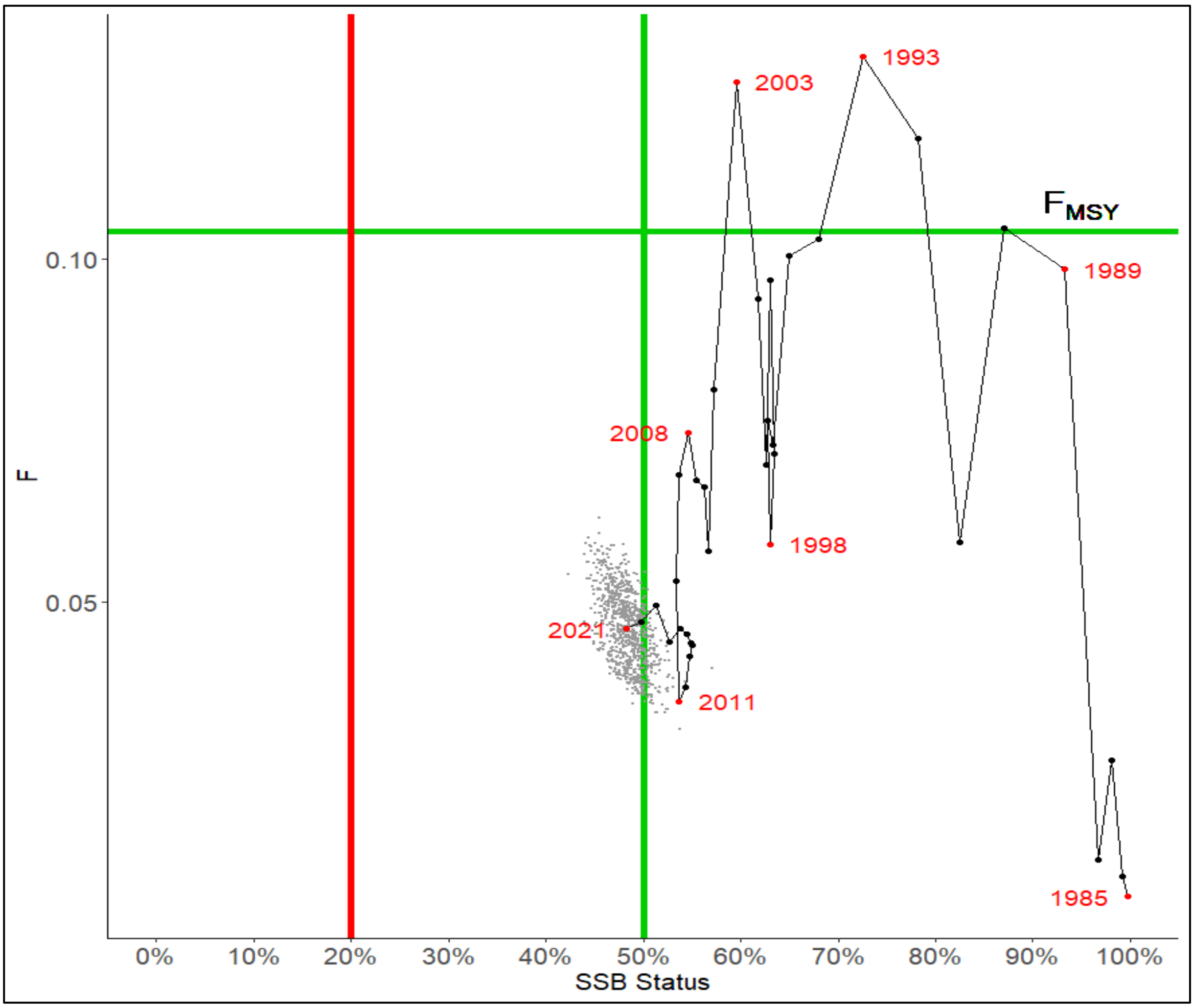

Figure 1: Markov Chain Monte Carlo (MCMC) Kobe plot for Patagonian toothfish (*Dissostichus eleginoides*) in Subarea 48.3 (lines) with the MCMC estimates of uncertainty around the 2021 estimate (points). The green and red vertical lines indicate the target (50% B_0) and limit (20% B_0) reference points respectively for toothfish under the CCAMLR decision rules, and the horizontal green line indicates the maximum sustainable yield (F_{MSY}) exploitation rate for the stock (~0.104 y^{-1}).

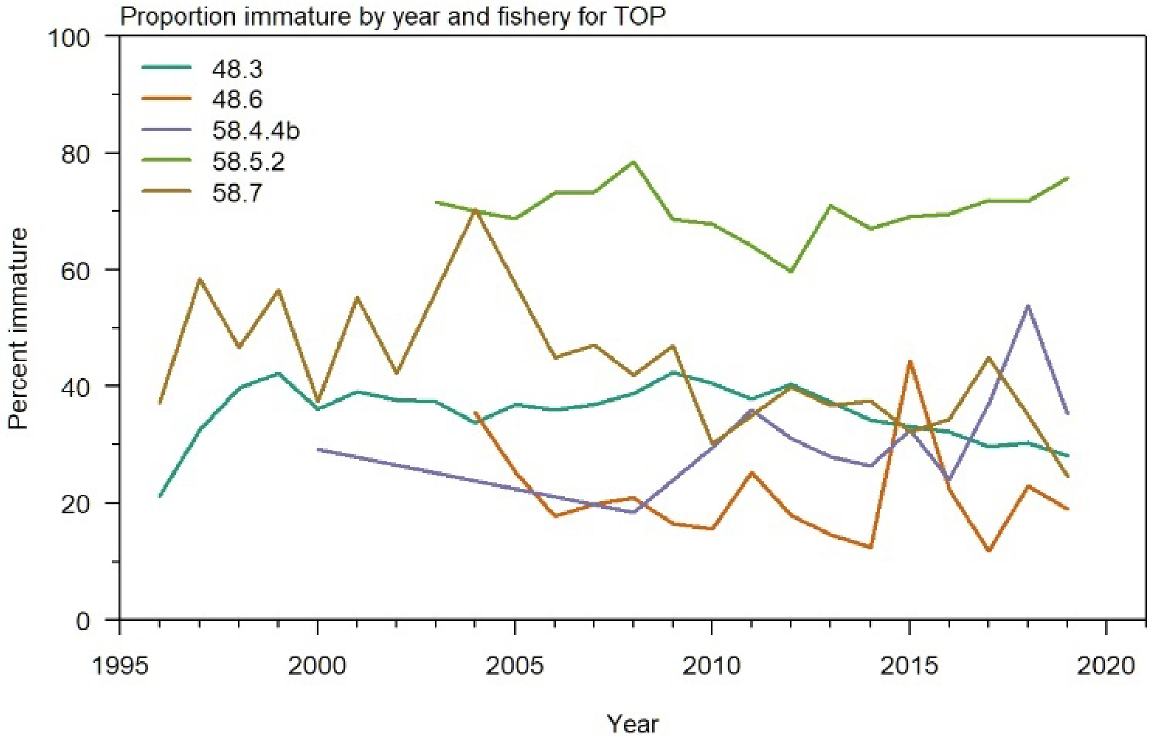

Figure 2: Percent immature fish by year in catches of Patagonian toothfish (*Dissostichus eleginoides*) fisheries across the Convention Area (reproduced from WG-FSA-2019, Figure 5c).

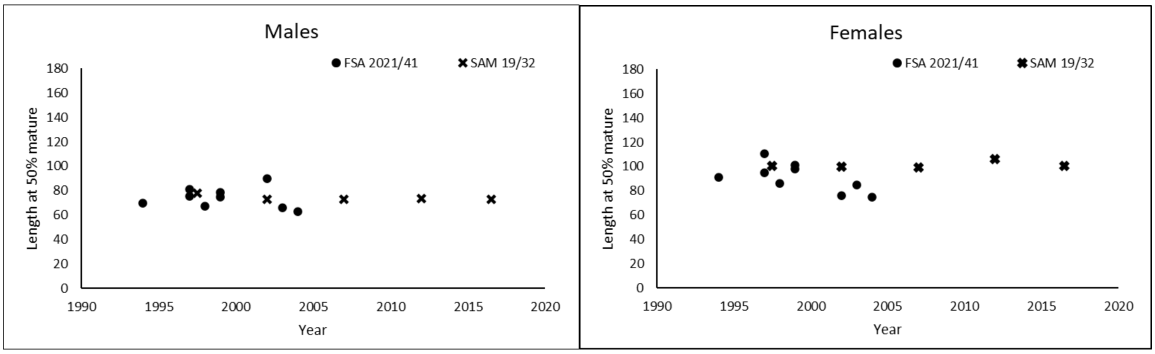

Figure 3: The time series of historic research paper estimates of length at first maturity presented in WG-FSA-2021/41 (circles), plotted with the five-year block estimates from WG-SAM-2019/32, standardised by depth, gear type and sex/depth interactions (reproduced from SC-CAMLR-40/BG/08, Figure 2).

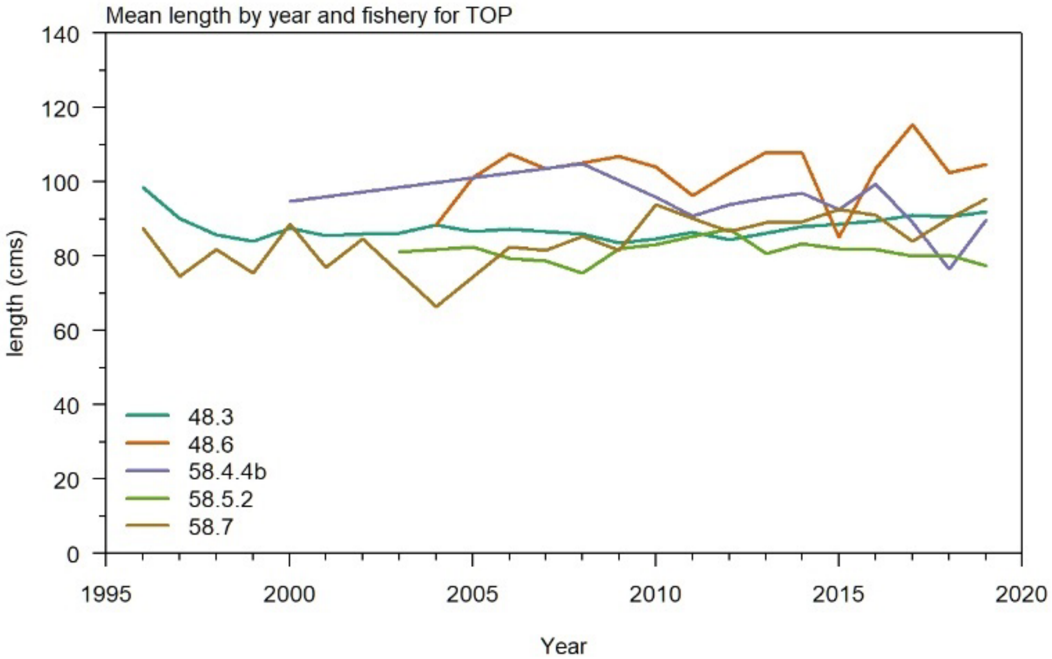

Figure 4: Mean length by year in catches of Patagonian toothfish (*Dissostichus eleginoides*) fisheries across the Convention Area (reproduced from WG-FSA-2019, Figure 4c).

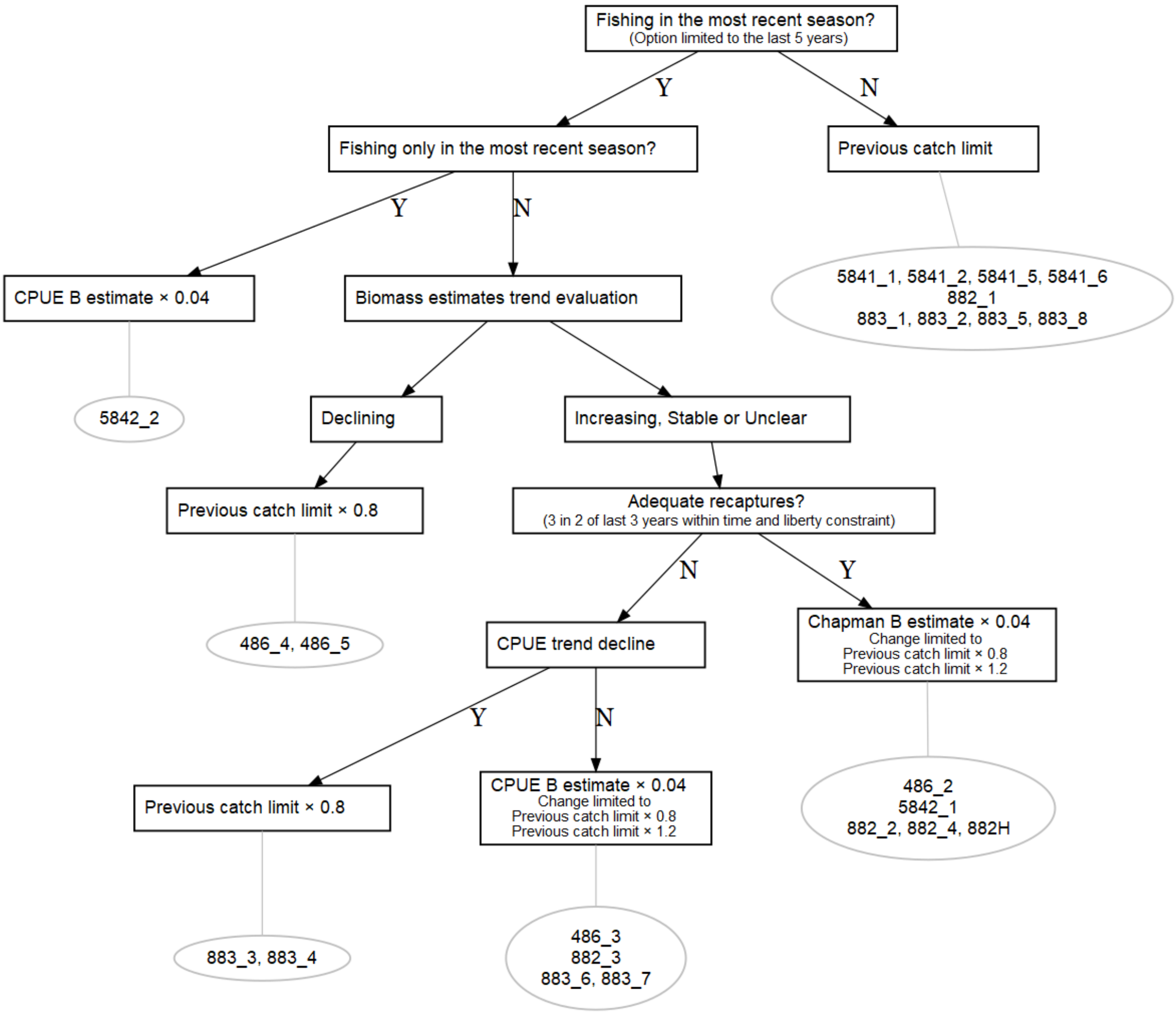

Figure 5: Updated decision tree of the trend analysis used to provide catch advice for research blocks and small-scale research units in data-limited toothfish fisheries (referenced in ovals) for the 2022/23 season.

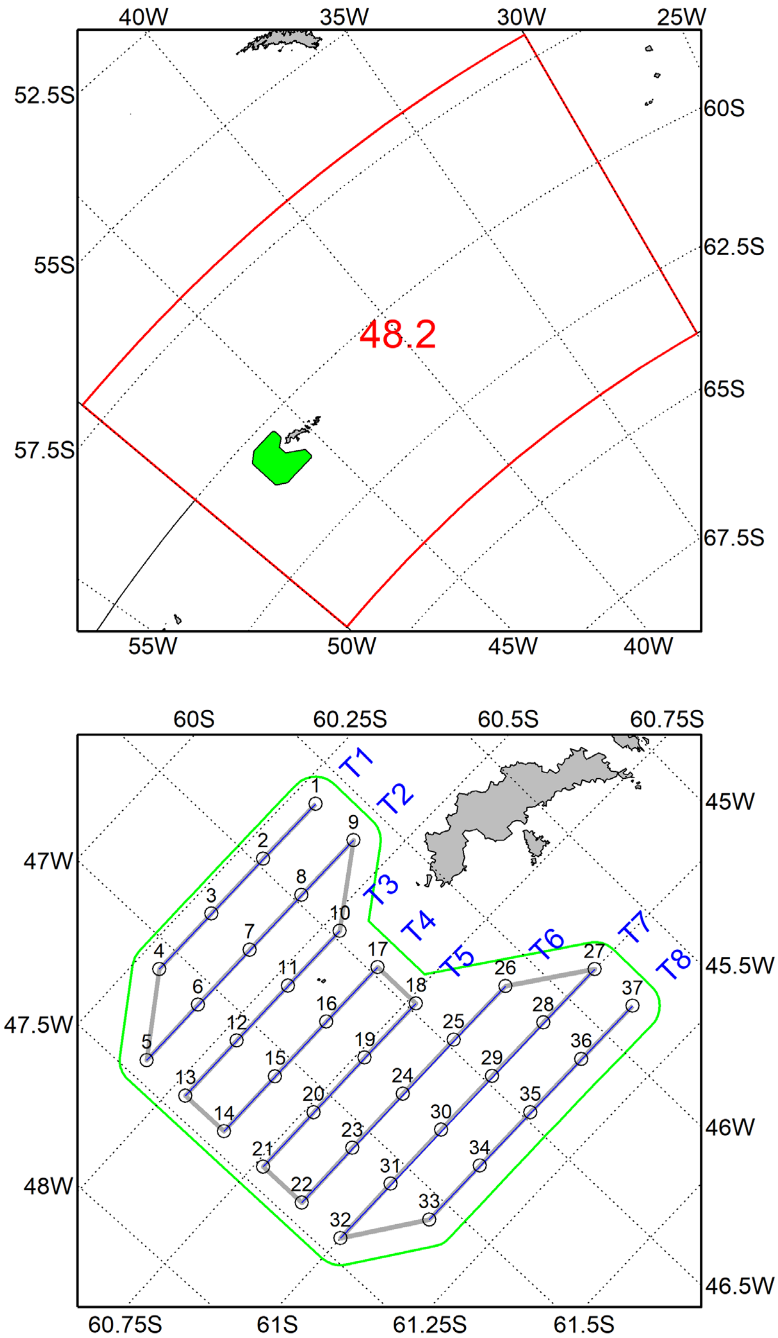

Figure 6: Survey area (green), transects (blue) and oblique haul locations (circles) in Subarea 48.2.

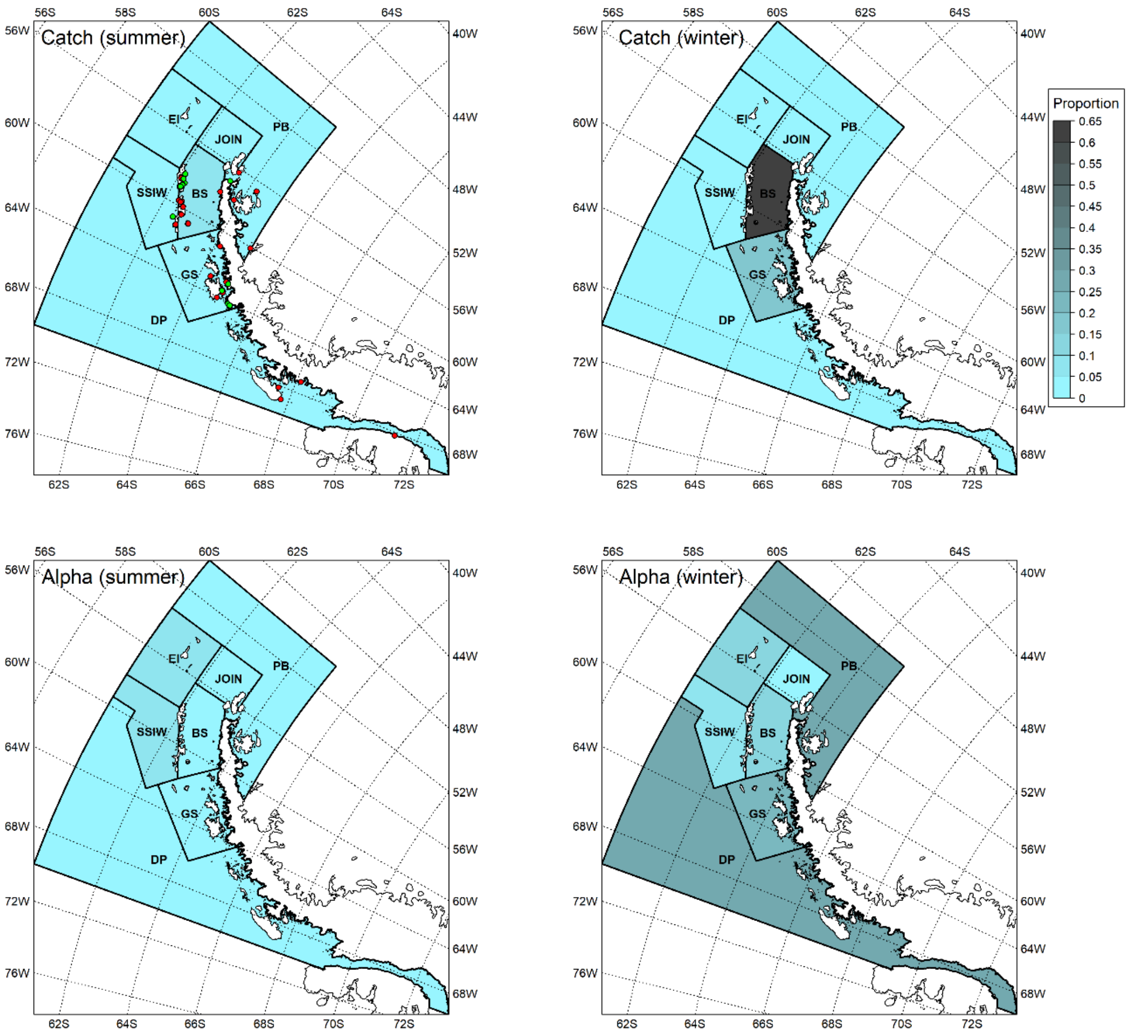

Figure 7: Distribution of krill catch (top) and alphas (bottom) in summer (left) and winter (right) in Subarea 48.1. Catch is shown here as a proportion of the total catch over the last five years (2018–2022), alphas correspond to proportions of the total catch limit for Subarea 48.1. CCAMLR Ecosystem Monitoring Program (CEMP) sites (green) and Council of Managers of National Antarctic Programs (COMNAP)-listed infrastructure (red) are shown in the top left-hand panel. EI – Elephant Island, JOIN – Joinville, BS – Bransfield Strait, SSIW – South Shetland Islands West, GS – Gerlache Strait, DP – Drake Passage, PB – Powell Basin.

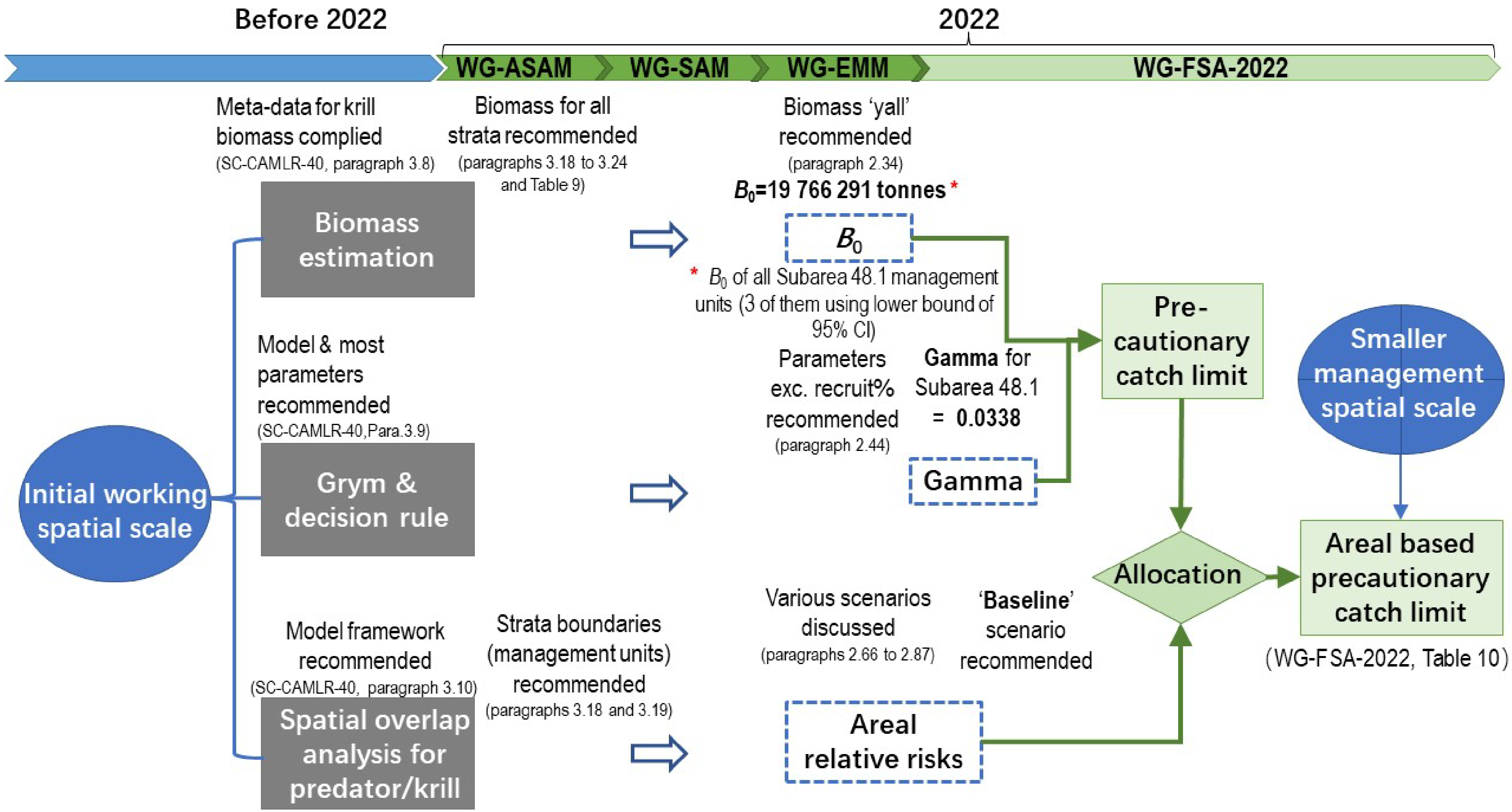

Figure 8: The three components and workflow of the revised krill management approach, as agreed at SC-CAMLR-40, paragraph 3.25, and Annex 8, and subsequent recommendations leading to the WG-FSA-agreed strata catch limits by each working group.

Appendix A

List of Registered Participants

Working Group on Fish Stock Assessment
(Hobart, Australia, 9 to 20 October 2022)

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Science Data Officer	Daphnis De Pooter
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Fisheries Monitoring and Compliance Data Officer	Henrique Anatole
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Finance Support Officer	Christine Thomas
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Administrative Services Officer	Amelia Stoneham
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French Translator	Bénédicte Graham
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Russian Translator	Anar Umerkhanova
Russian Translator	Blair Denholm
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Spanish Translator	Facundo Alvarez
Spanish Translator	Alejandra Sycz
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Data and Information Systems Manager	Gary Dewhurst
Database Administrator/Technical Analyst	Thomas Williams
Systems Analyst	Ian Meredith
IT Support Officer	James Eisenhower
Software Developer	Mingyun Qie
Technical Business Analyst	Mitchell John
Web Project Officer	Dane Cavanagh

Appendix B

Agenda

Working Group on Fish Stock Assessment
(Hobart, Australia, 10 to 20 October 2022)

1. Opening of the meeting

2. Adoption of the agenda

3. Review of data available

    3.1 Catch limit management
    3.2 Report of the Ross Sea Data Collection Plan workshop

4. Fish stock assessment and management advice

    4.1 Icefish (*Champsocephalus gunnari*)
        4.1.1 Assessment of *C. gunnari* in Subarea 48.3
        4.1.2 Assessment of *C. gunnari* in Division 58.5.2

    4.2 Toothfish (*Dissostichus* spp.)
        4.2.1 Assessment of Patagonian toothfish (*Dissostichus eleginoides*) in Subarea 48.3
        4.2.2 Assessment of Patagonian toothfish (*D. eleginoides*) in Division 58.5.2
        4.2.3 Assessment of Antarctic toothfish (*D. mawsoni*) in Subarea 48.4

    4.3 Biomass estimation for toothfish from trend analysis

5. Research fisheries

    5.1 Research plans in exploratory fisheries under Conservation Measure (CM) 21-02 and management advice
        5.1.1 Area 48
        5.1.2 Area 58

    5.2 Research proposals and notifications under CM 24-01 and management advice
        5.2.1 Subarea 48.2 icefish survey
        5.2.2 Ross Sea shelf survey
        5.2.3 Updated research plan for Subarea 88.3
        5.2.4 Research in Subarea 48.1

6. Non-target catch and incidental mortality associated with fishing

    6.1 Macrourids
    6.2 Skates
    6.3 Management of vulnerable marine ecosystems (VMEs) and habitats of particular concern
    6.4 Ecosystem structure and function

7. Krill (*Euphausia superba*)

8. Scheme of International Scientific Observation

9. Future work

10. Other business

11. Advice to the Scientific Committee

12. Adoption of the report and close of meeting.

Appendix C

List of Documents

Working Group on Fish Stock Assessment
(Hobart, Australia, 10 to 20 October 2022)

WG-FSA-2022/01 Rev. 1	Report of the Co-conveners of the Workshop on Conversion Factors for Toothfish (Virtual Meeting, 12 and 13 April 2022) Workshop Co-conveners (Mr N. Walker (New Zealand) and Mr N. Gasco (France))
WG-FSA-2022/02	Icefish spawning aggregation in the southern Weddell Sea including discussions and recommendations from WG-EMM-2022 K. Teschke, M. Eléaume, R. Konijnenberg, P. Brtnik and T. Brey
WG-FSA-2022/03	Fish by-catch in the krill fishery – 2022 update Secretariat
WG-FSA-2022/04	An update from the Secretariat on outstanding issues in krill fishery data relating to the reporting of by-catch, green weight estimation parameters and two-hourly catch reporting for continuous trawling vessels. Secretariat
WG-FSA-2022/05	Compendium of catch limit overruns from the 2018 to 2022 seasons Secretariat
WG-FSA-2022/06	Analysis of the risk of exceeding catch limits in the krill fishery using daily reporting Secretariat
WG-FSA-2022/07	Results from the 2022 random stratified trawl survey in the waters surrounding Heard Island in Division 58.5.2 D. Maschette, T. Lamb and P. Ziegler
WG-FSA-2022/08	A preliminary assessment for mackerel icefish (*Champsocephalus gunnari*) in Division 58.5.2, based on results from the 2022 random stratified trawl survey D. Maschette
WG-FSA-2022/09	Update on the Heard Island and McDonald Islands Patagonian toothfish (*Dissostichus eleginoides*) fishery in Division 58.5.2 P. Ziegler

WG-FSA-2022/10	Summary of environmental data collected during the *Dissostichus mawsoni* exploratory fishery in East Antarctica (Divisions 58.4.1 and 58.4.2) C. Miller, T. Lamb, P. Ziegler, J. Lee, S. Chung, C. Péron and N. Gasco
WG-FSA-2022/11	Tag linking – 2022 report Secretariat
WG-FSA-2022/12	Factors influencing conversion factors in CCAMLR toothfish fisheries Secretariat
WG-FSA-2022/13	2022 trend analysis – Estimates of toothfish biomass in research blocks
WG-FSA-2022/14	CCAMLR Marine Debris Monitoring Program, 2022 Secretariat
WG-FSA-2022/15	Preliminary analysis of seawater temperature(T) and salinity(S) in the southern part of Subarea 48.6, research blocks 3, 4 and 5 with CTD data sampled by FV *Tronio* in 2020 and 2021 T. Namba, R. Sarralde and J. Pompert
WG-FSA-2022/16	Genome-wide analyses indicate a lack of population structure in Antarctic toothfish (*Dissostichus mawsoni*) in the Atlantic sector of the Southern Ocean (CCAMLR Subarea 48.6). S.B. Piertney, P. Brickle, J.H.W. Pompert and A. Douglas
WG-FSA-2022/17	Proposal to conduct a local acoustic-trawl survey of *Champsocephalus gunnari* in Statistical Subarea 48.2 Delegation of Ukraine
WG-FSA-2022/18	Trophodynamics of the Antarctic toothfish (*Dissostichus mawsoni*) in the Antarctic Peninsula Subarea 48.1: prey composition and fatty acids profile K. Pérez, C. Cárdenas, F. Santa Cruz, M. González-Aravena, P. Gallardo, A. Rivero, K. Demianenko and P. Zabroda
WG-FSA-2022/19	A condition assessment and handling guideline for skate (Rajiforms) by-catch in longline fisheries: Lessons from the Southern Indian Ocean J. Faure, R. Jones, M. Grima, C. Péron, N. Gasco, T. Lamb, P. Ziegler and J. Cleeland
WG-FSA-2022/20	Preliminary study on the use of the vertebrae centrum in the age determination of skates in Crozet and Kerguelen waters J. Faure, J.M. Caraguel and C. Péron

WG-FSA-2022/21	Report on fish by-catch during *Dissostichus mawsoni* exploratory fishing in Divisions 58.4.1 and 58.4.2 (2016–2022) C. Péron, F. Rajaonalison and P. Ziegler
WG-FSA-2022/22	Recent trends in finfish by-catch from the krill fishery in Area 48 C.D. Jones
WG-FSA-2022/23	Developing the two-area population CASAL model for stock assessment of Antarctic toothfish (*Dissostichus mawsoni*) at the Subarea 48.6 T. Okuda and Y. Osawa
WG-FSA-2022/24 Rev. 1	Report of research fishing operations at Subarea 48.6 between the 2012/13 and 2021/22 fishing seasons Delegations of Japan, Spain and South Africa
WG-FSA-2022/25	Updating the model for the variability of egg and larval transport of Antarctic toothfish under the extreme SAM event in the East Antarctic region (Divisions 58.4.1 and 58.4.2) M. Mori, K. Mizobata, K. Kusaharaand T. Okuda
WG-FSA-2022/26	Continuing research plan for *Dissostichus* spp. under CM 24-01, paragraph 3, in Subarea 88.3 by Korea and Ukraine from 2021/22 to 2023/24 Delegations of the Republic of Korea and Ukraine
WG-FSA-2022/27	Diet composition and feeding strategy of Antarctic toothfish, *Dissostichus mawsoni*, in the Area 88 for the exploratory longline fishery of Korea in 2022 G.W. Baeck, S. Chung and J. Lee
WG-FSA-2022/28	Geographical diet variations of Antarctic toothfish (*Dissostichus mawsoni*) in Area 88 of CCAMLR S.R. Lee, S. Chung, J. Lee and H.-W. Kim
WG-FSA-2022/29 Rev. 1	Population genetic structure of Antarctic toothfish, *Dissostichus mawsoni*, from Subareas 88 in the Antarctic Ocean based on a large number of microsatellite markers H.-K. Choi, H. Park, S. Chung, J. Lee and H.J. Lee
WG-FSA-2022/30	Evaluation of proposed stratum-scale catch limits for the krill fishery in Subarea 48.1 to assess whether they are likely to be precautionary S. Hill, C. Darby, T. Dornan and G. Watters

WG-FSA-2022/31	Proposed workshop on integrating climate change and ecosystem interactions into CCAMLR science R. Cavanagh, M. Collins, C. Darby, T. Dahlgren, M. Eléaume, S. Hill, P. Hollyman, S. Kawaguchi, B. Krafft, E. Pardo, P. Trathan, A. Van de Putte, N. Walker, G. Watters and P. Ziegler
WG-FSA-2022/32	About results of age determination of the *Dissostichus* spp. and *Macrourus* spp. from the research longline catches in Subarea 48.1 by Ukrainian vessel *CALIPSO* in 2019–2021 P. Zabroda, I. Slypko, A. Bazhan and I. Mytiai
WG-FSA-2022/33	Update on the VAST (vector autoregressive spatio-temporal) modelling of grenadier relative abundance in Subarea 48.6 K. Sawada, A. Grüss and T. Okuda
WG-FSA-2022/34	Preliminary integrated stock assessment for the Antarctic toothfish (*Dissostichus mawsoni*) fishery in Divisions 58.41 and 58.4.2 P. Ziegler, C. Miller and D. Maschette
WG-FSA-2022/35	Alternative proportional recruitment estimates for Subarea 48.1 based on reanalysis of the US AMLR data series Y. Ying and X. Zhao
WG-FSA-2022/36	Otolith chemistry reflects local stock connectivity of Antarctic toothfish (*Dissostichus mawsoni*) between research blocks in Subarea 48.6: an updated report G.P. Zhu, L. Wei, T. Okuda, R. Sarralde and S. Somhlaba
WG-FSA-2022/37	Proposals to standardise the collection and processing of krill acoustic survey data S. Kasatkina and A. Abramov
WG-FSA-2022/38	Proposals to increase the efficiency of the tagging program in Subareas 88.1 and 88.2 O.Y. Krasnoborodko and S.M. Kasatkina
WG-FSA-2022/39	Where we are for the revision of CM 51-07 Y. Ying, Y. Zhao, X. Zhao, X. Wang and G. Fan
WG-FSA-2022/40	2022 Ross Sea shelf survey results J. Devine and M. Prasad

WG-FSA-2022/41 Rev. 1	Proposal to continue the time series of research surveys to monitor abundance of Antarctic toothfish (*Dissostichus mawsoni*) in the southern Ross Sea, 2022/23–2024/25: Research Plan under CM 24-01 Delegation of New Zealand
WG-FSA-2022/42	Update of skate tagging program in the Ross and Amundsen Sea regions B. Finucci and B. Moore
WG-FSA-2022/43	Update of age and growth validation of skates in the Ross Sea region using mark recapture B. Finucci, C. Maolagáin and J. Pompert
WG-FSA-2022/44	Report of the Workshop on the Ross Sea Data Collection Plan 2022 (Virtual Meeting, 11 and 12 August 2022) Workshop Co-Conveners (N. Walker and L. Ghigliotti)
WG-FSA-2022/45	Proposed medium-term research plan and data collection plan for the Ross Sea toothfish fishery J. Devine, M. Pinkerton, B. Moore, B. Finucci, A. Grüss, A. Dunn, J. Fenaughty, E. Pardo and N. Walker
WG-FSA-2022/46	Review of progress against the medium-term research plan for the Ross Sea region toothfish fishery J. Devine, M. Pinkerton, B. Moore, B. Finucci, A. Grüss, A. Dunn, J. Fenaughty, E. Pardo and N. Walker
WG-FSA-2022/47	Monitoring by-catch species in the Ross Sea region toothfish fishery B. Moore, A. Grüss, M. Pinkerton and J. Devine
WG-FSA-2022/48	VAST (vector-autoregressive spatio-temporal) modelling of macrourid relative abundance in the Ross Sea region to support by-catch management A. Grüss, B. Moore, M. Pinkerton and J. Devine
WG-FSA-2022/49	Characterisation of the toothfish fishery in the Ross Sea region through 2021–22 A. McKenzie, J. Devine and A. Grüss
WG-FSA-2022/50	Summary of the toothfish fishery and tagging program in the Amundsen Sea region (small-scale research units 882C–H) to 2021/22 A. McKenzie, J. Devine and A. Grüss
WG-FSA-2022/51	Withdrawn

WG-FSA-2022/52	Implementation of the CCAMLR Scheme of International Scientific Observation during 2021/22 and an update to commercial data forms and manuals. Secretariat
WG-FSA-2022/53	A draft workplan to progress management strategy evaluations of the CCAMLR trend analysis rules A. Dunn, P. Ziegler, J. Devine and the CCAMLR Secretariat
WG-FSA-2022/54	Reconciliation of CDS data with monthly fine-scale catch and effort data Secretariat
WG-FSA-2022/55	A tool for creating simulated survey outputs from longline data M. Kerr and T. Earl
WG-FSA-2022/56 Rev. 1	Fishery characterisation for Patagonian toothfish around South Georgia (Subarea 48.3) J. Marsh, T. Earl and C. Darby
WG-FSA-2022/57 Rev. 1	Assessment of Patagonian toothfish (*Dissostichus eleginoides*) in Subarea 48.3 T. Earl and L. Readdy
WG-FSA-2022/58	Assessment of Patagonian toothfish (*Dissostichus eleginoides*) in Subarea 48.3: Assessment diagnostics T. Earl and L. Readdy
WG-FSA-2022/59	Maturity and growth estimates of Patagonian toothfish in Subarea 48.3 between 2009 to 2021 J. Marsh, T. Earl, P. Hollyman and C. Darby
WG-FSA-2022/60	Preliminary tag-recapture based population assessment of Antarctic toothfish in Subarea 48.4 T. Earl, A. Riley and J. Marsh
WG-FSA-2022/61	Revised VME Taxa Classification Guide toothfish fishery – version 2 J. Devine, D. Tracey, S. Mills, D. Macpherson, D. Gordon and E. Mackay

Other documents

WG-FSA-2022/P01	Helminth diversity in teleost fishes from the South Orkney Islands region, West Antarctica T. Kuzmina, O. Salganskij, K. Vishnyakova, J. Ivanchikova, O. Lisitsyna, E. Korol and Y. Kuzmin *Zoodiversity*, 56 (2) (2022), doi: https://doi.org/10.15407/zoo2022.02.135
WG-FSA-2022/P02	Fatty acids linkage between mackerel icefish (*Champsocephalus gunnari*) and Antarctic krill (*Euphausia superba*) at South Georgia G.P. Zhu and J.Y. Zhu *Fish. Res*., 253 (2022): 106366
WG-FSA-2022/P03	Otolith shape as a tool for species identification of the grenadiers *Macrourus caml* and *M. whitsoni* B. Moore, S. Parker and M. Pinkerton *Fish. Res*., 253 (2022) 106370, doi: https://doi.org/10.1016/j.fishres.2022.106370
WG-FSA-2022/P04	Comparative biology of the grenadiers *Macrourus caml* and *M. whitsoni* in the Ross Sea region, Antarctica B. Moore, S. Parker, P. Marriott, C. Sutton and M. Pinkerton *Front. Mar. Sci*., 9: 968848, doi: 10.3389/fmars.2022.968848 (in press.)
WG-FSA-2022/P05	Whale depredation in the South Georgia Patagonian toothfish (*Dissostichus eleginoides*) fishery in the South Atlantic: a comparison of estimation methods T. Earl, E. MacLeod, M. Söffker, N. Gasco, F. Massiot-Granier, P. Tixier and C. Darby *ICES J. Mar. Sci*., 78 (10) (2021): 3817–3833, doi: https://doi.org/10.1093/icesjms/fsab212

Appendix D

Report of the Co-conveners of the Workshop on the Ross Sea Data Collection Plan 2022
(Virtual Meeting 11 and 12 August 2022)

Report of the Co-conveners of the Workshop on the Ross Sea Data Collection Plan 2022
(Virtual Meeting, 11 and 12 August 2022)

1. The Workshop on the Ross Sea Data Collection Plan (WS-RSDCP) was held online on 11 and 12 August 2022. The Workshop was co-convened by Dr L. Ghigliotti (Italy) and Mr N. Walker (New Zealand) and supported by the CCAMLR Secretariat. Scientists from 11 Members attended the Workshop.

2. At the opening of the meeting, Mr Walker welcomed and acknowledged the 32 participants (Attachment I) and noted the Workshop was an informal meeting to review the progress against the previous medium-term research plan for the Ross Sea (WG-FSA-14/60, SC-CAMLR-XXXIII, paragraph 3.209), and refine a proposal for a new medium-term research plan and an accompanying data collection plan.

3. Accordingly, this report is not an adopted report, but is a summary by the Co-conveners for the consideration of the Scientific Committee and its working groups. The intent is that the recommendations outlined below will be reported to WG-FSA-2022 for further discussion and agreed at SC-CAMLR-41 according to the Scientific Committee Rules of Procedure.

4. The terms of reference for the Workshop are given in Attachment II, the agenda in Attachment III and the list of papers submitted to the workshop in Attachment IV.

5. This report was prepared by the Co-conveners with support from the Secretariat.

Identify fishery-based medium-term research objectives

6. WS-RSDCP-2022/01 presented a review on progress against the 2014 medium-term research plan for the Ross Sea toothfish fishery (WG-FSA-14/60).

7. The Workshop discussed the review presented in this paper and noted further refinements which will be incorporated into an updated version of the paper to be presented to WG-FSA-2022, alongside this report.

8. During the Workshop, a table was developed to summarise the progress against the 2014 medium-term research plan research objectives (Table 1). The approach used to complete this was analogous to that utilised in the Scientific Committee Symposium, which involved indicating the scale of progress against each objective, in addition to providing a brief description of the research undertaken. The Workshop noted good progress against the 20 objectives, with nine complete or with significant progress, seven with some progress and only four with no progress. Several of these objectives were carried forward into the new data collection plan.

9. WS-RSDCP-2022/02 presented a proposed medium-term research plan for the next five to seven years. The long-term goals of the Ross Sea fishery based on Article II of CCAMLR can be summarised as:

(i) the target fished population is above a level which ensures stable recruitment

(ii) the ecological relationships between harvested, dependent and related populations are maintained

(iii) changes in the marine ecosystem that are not potentially reversible over two or three decades are prevented or minimised, with the overall objective of the conservation of Antarctic marine living resources.

10. Table 2 presents a revised summary of the proposed research objectives. This table shows the 2014 medium-term research plan research objectives and progress against them (as in Table 1) along with revised research objectives for a new proposal for the medium-term research plan for the Ross Sea toothfish fishery. The table also summarises the discussions during the Workshop on the data collection needs for each new research objective and whether the objective would be met by data collected by the fishery under Conservation Measure (CM) 41-01 and CM 41-09, or non-Olympic fishery research (e.g. CM 24-01) and/or other national research programs.

Develop a sampling plan to obtain necessary data

11. Table 3 was developed during the Workshop to provide the basis for an update to the previous data collection plan (WG-FSA-15/40). Table 3 includes details of the data to be collected, frequency of collection, priority and relevant protocols for each type of data. Each type of data to be collected is indicated as either baseline (i.e. for all vessels in the Ross Sea toothfish fishery to collect), or research (which would be undertaken on a voluntary basis and data managed by Members). For proposed additional baseline data requirements, it is noted where these can be undertaken using current baseline data collection methods by all vessels, and whether data collection forms and manuals would require any changes to accommodate these requirements.

12. During the Workshop there was discussion about the relative merits of either rotational sampling of the by-catch species groups: macrourids, skates and other species, or consistent but lower levels of data collected on all species each year. The observer coordinators present at the Workshop noted that observers prefer the rotational approach as it provides a clear priority for their work each season. However, clear concise instructions and protocols would be needed specific to each year to enable communication of the sampling requirements to observers.

13. The Workshop requested the Secretariat to contact a wider range of observer coordinators in advance of WG-FSA-2022 for feedback on the data collection plan and confirm which sampling approach for the by-catch species is preferred by observers. This information will enable WG-FSA-2022 to verify the by-catch sampling approach and the data collection plan.

Identify high priority non-Olympic fishery research activities (e.g. CM 24-01)

14. WS-RSCDCP-2022/03 presented initial suggestions for high-priority non-Olympic fishery research activities. These suggestions included:

(i) assess the spatial extent of the distribution of the Ross Sea Antarctic toothfish (*Dissostichus mawsoni*) population in the northeast of Subarea 88.1

(ii) determine connectivity of Antarctic toothfish in small-scale research units (SSRUs) 882A–B and H

(iii) assess the spatial extent of Antarctic toothfish distribution in SSRUs 882A–B and H outside main fishing areas

(iv) conduct experiments to investigate and improve current estimates of tagging mortality rates, tag recapture reporting rates, tag shedding and tag-related growth retardation in toothfish and skates (e.g. WG-FSA-13/54)

(v) continue the Ross Sea shelf survey, noting the important recruitment data it provides to the Ross Sea stock assessment

(vi) conduct experiments to determine the early life history and ecology of Antarctic and Patagonian toothfish (*Dissostichus eleginoides*), including under different temperature regimes

(vii) improve biological and ecological knowledge of skates to improve risk assessment and monitoring approaches.

15. Further suggestions for high-priority non-Olympic fishery research activities were identified during the Workshop and captured in Table 1. These suggestions included:

(i) winter survey sampling of the water column for toothfish eggs

(ii) use of acoustic data to explore distribution of toothfish at greater depths

(iii) estimating the buoyancy of developing eggs, larvae and juvenile Antarctic toothfish

(iv) directional swimming capabilities and behaviours of larvae and juveniles

(v) use of passive acoustics receivers to record marine mammal presence in the area

(vi) collection of additional data about the trophic relationships between Antarctic toothfish, killer whales (*Orcinus orca*) and Weddell seals (*Leptonychotes weddellii*) via biopsies and tags

(vii) post-release survival estimates for skates from pop-up satellite archival transmitting tags.

Identify voluntary programs to test novel data collection mechanisms

16. WS-RSCDCP-2022/03 presented some suggestions for voluntary Member-led programs to test novel data collection mechanisms on specific vessels. These suggestions were:

(i) collection of phytoplankton samples to aid in understanding phytoplankton distribution, seasonal abundance and impacts of climate change

(ii) Te Tiro Moana project – an ocean observation project that deploys temperature and depth sensors on fishing vessels.

17. Further suggestions were discussed during the Workshop and captured in Table 2. These included:

(i) measurement of physiological parameters (e.g. lactate) to indicate stress levels associated with the suitability evaluation process for tagging by-caught skates

(ii) inspection of sponges caught during Olympic fishing for fish eggs and recording data by scientific observers

(iii) photographic data collection for estimating abundance of cetaceans using photographic mark-recapture methods.

Next steps

18. The draft documents submitted to the Workshop and the tables produced during the workshop (Tables 1 to 3) will be combined to produce reports for submission to WG-FSA-2022 to discuss and agree a new medium-term research plan and the data required to progress it.

Table 1: Progress against the medium-term research plan for the Ross Sea toothfish fishery (WG-FSA-14/60). Comments on the work performed and suggestions for the 2023–2028 mid-term research plan are included (column 'notes'). Progress has been rated as: 0 – little or no progress; 1 – some progress; 2 – significant progress or complete. CPUE – catch per unit effort, MSE – management strategy evaluation, SPRFMO – South Pacific Regional Fisheries Management Organisation, SSRU – small-scale research unit.

Research objectives	Progress	Notes
3.1 Maintenance of the Antarctic toothfish population in the Ross Sea region above target levels		
3.1.1 Reduce uncertainty in toothfish model parameters		
(i) To spatially and temporally delineate toothfish spawning grounds	2	A spatial model of toothfish distribution by age and spawning state has been developed (SPM). This maps distributions of spawning toothfish by year and includes future projections. Hydrodynamic model with virtual toothfish eggs and larvae has been used to investigate early life-history strategies of toothfish, including the use of different spawning areas (published). Winter survey successfully found and measured buoyancy of developing toothfish eggs.
(ii) To delineate stock structure – especially in relation to SSRUs 882C–I	1	Research fishing in SSRUs 882A–B and in SPRFMO was undertaken to explore toothfish stock structure. A review of toothfish stock structure in Area 88 indicates two stocks for management purposes, a Ross Sea region stock and an Amundsen Sea region stock, which likely mixed during early life history but had limited mixing at the adult stages. Additional research in SSRUs 882C–H was considered necessary to develop and test stock hypotheses. Currently data quality is impacted by low spatial overlap between locations of released tagged fish and fishing effort in the subsequent year and reduction in fishing effort in the area.
(iii) To define and quantify fine-scale movement patterns, including by size and sex	2	Significant progress on spatial population modelling of toothfish to investigate movement and mixing. Analysis of movement patterns of recaptured toothfish and from pop-off satellite tags.
(iv) To improve estimates of initial (and longer-term) tagging mortality and tag detection	0	The effect of size and external factors (e.g. freezing or other extreme conditions) on the toothfish survivorship need to be investigated. Work had been undertaken on improved methods for estimating effective tagging survival and effective tagging rate, but this was not yet sufficient to provide updated parameter estimates used in the stock assessment model. Genetic mark-recapture techniques may provide an opportunity to estimate tagging mortality.

(continued)

Table 1 (continued)

Research objectives		Progress	Notes
(v)	To continue monitoring the relative abundance of sub-adults and to estimate recruitment variability and autocorrelation	2	The Ross Sea shelf survey has been carried out every year since 2012 and is ongoing, providing an important early warning signal of changes in recruitment of Antarctic toothfish as well as a platform for ecosystem research.
(vi)	To monitor key population-level parameters	2	Review of growth and length-weight parameters undertaken in 2019. These parameters will be monitored through the annual fishery characterisation, tag analysis and biennial stock assessment.
3.1.2	**Reduce management uncertainty**		
(i)	To continue to improve the stock assessment	2	Ongoing refinement work on the stock assessment along with the development and validation of Casal2 in 2022.
(ii)	To develop simple stock performance indicators/dashboard	1	A range of stock performance indicators are produced with the biennial stock assessment and made available through CCAMLR working groups. Also, information is published in New Zealand (Fisheries New Zealand stock assessment plenary). More work needed on a 'dashboard' which brings together stock performance indicators with environmental and ecosystem indicators.
(iii)	To develop prioritised list of MSE scenarios and begin MSE testing of high priority issues	1	MSEs underlying the establishment of the trend analysis decision framework were listed as a priority topic of WG-SAM-2018. A range of sensitivity studies have been carried out as part of the biennial stock assessment.
(iv)	To continue development of operating models as additional tag and fishery data are collected, through improved predictive layers, and better knowledge of life cycle	2	A spatially explicit age-structured population dynamics operating model (SPM) for Antarctic toothfish in the Ross Sea region was developed that allows exploration of spatial allocation factors, other than seabed area and CPUE. Other features should be included in the model, such as predator–prey overlap, ice dynamics, ecosystem features.

(continued)

Table 1 (continued)

Research objectives	Progress	Notes
3.2 Maintenance of ecosystem structure and function		
(i) To determine the temporal and spatial extent of the overlap in the distribution of toothfish and its key predators (in particular killer whales and Weddell seals)	2	Four field seasons of work on Weddell seals in the southwest Ross Sea have been carried out (Nov/Dec 2018; Feb/Mar 2019; Nov/Dec 2019; Feb/Mar 2020) to improve understanding of potential effects of fishing on Weddell seals and the role of the MPA in minimising any effects. This research includes the use of accelerometer tags, head-mounted cameras, satellite tags and bio tracers. Long-term moored hydrophones have been maintained at 3 locations in the Ross Sea region since 2018. Satellites have been used to map distributions of Weddell seals around the Antarctic coastline. Killer whales of ecotype C (TCKW) were studied in McMurdo Sound, Antarctica by dart biopsy sampling and photo identification (photo ID). By combining images with an existing catalogue compiled by the Orca Research Trust ('AKWIC') and photos submitted by 'citizen scientists', we created an expanded photo-identification catalogue for Antarctic killer whales. Preliminary analysis of the database provides evidence for long-distance migrations of TCKW between the Ross Sea and New Zealand waters.
(ii) To investigate the abundance, foraging ecology, habitat use, functional importance and resilience of key toothfish predators (in particular killer whales and Weddell seals)	2	As above, significant work on Weddell seals and type-C killer whales.
(iii) To develop methods of monitoring changes in relative abundance of key prey/by-catch species (in particular macrourids and icefish) on the Ross Sea slope and hence assess the potential impact of the toothfish fishery on these species	2	New bottom-trawl estimates of macrourids, icefish and other prey/by-catch species from the *Tangaroa* voyages in 2015, 2019. Underwater video collected from research voyages to investigate use as non-lethal survey method. Acoustic methods developed to estimate macrourid abundance. Spatio–temporal analysis of by-catch data (VAST).
(iv) To monitor diet of toothfish in key areas, especially on the Ross Sea slope	2	Analysis of toothfish stomach contents and stable isotopes for trophic investigation. Method for identifying species of macrourid from their otoliths developed (to be used for otoliths retrieved from toothfish stomachs, or to check species identification accuracy by observers from historical collections).

(continued)

Table 1 (continued)

Research objectives	Progress	Notes
(v) To simulate the effect of the fishery on populations of toothfish, its predators and its prey	1	New biological and modelling analyses completed, but the Minimum Realistic Model for simulating multispecies interactions between toothfish and prey/by-catch species is still being developed.
(vi) To develop quantitative and testable hypotheses as to the 'second-order' effects (such as trophic cascades, regime shift) and ensure data collection is adequate to monitor for any risks deemed reasonable	2	Modelling has simulated the trophic release (cascade) effect of reducing the abundance of toothfish on Antarctic silverfish in the Ross Sea region, and the corresponding potential trophic response of Adélie penguin populations (published). A range of satellite data have been analysed (and presented to CCAMLR) to investigate effects of climate variability/change in the Ross Sea region and look for regime shift. Changes in zooplankton distributions and habitat suitability in the Ross Sea have been modelled. Multifrequency acoustic data has been collected on multiple research voyages to the Ross Sea region to map and monitor mesopelagics (especially myctophids, silverfish, krill). Methods have been developed and published for monitoring primary productivity: (1) water column, (2) deep chlorophyll maxima, (3) production by sea-ice algae. Assessment of CMIP6 earth-system models for projecting future environmental change in the Ross Sea region.
(vii) To assess the impact of the toothfish fishery on Patagonian toothfish	0	Limited Patagonian toothfish caught in the Ross Sea fishery.
(viii) To estimate survivorship of released skates	1	Macroscopic categories of body injuries have been defined for skates to evaluate the likely survivorship before tagging and release. Relative rates of recapture of skates that had particular injuries were recorded for refining the survivorship evaluation criteria.

(continued)

Table 1 (continued)

Research objectives		Progress	Notes
(ix)	To develop semi-quantitative and spatially explicit risk assessments for macrourids and Antarctic skates, especially in the slope fishery of the Ross Sea	1	New data and modelling analyses have been collected as necessary precursors to developing a Minimum Realistic Model for simulating multispecies interactions between toothfish and prey/by-catch species. These components include: • New biological data on macrourids • New biological data and analysis for icefish • Spatio–temporal modelling (VAST) of by-catch species (macrourids, icefish, skates, eel cods, deep-sea cods) • Spatial population modelling of toothfish • Multiple methods to estimate/monitor macrourid abundance (trawl surveys, video, acoustic). Discrimination between the two most common macrourid species using otoliths has been achieved. The Minimum Realistic Model is not yet complete. Skates: Risk assessment for skates is underway based on previous risk assessment framework, but using the larger set of tag-release-recapture data, and new biological information on skates. Identification areas of importance for skates and macrourids such as egg laying, nursery or nesting grounds is needed in the future.
(x)	To develop methods to assess whether the potential impacts of the toothfish fishery on the ecosystem are likely to be reversible in two to three decades	0	No progress

Table 2: A proposed set of research priorities for a new medium-term research plan for the Ross Sea toothfish fishery based on the 2014 medium-terms research plan (WG FSA-14/60) and progress against them. Progress has been rated as: 0 – little or no progress; 1 – some progress; 2 – significant progress or complete. Research priorities that include elements that also lead to the understanding of the impacts of climate change are indicated by (-> **CLIMATE CHANGE**). CPUE – catch per unit effort, MSE – management strategy evaluation, SSRU – small-scale research unit, n/a – not applicable.

MTRP 2014 Research objectives	Progress	MTRP 2022 – Research priorities	Data collection needs	Geographic area of particular interest	Fishery-based research objectives	Non-Olympic fishery research and voluntary programs
1. Maintenance of the Antarctic toothfish population in the Ross Sea region above target levels						
a(i) To spatially and temporally delineate toothfish spawning grounds	2	Determine the early life history of toothfish, including under different temperature regimes (-> CLIMATE CHANGE)	Data on toothfish maturity (gonad stage, gonad weight), body condition (especially young fish). Also winter survey sampling of the water column for eggs.		x	x
a(ii) To delineate stock structure – especially in relation to SSRUs 882C–I	1	To assess the spatial extent of toothfish distribution in the northeast of Subarea 88.1 To determine connectivity of toothfish in SSRUs 882B, C and H Assess the spatial extent of toothfish distribution in SSRUs 882B, C and H outside main fishing areas	Size, sex distribution, CPUE data in water deeper than 2 000 m, acoustic data		x	x
a(iii) To define and quantify fine-scale movement patterns, including by size and sex	2	Use of specialized tags to better resolve the spatial and temporal distribution of toothfish	Fine-scale movement data from electronic tags			x
a(iv) To improve estimates of initial (and longer-term tagging) mortality, and tag detection	0	To improve estimates of relative rates of tag detection	Conventional tagging data from fishery or dedicated experiments		x	x
		To improve estimates of tag survival through a dedicated study or analysis of the residuals that include factors such as size, depth and weather	Data from the conventional tagging program (specific experiments might also be done).		x	x

(continued)

Table 2 (continued)

MTRP 2014 Research objectives	Progress	MTRP 2022 – Research priorities	Data collection needs	Geographic area of particular interest	Fishery-based research objectives	Non-Olympic fishery research and voluntary programs
a(v) To continue monitoring the relative abundance of sub-adults and to estimate recruitment variability and autocorrelation	2	To collect more information about the eggs of toothfish (to run the models about the egg distribution and advection). To continue monitoring to test the assumptions of the stock-recruitment relationship and steepness parameters using MSEs (-> CLIMATE CHANGE)	Age composition data to estimate recruitment-related parameters (mean recruitment, recruitment variability, stock recruitment relationship). Buoyancy estimate of developing eggs, larvae and juveniles. Directional swimming capabilities and behaviours of juveniles.		x	x
a(vi) To monitor key population-level parameters	2	To continue monitoring key population-level parameters (-> CLIMATE CHANGE)	Basic biology data (age at maturity, growth, length-weight relationship, sex ratio), mortality (natural mortality, total mortality depredation mortality)		x	
b(i) To continue to improve the stock assessment	2	To continuously improve the stock assessment (e.g. improve diagnostics, estimation of year-class strength, etc.) (-> CLIMATE CHANGE)	Length and otoliths. Population definition (stock affinity, location of spawning sites, spawning site fidelity), genetics		x	
b(ii) To develop simple stock performance indicators/dashboard	0	To improve communication and understanding of the stock assessment outputs	n/a			
b(iii) To develop prioritised list of MSE scenarios and begin MSE testing of high priority issues	1	To improve the stock assessment (e.g. improve diagnostics, estimation of year-class strength, etc.)	n/a			
b(iv) To continue development of operating models as additional tag and fishery data are collected, through improved predictive layers, and better knowledge of life cycle	1	Implementation of a spatially explicit age-structured population dynamics operating model (SPM) for Antarctic toothfish in the Ross Sea that includes ecosystem features (e.g. predator–prey, ice dynamics, etc.)	n/a			x

(continued)

Table 2 (continued)

MTRP 2014 Research objectives	Progress	MTRP 2022 – Research priorities	Data collection needs	Geographic area of particular interest	Fishery-based research objectives	Non-Olympic fishery research and voluntary programs
2. Maintenance of ecosystem structure and function						
Top predators						
(i) To determine the temporal and spatial extent of the overlap in the distribution of toothfish and its key predators (in particular killer whales and Weddell seals)	1	(i) To determine the temporal and spatial extent of the overlap in the distribution of toothfish and its key predators (in particular killer whales and Weddell seals)	Use of passive acoustics receivers to record whale presence in the area. Sightings from the vessels. Opportunistic observation of Weddell seals on the sea-ice. Collect photographs of killer whales (for photo identification). Additional data could include biopsies and tags.			x
(ii) To investigate the abundance, foraging ecology, habitat use, functional importance and resilience of key toothfish predators (in particular killer whales and Weddell seals)	1	(ii) To investigate the abundance, foraging ecology, habitat use, functional importance and resilience of key toothfish predators (in particular killer whales and Weddell seals)	Use of passive acoustics receivers to record whale presence in the area. Sightings from the vessels. Opportunistic observation of Weddell seals on the sea-ice. Collect photographs of killer whales (for photo identification). Additional data could include biopsies and tags.			x
By-catch species						
(iii) To develop methods of monitoring changes in relative abundance of key prey/by-catch species (in particular macrourids and icefish) on the Ross Sea slope and hence assess the potential impact of the toothfish fishery on these species	2	To continue to collect data on by-catch species to determine their productivity, basic life-history parameters, and develop methods of monitoring changes in relative abundance of key prey/by-catch species (in particular macrourids and icefish) and hence assess the potential impact of the toothfish fishery on these species (-> CLIMATE CHANGE)	By-catch species ID, location, biology, toothfish diet		x	

(continued)

Table 2 (continued)

MTRP 2014 Research objectives	Progress	MTRP 2022 – Research priorities	Data collection needs	Geographic area of particular interest	Fishery-based research objectives	Non-Olympic fishery research and voluntary programs
Ecosystem effects of fishing						
(iv) To monitor diet of toothfish in key areas, especially on the Ross Sea slope	2	To continue monitoring diet of toothfish (-> CLIMATE CHANGE)	Stomach sampling			x
(v) To simulate the effect of the fishery on populations of toothfish, its predators and its prey	2	Ecosystem modelling	n/a			
(vi) To develop quantitative and testable hypotheses as to the 'second-order' effects (such as trophic cascades, regime shift) and ensure data collection is adequate to monitor for any risks deemed reasonable	0	Ecosystem modelling	n/a			
(vii) To assess the impact of the toothfish fishery on Patagonian toothfish	0	To assess the impact of the toothfish fishery on Patagonian toothfish	Distribution and age data		x	

(continued)

Table 2 (continued)

MTRP 2014 Research objectives	Progress	MTRP 2022 – Research priorities	Data collection needs	Geographic area of particular interest	Fishery-based research objectives	Non-Olympic fishery research and voluntary programs
Skates						
(viii) To estimate survivorship of released skates	1	To estimate survivorship of released skates To estimate population abundance of skates To evaluate other 'hard structures' in skates for ageing purposes	Post-release survival estimates from pop-up satellite archival transmitting tags. Physiological stressors of capture and their influence on survival. Skate diet. Age composition by species. Identification of areas of importance to skate life history, including egg laying and size data. Evaluation of the accuracy of cryptic skate species identification.		x	
(ix) To develop semi-quantitative and spatially explicit risk assessments for macrourids and Antarctic skates, especially in the slope fishery of the Ross Sea	1	To continue to collect data on by-catch species to determine their productivity and basic life-history parameters (-> CLIMATE CHANGE)	Information to reduce uncertainty in life history and inform ecosystem models (e.g. length- and age-at-maturity, growth, length-weight relationships, and sex ratios, mortality rates). Validation of age estimates. Fishery selectivity. Spatial distributions. Population definition: stock structure, locations of spawning sites and spawning site fidelity. Obtaining information on the diet of by-catch species (macrourids in particular). Better species identification (especially for macrourids).		x	

(continued)

Table 2 (continued)

MTRP 2014 Research objectives	Progress	MTRP 2022 – Research priorities	Data collection needs	Geographic area of particular interest	Fishery-based research objectives	Non-Olympic fishery research and voluntary programs
(x) To develop methods to assess whether the potential impacts of the toothfish fishery on the ecosystem are likely to be reversible in two to three decades	0	Not specified	n/a			
Marine debris						
Not specified	Not specified	Quantify the effect of marine debris on the ecosystem and on toothfish populations	Data on density and distribution of marine debris including plastics and microplastics		x	
Alien species						
Not specified	Not specified	To monitor for new, unusual and rare species (-> CLIMATE CHANGE)	Record data and preserve example specimens for further analyses		x	

Table 3: Draft data collection plan for the Ross Sea toothfish fishery. V – vessel lead, O – observer lead, TOA – Antarctic toothfish, TOP – Patagonian toothfish, CHW – icefish spp., ANT – blue antimora, MRL – moray cod spp., TL – total length, SL – standard length, PL – pelvic length, WS – wingspan, SRZ – special research zone, SSRU – small-scale research unit, SIOFA – Southern Indian Ocean Fisheries Agreement.

Lead	Data collected	Frequency	Priority	Protocol	Current requirement	Change form	Change manual	Research/ baseline	Processing overhead
	Catch and effort data								
V	C2 and catch and effort data	Every set	Mandatory	CM-41/01(2019)	Yes			Baseline	Low
O	Observer tally period catch	ID to species group	Very High		Yes			Baseline	
	Ongoing yearly toothfish biological data (based on updated data collection plan in WG-FSA-2022/45)								
O	Length, sex, gonad stage	**TOA and TOP**: 35 per haul, target 7 per 1 000 hooks everywhere. TL and SL are requested	Very High	BIO-01, BIO-01a	Yes			Baseline	Low
O	Length, weight, sex, gonad stage and weight, axe handle	**TOA**: First 20 fish sampled per set	Very High	BIO-01, BIO-01a				Research	Low
O	Otoliths	**TOA and TOP**: 10 per set for each species.	Very High	BIO-01	Yes			Baseline	Medium
O	Genetics	**TOA**: 1 fin clip in ethanol per set from otolith fish, max of 50 combined **TOP**: 1 fin clip in ethanol per set, max of 50	Medium	BIO-04	No	Minor change	Minor change	Research	Medium
O	Liver weights	**TOA/TOP**: Record liver weight from first 10 fish sampled	Medium	BIO-05	No	Yes	Yes	Research	Low
O	Onboard stomach sampling: stomach weights, fullness, contents, digestive state	**TOA/TOP**: Record stomach weight, contents from first 10 fish sampled	Medium	BIO-05	No	Yes	Yes	Research	Low
O	Stomach samples (retained)	**TOA/TOP**: Freeze first 10 stomachs for analysis on shore	Medium	BIO-05	No	Yes (sample label)	Yes	Research	High
O	Muscle tissue	**TOA/TOP**: Freeze small sample of muscle tissue for stable isotope analysis	Medium	BIO-05	No	Yes (sample label)	Yes	Research	Medium
O	Conversion factors	**TOA/TOP**: Refer to WG-FSA-2022/01	High	BIO-03	Yes	No	Update	Baseline	Low

(continued)

Table 3 (continued)

Lead	Data collected	Frequency	Priority	Protocol	Current requirement	Change form	Change manual	Research/ baseline	Processing overhead
	Tagging								
V	Toothfish tagging	One per tonne (in Subarea 88.1 and SSRUs 882A–B), double tagged, overlap statistic >60%. Three fish per tonne (SRZ).	Very High	BIO-02, BIO-02a, BIO-19	Yes			Baseline	Low
V	Skate tagging	Vessel decision to tag skates. If tagging, only tag skates in good condition (include measurement of physiological parameters (lactate)). Record wingspan, any injury codes in comments.	Very High	BIO-07, BIO-07a, BIO-07b	No	Yes – if physio parameters are made baseline	No	Research (physiological parameters)	Low
V	Toothfish recaptures	**TOA and TOP**: Scan every fish for tags. Photograph tags with number readable. Keep stomach and muscle tissue sample. Length, weight, sex, gonad stage, gonad weight and otoliths.	Very High	BIO-05	Yes			Baseline	Low
V/O	Skate tag recaptures	Scan every skate for tags, identify species, photograph tags, bag and return first 10 tagged skates for the trip whole to NIWA with tag in situ, otherwise, sample biologically (PL, WS, TL, sex, stage, weight), collect thorns and freeze with label including tag number. If easier to send whole skate than thorns, feel free to do that. Note: all skates even if frozen whole must have PL, WS, TL, sex, stage, weight entered in eLongline form.	Very High	BIO-02, BIO-07	Yes			Baseline	Low
	Ongoing yearly bottom fishing effects								
V	Mid-point latitude and longitude of segment and total weight of any VME-indicator taxa	All segments. A segment is 1000 hooks or 1200m line.	Very High	BIO-11, BIO-11a	Yes			Baseline	Low
V	Mid-point latitude and longitude of segment, weight and ID VME-indicator taxa	Any segment where 5kg or more is caught, and 30% of other segments	Very High		Yes			Research	Low

(continued)

Table 3 (continued)

Lead	Data collected	Frequency	Priority	Protocol	Current requirement	Change form	Change manual	Research/ baseline	Processing overhead
V	VME samples	Retain a small subsample of VME specimens for all segments where 5 l/kg or more caught in a segment AND taxonomic ID is in question.	High	BIO-11, BIO-11a	No			Research	Low
O	VME (sponges)	Inspect sponges for presence of fish eggs and do something (counts, photos, and size of sponge; or collect eggs and sponge). Coordinate where samples go.	High	Protocol needed (Italy?)		If baseline	If baseline, (add protocol)	Research	
	Year-specific fish biological data – skates								
O	Skate biologicals: Species, length, (total/pelvic/disc width), weight, sex, gonad stage, condition, thorns on recaptures	On any dead or tag recapture skates only. Identify to species, measure PL, TL and WS, weight, sex, condition, stage. Thorns (at least 10) on recaptures.	Very High	BIO-12 SC-CAMLR-39/ BG/31	No (currently only required to sample up to 10 per line)	No	Yes		Low
	Year-specific fish biological data – CHW, ANT, MRL (focus species group season XX, season YY)								
O	ID to species, length, weight, sex, gonad stage and weight	All fish up to 10, every set (mixture) x-ref WG-FSA-10/32 and WG-FSA-15/40	Very High	BIO 2016/14	Yes except for gonad stage and sex	No	Yes if gonad stage and sex required		Low
O	Otoliths	5 otolith pairs every set	High	BIO2016/14	No	No	If baseline		Medium
	Year-specific fish biological data – Macrourids (Focus species group season XX, season YY)								
O	ID to species, length (TL and PAL), weight, sex, gonad stage and gonad weight	All fish up to 10, every set (mixture)	Very High	BIO 2015/12	Yes except for gonad stage and sex	No	Yes if gonad stage and sex required		Low
O	Stomach, isotope sample	Up to 50 but only non-everted stomachs from each species Isotope: from all fish with retained stomachs	High	BIO2015/12	No	Yes if baseline	Yes		High
O	Otoliths	5 otolith pairs every set (matched to fish with biological data)	High		No	No	Yes if baseline		

(continued)

Table 3 (continued)

Lead	Data collected	Frequency	Priority	Protocol	Current requirement	Change form	Change manual	Research/ baseline	Processing overhead
	Other data								
O	Squid beaks	Opportunistic from toothfish stomachs	Low	BIO-06	No	Yes	Yes	Research	
O	Squids	Up to 20 squids of any species with hooked tentacles, frozen whole (including from stomachs)	Low	BIO-16, BIO-16a, BIO-16b	No	Yes	Yes	Research	
O	Colossal Squid	Tissue samples (mantle, ink sac, digestive gland, beak)	Medium	BIO-16, BIO-16a	No	Yes	Yes	Research	
O	Fish specimens	Various opportunistic specimen collection for museum – see protocol	Low	BIO-09	No	Yes	Yes	Research	
V	Underwater camera	Longline autonomous camera. Every set possible	High	BIO-08	No	Yes	Yes	Research	
V	Acoustic data (e.g. for toothfish, macrourids)	Record data within the CCAMLR area (e.g. on ES60 echosounder)	High	Vessel			Yes	Research	
O	Sea lice observations	Subsample each line on form, link to vessel B grade	Low	BIO-15			Yes	Research	
V	Toothfish tagging training videos	Opportunistic video recordings of tagging and release methods used	High	BIO-19			Yes	Research	
O	Alien species	Freeze unusual specimens for museum	Very High				Yes	Research	
V	Zooplankton and microplastics (CPR)	Towing the CPR to collect zooplankton and microplastic samples. Requires the vessel to have gear and CPR expertise, and have filters fitted to all waste-water outlets on the vessel (to avoid plastic contamination)	Low	Plankton e-group = protocols			Yes	Research	
V	Passive acoustic recorder (tow)	Potential to deploy underwater hydrophones while on station (for sperm whales)	Low				Yes	Research	
V	Temp/salinity profilers on longline	Self-logging mini depth-temperature sensors on longlines to measure mixed layer depths	Medium				Yes	Research	

(continued)

Table 3 (continued)

Lead	Data collected	Frequency	Priority	Protocol	Current requirement	Change form	Change manual	Research/ baseline	Processing overhead
V	Minnow trap	Baited small traps deployed on freeline; one per set. Contents to be identified to lowest resolution possible. Count and weigh total amount of each species/species group. Freeze entire sample for museum. Ensure label includes ‘trap’ and haul number.	Medium	BIO-20			Yes	Research	
O	Air sampling	(Weather dependent.) Fill containers during steam down and return from range of latitudes: 45°S, 50°S, 53°S, 56°S, 59°S, 61°S, 64°S, 70°S, 75°S	Medium	Air samples_GNS			Yes	Research	
O	Cetaceans	Opportunistic whale sightings. Photographic data collection for estimating abundance of animals with notable marks. (Biopsies, tagging-noting specialised staff may be required.)	Medium	Cetaceans_2022; (SIOFA template, SIOFA CMM 2021/02 Annex E)	Sightings currently collected during tally period. Photography and biopsies really require specialist researchers		Yes	Research	
O	Seawater (acidity)	Fill small sampling bottle.	Medium				Yes	Research	
O	Plankton community sampling	Fill small sampling bottle with fixative	Medium	Plankton e-group = protocols			Yes	Research	

Attachment I

List of Registered Participants

Workshop on the Ross Sea Data Collection Plan 2022
(Virtual Meeting, 11 and 12 August 2022)

Co-Conveners	Dr Laura Ghigliotti National Research Council of Italy (CNR), Institute for the study of the anthropic impacts and the sustainability of the marine environment (IAS)
	Mr Nathan Walker Ministry for Primary Industries
European Union	Dr Sebastián Rodríguez Alfaro European Union
Germany	Ms Rebecca Konijnenberg Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research
Italy	Dr Marino Vacchi IAS – CNR
Japan	Mr Kyo Uehara Taiyo A&F Co., Ltd.
	Dr Takehiro Okuda Fisheries Resources Institute, Japan Fisheries Research and Education Agency
Korea, Republic of	Mr Hyun Joong Choi TNS Industries Inc.
	Dr Jeong-Hoon Kim Korea Polar Research Institute (KOPRI)
	Dr Haewon Lee National Institute of Fisheries Science
	Dr Eunhee Kim Citizens' Institute for Environmental Studies
	Mr Sang Gyu Shin National Institute of Fisheries Science (NIFS)
	Dr Sangdeok Chung National Institute of Fisheries Science (NIFS)

New Zealand	Dr Jennifer Devine National Institute of Water and Atmospheric Research Ltd. (NIWA)
	Mr Alistair Dunn Ocean Environmental
	Mr Jack Fenaughty Silvifish Resources Ltd
	Dr Brittany Finucci National Institute of Water and Atmospheric Research Ltd. (NIWA)
	Dr Bradley Moore National Institute of Water and Atmospheric Research Ltd. (NIWA)
	Dr Matt Pinkerton National Institute of Water and Atmospheric Research Ltd. (NIWA)
	Mr Enrique Pardo Department of Conservation
Norway	Dr Cecilie von Quillfeldt Norwegian Polar Institute
Russian Federation	Mr Oleg Krasnoborodko FGUE AtlantNIRO
	Mr Aleksandr Sytov FSUE VNIRO
	Dr Svetlana Kasatkina AtlantNIRO
South Africa	Mr Sihle Victor Ngcongo Imvelo Blue Environment Consultancy (Pty) LTD
	Mrs Melanie Williamson CapMarine Environmental
	Mr Christopher Heinecken Capricorn Fisheries Monitoring
Ukraine	Mr Pavlo Zabroda Institute of Fisheries and Marine Ecology (IFME) of the State Agency of Fisheries of Ukraine

	Mr Illia Slypko Institute of Fisheries and Marine Ecology (IFME) of the State Agency of Fisheries of Ukraine
United States of America	Dr George Watters National Marine Fisheries Service, Southwest Fisheries Science Center
CCAMLR Secretariat	Isaac Forster Fisheries and Observer Reporting Coordinator
	Daphnis De Pooter Science Data Officer
	Dr Steve Parker Science Manager
	Claire van Werven Research, Monitoring and Compliance Analyst

Attachment II

Terms of Reference for the Workshop on the Ross Sea Data Collection Plan (WS-RSDCP)

Date and location

11 and 12 August 2022

Co-conveners

Laura Ghigliotti (Italy) and Nathan Walker (New Zealand)

Objective

To develop research objectives to support the information needs of the Ross Sea region marine protected area and management of the Ross Sea toothfish fishery, with an emphasis on by-catch and ecosystem sampling requirements. At the same time, develop a fisheries-based data collection plan for fishing vessels and observers, including sampling procedures and supporting documentation.

Target attendees

CCAMLR Members (including observer program coordinators, and fishing industry operators) and the CCAMLR Secretariat.

Format

A hybrid format with an e-group for document review and discussion, followed by a virtual meeting to enable a live discussion and development of additional research activities. To be arranged with Secretariat support.

Outputs

To be developed as a Co-conveners report to WG-FSA-2022:

(i) identify medium-term research objectives
(ii) develop an associated data collection plan to meet the research objectives
(iii) identify high-priority fishery surveys or research activities
(iv) identify voluntary programs to test novel data collection mechanisms.

Financial requirements

A virtual meeting is proposed. Financial support for Secretariat participation and meeting support is requested.

Attachment III

Agenda

Workshop on the Ross Sea Data Collection Plan 2022
(Virtual Meeting, 11 and 12 August 2022)

1. Identify fishery-based medium-term research objectives

   1.1 Review 2014 plan progress
   1.2 Identify the fisheries-based research objectives to inform data collection needs

2. Develop a sampling plan to obtain necessary data

   2.1 Sampling plans and timetables for individual species/species groups or sample types for fishing vessels with clear, rationalised observer data requirements
   2.2 Develop sampling protocols required
   2.3 Identify any revisions necessary for forms or instructions

3. Identify high priority non-Olympic fishery research activities (e.g. CM 24-01)

   3.1 Research on the effects of the MPA on fish abundance (inside/outside comparisons)
   3.2 Out of season surveys (winter)
   3.3 Targeted sampling (e.g. tagging survival)

4. Identify voluntary programs to test novel data collection mechanisms

   4.1 Fishery target sampling activities (e.g. electronic monitoring)
   4.2 Ecosystem sampling activities (e.g. automated data collection methods)
   4.3 Physical oceanographic measurements (e.g. mixed layer).

Attachment IV

List of Documents

Workshop on the Ross Sea Data Collection Plan 2022
(Virtual Meeting, 11 and 12 August 2022)

WS-RSDCP-2022/01	Review of progress against the medium-term research plan for the Ross Sea toothfish fishery Delegation of New Zealand
WS-RSDCP-2022/02	Proposed medium-term research plan for the Ross Sea toothfish fishery Delegation of New Zealand
WS-RSDCP-2022/03	Research activities and voluntary programs for the Ross Sea region toothfish fishery Delegation of New Zealand

Appendix E

Format 1

Format for submitting finfish research plans in accordance with paragraph 6(iii) of Conservation Measure 21-02

Category	Information
1. Main objective	(a) Objectives for the research to meet the requirements of CM 21-02 (paragraph 1(ii). (b) Detailed description of how the proposed activities will meet the objectives, including annual research milestones, and end date of research.
2. Background	(a) List of previous research plans in this fishery (b) Information on the target species in this area, for example: • Stock hypothesis • Summary of available information on the target and dependent species • Biomass estimates and stock status of target species
3. Fishery operations	(a) Fishing Member/s (b) Vessel/s to be used: • Vessel/s name • Link to vessel/s notification (c) Description of fishing gear types to be used, and link to gear library (d) Fishing region/s (divisions, subareas and SSRUs) and geographical boundaries (e) Estimated dates of entering and leaving the CAMLR Convention Area
4. Fishing design	(a) Description and rationale of fishing design, for example: • Spatial arrangements or maps of stations/hauls (e.g. where effort limited) • Consideration of environmental conditions (e.g. sea ice) • Any stratification according to e.g. depth, vessels, gear or fish density • Proposed number and duration of stations/hauls (e.g. where effort limited) • Tagging rates and tag overlap statistics for tagging programs at the scale of research blocks (where applicable).
5. Data collection	(a) Types and sample size (e.g. by location/haul) of data to be collected, for example: • Related biological (including taxonomic resolution), with minimum observer sampling requirements as detailed in the Observer Sampling Requirements (Conservation Measure 41-01, Annex 41-01/A). • Ecological and environmental data • Acoustic data (where applicable)
6. Methods	(a) Methods and timeline for sample processing, for example: otolith ageing (b) Method for data analyses to achieve the objective in 1(a), for example: • Catch rate standardisation • Estimates of biological parameters • Stock assessment of target species
7. Delivery	(a) How and when will the research outcomes 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.

(continued)

Category	Information
8. Proposed catch limits	(a) Proposed catch limits and justification (b) Evaluation of the impact of the proposed catch on stock status, including: • rationale that proposed catch limits are consistent with Article II of the Convention • evaluation of timescales involved in determining the responses of harvested, dependent and related populations to fishing activities • information on estimated removals, including IUU fishing activities, where available. (c) Details of dependent and related species and the likelihood of their being affected by the proposed fishery.
9. Research capability	(a) Name(s) and address of the chief scientist(s), research institute or authority responsible for planning and coordinating the research. (b) Number of scientists and crew to be on board the vessel/s. (c) Is there opportunity for inviting scientists from other Members? If so, indicate a number of such scientists. (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.
10. Conservation measure exemptions	(a) If applicable, intended exemptions from relevant conservation measures in whole or in part, and justification. Any intended exemptions shall be necessary for the Research Plan and objectives of the proposed research.

Additional Guidelines for the Icefish Survey in Subarea 48.2

1. The Working Group recommended that the mackerel icefish (*Champsocephalus gunnari*) survey in Subarea 48.2 presented within WG-FSA-2022/17 be conducted for a one-year period with the following changes to better accomplish its goals:

(i) gridded station points (Tables 8 and 9 and Figure 6) become oblique tows to a depth of 200 m consistent with the method described in WG-EMM-18/23

(ii) up to an additional 32 target trawls be conducted to identify the composition of acoustic marks

(iii) a flow meter be included on net hauls with relevant data recorded

(iv) where possible, a 38 kHz transducer be included with the acoustic frequencies

(v) a krill by-catch limit of 279 tonnes be set for this research.

Gridded station trawls

2. At each station, a quantitative standard double oblique tow will be conducted from the surface down to 200 m (or to within 10 m of the bottom at stations shallower than 200 m). During the hauls, a constant ship's speed of 2.5 ± 0.5 knots is suggested. It is recommended to maintain a wire speed of 0.7 to 0.8 m sec^{-1} (42 to 48 m min^{-1}) during paying out and of 0.3 m sec^{-1} (18 m min^{-1}) during hauling as this will ensure that the net mouth angle remains constant during hauling within the speed ranges given above. When the net reaches maximum depth, the winch should be stopped for about 30 seconds to allow the net to stabilise before starting to retrieve the net. If the net is hauled from the stern of the ship, then the propeller of the ship should be stopped when the net reaches a depth of 15 to 20 m; this is to minimise the effects of the propeller action on the net operation and to avoid damage of the samples. The total time of the net haul from surface to bottom to surface is likely to be 40 minutes (WG-EMM-2018/23).

Target trawls

3. Directed or targeted net sampling effort will be necessary to reduce the uncertainty associated with the delineation of icefish in the acoustic data record. This sampling would be directed whilst conducting acoustic transects at a variety of acoustics registrations or 'acoustic morphs', some presumed to be icefish and some presumed not to be icefish. Such target net hauls should, as a general rule, be undertaken when significant changes in the acoustic scattering structures are observed. No more than eight target trawls should be conducted per transect (WG-EMM-2018/23).

Stock Assessment Modelling for *Euphausia superba*

1. WG-FSA-2022/35 calculated a range of proportional recruitment scenarios based on the US AMLR surveys. The values tested were based on (i) whether they included: daytime only, night time only, or all data, as well as (ii) whether all years of data were used, only those years with Joinville Island strata sampled (1997, 2002–2011), or those years with Joinville Island strata sampled continuously (2002–2011). The Working Group noted that all data should be used, and that the scenarios presented within WG-FSA-2022/35 did not include the 2020 *Atlantida* data (WG-EMM-2021/12).

2. Here an addition to the Grym scenarios is presented in WG-FSA-2022/35 which includes both day and night data from all US AMLR surveys which sampled Joinville Island strata (1997, 2002–2011) as well as the 2020 *Atlantida* survey. The mean and standard deviation of the proportional recruitment from the 12 surveys were 0.5047 and 0.2406 respectively. All other model parameters were chosen from scenario 18 of WG-FSA-2021/39 to be consistent with the models presented in WG-FSA-2022/39 (Table 1).

Table 1: Grym parameters and their initial values from WG-FSA-2021/39, scenario 18 and Appendix 1. Note, natural mortality is calculated within the model as a function of proportional recruitment. It is included here to provide an expected range for comparing to those calculated for proportional recruitment values.

Parameter	Subarea 48.1	Reference
First age class	1	Thanassekos (2021)
Last age class	7	Constable and de la Mare (1996)
t_0	0	Constable and de la Mare (1996)
L_∞	60 mm	Constable and de la Mare (1996)
k	0.48	Thanassekos (2021)
Start growth period (dd/mm)	21/10	Thanassekos (2021)
End growth period (dd/mm)	12/02	Thanassekos (2021)
Weight-length parameter – A (g)	0.000004	Maschette et al., (2021)
Weight-length parameter – B	3.204	Maschette et al., (2021)
Min length, 50% mature	37.6 mm	Maschette et al., (2021)
Max length, 50% mature	44.3 mm	Maschette et al., (2021)
Range over which maturity occurs	8 mm	Maschette et al., (2021)
Start of spawning season (dd/mm)	15/12	Kawaguchi (2016)
End of spawning season (dd/mm)	15/02	Kawaguchi (2016)
Monitoring interval (dd/mm)	01/01 to 15/01	Thanassekos (2021)
Recruitment function	*Proportional*	
Mean proportional recruitment	0.5047205	This study
SD of proportional recruitment	0.2406113	This study
Natural mortality range	0.5–1.1	Pakhomov (1995)
Min length, 50% selected	30 mm	Thanassekos (2021)
Max length, 50% selected	35 mm	Thanassekos (2021)
Range over which selection occurs	11 mm	Thanassekos (2021)
Fishing season (dd/mm)	01/12 to 30/11	Thanassekos (2021)
Reference date (dd/mm)	01/10	Thanassekos (2021)
Reasonable upper bound for Annual F	1.5	Constable and de la Mare (1996)
B_0logSD	0.361	Kinzley (2021)
Target escapement	75%	Constable and de la Mare (1996)

3. Two gamma values are calculated to meet the requirements of the decision rules. The first, that the probability of the spawning biomass dropping below 20% of its pre-exploitation median level over a 20-year harvesting period is 10%; the second, that the median krill escapement in the spawning biomass over a 20-year period is 75% of the pre-exploitation median level. The final step of the decision rules is to select the lower of the two as the level for calculation of krill yield. The yields that satisfy the two rules are 3.38% and 6.8% respectively, choosing the lower of the two results in a precautionary yield of 3.38% for Subarea 48.1. Diagnostic and projection plots are shown in Table 2 and Figures 1 to 3.

Table 2: Summary statistics of mortality based on mean and standard deviation for proportional recruitment using an inverse-beta distribution.

R.mean	R.sd	M mean	M min	M max	M prop in range
0.5047	0.2406	0.821	0.265	1.643	0.919

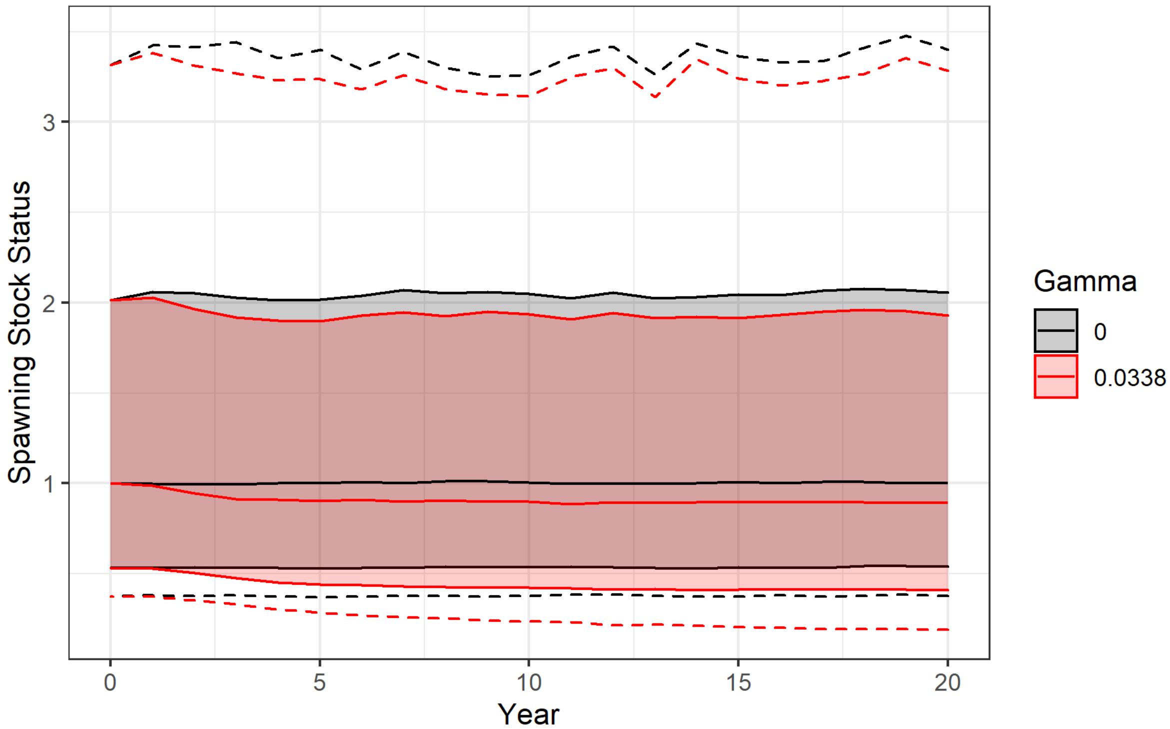

Figure 1: Spawning stock status for 20-year simulated krill population in Subarea 48.1 based on fished and unfished projection, showing median with 90% (shaded) and 97.5% confidence intervals (dashed).

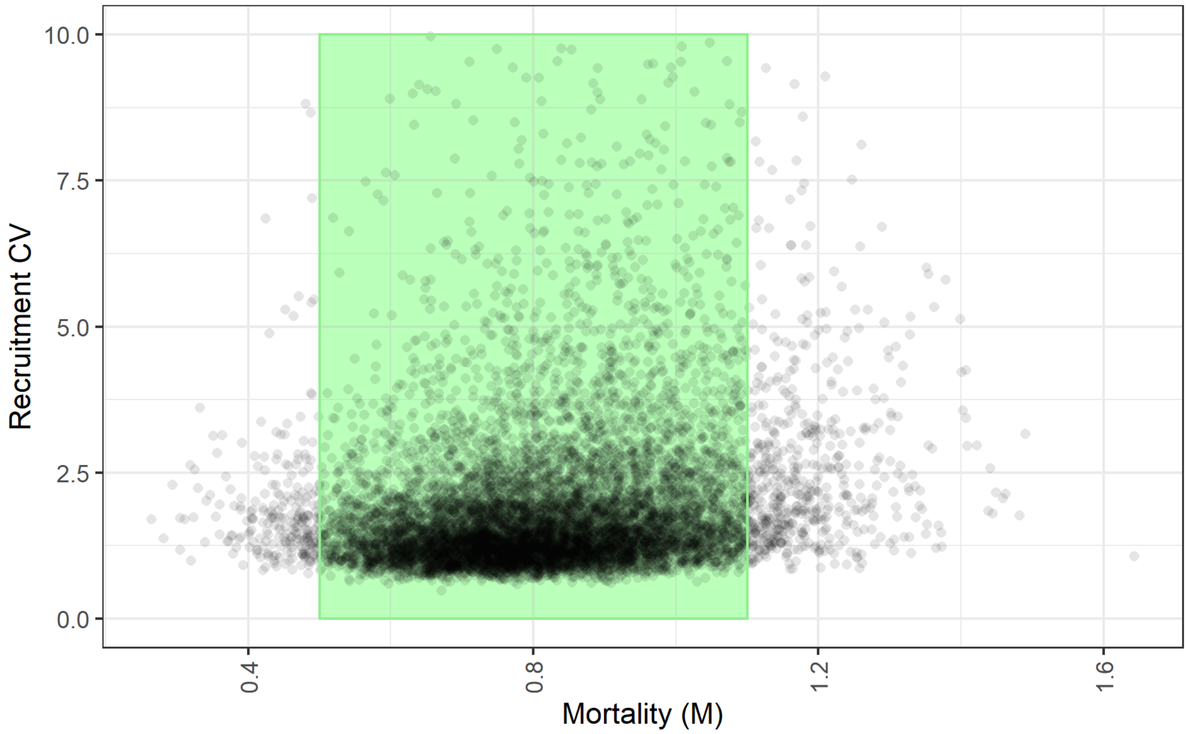

Figure 2: Comparison of mortality and recruitment CV for mean and standard deviation of proportional recruitment using an inverse-beta distribution. Mortality range 0.5–1.1 in green.

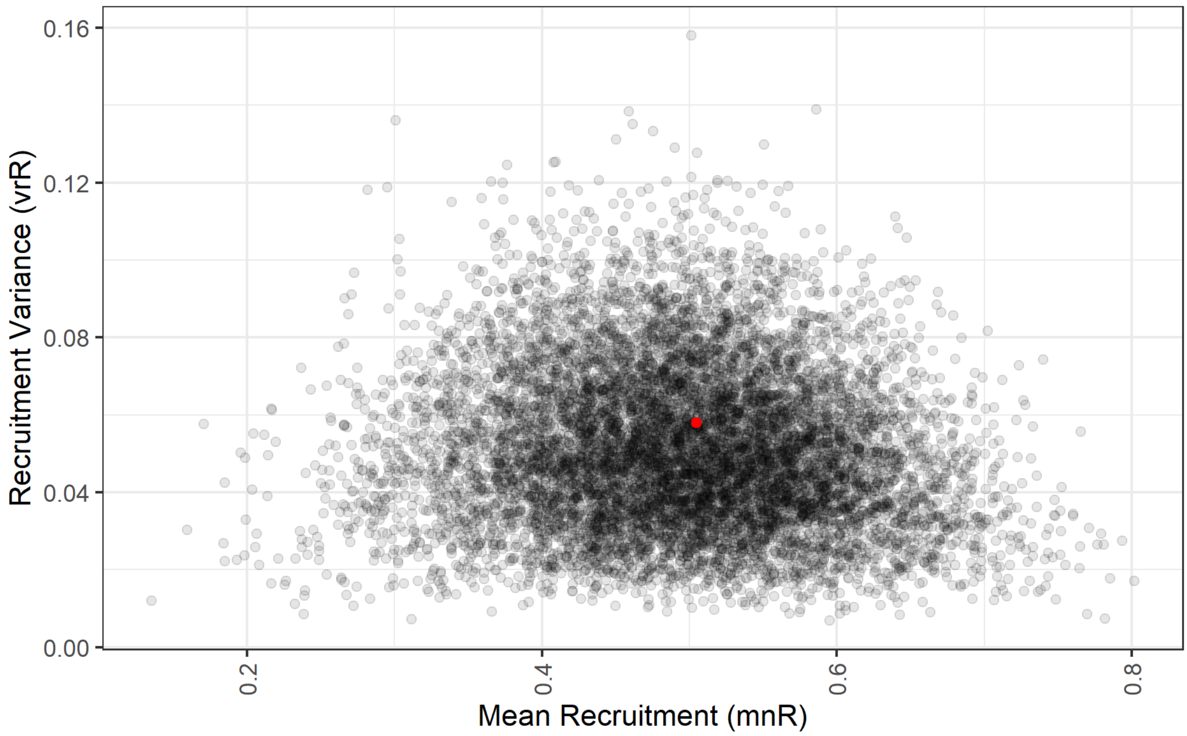

Figure 3: Estimated mean recruitment and recruitment variance for starting mean and standard deviation values for proportional recruitment using an inverse-beta distribution. Starting values for model indicated in red.

The Revised Krill Management Approach

1. WG-FSA noted that there was a requirement for a simplified explanation of the revised krill management approach used to provide advice to Scientific Committee and Commission. This appendix presents the workflow of the process that has been in development in scientific working groups and agreed by the Scientific Committee.

2. The approach is comprised of three components, namely the biomass estimation, the stock assessment using the GYM model in R (Grym) and the spatial overlap analysis (formerly called the risk assessment).

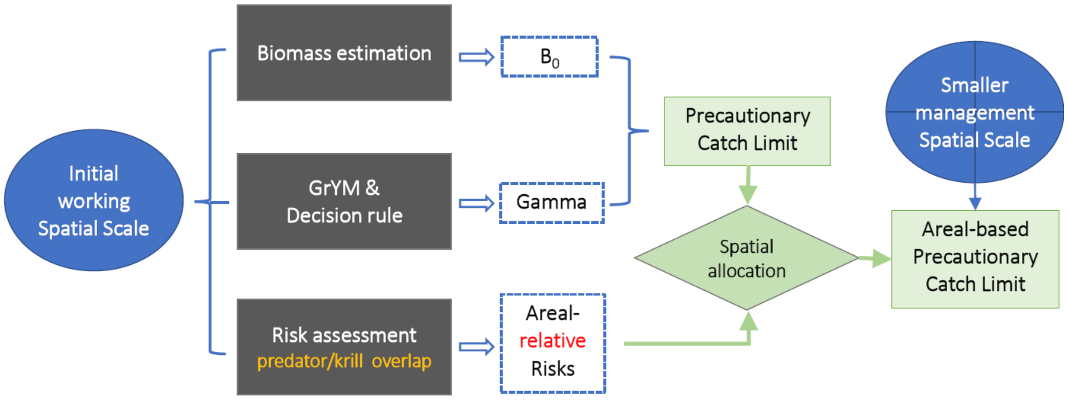

Figure 1: The three components and workflow of the revised krill management approach, as agreed at SC-CAMLR-40, Annex 8 (paragraph 3.25).

Biomass estimation

3. The first component of the framework is biomass estimation, which is to estimate the standing stock biomass (B_0) of the area-specific Antarctic krill stock in question. The B_0 estimate for Subarea 48.1 used in the present krill management approach is an aggregated outcome.

4. The biomass for the adjusted four US AMLR strata (Elephant Island, Joinville Island, Bransfield Strait and South Shetland Islands West) is averaged over multi-year survey data to address the dynamic (periodical) nature of krill recruitment; the biomass for the remaining three strata (Drake passage, Powell Basin and Gerlache Strait) is the lower one-sided 95% CI of the corresponding acoustic estimate based on one single survey.

Grym model assessment

5. The second component of the framework is the Grym (WG-SAM-2021) model assessment, which is used to estimate the precautionary harvest rate (gamma) used in the three-step CCAMLR decision rules developed to operationalise for krill management paragraph 3 of Article II of the Convention (SC-CAMLR-IX, Annex 4).

6. The rules as set out in Butterworth et al. (1992) and Constable et al. (2000):

(i) achieve a median (spawning) biomass of at least 75% of the pre-exploitation median (spawning) biomass over a 20-year period

(ii) achieve a less than 10% possibility that the spawning biomass falls below 20% of its pre-exploitation median level over a 20-year period

(iii) select the lower of the two values as the precautionary harvest rate of the specific krill stock.

7. When the precautionary harvest rate or gamma is derived, the precautionary catch limit can simply be obtained by multiplying the B_0 with gamma.

Spatial overlap analysis framework (formerly called risk assessment)

8. The third component of the framework is the spatial overlap analysis framework which was originally developed by Constable et al. (WG-FSA-2016/47) and applied by Kelly et al. (WG-EMM-2018/37) in the East Antarctic.

9. The framework used for advice, as implemented and described by Warwick-Evans et al. (WG-EMM-2021/27), can assess the relative overlap of the localised impacts of fishing on both predators and krill, apportioning catch levels in space and time to account for the inverse of the overlap index. Areas with lower overlap are allocated higher proportions of the catch limit, and areas with higher overlap will have lower catch proportions.

10. The framework does not reduce, or increase, the overall catch limit in a region, but only alters the spatial (between strata) and temporal (between summer and winter) distribution of catch limits.

Appendix I

Amended Terms of Reference for the Proposed Krill Fishery Observer Workshop

1. Assess the time allocations and instructions for the krill observer data collection requirements and identify the training requirements.

2. Provide a forum for Members to share experiences on the tasking of observers to develop common methods and approaches.

3. Provide opportunities for the information exchange between observers and CCAMLR scientists, including discussion on the importance and potential of observer data for advancing krill science and management.

4. Provide a forum for observers to share experiences on how to conduct the sampling recommendations from CCAMLR while managing an appropriate workload.

Appendix J

Report of the Co-conveners of the Workshop on Conversion Factors for Toothfish
(Virtual Meeting, 12 and 13 April 2022)

**Report of the Co-conveners of the Workshop
on Conversion Factors for Toothfish**
(Virtual Meeting, 12 and 13 April 2022)

Introduction

1. The Workshop on Conversion Factors for Toothfish was held online on 12 and 13 April 2022. The workshop was co-convened by Mr N. Walker (New Zealand) and Mr N. Gasco (France) and supported by the CCAMLR Secretariat. Scientists from 10 Members attended the Workshop.

2. At the opening of the meeting, Mr Gasco welcomed and acknowledged the 43 participants (Attachment I) and noted that the workshop was an informal meeting to review current procedures and develop standardised guidelines for on-board sampling procedures, including the calculation and use of conversion factors (CFs) in all CCAMLR toothfish fisheries (SC-CAMLR-40, paragraph 3.35). Accordingly, this report is not an adopted report, but is a summary by the Co-conveners for the consideration of the Scientific Committee and its working groups. The intent is that the recommendations and analyses outlined below will be reported to WG-FSA-2022 for further discussion and agreed at SC-CAMLR-41 according to the Scientific Committee Rules of Procedure.

Terms of reference and agenda

3. The Co-conveners recalled the terms of reference taken from WG-FSA-2021, paragraphs 2.6 and 2.7:

(i) To review and develop standardised guidelines for on-board sampling procedures and the calculation, and use of, CFs in all CCAMLR toothfish fisheries.

(ii) Review a summary of on-board sampling procedures, and an analysis of the calculation and implementation of CFs in deriving catch weights between and within vessels, Members and fisheries to be undertaken by the Secretariat as an update to WG-FSA-15/02, including consideration of the effect of CF variability on total catch removals.

(iii) Consider that the workshop be hosted virtually, facilitated by the Secretariat during March/April 2022, with the meeting of a duration of two days. Results from the workshop will be presented as a convener report to WG-FSA-2022.

4. The agenda was adopted (Attachment II).

5. This report was prepared by the Co-conveners with support from the Secretariat.

Review of onboard sampling procedures

6. Documents submitted to the meeting are listed in Attachment III.

7. WS-CF-2022/03 described the variables that influence CF values and how to improve their accuracy. It was noted that only one type of scale is used on French vessels, therefore it was not possible to determine the effect of the type of scale.

8. WS-CF-2022/01 described the analyses of CF data and its implication for estimation of total catch. This document showed that from 2016 through 2021 observer-reported values were more variable and typically higher than vessel-reported values, and that in most cases estimated green weight would be less than 4% higher if using the observer-reported CFs.

9. WS-CF-2022/02 described the sampling, calculation and use of CFs by New Zealand vessels. Observers are tasked with undertaking 2–3 CF samples of at least 20 fish per week. It was noted that the use of motion-compensated scales provide the best accuracy, although maintaining larger sample sizes may make the use of motion-compensated scales impractical when factory configurations make the use of the same scale onerous for both measurements. It was noted that clear illustration on the type of cuts being used would be welcome.

10. WS-CF-2022/04 presented an analysis of CF data from longline vessels in CCAMLR Subarea 48.3. Cut type, weighing method, seasonal variation, size of fish and vessel were likely important factors influencing CFs.

11. It was noted that a modelling approach on the data held by the Secretariat would provide valuable information that could be presented during the next Working Group on Fish Stock Assessment (WG-FSA) meeting.

12. During the review of current on-board sampling procedures, it was noted that there are no rules on how CFs are to be calculated or implemented beyond the instructions for Scheme of International Scientific Observation (SISO) observers on how to conduct a CF sampling test. Various Members undertake different approaches regarding personnel conducting CF tests, frequency of sampling, sample sizes, and if or how CFs are then used by the vessels when reporting their C2 data (see Figure 1).

13. With regard to the sampling methodology, the following key points were discussed:

(i) Draining the water from the stomach: The stomach often empties itself as the fish are being handled but, in some cases, it is observed that there is still significant water in the stomach. Draining the water is easy to do and important for accuracy. Noting that the increased accuracy gained by draining the water may be lost if not using motion-compensated scales.

(ii) Stomach contents: Depending on the geographic area, most stomachs are likely to be empty of prey, however, large volumes of prey in some stomachs could add additional variability to CFs. Some methods for emptying the stomach contents were mentioned, although damage to the end product may result.

(iii) Using un-bled fish: Sampling using un-bled fish is preferable but not always practical as the fish are bled immediately when brought on board many vessels. The volume of blood was estimated to be relatively small, with the largest fish likely to have less than 500 ml of blood removed.

(iv) Use fish in good condition: Do not use fish that have been preyed upon (liced (scavenging amphipods) or otherwise damaged by predators) for CF sampling.

(v) Batch or individual records: Recording CFs for individual fish within the sample has a benefit of providing an accurate size that can be used to calculate a length-frequency distribution for fish included in the sample. This can then be compared to the length-frequency distribution of the catch to see if the fish used for CF tests were representative of sizes of fish in the catch. It is possible to calculate an overlap statistic analogous to the tagging size overlap statistic to provide a metric indexing how well the CF of fish reflected the overall size distribution of the catch.

(vi) Type of scale: Motion-compensated scales are expensive. They can weigh fish up to 60 kg which represents most of the fish caught. Having a motion-compensated scale is a priority as without it, the other factors such as draining water are negligible errors. Large fish are difficult to move through the factory to the motion-compensated scales if not optimally located. Even with motion-compensated scales, condition factor tests should not be conducted if the weight data may not be accurate, for example in extremely rough weather.

(vii) Sample size and frequency of sampling: Undertaking smaller more frequent CF tests may lead to more accurate CF data. Currently no instructions are provided on how often to conduct CF tests.

(viii) Type of processing cut: It is important to report more detail on the cut used by the vessel, but clear descriptions would be needed as there is variation in the detail of how the cut is used. It was noted that market preference may be influencing the exact cuts used even within a trip.

(ix) Maturity stage: Gonad weight is worth collecting during CF tests as it gives information on the size of the gonad which influences CF value. Reproductive development could influence the CF in different seasons as well and could require sampling stratification.

(x) Location of fishing: More generally, it is important to recognise that different size fish exist in different locations and that CF will therefore vary geographically. Real-time sampling or stratification of CF sampling to occur when vessels enter new areas, or if fish migrate at certain times of the year, which changes the size distribution in an area. An analysis to standardise the relative impacts of various factors on the resulting CF would assist in developing procedures for data collection that account for the most influential variables (see paragraph 11).

(xi) Individual fish data: Attention must be paid to keep track of the fish through the process to obtain the final processed weight. It was noted that some vessels glaze the fish prior to the blast freezer and subsequent tail removal, and this might affect the final weight depending on when the final weight for the processing method is obtained (including changes due to additional water weight from the glazing and/or water loss in the freezing process).

(xii) Although observer CF tests are reported to the Secretariat, they are currently not routinely analysed or reported back to the working groups to identify potential data quality issues. The Workshop recommended standard reporting of CF data would be useful to identify how well the data collection system is performing.

14. The analysis undertaken by WS-CF-2022/03 indicated that CFs may not be required to be undertaken in real time during the fishing season, if stratification of fisheries using the appropriate factors was undertaken. The Workshop requested that the Secretariat undertake a similar generalised linear model (GLM) analysis to explore factors on which to base a stratified approach to setting CFs. Further consideration of the future approach should be based on this further analysis.

15. The Workshop considered that there was a need for a more consistent approach for undertaking CF tests and supplying data to the Secretariat, and a consistent approach for setting CFs to be utilised by the vessels. A suggested approach for this is given in Figure 2.

Development of draft guidelines

16. The Workshop recommended that the Secretariat develop a more complete guide to collecting CF data for both observers and vessels, updating that once the sampling methodology for CF tests and CF data implementation has been agreed. The current instructions are attached as Attachment IV.

17. The Workshop discussed various potential improvements to the guidelines, including potential benefits of smaller sample sizes undertaken more frequently. However, the Workshop considered that a power analysis should be undertaken to verify the ideal sample size for the strata determined by the GLM analysis.

Next steps

18. The Secretariat will undertake a standardisation analysis to identify recorded factors that influence the CF value and report to WG-FSA-2022.

19. The Workshop considered that a power analysis could guide data collection of CF data as it could determine required sample sizes given the accuracy needed in CFs for management purposes. The accuracy and power required would need to be specified by the Scientific Committee.

20. The Workshop recommended the Secretariat consider and propose a standard reporting of CF data to identify how well the data collection system is performing.

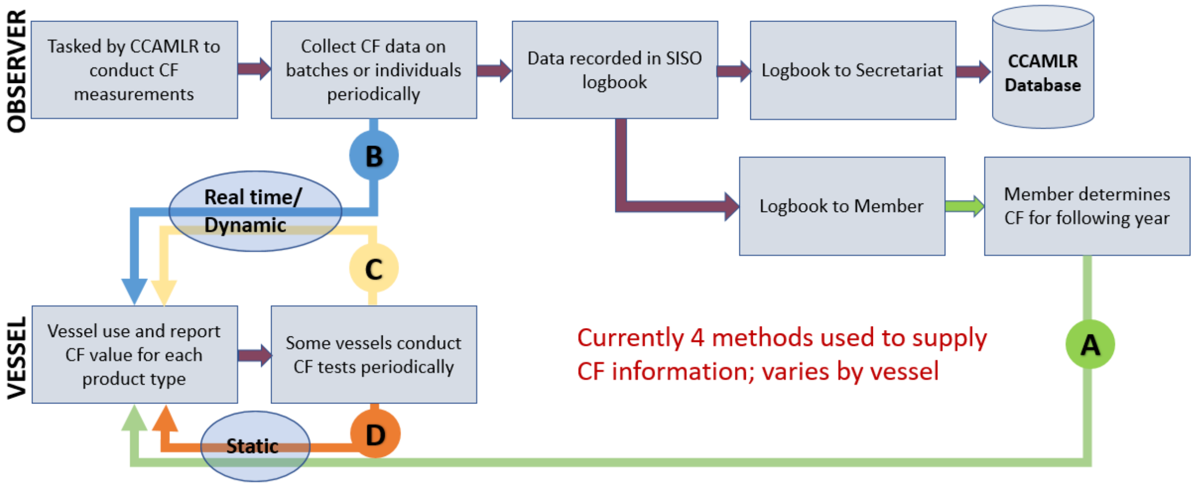

Figure 1: Diagram of the current variations on the use of CF information within CCAMLR. The letters A to D indicate the different pathways for CF data in current use.

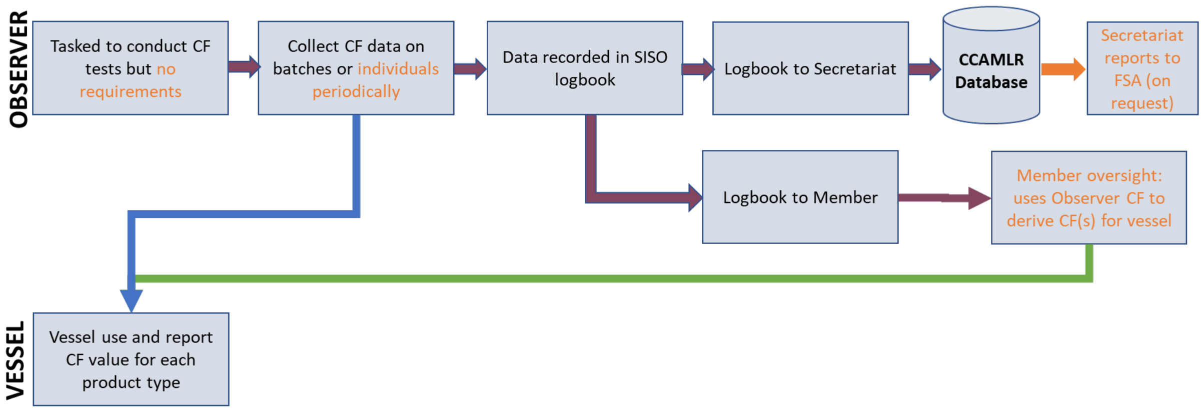

Figure 2: Diagram of the potential data flow for CF data in CCAMLR. The blue arrow indicates a real-time data flow to utilise the CF data. The green arrow would follow a static approach where CFs would be set by Members (or the Secretariat) in advance of each season.

Attachment I

List of Participants

Workshop on Conversion Factors for Toothfish
(Virtual Meeting, 12 and 13 April 2022)

Co-conveners	Mr Nicolas Gasco Muséum national d'Histoire naturelle
	Mr Nathan Walker Ministry for Primary Industries
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	Mr Rhys Arangio Austral Fisheries Pty Ltd
	Mr Tim Lamb Australian Antarctic Division, Department of Agriculture, Water and the Environment
	Mr Martin Tucker Australian Fisheries Management Authority
	Ms Claire Wallis Australian Fisheries Management Authority
	Dr Philippe Ziegler Australian Antarctic Division, Department of Agriculture, Water and the Environment
European Union	Mr Joost Pompert Pesquerias Georgia, S.L
	Dr Sebastián Rodríguez Alfaro European Union
France	Dr Marc Eléaume Muséum national d'Histoire naturelle
India	Dr Sendhil Kumar R Centre for Marine Living Resources and Ecology
Japan	Mr Sachio Hagiya Taiyo A & F Co. Ltd.

	Mr Naohisa Miyagawa Taiyo A & F Co. Ltd.
	Dr Takehiro Okuda Fisheries Resources Institute, Japan Fisheries Research and Education Agency
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	Dr Sangdeok Chung National Institute of Fisheries Science (NIFS)
	Dr Haewon Lee National Institute of Fisheries Science (NIFS)
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	Mr Christopher Heinecken Capricorn Fisheries Monitoring
	Mr Sihle Victor Ngcongo Imvelo Blue Environment Consultancy (Pty) LTD

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	Mr Dmitry Marichev LLC Fishing Company NEPTUNO
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	Mr Illia Slypko Institute of Fisheries and Marine Ecology (IFME) of the State Agency of Fisheries of Ukraine
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	Mr James Clark MRAG
	Dr Chris Darby Centre for Environment, Fisheries and Aquaculture Science (Cefas)
	Ms Sue Gregory Foreign and Commonwealth Office
	Mrs Rhona Kent WWF UK
	Ms Georgia Robson Centre for Environment, Fisheries and Aquaculture Science (Cefas)
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Mr Peter Thomson
Argos Froyanes

Mr Andrew Watson
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Eldene O'Shea
Compliance Officer

Dr Steve Parker
Science Manager

Alison Potter
Data Administration Officer

Claire van Werven
Research, Monitoring and Compliance Analyst

Attachment II

Agenda

Workshop on Conversion Factors for Toothfish
(Virtual Meeting, 12 and 13 April 2022)

1. Welcome

2. Review

    2.1 Current on-board sampling procedures
    2.2 Conversion factor calculation methodology
    2.3 Conversion factor implementation
    2.4 Effect of variability on total catch removals

3. Develop draft guidelines

    3.1 On board sampling
    3.2 Calculation
    3.3 Use of conversion factors

4. Next steps.

Attachment III

List of Documents

Workshop on Conversion Factors for Toothfish
(Virtual Meeting, 12 and 13 April 2022)

WS-CF-2022/01	A review of toothfish conversion factor data submitted by vessels and scientific observers, and implications for estimation of total catch CCAMLR Secretariat
WS-CF-2022/02	Sampling, calculation and use of conversion factors by New Zealand N.A. Walker, J. Fenaughty, A. Berry, M. Messina and A. Burgess
WS-CF-2022/03	Variables that drive conversion factors and how to improve their accuracy N. Gasco
WS-CF-2022/04	Analysis of conversion factor data from longline vessels in CCAMLR Subarea 48.3 J. Moir Clark, J. Chapman and R. Stacy

Other Documents

WG-FSA-15/77	Conversion factors used for Patagonian toothfish in Division 58.5.1 and Subarea 58.6 N. Gasco (France)
WG-FSA-2021/03	Results from the Conversion Factor Survey conducted by the Secretariat in 2020, from Members' vessels participating in CCAMLR toothfish fisheries CCAMLR Secretariat

Attachment IV

Current CCAMLR Conversion Factor Procedure

Conversion factor procedure

Process

1. The process of determining a conversion factor (CF) (Table 1) is by recording fish weights in an unprocessed state and later recording the weights of the same fish when processed. The CF value is the number obtained by dividing the green weight by the processed weight.

Number of fish and frequency of sampling

2. Sample five fish per individual haul with a weekly sample size of 25 individuals.

Table 1: CF step by step procedure.

1	Randomly select the fish that will be used for the process. It is important to select a range of fish sizes that are representative of the whole catch for the haul.
2	Drain the water from the fish's stomach using a sharp knife or a pipe (Figure 1) to ensure that water swallowed by the fish during the hauling process is not included as part of the live weight.
3	Weigh the fish whole and unprocessed, before any parts are removed.
4	Record the product type (e.g. HGT for headed, gutted and tailed) and, if appropriate, the cut type (e.g. straight cut).
5	Record the weight of the final processed product for each fish. For HGT, this is normally just the trunk of the fish (Figure 2). Calculate the CF by dividing the whole live weight by the processed weight.

Figure 1: Demonstration of a drain tube used for draining toothfish stomachs of water.

Figure 2: Trunks produced using the HGT processing method.

Appendix K

Updated Terms of Reference for WG-FSA

WG-FSA – SC-CAMLR-III (1984), paragraph 7.54.

1. To assess the status of fish stocks in the Convention Area.

2. To assess other Antarctic marine living resources (as defined in Article I of the Convention) as requested by the Scientific Committee.

3. To advise on the management measures needed to achieve the Commission's objective taking account of any requests made by the Scientific Committee.

4. To identify further research studies and data collection which would be required for improved stock assessment and/or other assessments related to paragraph 2.

5. To review and provide advice on research plans as required by the Scientific Committee.

6. To submit a report to the Scientific Committee which would, inter alia, assist the Committee in considering any management measure.